PRODUCT DEVELOPMENT IN DISH WASH CAKE MANUFACTURING INDUSTRY USING PROJECT MANAGEMENT

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Dedicated to

my father ***L. Divianadane***

my mother ***D. Andoniammalle***

and my sister-in-law ***Mrs. Saint Hillaire Jile***

who are the motivating forces for my study.

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ABSTRACT

PRODUCT DEVELOPMENT IN DISH WASH MANUFACTURING INDUSTRY USING PROJECT MANAGEMENT

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More recently during and after the coronavirus pandemic, there was a sudden increase in the demand for soap items, sanitizers, masks, medicines, and so on. There was a great struggle in the industrial sectors to meet the balance between the increased demand and supply of soaps, masks, and even vaccines. The research question is that during similar crises whether production in an industry could be increased rapidly by using project management techniques to solve crises. The present research is an attempt in this direction. This study was conducted in the dish wash soap manufacturing industry. In the present study, project management techniques were adopted to increase the production of dish wash soaps. After a thorough analysis of the manufacturing process of the soaps, seven important viable locations were identified in the existing mechanical system to make modifications and increase production. Consequently, some modifications were also made in human resources. The total production and other associated factors like quality, electrical power consumption, breakdown time and frequency, and excess giveaway were assessed before and after the modifications in a random sample of 33 shifts in nine months and compared. Statistical techniques, such as mean, standard deviation, and ANOVA were employed to analyze the data. The results showed that there was no change in the quality of the soap cake and electric power consumption after the modifications. The bulk manufacturing time, breakdown time, and frequency were reduced. The production of soap cake was increased considerably by 12.63%. More importantly, the result showed that the excess giveaway was reduced considerably. On the whole, the project management was a grand success in increasing in production of soap cake.

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LIST OF ABBREVIATIONS

APC	:	Automatic Process Control
APM	:	Agile Project Management
BT	:	Business Times
CCPM	:	Critical Chain Project Management
CEO	:	Chief Executive Officer
CIDB	:	Construction Industry Development Board
CPM	:	Critical Path Method
DM	:	Demineralized
EUG2016	:	European University Games 2016
FDA	:	Food and Drug Administration
FMEA	:	Failure Modes and Effects Analysis
GA	:	Genetic Algorithm
GSD	:	Global Software Development
HCHCr-D2	:	High Carbon High Chromium Die Steel
HEIs	:	Higher Educational Institutions
HRM	:	Human Resource Management
ICT	:	Information and Communications Technology
IEEE	:	Institute of Electrical and Electronics Engineers
IRNOP	:	International Research Network of Organizing by Projects
ISDP	:	Information Systems Development Projects
LNGO	:	Local Non - Governmental Organizations
LR	:	Logistic Regression
MFI	:	Microfinance Institutions
MSP	:	Micro Soft Project
NBC	:	Naive Bayes classifier
NPD	:	New Product Development
NPV	:	Net-Present-Value
OEE	:	Overall Equipment Effectiveness

OEM	:	Original Equipment Manufacturer
PDP	:	Product Development Process
pH	:	Potential Hydrogen
PLS-SEM	:	Partial Least-Squares Structural Equation Modelling
PM	:	Project Manager
PMBOK	:	Project Management Body of Knowledge
PMI	:	Project Management Institute
PMO	:	Project Management Office
PPE	:	Personal Productive Equipment
PPM	:	Part per Minutes
PS	:	Project Success
QC	:	Quality Control
R&D	:	Research and Development
RVP	:	Reid Vapour Pressure
SD	:	Standard Deviation
SEM	:	Scanning Electron Microscopy
SFD	:	Social Fund for Development
SLR	:	Systematic Literature Review
SMF	:	Standard Measuring Flask
SPC	:	Statistical Process Control
TBT	:	Team-Building Techniques
TL	:	Transformational Leadership
TWQ	:	Teamwork Quality

CHAPTER I:

INTRODUCTION

1 Introduction

In the course of human civilization, there have been numerous occasions when unexpected spikes in demand for certain goods have occurred in specific areas or globally due to various calamities. These rapid increases in consumption are often referred to as panic buying or stockpiling. Individuals tend to rush and purchase items when they anticipate shortages caused by disasters, emergencies, or other crises. This behavior can manifest locally or on a global scale, depending on the circumstances. Such events encompass both natural calamities like floods and tsunamis, as well as man-made catastrophes such as wars. A notable example of this phenomenon is the recent global COVID-19 outbreak. This situation resulted in a sudden increase in the demand for masks, sanitizers, cleaning supplies, and even COVID-19 vaccines.

The manufacturing of these products encountered substantial obstacles during this timeframe. It was decided that the implementation of effective project management approaches could substantially increase productivity and assist in aligning supply and demand throughout the crisis. By adopting suitable project management techniques, with minor modifications to goals, schedules, budgets, processes, and guidelines, production could potentially be enhanced, yielding advantages for both manufacturers and customers. This investigation seeks to employ project management methodologies in product development, with a particular emphasis on improving the production of dish wash soap cakes to fulfill demand during and after the COVID-19 pandemic. The study was undertaken at a major dish wash soap manufacturing plant in Puducherry, southern India.

1.1 Theoretical Perspectives of Project Management

A project is a unique undertaking that consists of interrelated activities with well-defined initiation and completion points. It typically involves individuals from multiple departments operating within specific constraints of resources, schedules, and requirements. According to Kerzner, a project comprises a series of tasks and activities aimed at achieving a specific objective within certain parameters, including designated start and end dates, financial limitations, and resource allocation. Dr. Juran, a quality expert, defines a project as a problem scheduled for resolution. This definition highlights that projects are intended to address issues and that inadequately identifying the problem can result in complications (Lewis, 1995). Project management encompasses a range of abilities and techniques for overseeing a project from its inception to successful completion. It involves utilizing knowledge, expertise, resources, and methodologies to handle project tasks, with the aim of fulfilling stakeholder requirements and expectations. A crucial aspect of project management is ensuring that the project is completed on schedule, within the allocated budget, and without sacrificing quality.

The advantages of project management are as follows.

- Assigning functional duties to ensure all tasks are covered, regardless of staff changes.
- Reducing the necessity for ongoing reporting.
- Establishing time constraints for scheduling purposes.
- Developing a method for conducting trade-off analyses.
- Evaluating progress in relation to established plans.
- Quickly recognizing issues to enable prompt corrective measures.
- Enhancing future planning capabilities through improved estimation techniques.

Despite the numerous advantages of project management, several challenges remain. These include project complexity, meeting specific client demands, organizational changes, potential risks, and technological advancements. To ensure successful project management, it is crucial to address and overcome these obstacles carefully. Effective project managers must also develop strategies to mitigate these challenges, such as implementing robust risk-management frameworks and fostering open communication channels with stakeholders. Additionally, embracing flexible methodologies and continuously updating skills to keep pace with technological advancements can help project teams to navigate the ever-evolving landscape of project management.

1.2 Project management frameworks

Project management frameworks serve as blueprints for various processes, tools, and tasks that contribute to a project's success. The most suitable framework allows a project manager to effectively track progress towards deliverables from the initial planning phase to the final milestone. Skilled project managers (PMs) do not rely exclusively on a single framework; instead, they evaluate the most appropriate methodology for each specific project. Some PMs use multiple frameworks within a single project to ensure comprehensive coverage. Typically, project managers employ five primary project management methodologies and frameworks, which are outlined in detail below.

1.2.1 Traditional Project Management

In conventional project management, projects are approached using a linear step-by-step model. This methodology comprises several stages: initiation, planning, execution, monitoring, and closure. Among software development teams, this traditional approach is often referred to as Waterfall Methodology. Royce (1970) initially defined the waterfall model as a software development lifecycle framework. This approach also includes subsets such as PRINCE2 and the Project Management Institute's PMBOK Guide (Project Management Institute (PMI) Global Standard, 2017). Conventional project-management approaches employ well-defined goals, established procedures, and comprehensive documentation. These methods assign specific roles to team members and establish clear accountability. However, the main drawback of these traditional techniques is their lack of flexibility. When unforeseen circumstances arise, project managers are forced to revisit and revise the entire project plan starting from scratch. While traditional project management approaches provide structure and clarity, they can be time-consuming and resource-intensive when adapting to changes. This rigidity can lead to project delays and increased costs, particularly in dynamic environments where requirements frequently evolve. Furthermore, emphasis on extensive documentation and formal processes may stifle creativity and innovation within the project team. In response to these limitations, flexible and adaptive project management methodologies have emerged. These agile approaches, such as Scrum and Kanban, prioritize iterative development, continuous feedback, and a rapid response to change. By breaking projects into smaller manageable units and encouraging frequent communication among team members, agile methodologies aim to enhance project adaptability and overall success rates.

1.2.2 Agile Methodology

Recently, agile project management (APM) has emerged as a novel approach for handling projects. Some authorities in the field predict that APM will dominate project management practices in the 21st century. A study conducted by Bergmann and Karwowski (2019) explored the effects of various project complexity factors and examined different frameworks related to project success and critical success factors. Their research culminated in a recommendation of APM dimensions that could potentially enhance project success, regardless of project type. Agile methodologies offer a superior approach for managing projects with highly complex and changing requirements. Malik et al. (2019) conducted a comprehensive literature review to examine the impact of implementing agile practices. Their assessment focused on the application of Scrum, a prominent agile development framework. The findings of this review suggest that adopting agile principles can enhance a project's overall productivity. Ciric et al. (2022) suggest that agile methodologies yield significantly better results in terms of project success than conventional approaches. The agile approach to project management employs a repetitive process that fosters an adaptable development cycle that is effective in software creation and other sectors. Within the agile framework, multiple lifecycles or iterations are incorporated, welcoming modifications throughout all stages of the project from inception to completion. This allows the project manager to adjust the project objectives as necessary during the course of the project, rather than adhering to a fixed, linear strategy. In Agile project management, large-scale plans are divided into smaller segments, called sprints. After each sprint, the teams have the opportunity to evaluate and adjust the project. This approach enables teams to respond effectively to new information, making it particularly beneficial for intricate projects and IT initiatives that involve software and application development. The Agile methodology encompasses various subsets, including scrum, scrum-ban, crystal, extreme programming, and adaptive project frameworks. Agile project management enhances team cooperation and joint efforts. This approach prioritizes the most crucial project outcomes. This allows for adaptable project goals and ongoing enhancements. Agile methodology facilitates quicker product creation and enables earlier identification of performance challenges. It also helps handle and reduce interdependencies. However, this approach may cause a project team to lose focus more easily. Furthermore, extended projects and those beyond software development may experience disjointed workflows and schedules.

1.2.3 Lean Methodology

The lean project management approach draws from lean manufacturing principles, aiming to enhance the value and reduce waste for optimal production efficiency. It targets the elimination of various forms of waste, such as excess inventory, overproduction, unnecessary transportation, excessive processing, resource overutilization, and operational inconsistencies. This methodology prioritizes customer requirements, which serves as the foundation for shaping the process. Lean project management is often integrated with other approaches, such as Agile and Six Sigma. Its fundamental principles include identifying value, visualizing project workflow, establishing flow, implementing pull systems, and pursuing continuous improvement. The Kanban Framework, a popular subset of lean, is frequently employed alongside this approach. Implementing lean methodology in project management offers several advantages including enhanced efficiency and concentration, reduced time and resource wastage, greater value delivery to clients and customers, and quicker project turnaround times. However, there are potential drawbacks to lean project management, such as limited inventory and resources, owing to its focus on eliminating waste. Additionally, depending on project type, it may be difficult to educate and inspire teams to adopt lean practices.

1.2.4 Six Sigma

Six Sigma project management focuses on meeting customer needs and reducing inefficiency. This approach complements lean methodologies, forming "Lean Six Sigma," which strives to reduce errors and enhance value. The foundation of Six Sigma project management lies in leadership, data analysis, and statistical methods with an emphasis on measurable outcomes. The process involves five key stages: problem identification, baseline measurement, data and metric analysis, product and output enhancement, and control-plan development. This methodology is particularly effective when combined with lean principles, aiming to optimize processes and deliver superior results.

Six Sigma project management offers several advantages, including an enhanced understanding of evolving customer requirements, enhanced product quality, minimized waste, decreased expenses, resilient processes and products, and ongoing enhancement. Nevertheless, Six Sigma can potentially create inflexibility that suppresses innovation and slows down delivery time. Furthermore, the emphasis on customer satisfaction in Six Sigma may result in flawed decision making. For instance, a team could opt for a more costly process due to a slight increase in customer satisfaction without recognizing that the additional expense may not be justified by the marginal improvement.

1.2.5 Critical Path Method

The Critical Path Method (CPM) is a straightforward approach for identifying the most impactful activities in a project and optimizing task allocation to meet deadlines without increasing expenses. The key components of this technique include a comprehensive list of necessary tasks and their expected durations, dependency relationships, and project milestones or deliverables. CPM is used to determine the most efficient route for project completion or milestone achievement. This process helps identify activities that must adhere to the schedule to avoid project delays. CPM shares similarities with Critical Chain Project Management (CCPM) methodology, which builds upon CPM by incorporating duration buffers to adjust the project timeline.

The Critical Path Method (CPM) serves multiple purposes in project management. This enables the identification of crucial project components and determines which tasks can be executed concurrently. CPM facilitates the formation of teams and networks for new initiatives while also boosting team member motivation. In addition, it provides an accurate estimation of the project's completion date. However, CPM can be challenging to oversee, particularly for extensive or intricate projects. Effective management may necessitate the use of specialized software to maintain a clear critical path, especially when projects undergo changes before completion.

1.3 Fundamentals of Project Management

Project success does not occur incidentally. This results from the dedicated efforts of skilled project managers and their teams, often involving minor injuries (paper cuts), hard work, and emotional investment. A solid grasp of the basics of project management is crucial for increasing the likelihood of project success. These fundamentals encompass various aspects such as process groups, cost and risk management, task oversight, project limitations, communication strategies, and change control. Regardless of the project management approach employed, these core principles contribute to the effective execution of any project.

1.3.1 Process Groups

The project management process is divided into five distinct stages, which are also known as process groups. These stages encompass Initiation, Planning, Execution, Monitoring and controlling, and Closing. Each of these process groups corresponds to a specific phase within the overall project management lifecycle.

Figure 1.1. *Project Management Lifecycle*

Initiating: The foundational and crucial phase of project management is the initial step. This stage involves identifying and grasping the project's necessities, aims, and specifications. By meticulously assessing what must be achieved, one can establish precise objectives and ensure the project aligns with stakeholder expectations. The project's commencement is signaled by the initiation phase. During this period, a team is formed to work on the project, and a document outlining the project's initiation is produced.

Planning: After identifying the requirements, the next step is to create a comprehensive plan. The planning phase involves defining activities, key milestones, timelines, and necessary resources to achieve project objectives. During this stage, goals are established, often utilizing the SMART criteria (Specific, Measurable, Attainable, Realistic, and Timely). A well-crafted plan acts as a guide, assisting the project team throughout the entire project lifecycle.

Executing: During the implementation phase, the project blueprint is put into action, with responsibilities allocated and project outcomes achieved. Successful execution hinges on effective teamwork, which requires assembling a diverse group of individuals with complementary skills and knowledge, while nurturing a collaborative and encouraging atmosphere. By working together, team members can exchange concepts, data, and duties, promoting creativity and collective efficiency.

Monitoring and Controlling: Project control involves overseeing progress, evaluating performance, and implementing necessary adjustments. This process ensures that projects remain on schedule, meet deadlines, and achieve desired results. Project managers employ various monitoring techniques and tools to maintain control, addressing risks and tackling problems as they emerge. During this phase, the project manager closely observes and assesses the project's advancement to ensure it stays aligned with its objectives.

Closing: During the final phase, the project concludes with formal acceptance of deliverables, compilation of documents, and official closure. This stage also serves as an opportunity for reflection, where both achievements and areas for improvement are identified and recorded to benefit future endeavors.

1.3.2 Cost Management

Throughout a project's duration, managing expenses is crucial. This process encompasses planning resources, estimating costs, setting budgets, and implementing financial controls. Project managers who neglect cost management are unlikely to adhere to financial constraints. Even if the project's objectives are met, exceeding the allocated budget prevents it from being considered entirely successful. Effective cost management requires continuous monitoring and adjustment throughout the project lifecycle. Project managers must regularly review actual expenses against the budget, identify potential cost overruns, and implement corrective actions when necessary. This proactive approach allows for timely decision-making and helps maintain the project's financial health.

Additionally, cost management extends beyond simply tracking expenses. It involves optimizing resource allocation, negotiating contracts with vendors, and identifying opportunities for cost savings without compromising project quality or scope. By fostering a cost-conscious culture within the project team, managers can encourage innovative solutions that maximize value while minimizing expenditure.

1.3.3 Risk Management

One of the most essential aspects of project management is risk management, without which project managers (PMs) are likely to encounter unexpected challenges. The primary focus is on comprehending potential risks to enable PMs to implement appropriate measures. Effective risk management involves identifying, assessing, and prioritizing potential threats to project success, as well as developing strategies to mitigate or respond to these risks. Project managers can utilize various tools and techniques, such as risk registers, probability-impact matrices, and contingency planning, to systematically address potential issues before they escalate. By proactively managing risks, project managers can enhance decision-making, improve resource allocation, and increase the likelihood of project success. This approach not only helps in avoiding costly surprises but also contributes to building stakeholder confidence and maintaining project momentum throughout its lifecycle. Typically, the risk management process involves several steps:

- Recognizing and evaluating potential threats.
- Delegating responsibility for these threats to suitable team personnel.
- Ranking project threats based on their impact and probability of occurrence.
- Devising and implementing strategies to address each threat.
- Overseeing the threat management approach and making necessary adjustments.

Although these steps may suggest that threat management is straightforward, there is always an element of unpredictability involved. Project leaders must be prepared to handle unforeseen threats with flexibility and strategic thinking.

1.3.4 Task Management

Successful project completion relies on the execution of various tasks by the project management team. One of the fundamental aspects of project management is task management, which encompasses the identification, supervision, and coordination of daily activities that need to be accomplished. This crucial component involves overseeing and organizing the necessary tasks that must be fulfilled on a day-to-day basis. Task management involves breaking down the project into smaller, manageable units and assigning responsibilities to team members. Effective task management requires clear communication, setting priorities, and establishing deadlines to ensure that all tasks are completed on time and within budget. Proper task management also includes tracking progress, identifying potential bottlenecks, and making necessary adjustments to keep the project on track. By implementing robust task management strategies, project managers can optimize resource allocation, improve team productivity, and increase the likelihood of project success.

1.3.5 Project Constraints

Constraints are an inherent part of any project, with the three primary ones being budget, schedule, and range. These elements are commonly referred to as the project management trinity, and they are practically inescapable in project execution.

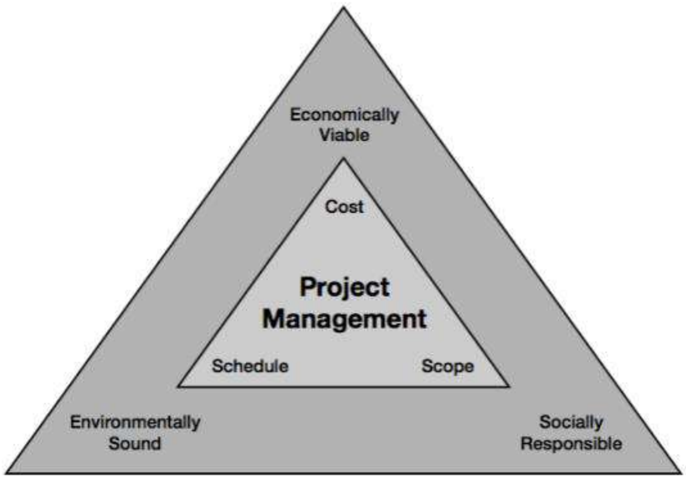


Figure 1.2. *Project Management Triangle*

- ***Cost:*** The project manager must adhere to the financial limitation by overseeing the project's expenses to ensure they remain within the established monetary boundaries. Beyond the primary constraints of budget, schedule, and range, projects often face additional limitations such as resource availability and quality requirements. These factors can significantly impact project outcomes and necessitate careful management and strategic decision-making throughout the project lifecycle. Project managers must balance these constraints while striving to meet stakeholder expectations and deliver successful results.

- ***Time:*** Effective time management in projects involves scheduling, tracking, and regulating the timeline. A visual tool like a Gantt chart can simplify this process. Effective time management in projects requires a comprehensive approach that goes beyond simple scheduling. Project managers must continuously monitor progress, identify potential delays, and implement corrective actions to keep the project on track. This often involves regular team meetings, progress reports, and the use of project management software to track tasks and milestones. In addition to time management, project managers must also balance other constraints such as resource allocation, budget limitations, and quality standards. This balancing act requires a deep understanding of project priorities, stakeholder expectations, and potential trade-offs. Successful project management often involves making difficult decisions and adjusting plans as new challenges or opportunities arise throughout the project lifecycle.
- ***Scope:*** The PM must establish a well-defined project scope at the project's outset, implement a mechanism for managing scope alterations, and consistently inform stakeholders about the scope as part of the scope constraint. This approach helps mitigate the risk of uncontrolled scope expansion, often referred to as scope creep. Effective scope management is crucial for project success, as it directly impacts other project constraints such as time, cost, and quality. Project managers must not only define the scope clearly but also develop robust change control processes to evaluate and approve any proposed modifications. Regular communication with stakeholders about the project scope helps manage expectations and prevents misunderstandings that could lead to scope creep. Maintaining a balance between scope flexibility and rigidity is essential. While adhering to the defined scope is important, project managers must also be prepared to adapt to changing circumstances or new information that may

necessitate scope adjustments. This requires a proactive approach to risk management and a keen ability to assess the potential impacts of scope changes on project objectives and constraints.

According to Ramachandran and Karthick (2019), the Gantt chart proves beneficial in multiple aspects of project management. It aids in optimizing human resource allocation, thereby reducing labor costs. Additionally, the chart serves as a crucial tool for effective material management, minimizing waste. Furthermore, it contributes to time efficiency in the manufacturing process, among other advantages.

1.3.6 Project Communication Management

Communication involves the reciprocal exchange of information and understanding between parties. It encompasses the sharing of ideas, messages, or data through various means, including verbal, nonverbal, written, or behavioral channels. This process serves as a mechanism for comprehending others' thoughts and emotions while also facilitating the expression of one's innovative ideas. In a professional setting, particularly within project management, effective communication is crucial for career advancement. The ability to convey and receive information appropriately in the workplace is fundamental to success in one's job.

Effective project communication management is crucial, as inadequate communication can lead to project failure. To address this, project managers must develop a comprehensive communication plan that outlines how information will be shared across project teams and initiatives. This plan should be applied to all communications throughout the project. The process of project communication management typically involves several key steps:

- ***Purpose:*** The communication's objective is clarified, specifying if it serves as a progress report, permission request, or schedule adjustment notification.
- ***Audience:*** The PM's communication targets are enumerated, including project sponsors, team participants, and clients.

- ***Message:*** Decisions are made regarding the message's substance and the specific elements to be included, such as financial plans, timelines, and expected outcomes.
- ***Channel:*** A choice is made regarding the channel for conveying the message, which could be either through email or casual conversation.
- ***Timeline:*** The time of delivery of the message is determined.

Effective management of communication helps ensure smooth operations and prevents potential delays that could hinder project progress.

1.3.7 Change Management

The common belief that well-crafted plans often fail is particularly relevant in project management. This is where change management becomes crucial, focusing on maintaining control during unexpected changes and developing solutions to keep projects on track. Project managers can utilize a change control plan to anticipate, respond to, and implement changes throughout the project's lifecycle. Moreover, successful project execution requires shared responsibility among all project stakeholders. Project professionals' capacity to create precise designs, cost estimates, and timelines can reduce the adverse impacts of economic uncertainty on project success (Amade et al., 2012).

1.4 Research Problem

The literature contains numerous studies on new product development (e.g. Shandilya et al., 2020; Belassi et al., 2017; Kok and Ligthart, 2014). However, research specifically focused on increasing product quantity is limited. Previous investigations have highlighted the impact of OEE on product development (Pardeep and Kumar, 2019; Ng and Chog, 2018; Muchiri and Pintelon, 2008). In the current context, it was anticipated that production quantity could be enhanced by improving OEE and implementing project management strategies. The current research, titled "PRODUCT DEVELOPMENT IN DISH WASH CAKE MANUFACTURING INDUSTRY USING PROJECT MANAGEMENT," aims to apply project management techniques to boost product quantity in a dish wash cake manufacturing industry, with particular emphasis on modifying machinery.

1.5 Purpose of Research

In certain situations within our society, the demand for specific products surges rapidly, causing industrial sectors to struggle in meeting these needs, which subsequently impacts the population. This research aims to investigate whether such crises can be addressed by implementing minor adjustments to industrial machinery, rather than making substantial alterations to the equipment. Specifically, this study explores the possibility of boosting dish wash soap cake production in the post-COVID-19 period through small-scale modifications to existing machinery.

1.6 Significance of the Study

Although this research focuses on the dish wash soap industry, its findings can be applied to enhance productivity in various sectors, including pharmaceuticals and food processing, during challenging times. The study's results offer insights on maintaining quality standards, controlling costs, and meeting deadlines without compromise.

1.7 Research Question

A crucial element in any research endeavor is the research question, which serves as the starting point for the entire process. It encapsulates the essence of the study, defining the problem to be addressed and the study's objective, while guiding the researcher towards a resolution.

In the current study, the research question is whether implementing project management techniques in an industrial setting can enhance dish wash soap cake production. Specifically, if minor adjustments to machinery can increase output while maintaining quality standards, adhering to time constraints, and keeping costs constant.

CHAPTER II:

REVIEW OF LITERATURE

2 Theoretical Framework

This research focuses on implementing project management techniques for product development in a dishwashing cake manufacturing industry. Prior to initiating any new investigation, researchers should familiarize themselves with previous studies in related fields through a comprehensive literature review. Such a review not only aids in selecting an appropriate research problem but also guides the adoption of a suitable study design. The following sections examine earlier research on project management across various topics.

2.1 Project Management

In recent times, project management has garnered significant attention, even at the highest levels of corporate leadership. Top executives have increasingly recognized the importance of project management in achieving swift convergence in enterprise project development and performance. Both industry professionals and academics have introduced innovative techniques, tools, and perspectives. The primary advantage of project management lies in its ability to create value through the timely and high-quality delivery of competitive products that benefit customers in the market.

Over the last ten years, business executives have recognized that project management is crucial for their financial success, and they are turning to it to enhance their operational efficiency and bring order to their processes. According to Gregory Balestrero, the CEO of Project Management Institute (PMI®), organizations is becoming aware that improved project execution is essential for achieving better financial outcomes (The Business Times, 2006).

A study by Nielsen et al. (2012) examined the role of project management in fostering value creation across various stages of collaborations between universities and industries. The research involved a longitudinal multi-case approach, utilizing 72 semi-structured interviews conducted over 2011 and 2012. These interviews explored the nature of collaborations, their initiation processes, and planning details. Additionally, the researchers investigated interpersonal relationships among participants and the impact of project management practices. The authors made a distinction between the success of project management and the overall success of a project. They aimed to identify exemplary practices and determine the criteria that set them apart from less effective approaches. The study's findings revealed that while project management success did not directly cause project success, it appeared to have a more evident connection to the efficient utilization of resources.

Makarova and Sokolova (2014) undertook research to explore methods for enhancing the foresight evaluation framework by examining and organizing the collective knowledge in project management. Their investigation was grounded in a comprehensive review of literature focusing on the assessment of both foresight and conventional projects. The researchers examined various project evaluation techniques within the project management domain and identified the key stages in the traditional project evaluation process.

Recent evaluations of foresight projects have revealed the most frequently used steps in assessing such initiatives. By comparing evaluation frameworks for foresight and traditional projects, suggestions for enhancing foresight evaluation methods can be made. The field of project management has provided valuable insights for foresight evaluation, including the creation of an evaluation model, increased utilization of quantitative techniques, development of evaluation scales, incorporation of economic indicators in assessments, and promotion of greater transparency and accessibility of evaluation outcomes.

Sudhakar (2013) conducted an analysis of the essential functions and recommended practices for software products. The study provided a comprehensive review, practical approach, and optimal strategies in software product management. The article explored various aspects of software product management, including concept development, prototype creation, requirements handling, planning, development, launch and implementation, marketing, coordination with program management, interaction with individual project management, and product discontinuation. The paper emphasized several best practices for managing software products and individual software projects. It presented a visual representation of software product management through a block diagram, illustrating its relationship with individual project management, product roadmap, and the progression of software products across different versions.

A study conducted by Spalek (2014) investigated the potential return on investment in project management. The researcher analyzed survey data collected from experts representing 194 selected companies. The findings revealed that the expenses associated with future projects are influenced by the project management maturity level and the specific industry sector. The research primarily focused on global machinery companies. The study explored the correlation between increased maturity and project costs in three distinct industries: machinery, construction, and information technology.

Pokharel et al. (2006) examined the significance of project management in high-tech and manufacturing sectors. Their research focused on how value is generated through the application of various project management tools, both front-end and back-end, in Asian high-tech and manufacturing operations. The study acknowledged the growing intricacy of projects in these industries. It proposed that as competition intensifies to improve the design, development, and launch of new products, issues related to process, people, and technology in developing complex products and systems have become increasingly crucial. The research contended that effective product development and associated manufacturing processes can only be achieved by implementing appropriate tools and methods. This approach would lead to improved performance in terms of project duration, expenses, and quality, as well as better utilization of skilled personnel and enhanced management of project risks and uncertainties. The study noted that project risk management encompasses product, process, and technology aspects. Inadequate planning and handling of these risks could result in projects facing challenges or failing altogether.

A research project examined the challenges of managing multiple internal development projects in multi-project settings. The investigation utilized organization-specific interviews, surveys, and workshops focused on two case project portfolios. The study identified six key problem areas: (1) Insufficient resources, skills, and methodologies; (2) Suboptimal management of the project-oriented organization; (3) Deficient project-level activities; (4) Inadequate information management; (5) Insufficient portfolio-level activities; and (6) Lack of commitment, along with unclear roles and responsibilities (Suvi and Artto, 2003). These findings shed light on the complexities involved in overseeing numerous internal development initiatives simultaneously.

A study by Zhang et al. (2015) examined how national and organizational cultures influence the daily operations of multinational project teams, specifically focusing on Chinese and Dutch project managers. The researchers scrutinized field observations and conducted interviews with representatives from various organizations in China and the Netherlands. Their analysis centered on how cultural disparities affected several aspects of project management, including risk assessment, team communication, budget and quality control, project scheduling, scope definition, and commitment fulfillment. The findings suggested that teams composed of members from diverse national and organizational backgrounds can contribute essential components for effectively blending different project management approaches.

Over the past few decades, organizations have increasingly adopted project management as a strategy to align and achieve their goals. The expansion of knowledge has led to a rise in the number of academic disciplines needed to address challenges in developing, producing, and distributing goods and services. Meeting the increasing demand for complex, sophisticated, and customized products and services relies on the ability to integrate product design into production and distribution systems. Project management equips organizations with effective tools to enhance their planning, implementation, and control of activities, as well as optimize the utilization of their human and material resources.

2.2 Agile Project Management

Agile project management (APM) represents one of various project lifecycle approaches. This methodology employs an iterative process, fostering adaptable development that proves effective in software creation and other industries.

Alsohybe and Sabrah (2019) consider APM a key solution for both software and non-software innovative organizations to navigate unstable environments. The success of APM has been demonstrated in the software sector. Since 2015, Yemen has experienced ongoing conflict, adversely impacting numerous sectors, including business and microfinance. The Social Fund for Development (SFD), Yemen's microfinance industry leader, sought ways to enhance Microfinance Institutions' (MFIs) capabilities amidst environmental turbulence. The study explored potential benefits of implementing APM in the microfinance sector, beyond its traditional software domain. The research involved interviews with eleven professionals across all management levels from three leading microfinance organizations. Additionally, three workshop discussions were conducted with twenty-two members of product development teams. Findings indicated that adopting APM could help these MFIs improve their resilience by addressing identified gaps and challenges.

Koskela and Howell (2002) have previously investigated the theoretical underpinnings of project management through multiple studies. This current research synthesizes these theoretical foundations and applies them to elucidate the innovative aspects of two project management approaches that significantly diverge from traditional methodologies: Last Planner and Scrum. These techniques have developed since the mid-1990s as practical solutions to address the shortcomings of conventional project management methods. Scrum originated in software development, while Last Planner emerged in the construction industry. The study demonstrates that both approaches reject the conventional theoretical basis of project management. Instead, they adopt, either implicitly or explicitly, alternative theories that are more suitable for their respective contexts.

Magnussen et al. (2024) conducted research examining the product owner's function in agile scrum projects. The researchers gathered data from 18 professionals across four companies through interviews. They analyzed the responses to determine common duties and responsibilities linked to the role. The findings indicated that the product owner plays a crucial part in facilitating effective collaboration between the scrum team and stakeholders by acting as a primary communicator, active team participant, and decision-maker for priorities. Nevertheless, the study also uncovered challenges such as ambiguity in role definition, difficulties with overall project perspective and planning, and communication issues. To address these obstacles, the research emphasized the importance of comprehensive training, well-defined role descriptions, and enhanced communication practices within scrum teams.

Project stakeholders aim to finish projects on schedule and within financial constraints while upholding quality standards and reducing environmental impact. However, various limitations and risks often hinder the initiation or advancement of operations during project implementation, frequently resulting in significant negative effects on overall project outcomes. According to Muayad and Younis (2021), there has been a lack of comprehensive studies comparing the pros and cons of different agile methodologies. Through an extensive literature review, they found that the agile approach can effectively represent most factors. They constructed a theoretical framework to illustrate how agile project management influences project performance in terms of expenses, schedule adherence, and quality. The research concluded that a nation's capacity to handle risks, manage costs, and capitalize on opportunities depends on its understanding of how agile methods affect its organizations and cultural norms.

Shameem et al. (2023) conducted a study to identify the key agile project characteristics that influence project outcomes and developed a cost-effective model to enhance the likelihood of successful completion in globally distributed environments. To accomplish these objectives, they utilized a Genetic Algorithm (GA). In this approach, an efficacy measure is formulated as a fitness function that optimizes the success of agile project outcomes in relation to cost. The researchers tested the optimization model using two distinct prediction models: Naive Bayes Classifier (NBC) and Logistic Regression (LR). Data was collected through surveys administered to globally distributed agile projects and subsequently analyzed. The findings demonstrated that the prediction models calculate the efficacy for the optimal solutions. Additionally, the ranking of project features based on their relative cost, as determined by NBC and LR, showed considerable similarities. T-test results indicated no significant differences between the rankings assigned by the two methods (NBC and LR). The study concluded that Global Software Development (GSD) organization management and agile teams should prioritize facilitating cost-effective successful implementation of agile projects.

Marnada et al. (2022) investigated the obstacles faced in APM. They conducted a Systematic Literature Review (SLR) using databases such as IEEE Explore, Science Direct, Emerald Insight, ProQuest, and Wiley Online. The study identified twenty-four best practices and linked them to the challenges encountered. The findings revealed that the most crucial hurdles were related to communication & coordination, people & organization, excessive scope requirements, and prioritization of user needs. The researchers proposed that these areas were considered the most significant challenges due to their potential to cause project delays and budget overruns.

A study by Ansari et al. (2024) examined how transformational and transactional leadership styles contribute to project success, with a particular emphasis on leadership's mediating role in agile project methodology. The researchers gathered data from a diverse group of 384 professionals, including IT Project Managers, working in various sectors such as Pharmaceuticals, Civil and Construction, Telecommunication, and Higher Educational Institutions (HEIs) in Oman. To ensure the measurement's reliability and validity, the authors employed conformity factor analysis, which yielded positive results. The theoretical framework was analyzed using Partial Least-Squares Structural Equation Modelling (PLS-SEM). The findings demonstrated that leadership enhances agile project methodology by promoting project excellence, boosting end-user satisfaction, and adding value through the achievement of triple constraints.

Meier and Kock (2024) investigated the connection between an agile project organization and individual team members' commitment. Their framework for agile project organization encompassed five aspects: cross-functional abilities, organizational culture, team autonomy, customer involvement, and operational methods. The researchers also delved into the factors that strengthen the link between agility and dedication. The investigation involved 286 participants from 70 product development projects. Findings revealed that agility correlated with dedication and three additional factors: a systematic implementation strategy, an entrepreneurial mindset, and a well-defined ideation approach. This comprehensive study provides valuable insights that could potentially transform current perspectives on agile project management.

A study by Radhakrishnan et al. (2022) investigated how project team attributes influence project agility and outcomes. The researchers analyzed survey data from 292 agile projects. Their findings indicated that team autonomy, collaboration with clients, and team diversity positively correlate with project agility. Furthermore, project agility was found to have a positive impact on project success. The researchers assessed project success using multiple criteria, including adherence to budget and timeline, meeting specifications, and satisfaction ratings from clients, sponsors, and team members. The study also found that team members' ability to adapt partially mediated the connection between project agility and success. These insights can help agile project managers empower team members to independently manage their work, develop effective methods, and create innovative solutions. Additionally, the findings support the recruitment of team members with diverse skills, expertise, and relevant domain knowledge. The study emphasizes the importance of involving clients in various project stages, including requirements gathering, design, testing, and reviews.

2.3 Project Success

Previous research has identified various strategies for achieving project success. A review of these investigations is presented below.

Amade et al. (2012) conducted research to investigate the factors contributing to successful project implementation in Nigeria, prompted by the country's low project delivery success rate, which has led to economic inefficiency and customer dissatisfaction. The study surveyed fifty project professionals working across six project sites in Anambra, Imo, and River States using a Likert five-point scale. The researchers developed an assessment tool incorporating twelve potential success factors identified in existing literature. The study employed statistical techniques such as factor analysis and regression to analyze the data. The findings indicated that environmental factors play a more crucial role in project success than the project team's skill set. The study concluded that successful project implementation requires collaborative efforts among stakeholders, the ability of project professionals to create precise designs, and clients' commitment to fulfilling their financial obligations.

Mehmet et al. (2020) investigated how commitment to learning influences the connection between evaluation and rewards on project success. The researchers employed Baron and Kenny's methodology for mediator analyses. Their findings revealed that commitment to learning acts as a mediator in the relationship between evaluation and reward and project success. In research and development teams, team members' dedication to learning plays a crucial role in determining how reward and evaluation affect project outcomes. The study suggested that when considering factors that impact team success, leaders should take into account the characteristics of an adhocratic organization.

Pirotti et al. (2022) investigated the impact of project management standards on project success, as well as the mediating role of Project Management Offices (PMOs) in this relationship, given the crucial function of PMOs and their contribution to project outcomes. The research focused on construction project-based organizations in Iran, involving Iranian project managers and construction professionals employed by toptier (grade-1) construction firms. To analyze the collected data, the researchers employed multivariate analysis techniques. They conducted exploratory and confirmatory factor analyses, followed by Structural Equation Modeling (SEM) to examine the relationships between variables. The findings supported the proposed conceptual framework and provided deeper insights into the current state of project management standard implementation in the studied context.

A separate investigation by Pirotti et al. (2020) examined the connection between various factors and project success in the construction sector. These factors included top management, project mission, personnel, communication, and schedule/plan. The research focused on managers and employees from construction firms registered with Malaysia's Construction Industry Development Board (CIDB). To evaluate the hypotheses, the researchers employed correlation and regression analysis. The study concluded by suggesting that both practitioners and academics should conduct further research to enhance the understanding of project success and to more thoroughly explore the factors influencing project success within Malaysia's construction industry.

Ramesh et al. (2018) conducted a study to evaluate the role of project management in achieving successful project outcomes. Their research aimed to: 1) determine the project manager's contribution to project success, 2) assess how managerial activities influence project outcomes, and 3) explore the effect of feasibility studies on project success. The researchers gathered data from 100 participants in the Warangal area using a convenient sampling approach. Participants were presented with key constructs to measure the study's feasibility, managerial functions including planning, human resource management, staffing, control, and coordination, as well as project success indicators. Statistical analyses, including regression and correlation, revealed that all aspects of the independent variables exhibited a positive association with project success.

A study by Blaskovics (2016) examined how project managers influence project success in the ICT industry. The research sought to determine the effect of project management approach on three success metrics, as well as how a manager's traits impact their management style and attitude. The findings confirmed these relationships. Various project management approaches (planning-focused, stakeholder-oriented, strategy-driven, and technocratic) were found to influence client satisfaction, the project triangle, and stakeholder contentment. Additionally, the personal attributes of managers were shown to affect their project management approach and leadership style. This is significant because project managers may adapt their leadership from an authoritarian to a more collaborative approach, potentially enhancing the likelihood of project success (Blaskovics, 2014).

Duale and Kaumbulu (2023) conducted a cross-sectional study to examine the impact of communication skills, leadership abilities, and conflict resolution capabilities of project teams on project outcomes in Local Non-Governmental Organizations (LNGOs) within the Borama district. The research involved 60 participants, including project managers, who completed questionnaires. The data was analyzed using various statistical methods, such as descriptive and inferential statistics, along with multiple regression analysis.

The findings revealed that project team communication skills did not significantly affect project success. In contrast, leadership skills and conflict resolution abilities of project teams were found to have a substantial influence on project outcomes. Additionally, the study demonstrated that project team competence played a significant role in determining project success.

Based on these results, the researchers suggested that LNGO boards of directors and project teams should receive appropriate training to develop the necessary knowledge and competencies for successful project implementation. Given the positive correlation between project team competence and project success, the study emphasized the importance of initiatives aimed at enhancing team competence to improve the likelihood of successful LNGO projects.

A study by Tufail and Anwar (2023) examined how Transformational Leadership (TL) influences Project Success (PS) through the sequential mediation of team-building and Teamwork Quality (TWQ). The researchers gathered data from 374 project managers overseeing Information Systems Development Projects (ISDP) using structured questionnaires. Hypotheses were tested using regression analysis. The findings revealed that teamwork and team building separately and sequentially mediate the relationship between project managers' TL and PS. Additionally, the study showed that project managers employing a TL style enhance PS by utilizing Team-Building Techniques (TBT) and TWQ. The results also demonstrated that team-building and teamwork act as repeated mediators between TL and PS. The research highlighted the importance of enhancing communication, cohesiveness, and coordination within TWQ.

Typically, project managers aim to maintain inflexible skills applicable to project conditions. The strength of these skills is influenced by the relationship between the project supervisor and team, which fosters experimentation and learning. A comprehensive review of existing literature also highlighted the absence of consensus regarding project complexity as a mediating factor between project success and project management abilities. Majeed et al. (2022) conducted research to explore the influence of project management on project achievement. Their study analyzed the effects of project management approaches and project intricacy on project outcomes.

The research examined project success outcomes by evaluating project complexity as a mediating factor between project management competencies and project achievement. This investigation analyzed compiled information on project intricacy and management capabilities. Data collection was conducted via online questionnaires, and the results were scrutinized using logistic regression techniques. The outcomes revealed that integrating project management skills with project complexity can contribute to project success. Additionally, the research did not substantiate the link between effective project management and project failure.

A case study conducted by Gomes and Romao (2016) examined the impact of benefits management and project management approaches on project success in organizations. Their research revealed that implementing a benefits management process for previously identified critical success factors led to enhanced project management practices and positively influenced project outcomes. The study's findings suggest that organizations can leverage this approach to identify and track the advantages of technology-related projects, potentially improving their overall success rate.

In his research, Cooke-Davies (2002) suggested that understanding project success requires addressing three distinct questions: What elements contribute to successful project management? Which factors result in a project's overall success? And what components lead to consistent project achievements? The author conducted an investigation into the genuine success factors in projects. This study draws upon recent empirical data collected from over seventy large-scale organizations, both multinational and national, to address each of these three inquiries and identify twelve critical factors that contribute to project success.

A study by Tatikonda and Rosenthal (2000) examined project management techniques employed during the implementation stage of new product development (NPD) initiatives. The research utilized a cross-sectional approach, analyzing 120 finished NPD projects across various assembled product sectors. Hierarchical moderated regression was used to evaluate the data. The findings revealed a positive correlation between project execution methods and project success, with these approaches proving effective both individually and collectively. This suggests that companies can achieve a balance between firmness and flexibility in product development through appropriate execution strategies. The researchers recommended that organizations implement these approaches at high levels and noted that a wide range of projects could be managed using similar execution methods.

Existing literature indicates that project success is influenced by several factors, including the application of a benefits management process to pre-identified critical success factors and the use of effective project execution methods.

2.4 Project Team

The group of individuals responsible for carrying out a project is known as the project team or project management team. The effectiveness of project management is partly influenced by the number of team members and their individual capabilities. Previous research has demonstrated the significant role that both the project team and project manager play in determining the overall success of a project.

A series of studies on factors associated with effectiveness of project teams was conducted by Fung. Fung and Cheng (2015) examined the impact of team building and participation on team cohesion, trust, and project performance among Malaysian project managers. Their research model expanded upon the work of Cohen and Bailey (1997). The study's findings demonstrated that project managers should increase team building and participation activities to enhance team trust and project performance, which can subsequently improve team cohesion. However, the research also cautioned project managers about the potential drawbacks of overly cohesive teams. Additionally, it emphasized the importance of carefully managing project team size and duration to prevent negative effects on team cohesion and project outcomes. This study provided insights into the relationships between attitudinal, behavioral, and performance outcomes derived from Cohen and Bailey (1997). The results highlighted the need for project managers to balance team-building efforts with awareness of potential negative consequences, while also considering the impact of project characteristics on team dynamics and performance.

A study by Fung and Ramasamy (2015) investigated how leadership roles affect team efficiency, satisfaction, and project outcomes. The researchers developed a model based on work by Cohen and Bailey (1997) and Yukl (2010). Their findings indicated a positive relationship between leadership roles and team effectiveness, suggesting that more frequent demonstrations of leadership by project managers lead to enhanced team performance. The study also revealed that improved team effectiveness resulted in greater team satisfaction and better project outcomes. Additionally, higher team satisfaction was found to directly contribute to improved project performance. Interestingly, the research showed that the project manager's execution of leadership roles did not have a direct impact on team satisfaction or project performance.

A research model was constructed by Fung (2021), drawing on Quinn (1988) leadership roles and Hoevemeyer (1993) five criteria of project team effectiveness, along with four demographic moderators: project management experience, project value size, project duration, and project team size. The research sought to examine how these four moderators influenced the connection between a project manager's leadership roles and the effectiveness of project teams in Malaysia. The study gathered data from 201 project managers and confirmed that leadership roles of project managers have a positive impact on team effectiveness. Additionally, the findings revealed that only project management experience and project duration positively moderated the relationship between leadership roles and project team effectiveness.

Utilizing the team effectiveness framework proposed by Cohen and Bailey (1997), Fung (2014) conducted an empirical investigation into the connections between team trust, cohesion, effectiveness, and satisfaction. The findings revealed that team trust directly influenced team satisfaction, cohesion, and project team effectiveness. Interestingly, while team cohesion did not have a direct impact on project team effectiveness, it did directly affect team satisfaction. Additionally, the study demonstrated that team satisfaction had a direct and positive influence on project team effectiveness. In essence, this suggests that team cohesion indirectly affected project team effectiveness through its impact on team satisfaction.

A research study by Fung and Ibrahim (2011) investigated the elements that contribute to project team effectiveness from the perspective of Malaysian project managers. The researchers utilized Cohen and Bailey's (1997) framework for team effectiveness to empirically assess key factors. Their findings revealed that while project managers' leadership roles do not have a direct impact on project team effectiveness, they do directly influence both team building and participation, as well as team-shared mental models. Furthermore, the study demonstrated that team building and participation, along with team-shared mental models, have a direct and positive effect on team effectiveness.

Gharaibeh (2019) conducted a case study in Jordan's construction industry to examine project team building. The research focused on three key aspects of project team building: communication, trust, and leadership among team members. The study emphasized the importance of team communication in construction projects due to their increasing technical and organizational complexity. Trust was identified as a crucial factor contributing to project success, while leadership was deemed essential for effective team management, particularly in construction. The researchers analyzed project documents, conducted interviews, and distributed questionnaires to key stakeholders to gather information on these three dimensions. The study identified obstacles and facilitators for each aspect of the project team-building model. Ultimately, the research culminated in the development of a framework for project team building based on the dimensions of trust, communication, and leadership.

Danchenko et al. (2020) investigated the psychological aspects of theoretically modeling the ideal number of project personnel. The research focused on project team management models, which are considered the most challenging to formalize in project management knowledge areas. The authors presented economic and mathematical models for managing project teams exhibiting threshold collective behavior, using a sea ship crew as an example. In the execution of specific projects, leadership and small group management experience often remains intuitive. This results in the individualization of knowledge, hindering the effective utilization of team management potential. Management science employs personnel management techniques that are typically examined in isolation, without considering the interplay of psychological processes and characteristics.

Aghania et al. (2019) examined the effects of collaborative communication on construction project outcomes in Indonesia. Their research employed quantitative methodologies to gather data from construction firms. The findings revealed a notable and affirmative connection between formal communication, willingness to communicate, and project collaboration. Notably, the willingness to communicate exhibited the strongest influence on project collaboration, followed by formal communication. To achieve optimal efficiency and effectiveness in the Indonesian context, the study emphasized the necessity of fluid project communication networks that facilitate the exchange of ideas and instructions throughout the entire project team, thereby enhancing coordination. The research suggested that open channels linking clients, consultants, and contractors can be established when consultants can request clear directives from clients and effectively convey them to contractors. This alignment of the three primary stakeholders enables them to address shared requirements and pursue common project goals. The study proposed that organizing a comprehensive kick-off meeting, where communication pathways can be negotiated among stakeholders, serves as an effective strategy to foster increased teamwork on a project.

2.5 Project Management and Innovation

Research indicates a strong correlation between project management and organizational innovation. A notable example is the research conducted by Vrchota and Rehor (2019) in the Czech Republic's manufacturing sector. Their study sought to examine how companies with and without project management approaches differ in their innovation investments and their perception of factors hindering further development. The findings revealed that out of the companies surveyed, 164 (70%) were project-oriented, and these firms demonstrated higher levels of innovation. The investigation aimed to contrast the innovation strategies and developmental constraints between project-managed and non-project-managed manufacturing enterprises.

Research findings indicate that companies without project management structures experience greater constraints compared to those with project management systems in place. For non-project-managed organizations, the primary challenges stem from governmental regulations, bureaucratic processes, and financial limitations. However, both types of enterprises share a common significant obstacle: a shortage of qualified personnel. This finding aligns with survey results reported by Thiry and Duggal (2005), who categorized this issue under societal barriers. Additionally, the study revealed that project-oriented businesses tend to allocate more resources towards technological advancements and innovation. This observation corresponds with the conclusions drawn by Keegan and Turner (2002), who noted that project-based firms either view innovation as universally beneficial or adopt a more measured approach in developing and implementing their innovation strategies.

A study by Kapsali (2011) examined the reasons behind the failure of traditional project management approaches in publicly-funded innovation deployment initiatives, and explored how incorporating systems thinking into project management could enhance project success. Through an analysis of 12 case studies from two EU innovation policies, the research revealed that employing systemic project management, which allows for adaptability in communication, planning, and control processes, led to improved outcomes for innovation projects. The key conclusion drawn from this study is that systems thinking methodologies offer the necessary flexibility to effectively handle the innovativeness, complexity, and uncertainty inherent in innovation projects, resulting in higher success rates.

Keegan and Turner (2002) investigated the applicability of conventional innovation concepts to project-based organizations. The researchers examined whether these firms foster an environment conducive to innovation or consider it beneficial. Drawing from studies across various industries, including telecommunications, financial services, engineering, information systems, procurement and construction, and computers, the paper revealed that the project control mechanisms employed by these companies tended to suppress innovation. The study determined that project-based firms, regardless of their sector, emphasized efficient project management, only allowing the use of excess resources when absolutely necessary. Moreover, innovation was not perceived as universally advantageous, but rather as expensive and risky. The research concluded that the intersection of 'innovation' and 'projects' remains dominated by notions of proper project management, rather than effective innovation management.

According to Ahn et al. (2010), the successful commercialization of emerging technological innovations relies on effectively evaluating and choosing projects for optimal resource allocation at the company level. Their research introduced a comprehensive model for distinguishing, ranking, and selecting investments in technology projects within an organization's portfolio. The study incorporated methods from project portfolio and strategic technology management to examine how a specific product in a diverse project portfolio could be prioritized and advanced. The findings suggested that implementing the proposed model to a set of biotechnology projects could improve the evaluation of internal capabilities and external competitiveness.

In a study by Yakovleva (2015), the crucial elements for choosing suitable methods in managing innovative projects were explored. The research examined various project management standards theoretically and evaluated their potential applications. Through an analysis of scholarly literature, the researcher investigated the practical implementation of these techniques. This approach allowed the author to make a theoretical contribution to project management by identifying and selecting appropriate techniques for innovation-focused projects. The study's theoretical findings suggested that two primary factors influence the selection of project management techniques: the impact on technique choice and the structure of the project selection process.

Un et al. (2010) examined the comparative influence of research and development partnerships with various entities - academic institutions, vendors, clients, and rivals - on product innovation. They posited that each collaborative R&D arrangement offers a distinct breadth of new knowledge to the company, resulting in varying effects on product innovation. The researchers hypothesized that R&D collaborations with universities would have the most significant impact on product innovation, followed by partnerships with suppliers, customers, and lastly, competitors. To test these hypotheses, they analyzed data from 781 manufacturing companies between 1998 and 2002. Contrary to their expectations, the study revealed that R&D collaborations with suppliers had the strongest positive effect on product innovation, with university partnerships coming in second.

Unexpectedly, the findings revealed that R&D partnerships with customers had no effect on product innovation, while collaborations with competitors seemed to hinder it. R&D alliances with suppliers or universities were found to offer relatively straightforward knowledge access, whereas those with customers or competitors presented greater difficulties in accessing knowledge. Consequently, these latter partnerships showed no correlation or even a negative relationship with product innovation. This suggests that the ease of knowledge acquisition, rather than the breadth of knowledge, is the key factor in successful R&D collaboration for product innovation. Furthermore, the study showed that the beneficial impact of R&D partnerships with universities and suppliers on product innovation persists over time, while the detrimental effect of collaborating with competitors is only temporary.

2.6 Project Management and New Product Development.

The connection between project management and innovation suggests that effective project management can result in the creation of novel products that meet consumer needs. However, successful new product development requires collaboration across various organizational departments and a supportive company culture. The following research demonstrates how these elements contribute to the successful execution of new product development initiatives.

A study by Carbonell and Escudero (2011) investigated how team autonomy and managerial output control, both individually and in combination, affect the rapidity of New Product Development (NPD). The research also delved into how product newness moderated these relationships. Analyzing 247 new product projects, the researchers discovered a positive correlation between managerial output control and NPD speed. They also observed a positive interaction between team autonomy and managerial output control on NPD speed. Specifically, team autonomy positively influenced NPD speed when managerial output control was high; otherwise, it had no effect. Regarding product newness, the findings revealed that managerial output control had a stronger positive impact on the speed of developing less innovative products compared to highly innovative ones.

A research investigation examined the impact of team independence on new product development (NPD). Patanakul et al. (2010) investigated the optimal conditions for employing autonomous teams in NPD. Drawing from contingency and information-processing theories, they proposed that self-governing teams would be more effective for projects involving high-tech novelty and radical innovation. To evaluate these propositions, the researchers compared the efficacy of four team structures: functional, autonomous, lightweight, and heavyweight. They assessed effectiveness using metrics such as development expenses, overall product success, and speed of development. The study controlled for factors like team experience, clarity of vision, and resource accessibility. Data from 555 NPD projects were analyzed, confirming the researchers' hypotheses. Autonomous teams outperformed other structures in projects with high technological novelty or radical innovation. Additionally, the findings indicated that heavyweight teams were superior for incremental innovation development. At the project level, these outcomes lend support to contingency and information-processing theories. The study's conclusions may have significant implications for NPD practices and offer insights into related areas such as disruptive innovation, ambidextrous organizations, corporate entrepreneurship, strategic innovation, and new ventures.

Rijsdijk and Van (2011) examined the impacts and interactions of three primary control mechanisms on New Product Development (NPD): process control, outcome control, and clan control. Process control involves defining appropriate behaviors, outcome control focuses on specifying and assessing desired employee outputs, and clan control relates to socialization processes among organization members.

The study analyzed data from 148 NPD projects in Dutch high-tech firms. Findings revealed that combining different control types can result in either synergistic or conflicting effects on various NPD project outcomes. Notably, outcome and clan controls worked synergistically to enhance process performance. This suggests that the advantages of increased goal clarity and project team autonomy through outcome controls can be amplified by fostering social cohesion. Conversely, process controls were found to impede the positive impact of clan controls on process performance.

The researchers concluded that failing to consider the interdependencies between different control mechanisms may result in an incomplete understanding of how companies can most effectively manage their new product development processes.

Deadlines are frequently encountered in product development and are often perceived as overly stringent. A study by Zhang (2016) examined the significance of deadlines in product development from an agency-theoretic standpoint. The research focused on a company that compensates an agent to oversee product development initiatives. The findings revealed that the likelihood of success is influenced by both the project's viability and the agent's efforts. The study suggested that to encourage sustained effort, the company must offer the agent a substantial reward for achieving success in the later stages of development. However, this approach of rewarding late success weakens the incentives for early-stage effort. Consequently, the company may find it more advantageous to enforce a strict, early deadline to prevent the agent from strategically delaying their efforts.

Unger and Eppinger (2006) examined the connection between product development risk and the management of Product Development Processes (PDPs). Their research explored various risks associated with product development and a range of different PDPs. The researchers contrasted the traditional, rigid staged PDP with the more flexible, spiral PDP and its variations. They proposed several metrics based on iteration and review to effectively identify and compare PDPs. The study incorporated data from ten company case studies. The findings revealed that software companies operating in rapidly changing markets, which conduct quick iterations and tests, tend to employ flexible PDPs. Conversely, manufacturing companies facing greater integration challenges and technical risks are more likely to use rigid PDPs. The study found that a company's risk profile plays a crucial role in determining which PDP is most suitable. The authors developed a method for improving PDP design based on risk management principles. They concluded that PDPs exhibit more variation than previously documented and that their proposed metrics are valuable for distinguishing between different PDPs. Additionally, they suggested that companies facing diverse risk scenarios can effectively customize their PDP designs to address their specific circumstances.

Messica (2008) investigated the impact of marketing on the optimal funding of new product development (NPD). The researcher introduced a model to determine the ideal allocation of marketing resources in relation to NPD. The investigation utilized a probabilistic Net-Present-Value (NPV) model to generate a set of three second-order, non-linear differential equations, which were then solved numerically to ascertain the optimal triple joint expenditure. The findings indicated that, in most instances, technical development costs should reach their peak and conclude before other expenses. Additionally, the research demonstrated a linear relationship between the termination time and the maximum expenditure for each of the examined efforts. Furthermore, a power-law correlation was observed between the required return and market potential.

Smits et al. (2009) performed a comparative case study using inductive methods to examine the balance between exploratory and exploitative market learning during the development of eight discontinuous NPD projects. These projects, which had been recently introduced to the market, were spread across six different business units of various multinational companies in the chemical industry. The researchers identified market knowledge as a multi-faceted construct, encompassing product, segment, application, and customer knowledge. They demonstrated how the balance between exploratory and exploitative market learning varied across these market knowledge dimensions and over time for each project. The study revealed three distinct market learning patterns, differentiated by their approach to balancing exploratory and exploitative market learning. Additionally, the research showed that certain organizational factors, including the positioning of the projects' primary marketing function and the roles of senior management in decision-making, played a part in shaping these different market learning patterns.

Kok and Ligthart (2014) explored the varying impacts of workforce flexibility on different types of new product development (NPD). Drawing from the resource-based theory of the firm, human resource management studies, and innovation management research, they categorized workforce flexibility into functional and numerical types. The researchers developed and examined hypotheses regarding the distinct effects of these flexibility types on NPD outcomes. Their study encompassed 284 large Dutch companies from diverse manufacturing and business services sectors. The findings revealed that functional workforce flexibility had a positive influence on incremental NPD. Conversely, internal numerical workforce flexibility negatively affected incremental NPD, while external numerical workforce flexibility showed a positive impact solely on major NPD. These results expand upon the resource-based theory of the firm, suggesting that human resource flexibility is a component of the dynamic capabilities enabling firms to reconfigure existing competencies. The study's implications indicate that managers in manufacturing and service industries can enhance incremental NPD outcomes by fostering a functionally flexible workforce through training and education. Additionally, they should avoid relying on overtime, as this form of internal numerical flexibility hinders incremental NPD. However, the use of fixed-term contracts to increase external numerical flexibility can boost major NPD efforts.

In their research on new product development (NPD), Tingting and Kevin (2014) introduced a novel concept called Buyer-Supplier Collaboration Quality (BSCQ). They characterized BSCQ as "the extent to which a buyer and supplier exploit shared resources while minimizing waste through interaction during project planning and execution". The authors validated the measurement structure of this new construct using data from 214 purchasing organizations. Employing resource dependence theory, they identified inter-organizational and project-specific precursors of BSCQ and elucidated its impact on NPD project outcomes. Their findings revealed a positive correlation between BSCQ and both design quality and project efficiency. Additionally, the study demonstrated that goal alignment, complementary capabilities, and inter-organizational coordination efforts enhance BSCQ, whereas relationship-specific investments between firms diminish it.

Souder (1988) investigated the management of relationships between R&D and marketing departments in new product development projects. The study identified seven strategies for R&D and marketing managers to collaborate effectively and prevent discord. These strategies include: (i) ensuring all staff members recognize that R&D/marketing interface issues are common, (ii) promoting vigilance among personnel to detect signs of R&D/marketing interface problems, (iii) providing equal recognition and public acknowledgment to both R&D and marketing staff, (iv) consistently emphasizing and demonstrating the importance of R&D and marketing collaboration, (v) utilizing mixed teams of R&D and marketing employees whenever possible, (vi) addressing personality conflicts and other issues promptly to prevent deep-rooted distrust, and (vii) recognizing that excessive harmony can lead to complacency between the two departments.

Belassi et al. (2017) conducted research on 95 U.S. organizations to examine how organizational culture impacts New Product Development (NPD) projects. Their study expanded the definition of organizational culture by employing factor analysis to categorize related cultural measures from existing literature. This analysis identified three key factors: management leadership, the organization's work environment, and its results orientation. The research demonstrated a notable influence of organizational culture on NPD, aligning with findings from previous studies.

The researchers suggested that companies should cultivate a positive work atmosphere with strong leadership from management. They emphasized the importance of fostering a culture that motivates employees to give their best effort and feel at ease when confronting unfamiliar situations or voicing their opinions. Most importantly, management should establish clear objectives, delegate responsibilities to employees, and promote their involvement in decision-making processes.

Research conducted by Shandilya et al. (2020) in Indian manufacturing sectors examined the overall views of three essential economic groups: students, industry experts, and others (including academics, entrepreneurs, and consumers). The investigation highlighted the significance of top-level management backing and the necessity to draw in foreign direct investment for new product development (NPD). Findings confirmed the vital function of R&D/marketing in NPD implementation and emphasized the importance of smooth communication between these departments.

A study on "concept shifting and the radical product development process" was conducted by Victor (2007). The researcher employed an inductive case-study approach, gathering data from 51 interviews with participants in six radical development projects. The study found that concepts were characterized by concept components, which included verbal stories, verbal metaphors, and physical prototypes. When new technical or market information necessitated changes to concepts, teams would replace individual concept components with new ones of a similar descriptive form. Notably, over half of the concept components emerged after the initial concept generation, during later elaboration and shifting phases. Interestingly, development teams maintained references to both the updated concept and the original, deferred concept. The research shed light on how formal processes could be enhanced in radical innovation contexts and how development teams utilize concepts in changing circumstances. The study also uncovered evidence of cross-industry benefits in New Product Development (NPD) among various manufacturing sectors, such as metal manufacturing, automotive, and food production. Upon examining different stages of NPD, the research identified "Testing," "Concept Development," and "Commercialization" as the three critical phases.

2.7 Equipment Efficiency and Product Development

Product development in an organization relies on more than just the organizational climate and interdepartmental cooperation. Overall Equipment Effectiveness (OEE) plays a crucial role as well. The significance of OEE in industrial product development is demonstrated by the following research studies.

Ng and Chog (2018) introduced a comprehensive conceptual framework in their research, highlighting the key factors that affect and contribute to Overall Equipment Effectiveness Improvement (OEEI). Their study also offers a thorough framework aimed at optimizing the three primary OEE components: enhancing process performance, boosting equipment availability, and improving quality yield. This framework serves as a user-friendly tool for managers, engineers, supervisors, and shop floor technicians to determine strategies for enhancing OEE in manufacturing facilities. The all-encompassing OEEI framework can be utilized to implement OEE in a more systematic and holistic manner. Additionally, the OEEI framework proves valuable in educating university students about the intricacies of improving OEE in manufacturing settings. The authors suggested that the developed OEE framework could potentially be adapted for use in other departments or industries. Furthermore, it aids industry professionals in accelerating the learning process during OEE implementation.

A study by Pardeep and Kumar (2019) explored the impact of Heijunka, a lean manufacturing technique, on enhancing productivity in India's automotive sector. Lean manufacturing is an approach focused on ongoing improvements in customer satisfaction, productivity, quality, and competitive edge. Heijunka specifically aims to streamline production processes, thereby creating opportunities for enhancing the manufacturing environment. Importantly, Heijunka prepared industries to meet anticipated demand. The research revealed that Heijunka significantly improved quality, productivity, and customer satisfaction. The industry observed notable increases in both human and machine productivity, with gains of 63% and 39% respectively.

In their research, Muchiri and Pintelon (2008) explored the use of Overall Equipment Effectiveness (OEE) as a performance measurement tool. The study highlighted the importance of developing robust performance-measurement systems for manufacturing processes in response to the growing demand for increased productivity in today's competitive global market. OEE is described as an instrument that quantifies various types of production losses and identifies areas for process enhancement. The researchers examined the evolution of OEE, which has led to the development of other tools such as production equipment effectiveness, total equipment effectiveness performance, overall plant effectiveness, overall factory effectiveness, and overall asset effectiveness. By analyzing two industrial cases of OEE application, the authors proposed a framework for categorizing and assessing production losses to determine overall production effectiveness. This framework also addresses discrepancies between theoretical concepts and practical applications, enabling the presentation of overall production/asset effectiveness.

The literature also includes research on predicting Overall Equipment Effectiveness (OEE). For instance, Ragazzini et al. (2024) noted that manufacturing system bottlenecks can significantly decrease efficiency and productivity. Their research introduced an innovative digital twin-based framework for predicting bottlenecks, aiming to enhance performance through production control adjustments. This approach employs a digital twin to forecast and address bottlenecks in manufacturing systems, allowing for the simulation of future system behavior while considering current conditions. The predicted bottleneck information is then utilized to inform production control decisions by modifying order release and sequencing based on the anticipated bottleneck.

Another study in the field explored the effective application of the Failure Modes and Effects Analysis (FMEA) technique (Bahrami et al., 2012). FMEA is a systematic, team-based tool typically employed to prevent, identify, eliminate, or manage potential errors in a system, process, or project. The research outlined the functions and objectives of the FMEA technique and elaborated on its applications in project implementation and management. Additionally, the study detailed how FMEA can be utilized at various stages of project execution to systematically improve processes and reduce project expenses.

2.8 Control and Excess Giveaway in Product Development

Research indicates that managing excess giveaway can benefit product development by reducing quantity and costs. A study by Peeters et al. (2019) examined throughput control and giveaway reduction in a poultry product batcher. Recent industry changes have imposed strict deadlines on poultry plants, necessitating better control over the batching process. The research emphasized the importance of meeting target throughput and deadlines while minimizing giveaway. The authors developed an algorithm to manage a poultry product batcher, aiming to achieve desired throughput and reduce excess giveaway. Through simulation, they demonstrated that their proposed algorithm could effectively control throughput and minimize giveaway across various conditions.

According to research by Hueni et al. (2022), a computerized system for blending gasoline has led to annual savings exceeding $500,000 by minimizing product giveaways. This setup employs a standalone, feed-forward control mechanism that utilizes two microprocessor-based blend controllers operating in parallel, supported by a host computer. The system incorporates online analyzers to measure octane, Reid Vapor Pressure (RVP), and volume-to-liquid ratio. The implementation of this new system has significantly improved on-stream time with automatic supervisory control, increasing it from 50% to more than 95%.

Venkatesan (2003) outlined a technique for managing product quality through the application of engineering or Automatic Process Control (APC) and Statistical Process Control (SPC) methods. APC regulates process variables including feed rate, viscosity, temperature, product quality, and pressure, while SPC focuses on product quality control. These two approaches intersect at the boundary of their respective methodologies. By employing these strategies, it becomes feasible to manufacture products with desired qualities while maintaining an acceptable range of variation in measured output characteristics. The primary objective of APC is to keep crucial process variables close to their designated set points for extended periods. In certain process control scenarios, feedback control is essential, yet achieving stability in the feedback loop can be challenging. Disturbances affect the process, and when combined with dynamics and dead time issues, they further complicate process control. Practitioners in this field face difficulties when addressing process delay and dynamics.

Controlling product variability is achievable through the development and simulation of a feedback control algorithm for dead-time processes. It is not uncommon to encounter issues related to feedback control stability, controller limitations, and dead time compensation when striving for minimum variance control at the output.

Although not widely reported in the media, there has been an increasing body of research focused on reducing waste caused by inefficient production processes. In the food processing industry, significant waste occurs through "giveaways" in overfilled containers and "throwaways" from under-filled products that fail to meet standards and are discarded. Ridgway et al. (1999) suggested that global environmental concerns have led to increased commercial attention on waste product elimination and hazardous material disposal. The researchers explored the use of ultrasound monitoring as an online method for measuring fluid levels in food containers. This technique has the potential to provide accurate measurements and, when combined with appropriate control strategies, could offer an effective solution to minimize or eliminate waste issues.

The study aimed to examine controller design methodologies for a bottling process. Using MATLAB® and SIMULINK® software, the bottling process was modeled, and various controller designs were implemented to enhance the process's response characteristics. The research investigated both digital control and fuzzy logic controller design approaches. The digital controller, designed using the direct digital design method, resulted in improved system performance. Operating with a predetermined set of rules, the fuzzy logic control demonstrated excellent functionality with the bottling system. The implementation of these controllers led to improvements in bottle-fill times and increased stability in response to changing carousel delays. The results indicated that fuzzy logic can be applied efficiently and effectively in this conte

2.9 Summary

The literature review examines research highlighting the significance of project management and various elements contributing to project success within organizations. Some studies demonstrate the influence of project teams on successful outcomes and how project management fosters innovation and new product development. Additional research explores the effects of organizational culture and Overall Equipment Effectiveness (OEE) on product development. However, there is a lack of research investigating how implementing project management techniques can rapidly boost industrial production to meet market demands. This gap in the literature serves as the basis for the current study. This study aims to address the identified research gap by exploring the potential of project management techniques to quickly enhance industrial production in response to market demands. By investigating this unexplored area, the research seeks to provide valuable insights into the practical application of project management principles in industrial settings, potentially offering new strategies for organizations to improve their production capabilities and market responsiveness. The findings from this study could have significant implications for both academic research and industry practices. By bridging the gap between project management theory and industrial production, the research may uncover new approaches to optimize manufacturing processes, reduce lead times, and increase overall productivity. Additionally, the results could contribute to the development of more effective project management frameworks tailored specifically to the needs of industrial production environments.

CHAPTER III:

METHODOLOGY

3.1 Overview of the Research Problem

In recent years due to the process of globalization, the demand for essential commodities has risen rapidly as a result of disasters. For example, the prevalence of COVID-19 created a great demand for vaccinations, medicine, sanitizers, detergents and soaps, masks etc. In such situations, the industries producing these commodities struggled a lot to meet the demand. In order to overcome these crises a mechanism should be developed in the industrial sectors. One such mechanism would be making little modifications to the existing machinery and increasing the production to meet the demands. The present study is one such attempt. The study attempted to increase the production of dish wash soap cake in the detergent industry using project management.

3.2 Operationalization of Theoretical Constructs

3.2.1 Soap Production

In the present study, soap production is referred to the production of EXO round dish wash soap cake. This soap is used to clean dishes at houses, hotels, hospitals, canteens etc. It fights against germs and is thus helpful to be hygienic in day-to-day life. There was great demand for this kind of soap cake during COVID-19. Exo round dish wash soap cake is one of the most popular dish wash soaps in India. In the present study soap production is measured by the number of cases each of which contains 36 pieces of 500 gm each.

3.2.2 Bulk Manufacturing Time

In the production of soap, the major powder ingredients used are the natural minerals which are obtained from the mines like Soda ash, Feldspar, China clay, and Ginger. They are sieved through #12 mesh and added with liquid substances like LABSA (Linear Alkyl Benzene Sulfonic Acid), sodium silicate, and sufficient water. The colour ingredients are passed through 45-micron filters. All these ingredients are mixed together homogeneously in the Double sigma mixer. The output is in the form of lumps. The above process is called bulk manufacturing of dish wash soap. This process is performed prior to making a round-shaped dish wash soap cake. The duration of all the processes is called "Bulk manufacturing time". The bulk manufacturing time is measured in minutes.

3.2.3 Electrical Power Consumption

Production of soap requires electrical power to run the machinery. Electrical power consumption is measured in KW/hr.

3.2.4 Quality of Soap

Quality is an important parameter of any product that cannot be compromised. For wider marketing and distribution, the quality of the product is to be maintained. In the present study the quality of soap is assessed in terms of Anionic Active Percentage, pH value, Moisture Percentage, and Total Alkalinity Percentage.

Anionic Active Percentage

The anionic active percentage is one of the qualities of the soap which removes the dirt from vessels. The anionic active percentage of the soap is assessed by the following method. First, a soap cake is cut into four parts radially and the inner portion of the soap cake is sieved into small particles. From this 5 gm of sample is taken and added with 100 ml of hot water at 100°C and placed on the magnetic stirrer for around 10 minutes to get a homogenous solution. This solution is added with 400 ml of DM water at room temperature. Thus a 500 ml of soap solution is obtained in a standard measuring flask (SMF). From this soap solution, 10 ml of soap solution was taken and added with 10 ml acid indicator, 10 ml chloroform ($CHCl_3$), and titrated with Hymine (0.004 molar solution) until a grayish blue color solution is arrived at.

The reading is taken and anionic active % is calculated using the formula below.

$$\text{Active percentage} = \frac{\text{V1 x N1 x M x 500 x 100}}{\text{V2 x W x 1000}}$$

Where:

V1 = Volume of Hyamine consumed in mm^3

M = Molecular weight in gm

N1 = Molarity of Hyamine (0.004)

V2 = Volume of the sample taken in mm^3

W = Weight of the sample taken in gm

As per the R&D recommendation, the Anionic Active percentage must be between 13.25% and 14.25% in the dish wash soap cake. The dish wash soap is active and has a good cleaning effect only in this range.

pH value

pH value is the quality of soap that protects the human hands from itching and the vessels from corroding and eroding. When the pH value is less than 7 the product is acid in nature it may erode and corrode the pans/vessels. If the pH value is more than 11 it causes itching in the human hand. If the pH value is 10 to 11 the detergency efficiency is active and the cleaning effect is better. The pH value is measured by the following method.

A soap cake is cut into four parts radially and the inner portion of the soap cake is sieved into small particles. From this 5 gm of sample is taken and added 100 ml of hot water at 100°. It is placed on the magnetic stirrer for 10 minutes to get a homogenous solution. To make 1% of the solution 500ml DM water is added to the solution, shaken well, and transferred to the glass bowl. Then the pH value is checked in the digital pH meter. In the present context, the pH value is maintained between 10 and 11.

Moisture Percentage

Moisture percentage is the level of water present in the soap cake. If the moisture is higher than 8% the outcome soap cake has been found to be dented without regular shape. If the moisture is less than 6%, the vacuum plodder extruder will not push out properly through the extrusion die. Further, it creates more torque on the motor causing damage in the motor and gearbox. Also, the binding effect of the soap cake is less and it causes more cracks in the soap cake. There is an inverse relationship between moisture and anionic active percentage. When the moisture percentage increases, the Anionic active percentage decreases. When the Moisture percentage decreases, the Anionic active percentage increases.

The moisture percentage of the soap cake is measured by the following method. A soap cake is cut into four parts radially and the inner portion of the soap cake is sieved into small particles. From this, 5 gm of sample is taken, weighted and the value is noted down (wet sample). Then this sample is placed in the hot air oven for 2 hrs at 105°. Now the sample is weighted and the value is noted down (dry sample). The difference between wet and dry samples is the loss on drying. This is called the moisture percentage. As per the R&D recommendation, the moisture percentage must be between 6% and 8%. Only in this range the soap formation and color appearance is good.

Total Alkalinity Percentage

Total alkalinity is the quality of soap cake associated with the cleaning effect. There is a direct relationship between total alkalinity and pH value. When the total alkalinity percentage increases, the pH value also increases. When the total alkalinity percentage decreases, the pH value also decreases. The total alkalinity percentage of the soap is assessed by the following method.

A soap cake is cut into four parts radially and the inner portion of the soap cake is sieved into small particles. From this, 5 gm of sample is taken and added with 100 ml of hot water at 100°. It is placed on the magnetic stirrer for 10 minutes to get a homogenous solution. This solution was added with 400 ml of DM water at room temperature. Thus a 500 ml of soap solution is obtained in a standard measuring flask (SMF). From this soap solution, 50 ml of soap solution is taken and added with 10 ml methyl orange indicator and titrated with hydrochloric acid until a violet color solution is arrived at.

The reading is taken and the total alkalinity percentage is calculated using the formula below.

$$\text{Total alkalinity Percentage} = \frac{\mathbf{V \times N \times 31 \times 500 \times 100}}{\mathbf{50 \times W \times 1000}}$$

Where

V = Volume of Hydrochloric acid solution in mm^3

N = Normality of standard Hydrochloric acid

W = Weight of the sample taken in gm

As per the R&D recommendation, the total alkalinity percentage should be a minimum of 2.3%. Because the dish wash soap is active and has a good cleaning effect above this total alkalinity percentage level.

3.2.5 Excess Giveaway

Excess giveaway is the quantity of content of any product present more than the prescribed value. Even though this quantity is meager it is quite natural that the content will go up during the larger production. So it will lead to a great loss if not controlled. In the present context, the prescribed weight of the soap is 500 grams. There is an arrangement in the machinery to calculate the excess giveaway. The excess giveaway is checked every hour and noted down with the help of an online QC person.

3.2.6 Breakdown Time and Frequency

Machine downtime due to malfunctions is referred to as breakdown time. This period begins when the equipment fails and ends when it resumes operation. The importance of minimizing breakdown time is clear. Frequent machine failures result in lost production hours, and prolonged repair times worsen the situation. Each minute spent fixing a non-functional machine equates to a minute of lost productivity. Consequently, this can lead to financial losses ranging from hundreds to potentially thousands of dollars.

3.3 Research Purpose and Questions

There are always some instances to increase production in the industrial sectors to meet the increased demand in the market environment. Under such circumstances, the production of a particular commodity has to be increased rapidly in the industrial sectors keeping time, quality, and power consumption unaltered. Gregory Balestrero, Project Management Institute's (PMI®) CEO, believes that companies are realizing the need for better project execution to produce better bottom-line results (The Business Times, 2006). Spalek (2014) reported the relationship between an increase in maturity and future project costs in three industries: machinery, construction, and information technology. Further studies reveal that OEE is an important factor in product development (Muchiri and Pintelon, 2008; Ng and Chog, 2018; Pardeep and Kumar, 2019).

The project management technique was adopted in the present study to increase the production of soap cakes by improving the OEE thereby making some modifications in the machinery.

The primary goals of this research are:

1. To examine the production of soap cakes in the soap manufacturing industry after making modifications in the machinery and keeping manufacturing time, power consumption, and quality unaltered.
2. To examine the level of the excess giveaway in the soaps after making modifications in the machinery.
3. To examine the level of the breakdown time and frequency of the machinery after making modifications to the machinery.

To evaluate these objectives, several hypotheses were developed and subsequently examined:

H0.1 There is no significant difference in the quality of soap cake between before and after modifications in the machinery.

H0.2 There is no significant difference in electrical power consumption between before and after modifications in the machinery.

H0.3 There is no significant difference in bulk manufacturing time between before and after modifications in the machinery.

H0.4 There is no significant difference in breakdown time and frequency between before and after modifications in the machinery.

H0.5 There is no significant difference in excess giveaway between before and after modifications in the machinery.

H0.6 There is no significant difference in the production level of soap cake between before and after modifications in the machinery.

3.4 Research Design

Generally recognized are five fundamental principles of project management: well-defined project aims and goals, thorough planning and scheduling, involvement and communication with stakeholders, capable and authorized project teams, and ongoing supervision and flexibility. This research incorporates the following principles:

3.4.1 Clear Project Goal and Objectives

For project success, it is crucial to define clear project objectives. These objectives should align with the SMART criteria, meaning they need to be specific, measurable, achievable, relevant, and time-bound.

***Figure 3.1** The SMART framework*

The present study has a specific goal of increasing the production of dish wash soap cake in the detergent industry. The increase in the production of soap is measurable and attainable. During the COVID-19 pandemic, there was a great demand for dish wash soap cake. So there was a need for the industry to increase the production and meet the demand. So the goal is relevant. Time limit is an important aspect in the production sector to solve the crisis in time. It was intended in the present study to increase the production of dish wash soap cake in six months.

3.4.2 Effective Planning and Scheduling

A comprehensive project planning provides a road map to pass through and achieve objectives. The planning should incorporate elements like well-defined activities, allocation of resources and creating a realistic timeline. The planning also includes identifying critical milestones and task dependencies to optimize resource utilization and minimize delays.

In the present contest comprehensive planning and scheduling were made in the first meeting of the project management team constituted for this purpose. The Cause-Effect of the production increase was discussed using a Fish-bone approach.

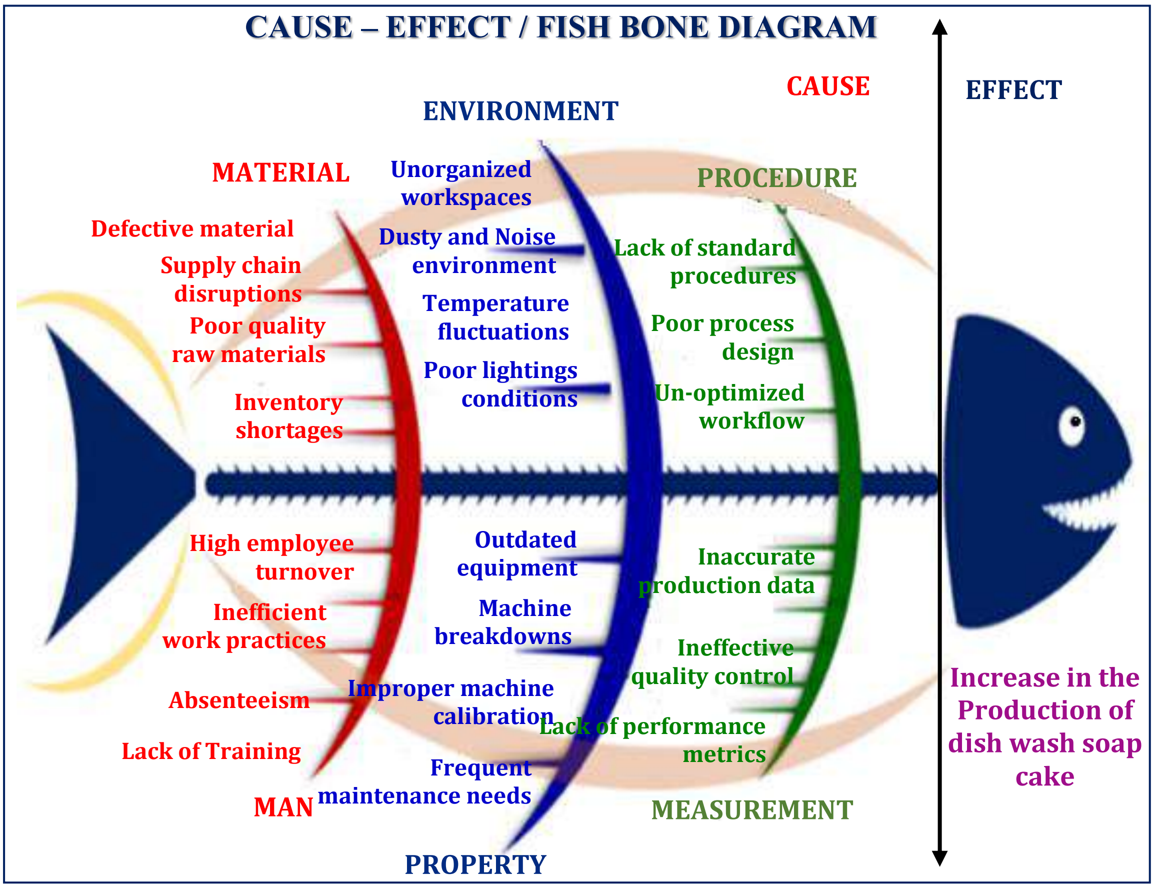


Figure 3.2. *Cause-effect diagram*

The fish-bone approach allowed the project management team to brainstorm and identify the important areas to be improved to boost production output. The areas fall under Man, Material, Properties, Environment, Measurement, and procedure. By drilling down into each area the project management team located "poor process design" as the area to be improved. Because there were studies in the literature that suggest the important role of OEE in product development (Muchiri and Pintelon, 2008; Ng and Chog, 2018; Pardeep and Kumar, 2019). As a result, it was decided to improve OEE and increase production by making modifications in the machinery with minimum budget cost and time schedule and without affecting the quality of the product and electrical power consumption.

Budgeting

The industry where the present study is undertaken has some standard policy in budgeting. If the budgeted cost payback period is within one and half a year the project will be approved otherwise it will be rejected. So to get the approval of the project from the factory manager the payback period was calculated and tabulated below.

Table 3.1. *Details of modifications and costs of modifications.*

XXX Labs Limited. **Calculation of Payback Period** [Cost of Investment/Annual Cash Flows]			
Plant Code: 1076 **Unit Name: XXX Unit** **CAPEX Name: Machine Modification for Productivity Improvement** **A. Investment:**			
Sl. No	**Particulars of Investment**	**Details of modifications**	**Value in INR**
1	Batch Mixing Area	Providing Hopper on the Top of the Mixer	75,000.00
		Providing a Rotary-vane feeder with a motor	23,000.00
		Labour Charge for Installation	3,200.00
2	Cutting and Embossing Area	New round cutting blade cost for 14 Nos	16,800.00
		Modification/correction in Soap de-flash Plate	5,850.00
		Modification in Jigs (Machining)	6,650.00
		Change the fixture Chain & sprocket from 5/8" to 1/2"	27,560.00
		Labour charge for re-assembling and testing	18,750.00
3	Integration of Cutting and Embossing System	Providing additional pneumatic cylinders and assembly	12,500.00
4	Soap Ejection System	Providing the pushing mechanism	5,850.00
		Soaps roller guide	25,000.00
5	Packing Conveyor	Implementing a new conveyor for Scrubber & Lid placing	79,000.00
6	Soap Tilting System	Providing a soap tilting guide for bottom PKD printing	1,750.00
7	Process Modification in Heat Treatment	No cost involvement	**--**
		Total Cost	**3,00,910.00**
		Add GST 18%	**54,163.80**
		Packing and fright charges 2%	**7,101.48**
		Contingency 7.5%	**26,630.54**
		Total Cost of Investment	**3,88,805.8**

Table 3.2. *Details of cost savings.*

B. Annual Cash flow (Savings)		
Sl. No	**Details of Cost Saving for One Year**	**Value in INR**
1	Expecting productivity increased the Target from 1250 to 1700 cases/shift.	
	Manpower Cost	29,62,156.28
	Machinery Depreciation Cost	6,70,634.50
	Repair &Maintenance Cost	3,33,529.41
	Factory Over Head Cost	21,44,251.11
	Electricity power consumption Cost	5,13,764.89
	Sub Total	**66,24,336.19**
2	The excess giveaway was reduced by the process method of preparing cutting blade and monitoring soap weight from 1.0% to 0.25%. Bulk saving is about 110.16 Mt/year. and its raw materials cost around Rs.	**53,19,699.95**
3	Container and lid wastage eliminated from 0.37% to 0.0%. And its packing material cost around Rs.	**5,84,165.03**
4	Grinding machine running and Man power cost involved around Rs.	**51,120.00**
	Total Annual Cash Flow (Savings) Rs.	**1,25,79,321.17**
The Payback = Total Cost Investment (A) / Total Annual Cash Flow (B) x 12		**15 Days**

The calculation of payback period shows that there is a return of Rs. 1,25,79,321.17 /- to the company within half a month (15 days). The payback period arrived at was less than one month. Since the payback period is less than one month the project was approved by the management committee.

Apart from this gain the company gets some additional gains by the way of modifications. These gains are detailed below.

1. Recycling material is reduced from 5.8 Kg to 4.9 Kg/stroke.

2. Machine utilizations is improved.

3. Integration of cutting and embossing machines in one structure reduces the length of the machine from 10.50 meters to 5.80 meters. Due to this no heat is generated

in the servo motor. During operation, the machine is running smoothly without being struck. i.e. the machine stoppage is eliminated thereby reducing the maintenance cost.

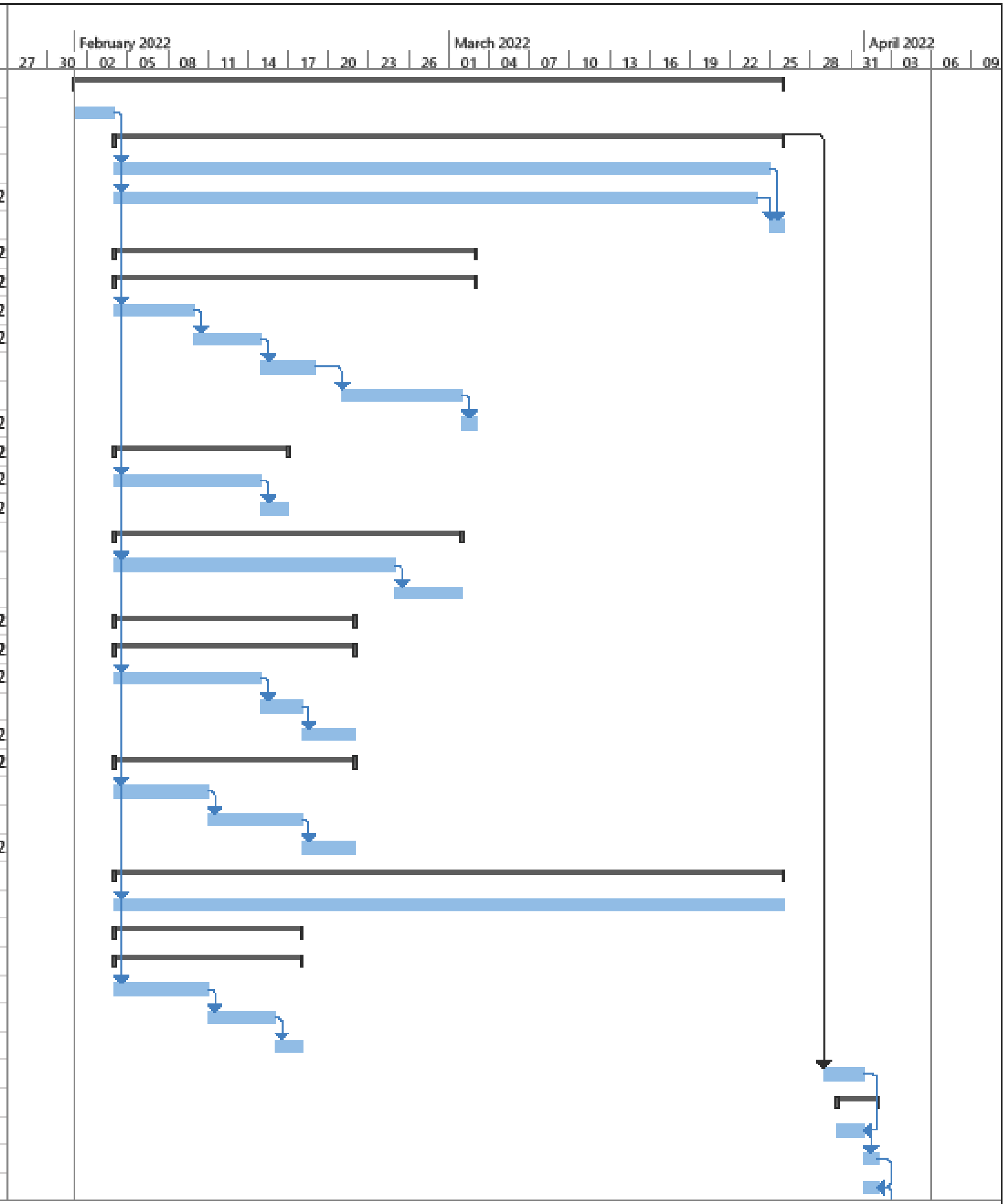
4. Due to the elimination of the wastage of packing materials (wastage is nil), the waste separation works and regrinding works are also eliminated. The costs involved in the grinding machine, electric power, manpower, and space are saved.

Scheduling

Once the approval of the project was obtained from the factory manger, the scheduling i.e. the timeline of the project was prepared. Nowadays many software project tools and techniques are available in the world like Primavera, Project Manager, MS Project, Teamwork Project, Trello, Jira, Backlog, Clickup, and Wrike etc. The MS Project tool was chosen for the present project, because it is user-friendly, familiar in India, and it is easily available in the market. Figure 3.3 shows the Gantt chart prepared using the MS Project Tool.

The Gantt chart shown bellow clearly explains that the total project time is 39 working days (except Sunday), i.e. the lead time is around 2 Months. The preliminary works had been completed and kept ready in the offline process from 1st February to 29th March. The machine stoppage is required from 30th March to 3rd April and one Sunday (3rd April) is also included for installation, commissioning, conducting the trial run, and recording the observations. The new production process can start from the 4th of April for observation, data collection and fine-tuning of the operation. A period of 10 days is taken for fine-tuning of the operation and immediately after this period, the data regarding the product outcome is collected for analysis. It is to be noted that the above-mentioned pre-plan schedule will in no way affect the monthly regular production.

ID	Task Mode	Task Name	Duration	Start	Finish
1		**Machine Modification for Productivity Improvement**	39 days	Tue 01-02-22	Fri 25-03-22
2		Capex approval	3 days	Tue 01-02-22	Thu 03-02-22
3		**Batch making Area**	36 days	Fri 04-02-22	Fri 25-03-22
4		Hopper on Top of Mixer-Purchase	35 days	Fri 04-02-22	Thu 24-03-22
5		A rotary-vane feeder with motor - Purchase	34 days	Fri 04-02-22	Wed 23-03-22
6		Sub Assembly & Test	1 day	Fri 25-03-22	Fri 25-03-22
7		**Cutting and Empossing Area**	19 days	Fri 04-02-22	Wed 02-03-22
8		**New round cutting blade cost for 14 Nos**	19 days	Fri 04-02-22	Wed 02-03-22
9		Procure Material	4 days	Fri 04-02-22	Wed 09-02-22
10		Machining work	3 days	Thu 10-02-22	Mon 14-02-22
11		Heat treatment & Hardening	4 days	Tue 15-02-22	Fri 18-02-22
12		Special Coating	7 days	Mon 21-02-22	Tue 01-03-22
13		Collection	1 day	Wed 02-03-22	Wed 02-03-22
14		**Modification in Soap de-flash Plate**	9 days	Fri 04-02-22	Wed 16-02-22
15		Procure Material	7 days	Fri 04-02-22	Mon 14-02-22
16		Machining work	2 days	Tue 15-02-22	Wed 16-02-22
17		**Change the fixture Chain and sprocket from 5/8" to 1/2"**	18 days	Fri 04-02-22	Tue 01-03-22
18		Procure Material	15 days	Fri 04-02-22	Thu 24-02-22
19		Assembling Jig and Fixture	3 days	Fri 25-02-22	Tue 01-03-22
20		**Soap Ejection System**	12 days	Fri 04-02-22	Mon 21-02-22
21		**Providing the pushing mechanism**	12 days	Fri 04-02-22	Mon 21-02-22
22		Procure Material	7 days	Fri 04-02-22	Mon 14-02-22
23		Machining work	3 days	Tue 15-02-22	Thu 17-02-22
24		Sub Assembly unit	2 days	Fri 18-02-22	Mon 21-02-22
25		**Soaps roller guide**	12 days	Fri 04-02-22	Mon 21-02-22
26		Material Procure	5 days	Fri 04-02-22	Thu 10-02-22
27		Machining work	5 days	Fri 11-02-22	Thu 17-02-22
28		Sub Assembly unit	2 days	Fri 18-02-22	Mon 21-02-22
29		**Packing Conveyor**	36 days	Fri 04-02-22	Fri 25-03-22
30		Out sourcing - Purchase	36 days	Fri 04-02-22	Fri 25-03-22
31		**Soap Tilting System**	10 days	Fri 04-02-22	Thu 17-02-22
32		**Providing a soap tilting guide for bottom PKD printing**	10 days	Fri 04-02-22	Thu 17-02-22
33		Material Procure	5 days	Fri 04-02-22	Thu 10-02-22
34		Machining work	3 days	Fri 11-02-22	Tue 15-02-22
35		Sub Assembly unit	2 days	Wed 16-02-22	Thu 17-02-22
36		Mixer hopper erection work	3 days	Tue 29-03-22	Thu 31-03-22
37		**Cutting and Empossing machine**	3 days	Wed 30-03-22	Fri 01-04-22
38		Dismantling and cleaning	2 days	Wed 30-03-22	Thu 31-03-22
39		New chain, Jig and fixture assembling	1 day	Fri 01-04-22	Fri 01-04-22
40		De-Flash plate and Cutting Blade changing	1 day	Fri 01-04-22	Fri 01-04-22



Project: Project
Date: Sun 15-12-24

Task		Project Summary		Manual Task		Start-only		Deadline	
Split		Inactive Task		Duration-only		Finish-only		Progress	
Milestone		Inactive Milestone		Manual Summary Rollup		External Tasks		Manual Progress	
Summary		Inactive Summary		Manual Summary		External Milestone			

Figure 3.3. *Gantt Charts prepared using the MS Project tool.*

3.4.3 Project Risk Management

According to Pokharel et al. (2006), effective project risk management encompasses product, process, and technology aspects. Inadequate planning and handling of these risks can result in project challenges or failures. However, successful management of complex projects, utilizing appropriate front-end, in-process, and back-end tools, can lead to successful outcomes and economic benefits.

So in the present study, while making the modifications in the machineries the investigator has to face some risks. For example primarily to do the modifications, the production has to be stopped for at least 5 days. So pre-plan needs to be made well in advance to achieve the monthly regular production. Therefore these five days are chosen in such a way that this period falls at the end of the current month and at the beginning of the next month. It would be better if a Sunday (a weekly holiday in India) comes in this period. Special permission has to be obtained from the factory manager for Sunday work and night shifts. Further, one supervisor needs to be allotted from the HR department to supervise these works. During pre-plan, the machine tools, consumables, and Personal Productive Equipment (PPE) are to be collected from the engineering stores and kept in a safe and secured place for Sunday work and night shift. Labor welfare measures like providing tea, biscuits, meals etc. have to be arranged. One safety officer for monitoring and giving instructions to follow the safety rules needs to be allotted.

Staffing and Resources

The investigator easily planned and prepared the workforce allotment in this project, because the industry where the research is being conducted has its own tool room set-up and also well-agile teams like, electrical, mechanical, and process instrumentation. As this is a short-term project ‘the make or buy decision’ was applied. Some mechanical components are made in its own tool room section and other assembling and process instrumentation works are carried out by the related team with good stuff. The heat treatment and special coating operations are done near the resources area. As the industry is located in a well-established industrial estate, some machinery and systems are procured from nearby industries. Thus the resourcing part is not difficult.

3.4.4 Project Launch and Execution

Once the planning is over the project is launched carefully step by step. Some minor changes would be made in the project execution to the changing circumstances. The project consists of making modifications to the machinery and human resources. The modifications in the machinery are made in the batch mixing area, cutting, and embossing area. However, the time, quality, and power consumptions are held constant and the cost of modifications in the machinery is kept minimum. The time schedule for the study is nine months i.e. December 2021 to August 2022. During the execution, the laborers were mobilized accordingly. Specific tasks are assigned to suitable laborers. The step-by-step execution of the project is detailed below.

3.4.5 Stakeholder Engagement and Communication

Stakeholder engagement involves identifying and involving relevant stakeholders and establishing regular and open communication channels. Gharaibeh (2019) in his study concluded that the effectiveness of team communication in projects is becoming increasingly important due to the growing technical and organizational complexity of construction projects. This provides timely updates, seeks feedback, and fosters collaboration to ensure stakeholders are informed and engaged throughout the project. The stakeholders of this project are depicted in the following flow chart.

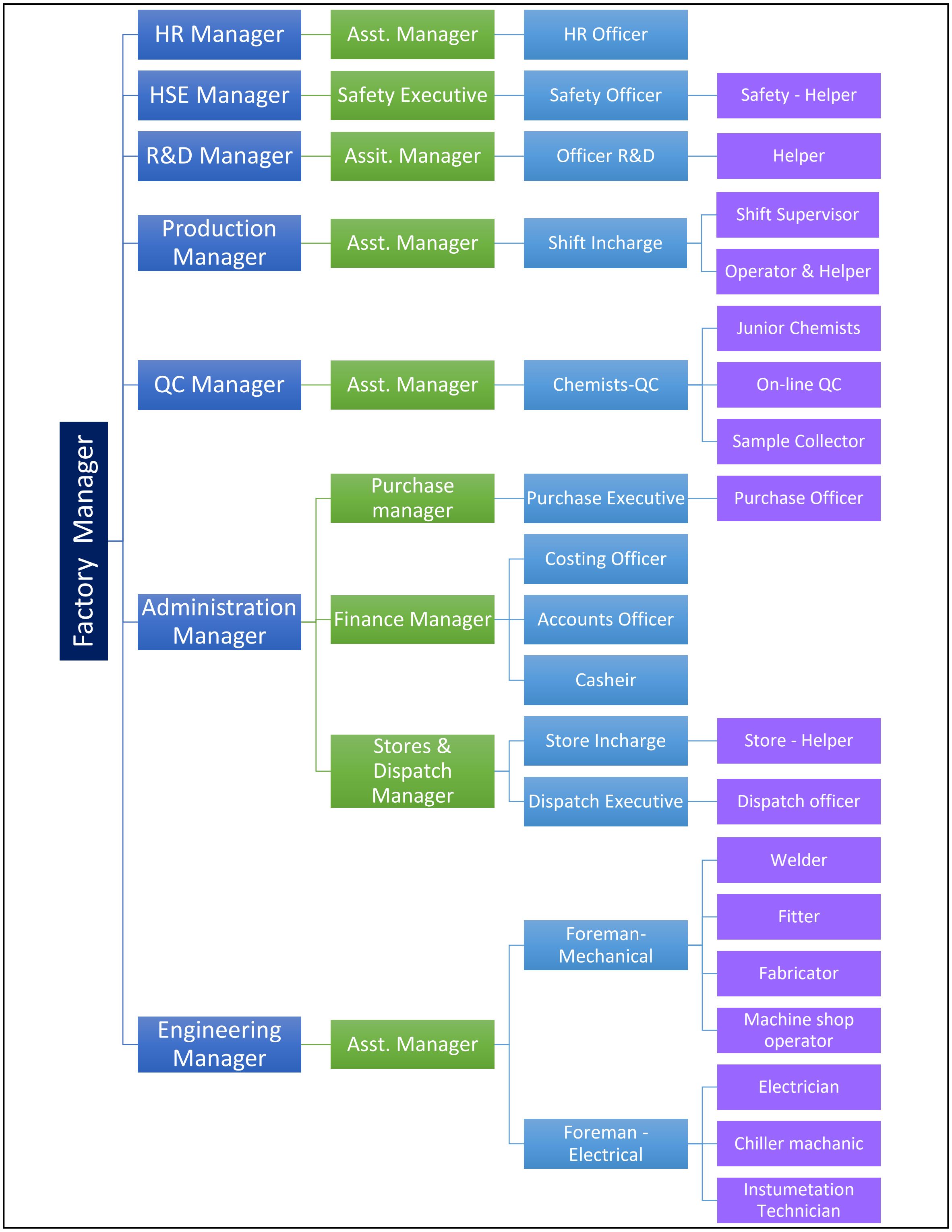


***Figure.* 3.4**. *Organization chart of the industry.*

In the present study the managers of the various departments, technicians, and employees are coordinated to carry out the projects. WhatsApp and mail ID groups were started among the stakeholders to establish regular and open communication channels and to make necessary updates. A project information notice board was placed on the walls of the project working site so as to inform the developments in the project.

3.4.6 Skilled and Empowered Project Team

Successful project execution necessitates a capable project manager and a team of qualified, content individuals who are well-suited for the job. While the project manager has specific duties, the remaining tasks are distributed among team members. Research has highlighted the significance of organizer satisfaction and the potential long-term benefit of developing an experienced workforce (Škorić et al., 2017). To ensure project success, it is crucial to assemble a proficient team with the appropriate skills and knowledge. Team members should be given well-defined roles and responsibilities, as well as the necessary resources and authority. This approach fosters a cooperative environment that improves project outcomes.

Research has shown that project managers can enhance team trust and project outcomes by implementing more team-building activities and encouraging participation (Fung and Cheng, 2015). Furthermore, studies indicate that when project managers exercise their leadership role more often, the project team's effectiveness increases (Fung and Ramasamy, 2015). Keeping these views in mind, in the present study, a project management team was formed comprising of members from various departments of the industry and specific roles were assigned to them.

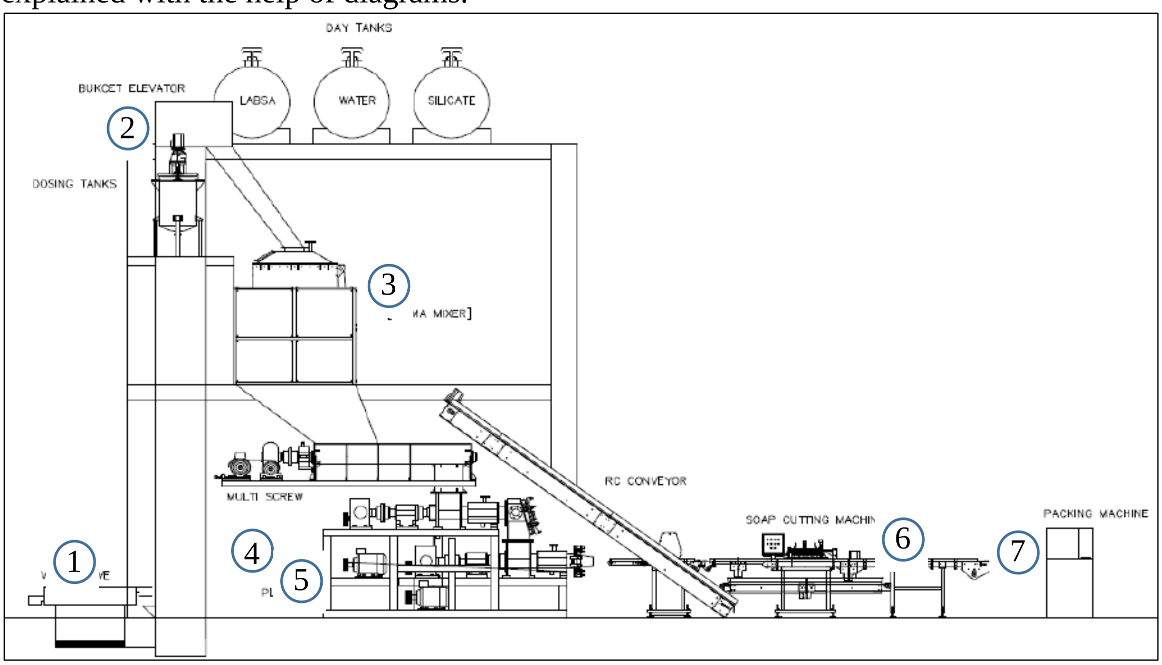
The engineering teams both mechanical and electrical made the modifications in the machineries, setting and Programmable Logic Controllers programming and altered. The R&D team ensured that the product parameters did not deviate from the specific limit and finally, the skilled members of the Quality team examined the quality of the soap cakes and approved them.

3.4.7 Continues Monitoring and Adaptation

To ensure project success, it is crucial to establish robust monitoring systems that assess progress towards objectives, detect potential obstacles, and implement necessary adjustments. Such measures foster flexibility and proactive risk handling, allowing teams to effectively manage dynamic project landscapes and sustain momentum. The project management team gathered for a weekly session to address challenges and evaluate the project's advancement.

3.5 Process of Soap Cake Production

In this section, a detailed account of the functioning of the machines during soap cake production is given. Further, the places where modifications were made were also explained with the help of diagrams.



1. Vibratory Sieve, 2. Bucket Elevator, 3. Sigma mixer, 4. Multi Screw, 5. Plodder, 6. Soap Cutting Machine, 7. Case Packing Machine

Figure 3.5. *Schematic diagram of process flow of dish wash cake manufacturing industry.*

Vibratory Sieve

A vibratory sieve, also known as a vibrating screen, is a mechanical screening device. It is used to separate particles by size through the vibration of a sieve surface. It is commonly used in industries such as food processing, pharmaceuticals, chemical engineering, mining etc.

Bucket Elevator

A bucket elevator is used to carry raw materials at a slow speed vertically using buckets. It is fixed in the flat belt at a uniform pitch distance. The total arrangements are covered by a steel sheet to avoid the spillage of the powder outside. It was driven by the electrical motor with the desired torque gearbox assembly which in turn connected to the drum shaft. The capacity of the bucket elevator is 24 MT/hr. It is efficient for transporting materials to elevated levels but it is not suitable for horizontal transport. To avoid rust/corrosion most of the bucket elevators are made up of plastic or silver steel.

Sigma Mixer

The Sigma mixer was connected to a batch-holding vessel, where the materials were accurately measured and transferred to the sigma mixer. The Sigma mixer blends the ingredients thoroughly to make a homogeneous mixture. The Sigma mixer has two Sigma-shaped blades that rotate in horizontal and overlapping motions. It has two shafts, one for each blade, which rotate in opposite directions creating a kneading action that effectively mixes and blends the ingredients of the soap.

Soap sigma mixers provide efficient mixing and blending of soap ingredients. The mixer's design ensures high-quality soap production, with minimal ingredient degradation. Soap Sigma mixers are designed for easy cleaning and maintenance. The mixer can handle a wide range of soap recipes and ingredients.

Multi Screw Feeder

Once the mixing process is completed, the bulk material is fed into a multi-screw feeder. This feeder transfers the bulk material to an extrusion vacuum plodder. Soap multi-screw mixers, also known as multi-screw extruders or triple-screw mixers, are specialized mixers designed for soap manufacturing.

There are typically three screws, which rotate in a synchronized manner. The multi-screw feeder provides efficient mixing and kneading of soap ingredients. The multi-screw feeder design ensures high-quality soap production, with minimal ingredient degradation. It is designed to handle a wide range of soap recipes and ingredients and for easy cleaning and maintenance.

Vacuum Plodder

When the soap ingredients are mixed homogenously, the mixture is sent through an extruder to obtain soap bars. These bars are then conveyed to a machine called vacuum plodder which is also known as twin worm duplex vacuum plodder. The vacuum plodders are specialized machines designed for soap manufacturing. This advanced equipment enhances the shape and texture of the bars by removing any excess air or moisture.

The vacuum plodder has two screws that rotate in a synchronized manner, providing efficient mixing and kneading. The vacuum system removes air from the soap mixture, resulting in a more uniform product. The design of the plodder allows for the continuous extrusion of soap bars. There is a heating/cooling system that controls the temperature of the soap bar and a pressure control system that regulates the pressure. The vacuum plodder ensures a more uniform soap product. The continuous extrusion process and automated pressure control system increase efficiency and reduce labor costs.

Cutting machine and Embossing Machine

Upon leaving the plodder, the soap bars underwent cutting. A conveyor system transported them to the cutting and embossing machines, which divided the soap into billets and imprinted the required logo. The initial cutter sliced the bars from the vacuum plodder into uniform lengths, utilizing a sensor-based cutting system. This user-friendly setup accommodated various bar lengths. The bars were automatically detected and moved forward for secondary round-bar cutting and embossing. Following this process, the soap cakes were transferred via an off-take conveyor to the carton packing machine, where the scrubber, top lid, and finlay were added. Excess trimmings were removed by a conveyor and directed to an inclined belt conveyor, which connected to a multiscrew conveyor for recycling purposes. The machinery was engineered with adaptability, allowing for swift transitions between different pack sizes.

Carton Case Packing Machine

A carton-packing machine seals small boxes with a tape. It features a compact design and user-friendly operation, with adjustable settings. This is ideal for e-commerce, retail, and small-scale manufacturing. For situations where carton sizes remain consistent, a carton-case packing machine is ideal. This equipment is well-suited for the continuous sealing of uniformly sized cartons. Various industries utilize this machine, including home appliance manufacturers, food producers, general merchandise companies, pharmaceutical firms, and chemical plants. The production process for soap cakes is illustrated in the accompanying flowchart.

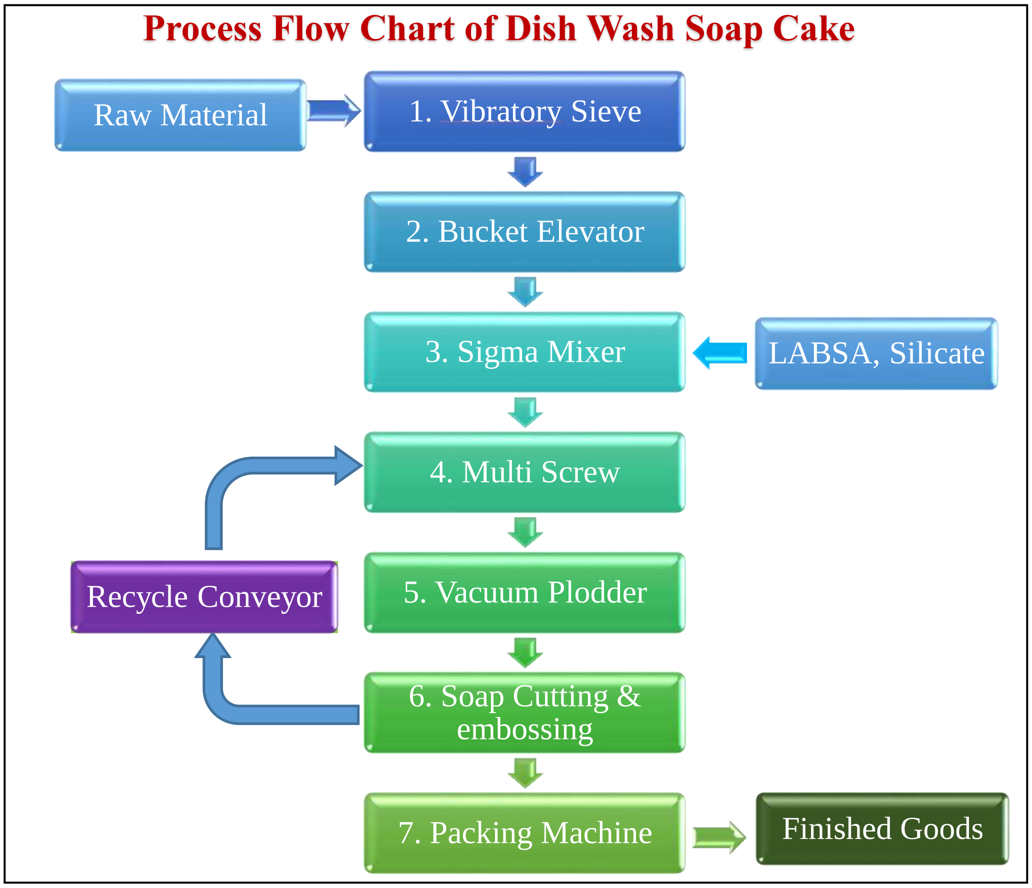


Figure 3.6. *Process flow chart of dish wash cake production.*

3.6 Modifications made in the Machineries.

In this existing processing system the following modifications are made to caryout the research and examine the production level. The modifications are made in batch mixing area, cutting and embossing machines, ejection system, packing system, soap tilting system and heat treatment system.

3.6.1 Providing a Hopper on the Mixer

The modification made in the batch mixing area is providing a storage hopper on the top of the mixer. By providing a storage hopper, all the powder raw materials (powders 1, 2, 3 & 4) are transferred through a bucket elevator whose capacity is 12 Mt/Hr. The total weight of the powder materials 1 & 2 is 393 kg and the total weight of the powder materials 3 & 4 is 795 Kg. By following the batch mixing sequences as recommended by the R&D

section, the transfer time taken from the data-sheet is 12 min. By providing a hopper the material transfer time is reduced to 2 min. Because this transfer happens when the mixing operation is going on in the Sigma mixer and thus there is pre-storage of the raw materials like powders 1 & 2 and powders 3 & 4 in the correct sequence.

After carrying out these modifications, the data regarding the batch time are collected batch wise and shift wise and tabulated. The machine control with the parameters like temperature, noise, and vibration level during the trial are also observed. The data in respect of these parameters are compared with the data obtained before the modifications.

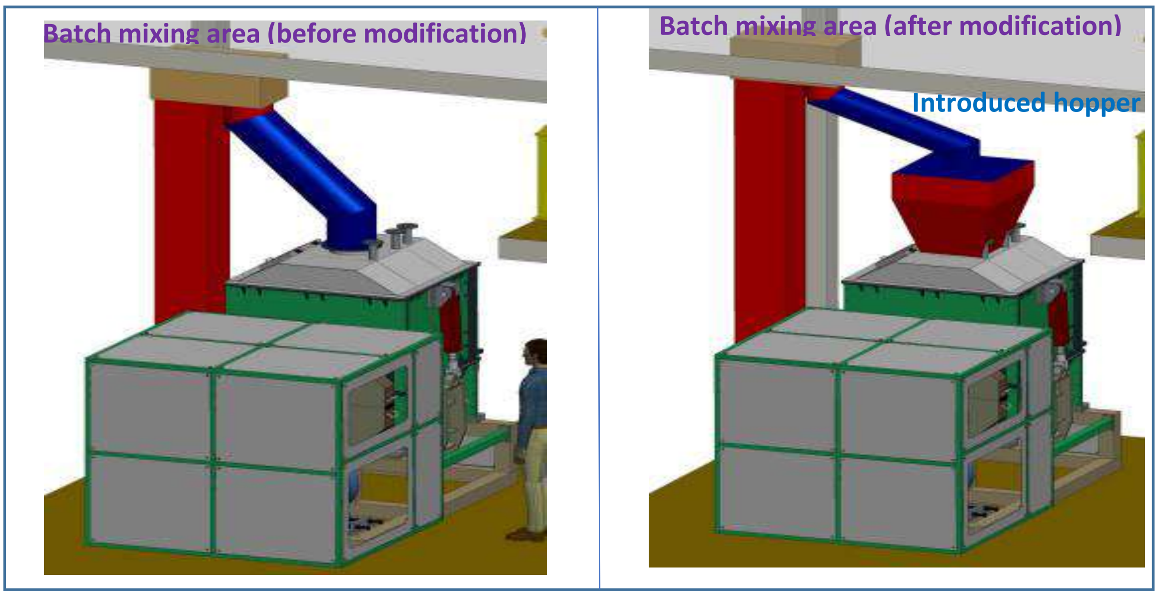


Figure 3.7. *Modifications made in the batch mixing area.*

3.6.2 Increasing the number of Cutting Blades and Embossing

In the existing machine the jigs and fixtures are fitted in the 5/8” duplex chain and its corresponding drive sprockets. The distance between one jig and another is 127 mm. It is called the pitch distance. Therefore the round soap is cut and picked from a bar length of 127 mm. In order to increase the production the pitch distance is reduced from 127 mm to 115 mm and the 1/2" duplex chain and sprockets are used. This is the optimized design available in the market.

By this modification, the distance between one jig and another is reduced. Eventually, the number of cakes per stroke is increased from 12 to 14, and at the same time the quantity of recycling material is reduced.

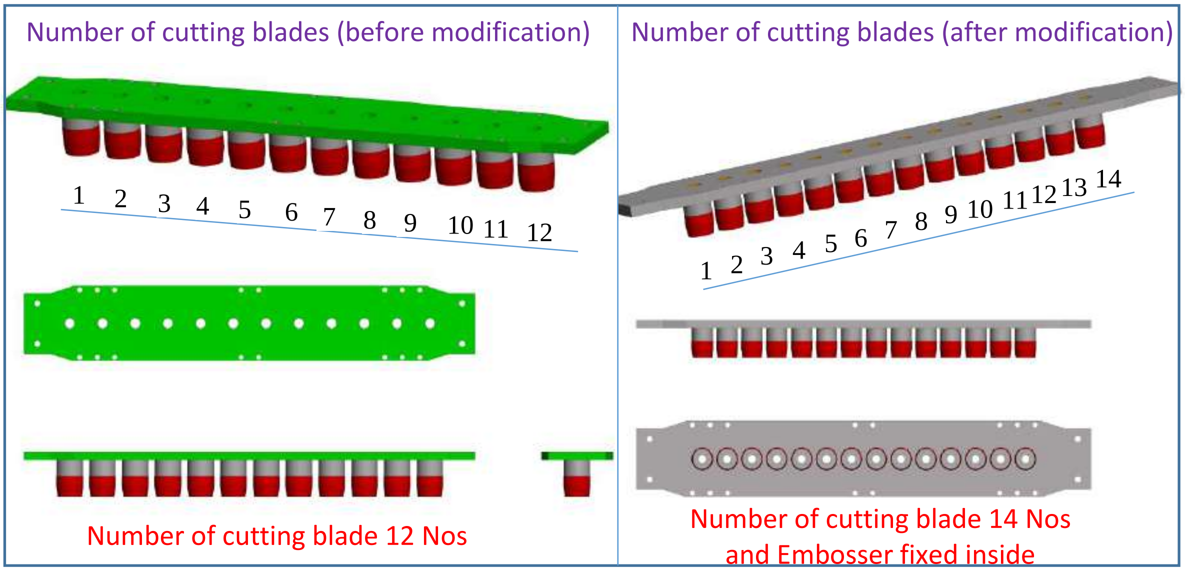


Figure 3.8. *Modifications made in the cutting and embossing system.*

3.6.3 Integration of the Cutting and Embossing Systems

In the existing machinery the cutting system and the embossing system are functioning separately. In order to reduce the length of the machine and reduce the current load of the servo motor one modification is made in cutting and embossing area. The modification made here is the embossing system is integrated with the cutting system. Thus the cutting and embossing functions are carried out simultaneously and in one place. However, the over heat of the servo motor is reduced thereby reducing the breakdown. But the cycle time is unaltered.

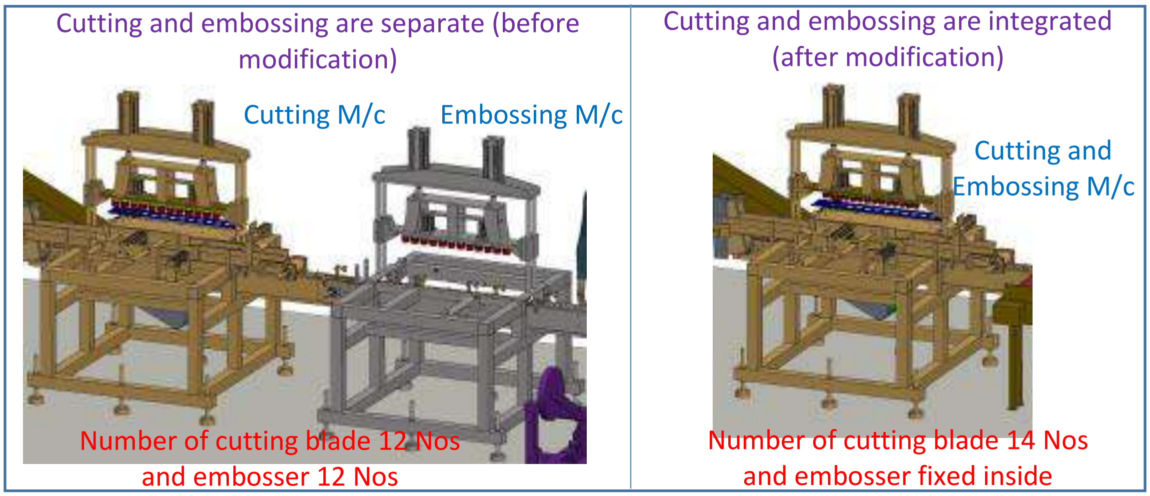


Figure 3.9. *Integration of cutting and embossing systems.*

3.6.4 Changing the Ejection System

In the existing system the final product i.e. the soaps with container and lid are ejected through a guided metal sheet. During ejection, the lids are missing on some soaps due to human error. While passing through the metal-sheet guides, these lid-missed soaps with the container get deformed and struck in the machine. This causes trouble in the ejection system and leads to the stoppage of the machine. Moreover, the soap container, the soap and the scrubber are damaged. Thus the quantity of the recycling material is increased and the soap container wastage and the scrubber wastage are also increased. In order to reduce these wastages a new system of ejection is introduced. The ejection system is made in such a way that the soaps with the container are ejected by a pushing mechanism. This modification reduces the rejection percentage of soap containers, lids, and scrubbers and reduces the percentage of recycle materials.

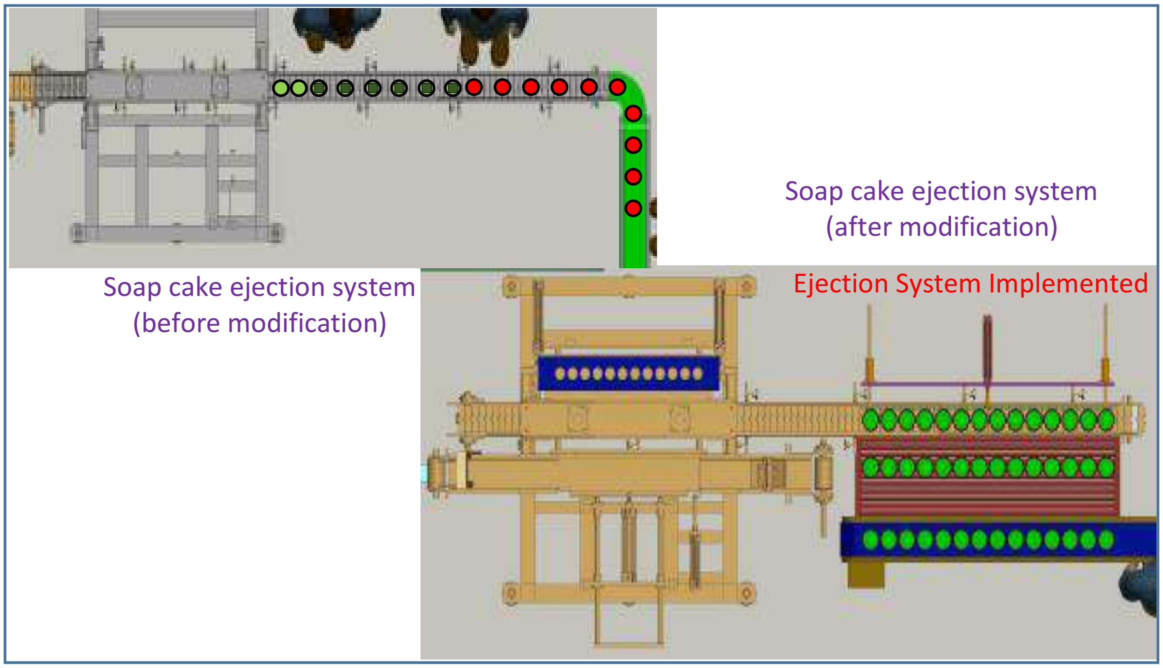


Figure 3.10. *Modification in the ejection system.*

3.6.5 Introducing Packing Conveyor System

In the existing system, the scrubbers and lids are placed manually in the cutting and embossing machine. The total cycle time of operation is 6 seconds. But the placing time allowed is only 3 seconds. During the rest of the 3 seconds, the jigs are moving for the second stroke of operation. So placing scrubbers and lids is difficult leading to fatigue of the laborers and hence some scrubbers and or lids are missing on the lineTo solve this problem, a new packing conveyor is introduced. With this change, the soaps with the container are carried forward by the conveyor from the cutting and embossing machines. This conveyor runs slowly with workable speed. Now the laborers get a complete 6 seconds for placing the scrubber and lid. The work becomes easy for them and hence they do not develop fatigue. Consequently, the scrubber and lid are placed properly on the soap with container without any missing.

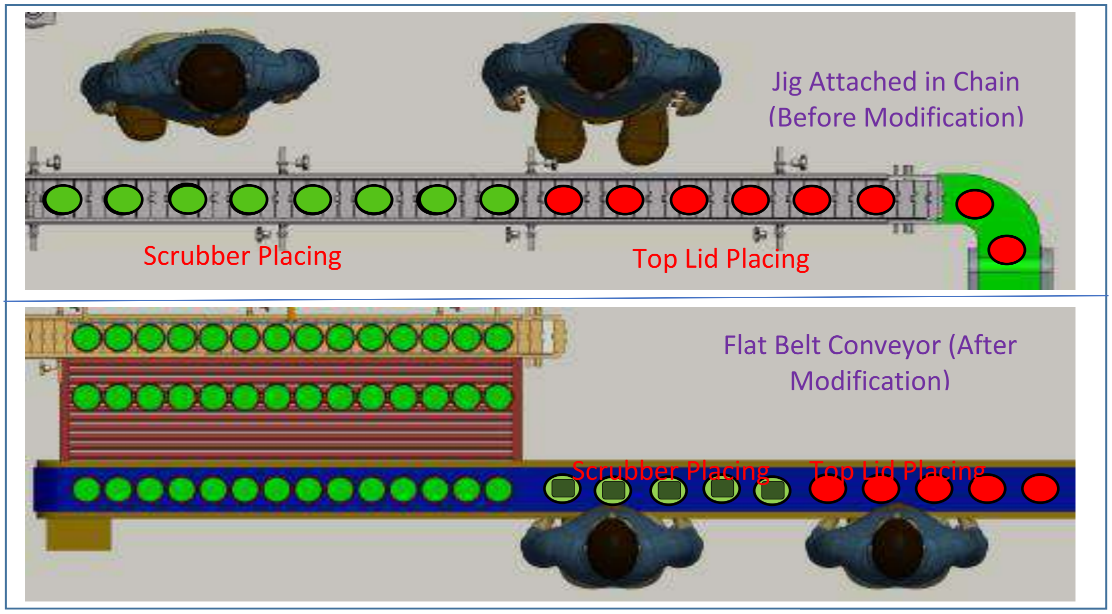


Figure 3.11. *Introduction of conveyor belt.*

3.6.6 Introducing Soap Tilting System

In the existing system, the soaps with containers are tilted by 180° for printing of PKD at the bottom of it. It creates fatigue among the laborers. Further doing repeated operations at the line speed of 120 PPM makes the laborers stressed. In order to reduce the fatigue and stress of laborers, a Kaizen technique is used to tilt the soaps by 180°. This is a simple mechanism where the soaps with containers are guided through the SS steel sheet that provides a regular path in the existing printing conveyor without any cost investment. Also by this modification one manpower is eleminated.

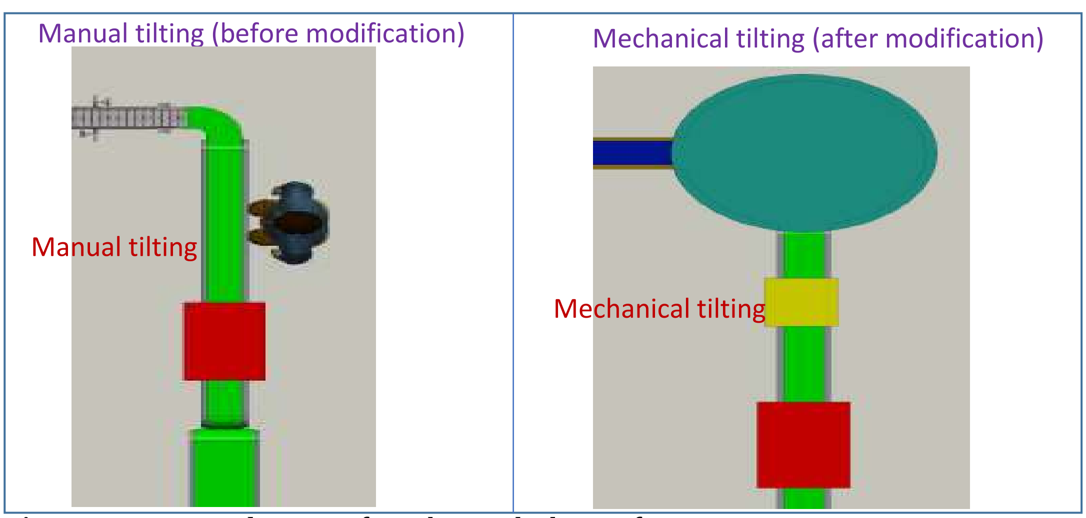


Figure 3.12. *Introduction of mechanical tilting of soap*

3.6.7 Process Modification in Heat Treatment

In the process of making soap cakes, an extrusion die is used to make soap bars and maintain their thickness. Earlier this extrusion die was a single piece. After usage due to erosion of this die the shape of the soap goes irrugular and also the level of excess giveaway goes up. Further, this extrusion die can't be re-used. Now the extrusion die is modified into having two split halves and an 'insert' is added with it. The insert is made up of HCHCr-D_2 metal hardened through heat treatment and coated with tin metal. This causes less erosion of the insert leading to maintaining the weight and thickness of the soap cake. Moreover, this modified split-half extrusion die can be reused only by changing the two inserts.

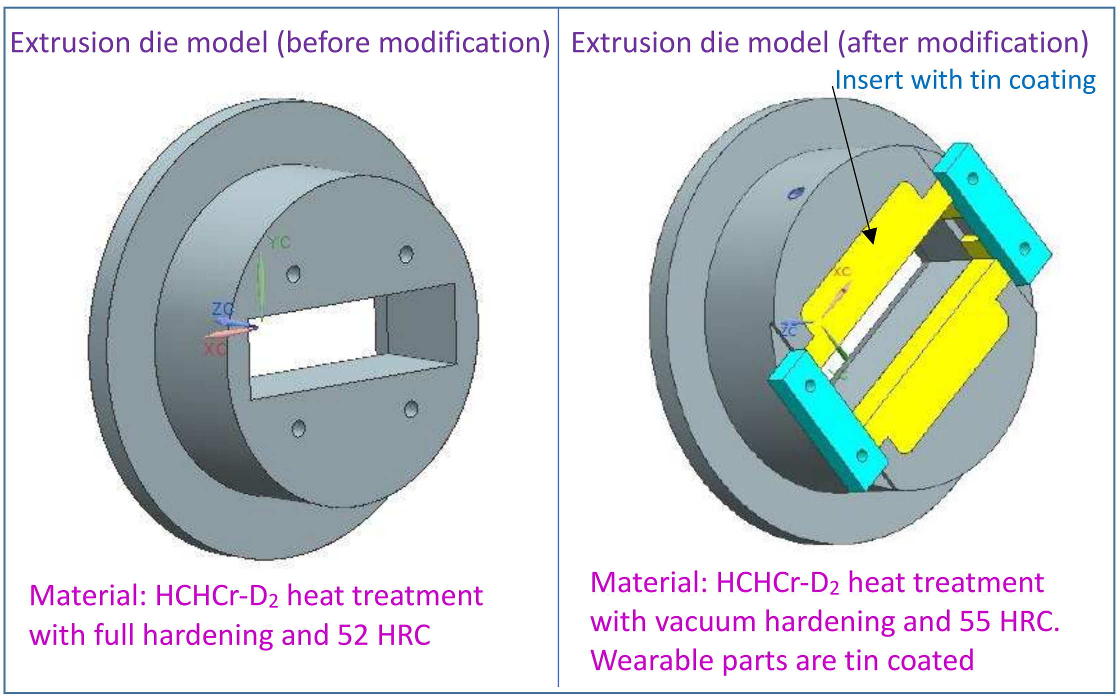


Figure 3.13. *Modification in extrusion die*

One more process modification in heat treatment was done to the round shaped cutting blads. A round shaped cutting blade is used to cut the round soap cake out of the extrusion soap bar. In order to increase the life time of cutting balde and to reduce the excess giveaway in the product, the round cutting blade is modified. Earlier the cutting blade is made up of P-22 grade metal and heat treated though flame hardening and the inner and outer surfaces of the blade were hard chrome coated. Now the cutting blade is made up of P-20 grade metal and heat treated through vacuum hardening and the inner and ourter surfaces of the blade were tin coated. This leads to increased life time of the cutting blade and to reduced excess giveaway.

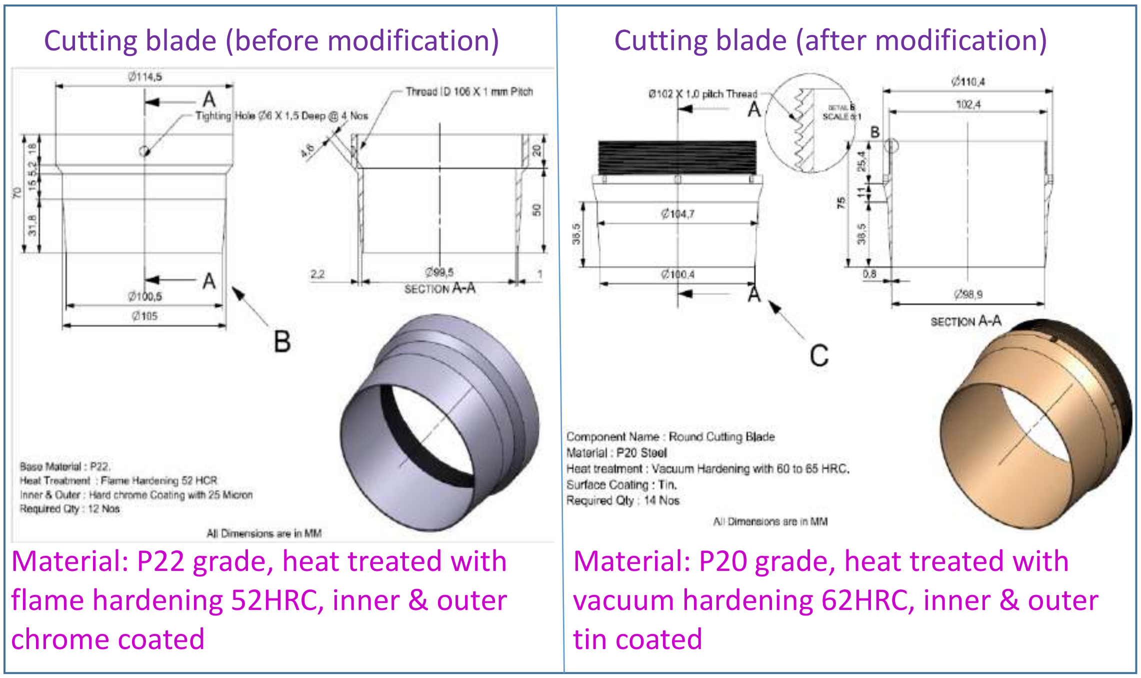


Figure 3.14. *Modification in cutting blade*

Another modification made in this area was the change in the position of the thread in the blade holder. Earlier the thread was outside of the blade holder but now it was shifted to inside of the blade holder. This modification reduced the length of the soap cutting pitch distance thereby increasing the number of soap cakes from 12 to 14 per extrusion bar. Also this reduced the re-cycling of material.

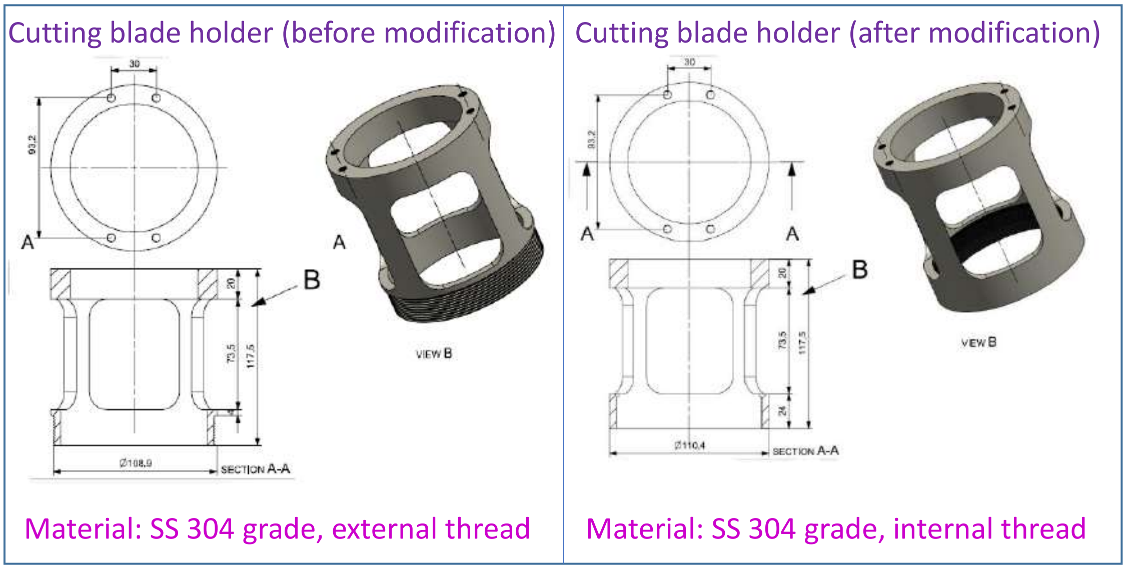


Figure 3.15. *Modification in cutting blade holder*

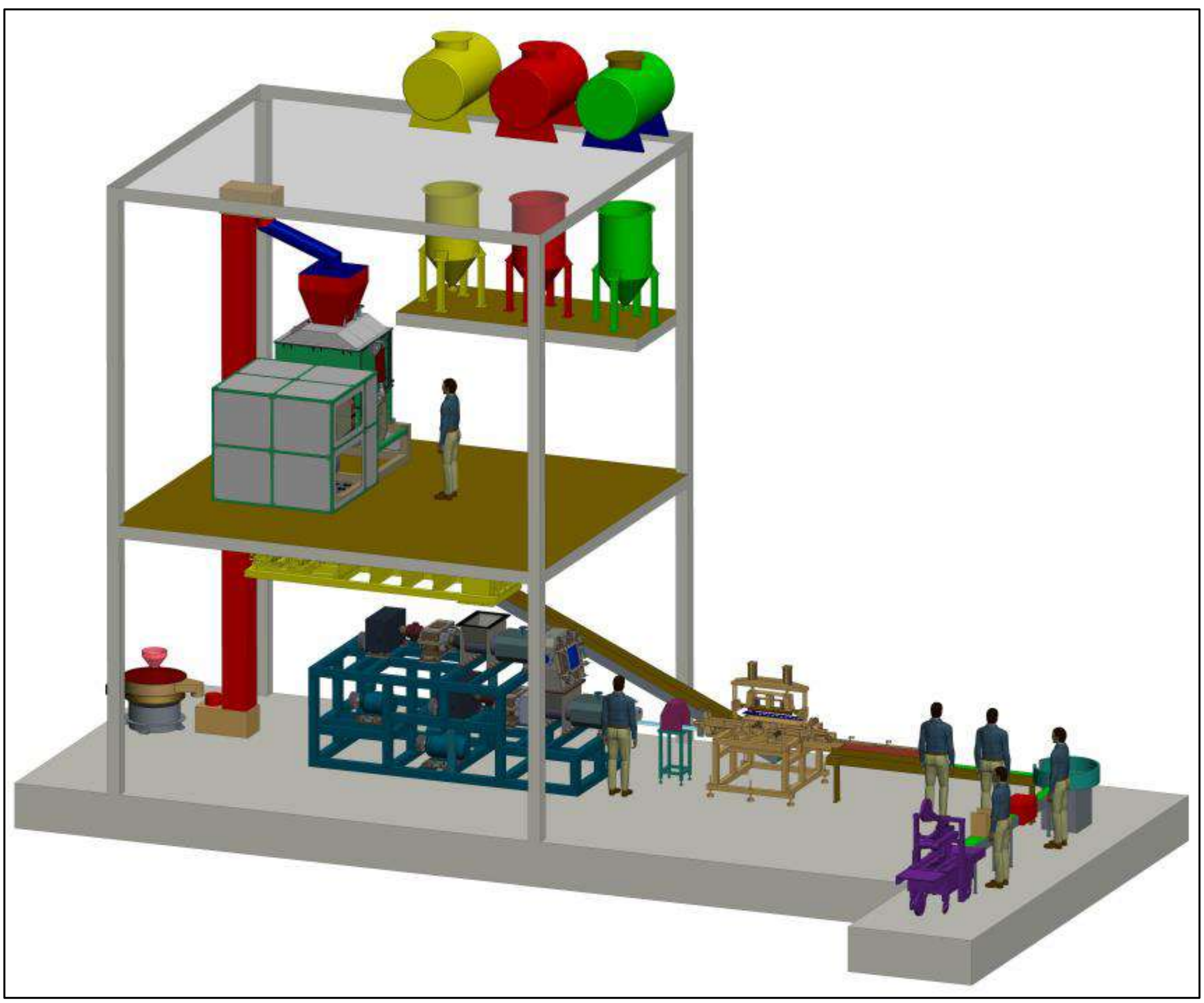


Figure 3.16. *Dish wash soap plant after modifications*

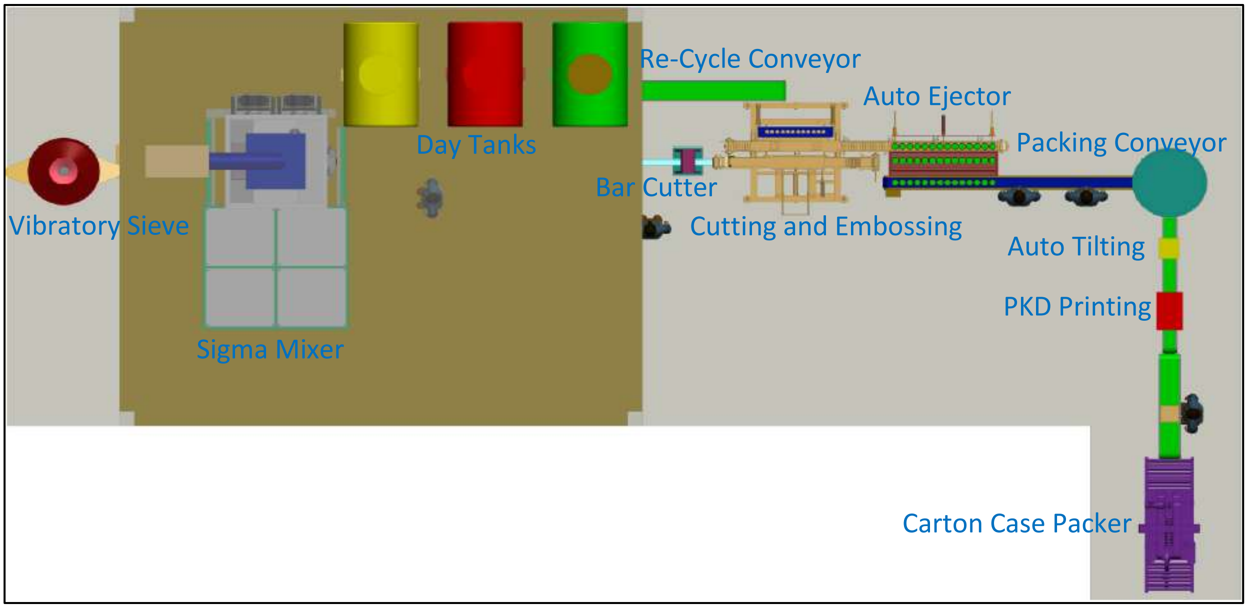


Figure 3.17. *Top view of soap production plant after modifications*

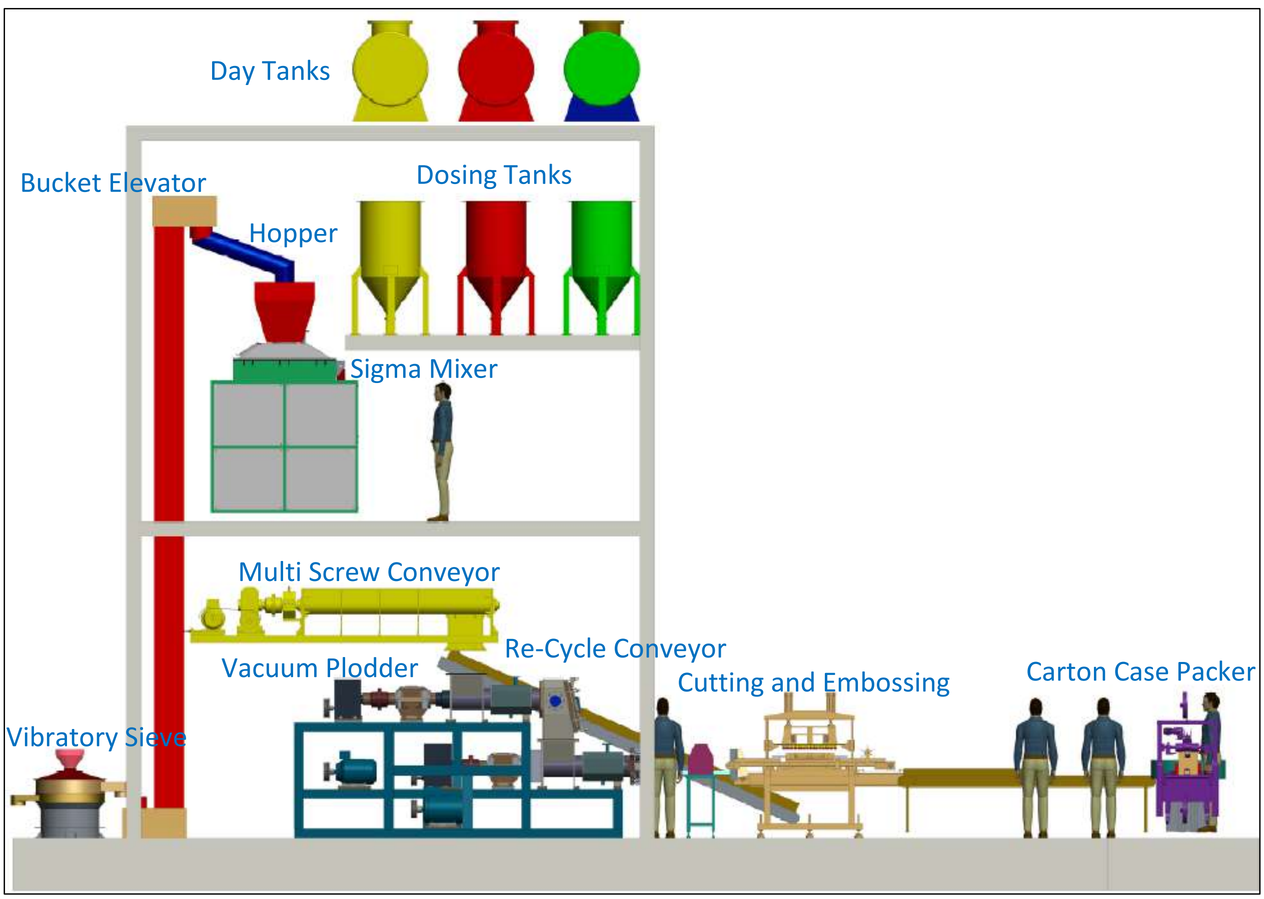


Figure 3.18. *Side view of soap production plant after modifications*

3.7 Population and Sample

The study was conducted in a dish wash soap manufacturing industry located in Puducherry, South India. Production of soap cake is going on in the industry in three shifts, namely A, B, and C per day. The production level of soap is measured shift-wise. These shifts constitute the population of the study.

Data pertaining to before modifications had been collected from 13/12/2021 to 17/3/2022, a duration of 3 months and 6 days. There are 83 clear working days. Employees work in 3 shifts each day. So there are 249 shifts for data collection. Among the 249 shifts, a random sample of 33 shifts (13%) was selected for data collection (Table 3.3).

After collecting the data pertaining to before modifications, the machines were stopped from 18/03/2022 to 03/04/2022 for doing modification works like installation, commissioning, conducting trial runs, and recording the observations.

Data pertaining to after modifications had been collected from 04/04/2022 to 06/07/2022, a duration of 3 months and 2 days. There are 55 clear working days. Employees work in 3 shifts each day. So there are 165 shifts for the data collection. Among the 165 shifts, a random sample of 33 shifts (20%) was selected for data collection (Table 3.4).

Table 3.3. *Selection of sample before modifications*

Sl. No.	Date	Shift
1	11-12-2021	C
2	21-12-2021	A
3	22-12-2021	B
4	22-12-2021	C
5	01-01-2022	A
6	01-01-2022	B
7	04-01-2022	C
8	06-01-2022	A
9	08-01-2022	B
10	08-01-2022	C
11	17-01-2022	A
12	17-01-2022	B
13	18-01-2022	C
14	25-01-2022	A
15	25-01-2022	B
16	31-01-2022	C
17	02-02-2022	A
18	02-02-2022	B
19	05-02-2022	C
20	11-02-2022	A
21	14-02-2022	B
22	17-02-2022	C
23	21-02-2022	A
24	22-02-2022	B
25	23-02-2022	C
26	01-03-2022	A
27	03-03-2022	B
28	10-03-2022	C
29	11-03-2022	A
30	12-03-2022	B
31	16-03-2022	C
32	17-03-2022	A
33	17-03-2022	B

Table 3.4. *Selection of sample after modifications*

Sl. No	Date	Shift
1	04-04-2022	B
2	07-04-2022	A
3	08-04-2022	C
4	11-04-2022	B
5	12-04-2022	A
6	12-04-2022	C
7	21-04-2022	A
8	22-04-2022	B
9	22-04-2022	C
10	27-04-2022	C
11	28-04-2022	A
12	03-05-2022	A
13	03-05-2022	B
14	12-05-2022	A
15	12-05-2022	C
16	18-05-2022	B
17	18-05-2022	C
18	19-05-2022	A
19	22-05-2022	C
20	25-05-2022	B
21	28-05-2022	B
22	03-06-2022	A
23	03-06-2022	B
24	08-06-2022	C
25	09-06-2022	B
26	12-06-2022	C
27	14-06-2022	A
28	15-06-2022	B
29	18-06-2022	C
30	25-06-2022	A
31	06-07-2022	A
32	06-07-2022	B
33	06-07-2022	C

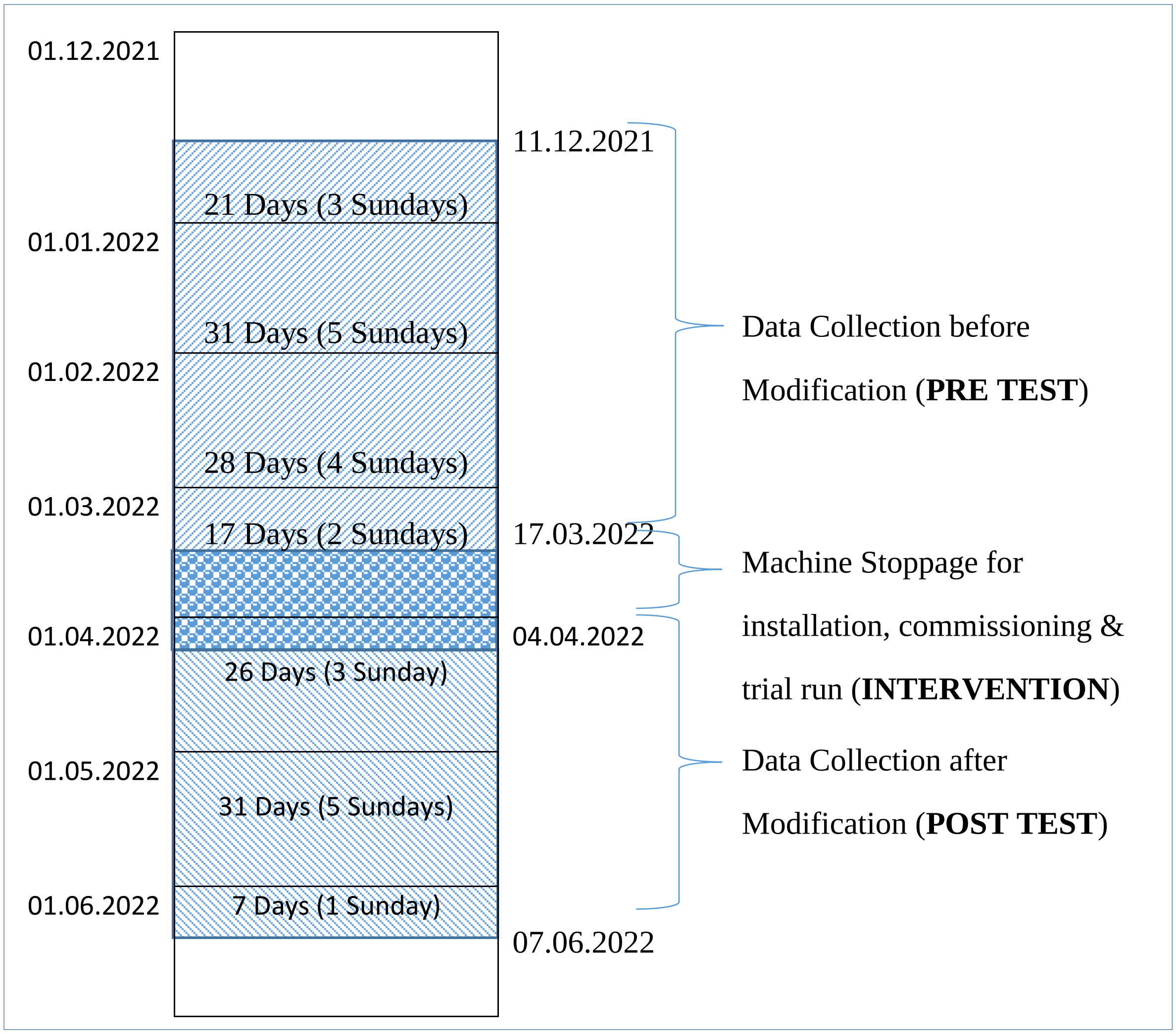


Figure 3.19. *Timeline chart of the study.*

3.8 Data Collection Procedures

This study used primary data for the analysis. Data pertaining to various variables involved in the study, viz. production of soap cakes, bulk manufacturing time, power consumption, anionic active percentage, pH value, moisture percentage, total alkalinity percentage, breakdown time and frequency, and excess giveaway, were obtained from the concerned departments before and after the modifications in the machinery and tabulated (Table 3.5 and Table 3.6).

Table 3.5. *Data collected before modifications (Raw data)*

Sl. No.	Production in cases	Bulk manufacturing time	Power consumption in kWh	Anionic Active in %	pH value	Moisture in %	Total Alkalinity in %	Down time in min.	Frequency	Soap weight in gm
1	1116	30	503	12.96	10.54	7.64	3.82	115	4	504.3
2	1163	30	502	12.86	10.25	7.84	3.84	101	3	503.5
3	1346	30	504	13.05	10.36	7.28	3.81	46	2	504.7
4	1401	30	502	13.06	10.24	7.68	3.83	30	1	504.6
5	1097	30	505	13.04	10.26	7.84	3.85	121	4	504.5
6	1448	29	504	13.57	10.05	7.58	3.82	16	1	505.2
7	1386	30	504	13.06	10.12	7.84	3.81	34	1	504.3
8	1613	30	503	13.54	10.56	7.82	3.86	0	0	505.1
9	1554	30	502	13.09	10.48	7.84	3.87	0	0	503.8
10	1516	30	504	13.1	10.64	7.86	3.89	0	0	504.7
11	1332	30	504	13.05	10.09	7.54	3.86	50	2	505.6
12	1584	30	504	13.04	10.21	7.56	3.84	0	0	504.9
13	1485	30	503	13.06	10.13	7.68	3.86	0	0	505.4
14	1460	30	502	12.95	10.26	7.64	3.87	12	0	505.6
15	1620	30	503	13.11	10.14	7.83	3.85	0	0	505.4
16	1127	29	502	13.09	10.34	7.84	3.82	112	4	504.5
17	1485	30	502	13.08	10.18	7.67	3.85	0	0	504.9
18	1432	30	504	12.97	10.04	7.75	3.86	20	1	504.8
19	1035	30	504	12.89	10.29	7.78	3.84	140	5	504.5
20	1353	30	503	13.06	10.34	7.84	3.87	44	1	504.7
21	1507	30	504	12.96	10.21	7.86	3.82	0	0	505.1
22	1306	30	502	12.97	10.16	7.82	3.86	58	2	503.9
23	1153	30	503	13.06	10.13	7.68	3.81	104	3	504.6
24	1259	30	501	13.09	10.21	7.69	3.82	72	2	505.5
25	1496	30	503	13.06	10.42	7.84	3.84	0	0	504.4
26	1445	30	502	13.07	10.13	7.82	3.86	17	1	505.2
27	1435	29	502	13.06	10.21	7.86	3.87	20	1	504.8
28	1369	30	501	13.09	10.06	7.84	3.82	39	1	505.1
29	1354	30	504	13.11	10.48	7.86	3.86	44	1	504.8
30	1336	30	503	13.05	10.11	7.84	3.85	49	2	505.4
31	1439	30	502	13.04	10.21	7.82	3.84	18	1	503.9
32	1513	30	502	13.07	10.04	7.82	3.89	0	0	504.5
33	1489	30	503	13.02	10.21	7.86	3.84	0	0	505.3

Table 3.6. *Data collected after modifications (Raw data)*

Sl. No.	Production in cases	Bulk manufacturing time	Power consumption in kWh	Anionic Active %	pH value	Moisture in %	Total Alkalinity in %	Down time in min.	Frequency	Soap weight in gm
1	1138	26	501	13.01	10.51	7.86	3.81	109	4	501.2
2	1295	27	501	13.05	10.42	7.72	3.84	62	2	500.5
3	1295	26	503	13.04	10.06	7.54	3.86	62	2	500.7
4	1258	26	502	13.02	10.85	7.81	3.87	73	2	500.3
5	1397	26	503	13.01	10.84	7.64	3.82	31	1	501.1
6	1860	27	502	13.04	10.76	7.81	3.85	0	0	500.6
7	1471	26	503	13.08	10.68	7.62	3.86	9	0	500.2
8	1547	26	501	13.09	10.05	7.85	3.87	0	0	501.2
9	1611	26	502	13.04	10.65	7.58	3.84	0	0	501.1
10	1543	27	502	13.05	10.84	7.46	3.86	0	0	500.2
11	1055	26	503	13.07	10.05	7.76	3.87	134	4	501.2
12	1581	26	503	12.89	10.41	7.54	3.85	0	0	501.2
13	1515	26	501	12.88	10.65	7.85	3.86	0	0	500.8
14	1601	26	503	13.01	10.57	7.64	3.89	0	0	500.3
15	1601	26	504	13.08	10.41	7.84	3.84	0	0	500.6
16	1676	26	502	13.12	10.23	7.51	3.87	0	0	500.4
17	1743	26	503	13.08	10.15	7.58	3.82	0	0	501.1
18	1696	27	502	13.05	10.48	7.83	3.84	0	0	500.7
19	1640	26	501	12.86	10.37	7.81	3.85	0	0	500.1
20	1618	26	503	12.91	10.29	7.76	3.84	0	0	500.5
21	1545	26	501	13.05	10.41	7.84	3.87	0	0	500.3
22	1713	26	503	12.95	10.34	7.64	3.86	0	0	500.2
23	1750	26	502	13.01	10.27	7.51	3.82	0	0	501.1
24	1634	26	501	13.05	10.12	7.45	3.81	0	0	501.2
25	1656	26	503	13.15	10.06	7.81	3.89	0	0	501.1
26	1678	26	503	13.11	10.11	7.45	3.84	0	0	500.8
27	1631	26	503	13.14	10.21	7.58	3.81	0	0	500.4
28	1640	26	502	13.05	10.13	7.84	3.87	0	0	500.7
29	1566	27	503	13.06	10.24	7.54	3.86	0	0	500.5
30	1630	26	502	12.95	10.17	7.76	3.84	0	0	501.1
31	1620	26	501	12.93	10.06	7.84	3.85	0	0	500.9
32	1598	26	503	13.05	10.41	7.46	3.83	0	0	500.8
33	1618	26	504	13.04	10.28	7.59	3.84	0	0	500.6

3.9 Data Analysis

The obtained data were subjected to statistical analysis through SPSS software package. Statistical tools like Descriptive statistics and ONEWAY ANOVA were employed to test the hypothesis. The output of the analysis are presented in Figure 3.20.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Production (Before)	33	1035	1620	1383.45	154.768
Production (After)	33	1055	1860	1558.18	175.568
Bulk manufacturing time (Before)	33	29	30	29.91	.292
Bulk manufacturing time (After)	33	26	27	26.15	.364
Electrical Power Consumption (Before)	33	501	505	502.91	1.011
Electrical Power Consumption (After)	33	501	504	502.30	.918
Anionic Active % (Before)	33	12.86	13.57	13.0691	.13907
Anionic Active % (After)	33	12.86	13.15	13.0279	.07236
pH value (Before)	33	10.04	10.64	10.2455	.15819
pH value (After)	33	10.05	10.85	10.3661	.25087
Moisture % (Before)	33	7.28	7.86	7.7564	.13024
Moisture % (After)	33	7.45	7.86	7.6764	.14456
Total Alkalinity % (Before)	33	3.81	3.89	3.8455	.02237
Total Alkalinity % (After)	33	3.81	3.89	3.8485	.02152
Break downtime (Before)	33	0	140	38.24	42.423
Break downtime (After)	33	0	134	14.55	33.964
Frequency (Before)	33	0	5	1.30	1.425
Frequency (After)	33	0	4	.45	1.092
Soap weight (Before)	33	503.5	505.6	504.773	.5340
Soap weight (After)	33	500.1	501.2	500.718	.3618
Valid N (list wise)	33				

Figure 3.20. *Output of the analysis through SPSS statistical software.*

Descriptive								
Production in cases								
					95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
1	33	1383.45	154.768	26.942	1328.58	1438.33	1035	1620
2	33	1558.18	175.568	30.562	1495.93	1620.44	1055	1860
Total	66	1470.82	186.325	22.935	1425.01	1516.62	1035	1860

ANOVA					
Production					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	503738.727	1	503738.727	18.392	.000
Within Groups	1752871.091	64	27388.611		
Total	2256609.818	65			

Descriptive								
Bulk Manufacturing Time in min								
					95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
1	33	29.91	.292	.051	29.81	30.01	29	30
2	33	26.15	.364	.063	26.02	26.28	26	27
Total	66	28.03	1.921	.236	27.56	28.50	26	30

ANOVA					
Bulk Manufacturing Time					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	232.970	1	232.970	2139.270	.000
Within Groups	6.970	64	.109		
Total	239.939	65			

Figure 3.20. *Output of the analysis through SPSS statistical software (contd...)*

Descriptive								
Electrical Power Consumption								
					95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
1	33	502.91	1.011	.176	502.55	503.27	501	505
2	33	502.30	.918	.160	501.98	502.63	501	504
Total	66	502.61	1.006	.124	502.36	502.85	501	505

ANOVA					
Electrical Power Consumption					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.061	1	6.061	6.497	.013
Within Groups	59.697	64	.933		
Total	65.758	65			

Descriptive								
Anionic Active Percentage								
					95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
1	33	13.0691	.13907	.02421	13.0198	13.1184	12.86	13.57
2	33	13.0279	.07236	.01260	13.0022	13.0535	12.86	13.15
Total	66	13.0485	.11194	.01378	13.0210	13.0760	12.86	13.57

ANOVA					
Anionic Active Percentage					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.028	1	.028	2.281	.136
Within Groups	.786	64	.012		
Total	.814	65			

Figure 3.20. *Output of the analysis through SPSS statistical software (contd...)*

Descriptive								
pH Value								
					95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
1	33	10.2455	.15819	.02754	10.1894	10.3015	10.04	10.64
2	33	10.3661	.25087	.04367	10.2771	10.4550	10.05	10.85
Total	66	10.3058	.21679	.02668	10.2525	10.3591	10.04	10.85

ANOVA					
pH value					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.240	1	.240	5.457	.023
Within Groups	2.815	64	.044		
Total	3.055	65			

Descriptive								
Moisture Percentage								
					95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
1	33	7.7564	.13024	.02267	7.7102	7.8025	7.28	7.86
2	33	7.6764	.14456	.02517	7.6251	7.7276	7.45	7.86
Total	66	7.7164	.14235	.01752	7.6814	7.7514	7.28	7.86

ANOVA					
Moisture Percentage					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.106	1	.106	5.578	.021
Within Groups	1.212	64	.019		
Total	1.317	65			

Figure 3.20. *Output of the analysis through SPSS statistical software (contd...)*

Descriptive								
Total Alkalinity Percentage								
					95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
1	33	3.8455	.02237	.00389	3.8375	3.8534	3.81	3.89
2	33	3.8485	.02152	.00375	3.8409	3.8561	3.81	3.89
Total	66	3.8470	.02184	.00269	3.8416	3.8523	3.81	3.89

ANOVA					
Total Alkalinity Percentage					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	1	.000	.314	.577
Within Groups	.031	64	.000		
Total	.031	65			

Descriptive								
Breakdown Time								
					95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
1	33	38.24	42.423	7.385	23.20	53.29	0	140
2	33	14.55	33.964	5.912	2.50	26.59	0	134
Total	66	26.39	39.956	4.918	16.57	36.22	0	140

ANOVA					
Breakdown Time					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9265.515	1	9265.515	6.275	.015
Within Groups	94506.242	64	1476.660		
Total	103771.758	65			

Figure 3.20. *Output of the analysis through SPSS statistical software (contd...)*

Descriptive

Frequency

					95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
1	33	1.30	1.425	.248	.80	1.81	0	5
2	33	.45	1.092	.190	.07	.84	0	4
Total	66	.88	1.330	.164	.55	1.21	0	5

ANOVA

Frequency

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11.879	1	11.879	7.370	.009
Within Groups	103.152	64	1.612		
Total	115.030	65			

Descriptive

Soap weight

					95% Confidence Interval for Mean			
					Lower Bound	Upper Bound		
1	33	504.773	.5340	.0930	504.583	504.962	503.5	505.6
2	33	500.718	.3618	.0630	500.590	500.846	500.1	501.2
Total	66	502.745	2.0923	.2575	502.231	503.260	500.1	505.6

ANOVA

Soap weight

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	271.249	1	271.249	1303.833	.000
Within Groups	13.315	64	.208		
Total	284.564	65			

Figure 3.20. *Output of the analysis through SPSS statistical software (contd...)*

3.10 Research Design Limitations

- Even though there are a number of ways to increase the production level, the study considered only one way i.e. making modifications to the existing machinery.
- The sample size is only 33. The sample may be increased to get a more reliable result.
- The effects of modifications in the machinery on the production were measured immediately after the modifications. But, if the effects are measured after some ten to twelve months the production can show more increase.
- The quality of the soap cake is assessed only in terms of anionic active percentage, pH value, moisture percentage, and total alkalinity percentage. But other parameters like the color and perfume level of the soap cake etc. may also be included.

3.11 Conclusion

The present study aimed to increase production outcomes to face a sudden raise in the demand in the dish wash soap cake manufacturing industry using project management techniques. The project management team brainstormed various factors to increase the product outcome in the industry using a fish-bone approach. The project management team arrived at a solution of making modifications to the existing machinery to increase production and keep other factors associated with it unaltered. Accordingly, the objectives were framed and hypotheses were formulated. Data pertaining to production output and the variables associated with it have been collected before and after the modifications. The two sets of data were compared using SPSS statistical software. The results are presented in the next chapter.

CHAPTER IV:

RESULTS

The present study was an attempt to increase the production of dish wash soap in an industry using the project management technique. A project management team was constituted for this purpose. After analyzing various possibilities the project management team decided to increase the production by way of making some modifications in the existing machinery. The data pertaining to production level and other associated variables like quality, bulk manufacturing time, electrical power consumption, breakdown time and frequency, and excess giveaway have been collected before and after modifications. The data were subjected to statistical analysis and the following research questions are addressed.

4.1 Research Question One

Modifications were made to the production process in seven places. These modifications could have changed the quality of the soap cake. **Whether there is a change in the quality of the soap cake after the modifications is the research question to be answered**. Accordingly, the null hypothesis has been formulated and tested for statistical significance.

H0.1 There is no significant difference in the quality of the soap between before and after modifications in the machinery.

The quality of soap cake has been determined in the present study through Anionic active percentage, pH value, moisture percentage, and total alkalinity. Data with regard to these variables have been obtained before and after modifications and the two sets of the data were compared through ONEWAY ANOVA.

Anionic Active Percentage.

Table 4.1. *Descriptive statistics of the data pertaining to* ***anionic active percentage*** *before and after modifications in the machineries.*

	N (No. of Shift)	**Mean (Anionic active %)**	**SD**	**Min (Anionic active %)**	**Max (Anionic active %)**
Before modification	33	13.069	0.139	12.86	13.57
After modification	33	13.027	0.072	12.86	13.15

Table 4.1 shows the descriptive statistics of the data pertaining to anionic active percentage. The mean of the Anionic active percentage value before modification is 13.069 (SD = 0.139) percentage and after modifications, it is 13.027 (SD = 0.072). In order to test the statistical significance of the difference in anionic percentage the data were subjected to ONEWAY ANOVA and the results are presented hereunder.

Table 4.2. *Results of ONEWAY ANOVA of the data pertaining to* ***anionic active percentage.***

Sources of variation	**Sum of square**	**df**	**Mean square**	**F value**	**LS**
Between group	0.030	1	0.030	2.486	0.120
Within group	0.784	64	0.012		
Total variation	0.814	65			

Table 4.2 shows the results of ONEWAY ANOVA with regard to anionic active percentage in the soap. The obtained F-value of 2.486 reveals that it is not significant at 0.01 level. The result implies that there was no significant difference in the level of anionic active percentage in the soap between before and after modifications made in the machinery.

pH Percentage

Table 4.3. *Descriptive statistics of the data pertaining to* ***pH value*** *before and after modifications in the machineries.*

	N (No. of Shift)	Mean (pH value)	SD	Min (pH value)	Max (pH value)
Before modification	33	10.245	0.158	10.04	10.64
After modification	33	10.366	0.250	10.50	10.85

Table 4.3 shows the descriptive statistics of the data pertaining to pH Value. The mean of pH value before modifications is 10.245 (SD = 0.158) and after modification, it is 10.366 (SD = 0.250). In order to test the statistical significance of the difference in pH value the data were subjected to ONEWAY ANOVA and the results are presented hereunder.

Table 4.4. *Results of ONEWAY ANOVA of the data pertaining to* ***pH value.***

Sources of variation	Sum of square	df	Mean square	F value	LS
Between group	0.218	1	0.218	4.910	0.030
Within group	2.837	64	0.044		
Total	3.055	65			

Table 4.4 shows the results of ONEWAY ANOVA with regard to pH Value present in the soap. The obtained F-value 4.910 revels that it is not significant at 0.01 level. The result implies that there was no significant difference in the level of pH value in the soap between before and after modification made in the machines.

Moisture Percentage

Table 4.5. *Descriptive statistics of the data pertaining to **moisture percentage** before and after modifications in the machineries.*

	N (No. of shift)	**Mean (Moisture Percentage)**	**SD**	**Min (Moisture Percentage)**	**Max (Moisture Percentage)**
Before Modification	33	7.7564	0.130	7.28	7.86
After Modification	33	7.676	0.144	7.45	7.86

Table 4.5 shows the descriptive statistics of the data pertaining to Moisture percentage. The mean Moisture percentage before modification is 7.7564 (SD = 0.130) percentage and after modifications, it is 7.676 (SD = 0.144). In order to test the statistical significance of the difference in moisture percentage the data were subjected to ONEWAY ANOVA and the results are presented hereunder.

Table 4.6. *Results of ONEWAY ANOVA of the data pertaining to **moisture percentage.***

Sources of variation	**Sum of square**	**df**	**Mean square**	**F value**	**LS**
Between group	0.084	1	0.084	4.357	0.041
Within group	1.233	64	0.019		
Total	1.317	65			

Table 4.6 shows the results of ONEWAY ANOVA with regard to the moisture content present in the soap. The obtained F-value of 4.357 reveals that it is not significant at 0.01 level. The result implies that there was no significant difference in the level of moisture content present in the soap between before and after modifications made in the machinery.

Total Alkaline Percentage

Table 4.7. *Descriptive statistics of the data pertaining to* ***total alkaline percentage*** *before and after modifications in the machineries.*

	N (No. of shifts)	**Mean (Total alkaline in %)**	**SD**	**Min (Total alkaline in %)**	**Max (Total alkaline in %)**
Before modification	33	3.8455	0.022	3.81	3.89
After modification	33	3.8485	0.021	3.81	3.89

Table 4.7 shows the descriptive statistics of the data pertaining to the total alkaline percentage. The mean of the total alkaline value before modification is 3.8455 (SD = 0.022) percentage and after modifications, it is again 3.8485 (SD = 0.021). In order to test the statistical significance of the difference in total alkaline percentage the data were subjected to ONEWAY ANOVA and the results are presented hereunder.

Table 4.8. *Results of ONEWAY ANOVA of the data pertaining to* ***total alkaline percentage.***

Sources of variation	**Sum of square**	**df**	**Mean square**	**F value**	**LS**
Between group	2061.877	1	2061.877	0.941	0.336
Within group	140264.759	64	2191.637		
Total	142326.36	65			

Table 4.8 shows the results of ONEWAY ANOVA with regard to total alkaline present in the soap. The obtained F-value of 0.941 reveals that it is not significant at 0.01 level. The quality of soap is assessed in terms of Anionic active percentage, pH value, moisture percentage, and total alkalinity. The results show that there is no significant

change in the quality of soap cake with regard to anionic active percentage (Tables 4.1 and 4.2), pH value (Tables 4.3 and 4.4), moisture percentage (Tables 4.5 and 4.6), and total alkalinity (Tables 4.7 and 4.8). Therefore the stated null hypothesis that there is no significant difference in the quality of the soap between before and after modifications in the machinery (H0.1) is accepted.

4.2 Research Question Two

Modifications were made to the machinery to increase the production of soap. Consequently, there may be changes in the consumption of electrical power. **Whether there is a change in the electrical power consumption after the modifications is the research question to be answered**. Accordingly, the null hypothesis has been formulated and tested for statistical significance.

H0.2 There is no significant difference in **electrical power consumption** between before and after modifications in the machinery.

In order to test this hypothesis the data pertaining to the electrical power consumption have been obtained before and after modifications. These data were subjected to ANOVA.

Table 4.9. *Descriptive statistics of the data pertaining to* ***electrical power consumption*** *before and after modifications in the machineries.*

	N (No. of Shifts)	Mean (Power consumption in kWh)	SD	Min (Power consumption in kWh)	Max (Power consumption in kWh)
Before modification	33	502.91	1.011	501	505
After modification	33	502.30	0.918	501	504

Table 4.9 shows the descriptive statistics of the data pertaining to the electrical power consumption before and after modification. The mean of the electrical power consumption before modification is 502.91 (SD = 1.011) kWh per shift and after modifications, it is found to be 502.3 (SD = 0.918) kWh per shift. In order to test the statistical significance of the difference in electrical power consumption the data were subjected to ONEWAY ANOVA and the results are presented hereunder.

Table 4.10. *Results of ONEWAY ANOVA of the data pertaining to* ***electrical power consumption.***

Sources of variation	**Sum of square**	**df**	**Mean square**	**F value**	**LS**
Between group	5.598	1	5.598	5.955	0.017
Within group	60.160	64	0.940		
Total	65.758	65			

Table 4.10 shows the results of ONEWAY ANOVA with regard to the electrical power consumption. The obtained F-value 5.955 reveals that it is not significant at 0.01 level. Hence the stated hypothesis that there is no significant difference in electrical power consumption between before and after modifications in the machineries (H0.2) is accepted.

4.3 Research Question Three

Modifications were made in the machineries in the bulk manufacturing area. So it was expected that there may be a change in the bulk manufacturing time. **Whether there is a change in the bulk manufacturing time after the modifications is the research question to be answered.** Accordingly, the null hypothesis has been formulated and tested for statistical significance below.

H0.3 There is no significant difference in **bulk manufacturing time** between before and after modifications in the machinery.

In order to test this hypothesis the data pertaining to the bulk manufacturing time have been obtained before and after modifications. These data were subjected to ANOVA.

Table 4.11. *Descriptive statistics of the data pertaining to* ***bulk manufacturing time*** *before and after modifications in the machineries.*

	N (No. of Shifts)	Mean (Bulk manufacturing time in min)	SD	Min (Bulk manufacturing time in min)	Max (Bulk manufacturing time in min)
Before modification	33	29.91	0.29	29	30
After modification	33	26.15	0.36	26	27

Table 4.11 shows the descriptive statistics of the data pertaining to the bulk manufacturing time before and after modification. The mean of the bulk manufacturing time before modification is 29.91 minutes (SD = 0.29) and after modification, it is found to be 26.15 minutes (SD = 0.36). In order to test the statistical significance of the difference in bulk manufacturing time the data were subjected to ONEWAY ANOVA and the results are presented hereunder.

Table 4.12. *Results of ONEWAY ANOVA of the data pertaining to* ***bulk manufacturing time.***

Sources of variation	Sum of square	df	Mean square	F value	LS
Between group	232.9696	1	232.9696	2139.26	0.000
Within group	6.9696	64	0.1089		
Total	239.9393	65			

Table 4.12 shows the results of ONEWAY ANOVA with regard to the bulk manufacturing time. The obtained F-value is 2139.26. It is significant at 0.01 level. Hence the stated null hypothesis that there is significant difference in bulk manufacturing time between before and after the modifications in the machinery (H0.3) is rejected.

4.4 Research Question Four

It was expected that the modifications made in the machinery could have been reflected in the break downtime and frequency. **Whether there is a change in the breakdown time and frequency after the modifications is the research question to be answered**. Accordingly, the null hypothesis has been formulated and tested for statistical significance.

H0.4 There is no significant difference in **breakdown time and frequency** between before and after modifications in the machinery.

In order to test this hypothesis the data with regard to breakdown time and breakdown frequency have been obtained and subjected to ONEWAY ANOVA.

Table 4.13. *Descriptive statistics of the data pertaining to* ***breakdown time*** *before and after modifications in the machineries.*

	N (No. of Shift)	**Mean (Breakdown time in min)**	**SD**	**Min (Breakdown time in min)**	**Max (Breakdown time in min)**
Before modification	33	38.24	42.42	0	140
After modification	33	14.55	33.96	0	134

Table 4.13 shows the descriptive statistics of the data pertaining to breakdown time. The mean breakdown time before modification is 38.24 (SD = 42.42) minutes/shift and after modification, it is 14.55 (SD = 33.96) minutes/shift. In order to test the statistical

significance of the difference in breakdown time the data were subjected to ONEWAY ANOVA and the results are presented hereunder.

Table 4.14. *Results of ONEWAY ANOVA of the data pertaining to* ***breakdown time.***

Sources of variation	Sum of square	df	Mean square	F value	LS
Between group	10568.353	1	10568.353	7.257	0.009
Within group	93203.404	64	1456.303		
Total	103771.758	65			

Table 4.14 shows the results of ONEWAY ANOVA with regard to the breakdown time. The obtained F-value 7.257 reveals that it is significant at 0.01 level. The results indicate that there is a significant difference in breakdown time between before and after modifications.

Table 4.15. *Descriptive statistics of the data pertaining to* ***breakdown frequency*** *before and after modifications in the machineries.*

	N (No. of shift)	Mean (Frequency)	SD	Min (Frequency)	Max (Frequency)
Before Modification	33	1.30	1.425	0	5
After Modification	33	0.45	1.092	0	4

Table 4.15 shows the descriptive statistics of the data pertaining to breakdown frequency. The mean breakdown frequency before modification is 1.30 (SD = 1.425) times/shift and after modifications, it is 0.45 (SD = 1.092) times/shift. In order to test the statistical significance of the difference in breakdown frequency the data were subjected to ONEWAY ANOVA and the results are presented hereunder.

Table 4.16. *Results of ONEWAY ANOVA of the data pertaining to* ***breakdown frequency.***

Sources of variation	Sum of square	df	Mean square	F value	LS
Between group	13.429	1	13.429	8.459	0.005
Within group	101.601	64	1.588		
Total	115.030	65			

Table 4.16 shows the results of ONEWAY ANOVA with regard to breakdown frequency. The obtained F-value 8.549 reveals that it is significant at 0.01 level.

The results in Tables 4.14 and 4.16 reveal that there was a significant difference in breakdown time and breakdown frequency between before and after the modifications. Hence the stated null hypothesis that there is no significant difference in breakdown time and frequency between before and after modifications in the machinery (H0.4) is rejected.

4.5 Research Question Five

The modifications made in the machinery, particularly in the cutting and embossing system could have been reflected in the excess giveaway. **Whether there is a change in the excess giveaway after the modifications is the research question to be answered**. Accordingly, the null hypothesis has been formulated and tested for statistical significance.

H0.5 There is no significant difference in **excess giveaway** between before and after modifications in the machineries.

In order to test this hypothesis the data with regard to excess giveaway before and after modifications have been obtained and subjected to ONEWAY ANOVA.

Table 4.17. *Descriptive statistics of the data pertaining to* ***excess giveaway*** *before and after modifications in the machineries.*

	N (No. of Shift)	Mean (Soap weight in gram)	SD	Min (Soap weight in gram)	Max (Soap weight in gram)
Before Modification	33	504.773	0.534	503.5	505.6
After Modification	33	500.718	0.361	500.1	501.2

Table 4.17 shows the descriptive statistics of the data pertaining to excess giveaway. The mean of soap weight before modification is 504.733 grams (SD = 0.534) and after modification, it is 500.718 grams (SD = 0.361). In order to test the statistical significance of the difference in excess giveaway the data were subjected to ONEWAY ANOVA and the results are presented hereunder.

Table 4.18. *Results of ONEWAY ANOVA of the data pertaining to* ***excess giveaway.***

Sources of variation	Sum of square	df	Mean square	F value	LS
Between group	251.160	1	251.160	481.215	0.000
Within group	33.403	64	0.522		
Total	284.564	65			

Table 4.18 shows the results of ONEWAY ANOVA with regard to excess giveaway present in the soap. The obtained F-value 481.215 reveals that it is significant at 0.01 level. Therefore the stated null hypothesis that there is no significant difference in Excess giveaway between before and after modifications in the machineries (H0.5) is rejected.

4.6 Research Question Six

In order to increase the production of soap cake the project management team made some modifications in the machinery. **Whether there is a change in the production level of soap after the modifications is the research question to be answered**. Accordingly, the null hypothesis has been formulated and tested for statistical significance below.

H0.6 There is no significant difference in the **production level of soap cake** between before and after modifications in the machinery.

In order to test this hypothesis the data pertaining to the soap production have been obtained before and after modifications. These data were subjected to ANOVA.

Table 4.19. *Descriptive statistics of the data pertaining to the* ***production of soap cakes*** *before and after modifications in the machineries.*

	N (No. of Shifts)	Mean (production in no. of cases)	SD	Min (production in no. of cases)	Max (production in no. of cases)
Before modification	33	1383.45	154.768	1035	1620
After modification	33	1558.18	175.568	1055	1860

Table 4.19 shows the descriptive statistics of the data pertaining to soap production before and after modification. The mean of the soap production before modification is 1383.45 (SD = 154.768) cases and after modification, it is observed as 1558.18 (SD = 175.568) cases. In order to test the statistical significance of the difference in the production level of soap cakes the data were subjected to ONEWAY ANOVA and the results are presented hereunder.

Table 4.20. *Results of ONEWAY ANOVA of the data pertaining to* ***soap production.***

Sources of variation	Sum of square	df	Mean square	F value	LS
Between group	510581.335	1	510581.335		
Within group	1746028.483	64	27281.695	18.715	0.000
Total	2256609.818	65			

Table 4.20 shows the results of ONEWAY ANOVA with regard to soap production. The obtained F-value of 18.715 reveals that it is significant at 0.01 level. Hence the stated null hypothesis that there is no significant difference in the production level of soap cakes between before and after modifications in the machineries (H0.6) is rejected.

4.7 Summary of Findings

The present study was conducted to develop dish wash soap cake product in terms of quantity using project management techniques. The project management team formed for this purpose decided to increase the production by way of making some modifications to the existing machinery. In order to address the research question that whether there is a change in the production level of soap cakes and other variables associated with it, the hypotheses have been formulated accordingly and tested. In order to test the hypothesis data with regard to soap production and other variables like quality of soap cake, electrical power consumption, bulk manufacturing time, breakdown time and frequency, and excess giveaway have been obtained before and after the modifications. The two sets of data were compared with the help of ONEWAY ANOVA statistics. The results showed that

- There was no significant difference in the quality of the soap cake between before and after modifications.
- There was no significant difference in the electric power consumption between before and after modifications.
- There was a significant difference in the bulk manufacturing time between before and after modifications.
- There was a significant difference in the breakdown time and frequency between before and after modifications.
- There was a significant difference in the excess giveaway between before and after modifications.
- There was a significant difference in the production of soap cake between before and after modifications.

4.8 Conclusion

As per the recommendation of the project management team modifications were made in the machineries to increase soap cake production. The results of the analysis of the data showed that there was no significant difference in the quality of soap cake and electrical power consumption. However, there was a significant difference in the bulk manufacturing time, breakdown time and frequency, excess giveaway, and production of soap cake.

CHAPTER V:

DISCUSSION

The review of the literature shows that neglecting the interdependencies between different controls may lead to an incomplete insight into how firms can most effectively manage their new product development processes (Rijsdijk and Ende, 2011). Further Shandilya et al. (2020) observed that the R&D aspect and the Sales aspect both play a crucial role in the implementation of NPD and the responses prove that both of them need to have seamless communication between them as their end objective is the same.

Therefore, in consultation with the R&D team of the industry, the manufacturing process and the past history of the problem shooting places in the machinery were thoroughly studied. Then an attempt was made to find out the places where modifications can be made in the machineries to increase the production. Various alternatives for increasing production were generated, but without changing the manufacturing cost, time, power consumption, and quality. Among the alternatives, seven viable alternatives were finalized to proceed with. Accordingly, modifications were made to the existing machinery and human resources. The product outcome obtained after the modification is compared with the product outcome obtained before the modification through statistical analysis. The results are discussed hereunder research question-wise.

5.1 Quality of Soap Cake

With regard to the quality of soap cake **whether there is a change in the quality of soap cake after the modifications is the research question to be answered**. The results in Tables 4.1 and 4.2 show that there is no change in the anionic active percentage of the soap after the modifications. Similarly, the results in Tables 4.3 and 4.4 show that there is no change in the pH value, and the results in tables 4.5 and 4.6 show that there is no change in the moisture percentage. Also the results in Tables 4.7 and 4.8 show that there is no change in the total alkalinity percentage. On the whole, the results show that there is no change in the quality of soap cake after modifications. Probably the reason would be the modifications were made only in the machinery but not in the ingredients used for soap cake production. As the modifications were made in the machinery, it did not affect the quality of the soap cake.

5.2 Electrical Power Consumption

With regard to electric power consumption **whether there is a change in the electric power consumption after the modifications is the research question to be answered**. The result in Table 4.9 shows the mean consumption of electrical power before (502.91 kWh) and after (502.30 kWh) the modifications. The results in Table 4.10 show that this difference is not significant at 0.01 level. This result implies that there was no significant difference in the level of electrical power consumption between before and after modifications made to the machines. This is probably because no power equipment was added during the modification. It is also to be noted that the modifications made to the machinery did not consume extra power in the production process.

5.3 Bulk Manufacturing Time

With regard to bulk manufacturing time **whether there is a change in the bulk manufacturing time after the modifications is the research question to be answered**. The results in Table 4.11 show that there is a difference in manufacturing time before (29 minutes) and after (26 minutes) the modification. The results in Table 4.12 show that this difference is significant at 0.01 level.

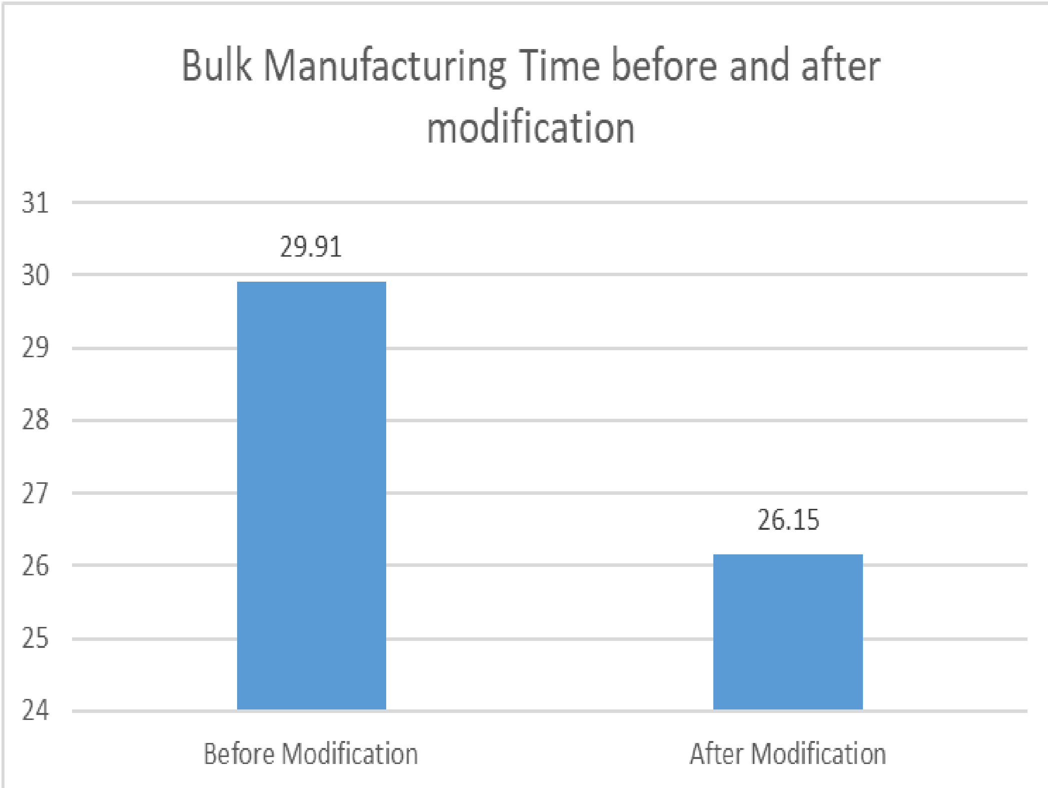


Figure 5.1. *Difference in bulk manufacturing time between before and after modification.*

This result implies that there was a significant difference in the level of bulk manufacturing time between before and after the modifications made in the machines. The results indicate that the bulk manufacturing time has been decreased from 29 minutes to 26 minutes per batch after modification. Even though the difference is very small, it has a huge effect on the production of soap in the long run. Earlier the powder ingredients were fed into the Sigma mixer gradually with the support of bucket elevator. Now a storage hopper is introduced between the bucket elevator and the Sigma mixer to collect the ingredients (that moved gradually before modifications) and to feed into the Sigma mixer all of a sudden. This change in the Sigma mixer might have reduced the bulk manufacturing time.

5.4 Breakdown Time and Frequency

With regard to breakdown time and frequency **whether there is a change in the breakdown time and frequency after the modifications is the research question answered**. The results in Table 4.13 show the difference in breakdown time before (38.24 minutes) and after (14.55 minutes) modifications. The results in Table 4.14 show that this difference is significant at 0.01 level.

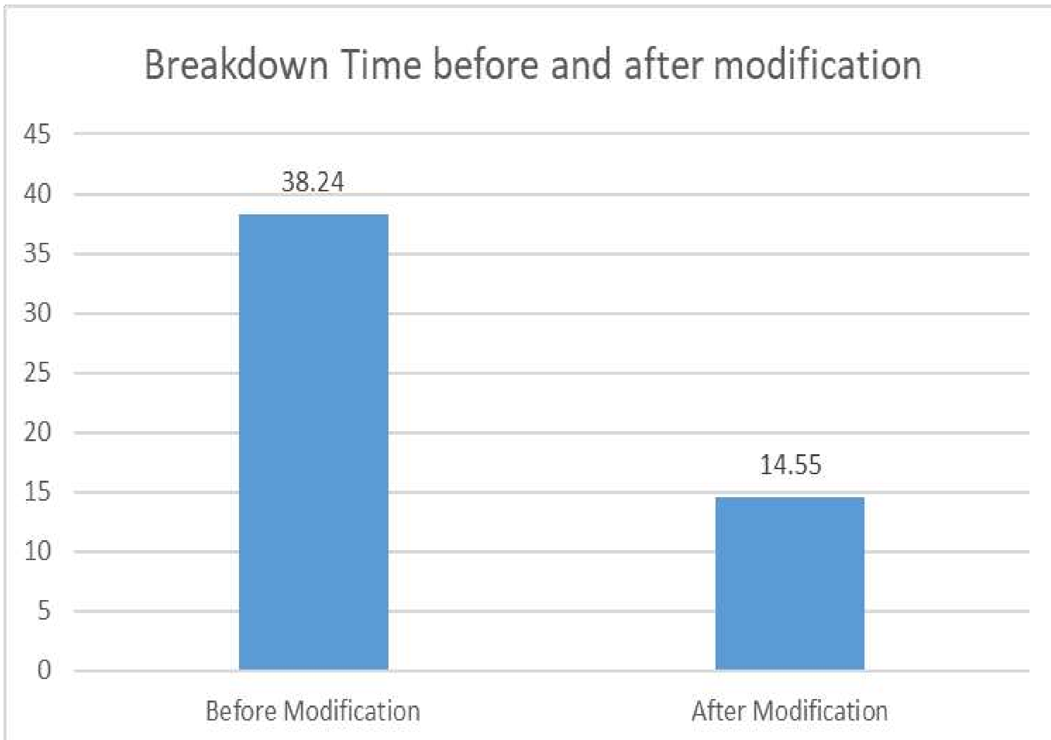


Figure 5.2. *Difference in breakdown time between before and after modifications.*

This result implies that there was a significant difference in breakdown time between before and after the modifications made in the machines. More precisely breakdown time has been reduced by 23 min. 41 sec. per shift. Further, the results in Table 4.15 show the difference in breakdown frequency before (1.30) and after (0.45) modifications. The results in Table 4.16 show that this difference is significant at 0.01 level.

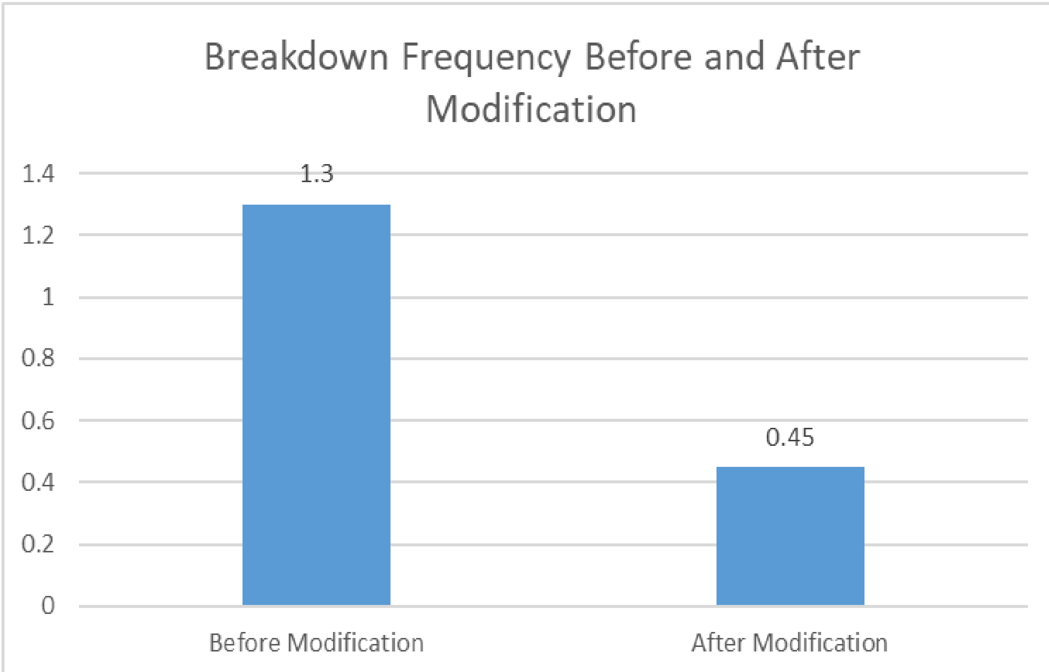


Figure 5.3. *Difference in breakdown frequency between before and after modifications*

This result implies that there was a significant difference in the level of breakdown frequency between before and after modifications made in the machines. It was evident that the breakdown frequency was considerably reduced after the modifications.

5.5 Excess Giveaway

With regard to the excess giveaway **whether there is a change in the excess giveaway after the modifications is the research question to be answered.** The results in Table 4.17 show the soap weight before and after modifications. Before modification the weight of the soap is 504.77gm and after modification it is 500.72gm. The results in table 4.18 show that this difference is significant at 0.01 level.

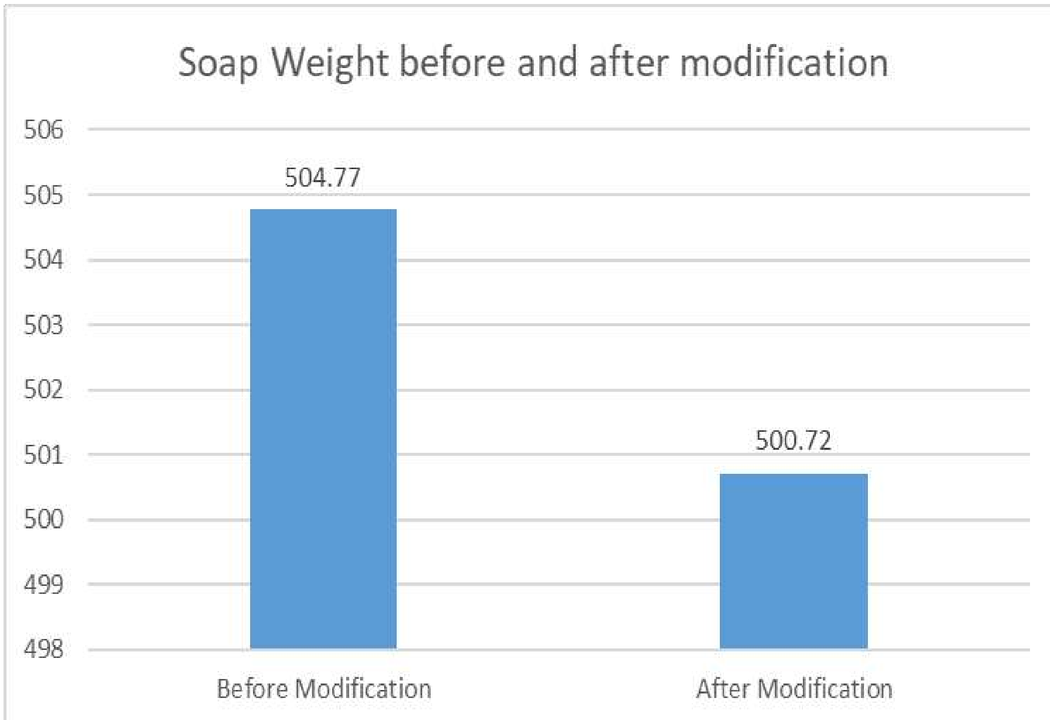


Figure 5.4. *Difference in excess giveaway between before and after modifications.*

This result implies that there was a significant difference in the level of excess giveaway between before and after the modifications made in the machines. The excess giveaway after the modifications is smaller (M = 500.718 grams) when compared to the excess giveaway before the modifications (M = 504.773 grams). The results indicate that the excess giveaway was reduced by 4.05 grams per soap cake.

There are studies in the literature to show that reducing excess giveaway is an aspect of product development (Peeter et al., 2019 and Hueni et al., 2022). In the present study, as an attempt to increase the production the excess giveaway is reduced.

5.6 Production Level of Soap Cakes

With regard to the production level of soap cakes **whether there is a change in the production level of soap cakes after the modification is a research question to be answered**. The results in Table 4.19 show the mean production of soap cake before the modifications is 1383.45 cases per shift and after the modifications, it is 1558.18 cases per shift. The result in Table 4.20 reveals that this difference is significant at 0.01 level.

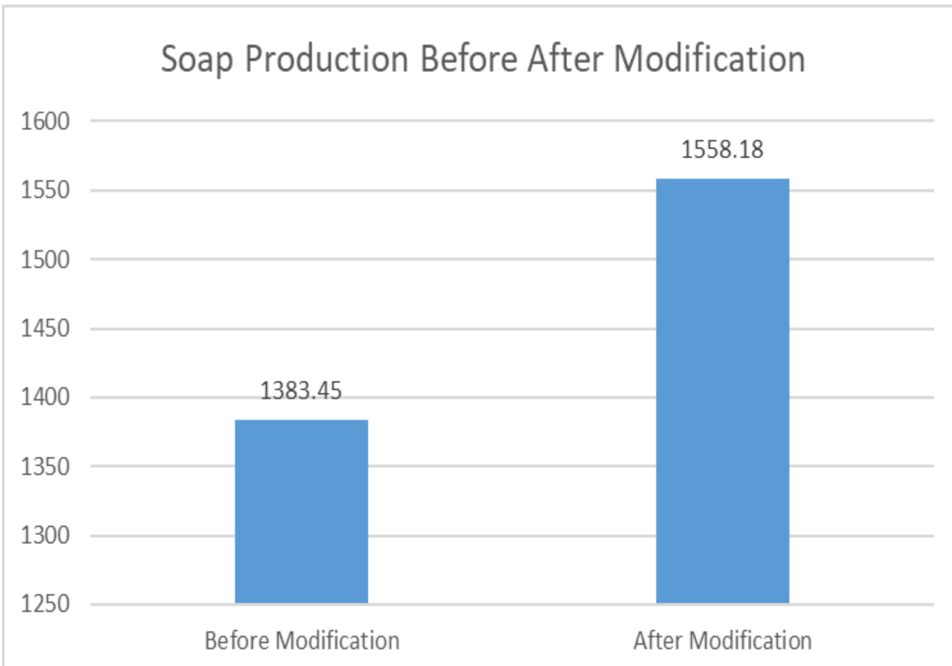


Figure 5.5. *Difference in production between before and after modification.*

This result implies that there was a significant difference in the level of soap production between before and after the modifications made in the machines. The results indicate that there is an increase of 174.73 cases per shift. There is a 12.63% increase in the production outcome per shift after the modifications. Probably this is the effect of modifications in the batch mixing area which decreased the bulk manufacturing time (vide table 4.11) and the effect of modification in the cutting and embossing system which increased the number of soap-cuttings per stroke.

Summary

In this study, project management was applied to increase the production of soap cake. Among the many alternative solutions brainstormed, the project management team selected the one that suggested making modifications to existing machines. Accordingly, modifications were made to the machinery was modified. The data obtained before and after modification showed that there was no change in the quality of the soap cake or in electric power consumption. However, there was a change in the bulk manufacturing time, breakdown time and frequency, excess giveaway, and product outcomes. More precisely, the bulk manufacturing time, breakdown time and frequency, and excess giveaway were reduced, and product outcomes increased by 12.63%. Thus the project and the project management were successful.

CHAPTER VI:

SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

The present study is "Product Development in Dish Wash Cake Manufacturing Industry using Project Management." This study was conducted in a dishwash soap cake manufacturing industry in Puducherry, South India. It aimed to adopt project management techniques to increase production outcomes in terms of quality, electrical power consumption, processing time, etc. As the success of project management depends on manpower collaboration, a project management team is formed.

6.1.1 Team collaboration among committee members in project management

A management committee comprises individuals who collaborate towards a shared objective by contributing diverse and essential expertise. Crucial elements of project success include selecting team members, establishing team identity, and implementing standardized operational procedures. Furthermore, previous research has indicated that environmental elements play a more significant role in successful project implementation than a team's skill set (Amade et al. 2012). One key environmental factor is the entire organizational hierarchy, from top-level executives to entry-level employees.

The personnel in the present organization are talented and skilled. Apart from their professional skills, they have good communication skill and interpersonal skills. Their interpersonal skills help them to communicate and collaborate with others and make interpersonal relations smooth and cordial in the organization. Thus a conducive organizational climate prevails in the present organization. Studies revealed a positive effect of organizational culture on product development (e.g. Belassi et al., 2017). This helped the investigator to form a skilled project management team for the implementation of the project successfully. In the present study, a project management team comprising personnel from various departments was formed. They played their roles effectively and it was integrated for the success of the project as follows.

The R&D department is concerned with product development therefore their role is very crucial in this project, particularly in maintaining the quality of soap cake by fixing the standard of parameters involved. After modification, they examined the process at every step like batch mixing, Soap extrusion, Soap cutting and embossing etc. The personnel in the engineering department are responsible for the initiation of the project. They took care of the execution of machines after modifications. For example, they checked and monitored whether the noise, vibration, and electric power in amps were in the tolerable limit. They provided their suggestion for the functioning of the machine as and when it is needed.

The personnel in production department are involved in the production activity. They handled the machines in the desired direction. They monitored the quality of the soap cake during the study period. They kept a watch on the production time and also provided suggestions for the effortless operation of the machine. After modification, they identified the teething troubles in the machine which were rectified for the smooth function of the machines.

The personnel in the quality control department gave their support and cooperation in taking measurement with regard to the quality of soap cake like anionic active percentage, pH value, moisture percentage, and total alkalinity percentage. The purchase and finance department purchased proper materials for modifications to the machinery at scheduled times and at a nominal cost. They monitored and indicated when the finances went beyond the limit.

6.1.2 Modifications made to the existing machinery

The project management team executed modifications to the machinery across seven identified areas within a 15-day timeframe. The following section outlines the specific changes implemented during this process.

Modification in Batch Mixing area.

Earlier the powder ingredients are fed into the Sigma mixer gradually through the bucket elevator. It took around 8 minutes for the material to transfer. In order to reduce the material transferring time, as it was recommended by the project management team, a storage hopper was introduced in the batch mixing area. The introduction of the storage hopper in the batch mixing area not only reduced material transfer time but also improved overall process efficiency. This modification allowed for a more continuous and streamlined flow of powder ingredients into the Sigma mixer, eliminating the need for frequent stops and starts associated with the bucket elevator system.

***Increasing the number of Cutting Blades and Embossing*.**

The soap-cutting machine initially had a capacity of 12 blades, enabling it to process a dozen soaps in one operation. In an effort to increase output, the project management team upgraded the machine's capabilities, allowing it to handle 14 soaps per cycle. Similarly, they enhanced the embossing mechanism to match this new capacity, expanding it from 12 to 14 as well. This upgrade in capacity not only increased the overall production volume but also improved the efficiency of the soap manufacturing process. The synchronization between the cutting and embossing mechanisms ensured a seamless workflow, minimizing bottlenecks and reducing idle time between operations.

By increasing the capacity from 12 to 14 soaps per stroke, the project management team has potentially boosted overall production by approximately 16.7%. This significant improvement in productivity could lead to reduced production time, lower operational costs, and increased ability to meet growing market demands for soap products.

Integration of Cutting and Embossing Systems.

Previously, the cutting and embossing operations were conducted independently, and the conveyor system was considerably longer. To increase production efficiency, these processes have been combined, resulting in a reduction of the conveyor length from 10.5 meters to 5.8 meters. This integration of cutting and embossing operations has not only streamlined the production line but also significantly reduced the factory's spatial footprint. The compact design allows for better utilization of floor space, potentially creating room for additional equipment or storage areas, and improving overall workflow efficiency.

Changing the Ejection System.

Earlier in the soap ejection system, the soaps with bowels are ejected from a strip guided by two rims through sliding process. It caused damage to soaps. Therefore the bowel-holding jigs were modified in such a manner that the soaps with the bowels were pushed gently through the pneumatic system to the packing conveyor for the next process. The modification of the bowel-holding jigs not only improved the handling of soaps but also enhanced the overall efficiency of the production line. By implementing a pneumatic system for gentle pushing, the risk of soap damage was significantly reduced, leading to fewer quality control issues and less product waste.

Introducing Packing Conveying System.

Earlier the cutting and embossing machines were functioning with start and stop action. It took 5 seconds for each stroke and delivered 12 soaps. So it was difficult for the employee who puts the scrubber on the soap and for the employee who puts and locks the top lid. In order to make their job easy and to speed up the packing process a new packing conveyor was introduced which transfers the soaps slowly and continuously. The introduction of the new packing conveyor not only improved efficiency but also reduced the physical strain on employees. This continuous motion system allowed workers to perform their tasks more comfortably and accurately, as they no longer had to keep up with the abrupt start-stop rhythm of the previous machine. Additionally, the slower, steady movement of soaps along the conveyor likely decreased the chances of errors or damage during the packing process, potentially leading to higher quality control and reduced waste.

Introducing Soap Tilting System.

In the past, workers manually flipped the soap bowls 180 degrees to apply the PKD. To streamline this operation, the project management team introduced an automated soap bowl tilting mechanism. This upgrade not only sped up the process but also decreased the workforce requirements by removing one worker from the production line. The automated soap bowl tilting mechanism not only improved efficiency but also enhanced workplace safety by reducing the risk of repetitive strain injuries associated with manual flipping. This technological advancement allowed the remaining workers to focus on more complex tasks, potentially leading to increased job satisfaction and skill development.

Process Modification in Heat Treatment.

Earlier the soap extrusion die was heat treated by the material of HcHcr-D_2 at 55 HRC. This caused more wear and tear in the extrusion die which in turn caused more level of excess giveaway and also irregularity in the shape of the soap. The project management team modified the extrusion die into a split-half die and a hard chrome coating is given at the product contact area. It reduced the wear and tear of the extrusion die and also the shape of the soap was maintained. Moreover, the extrusion die may be reused only by changing the split jaw alone.

6.1.3 The Outcome of the Study

The study was conducted during the first half of the year 2022. The production was observed before modifications in a sample of 33 shifts and the production was observed in a sample of 33 shifts after modifications. The difference in the production was calculated and tested for statistical significance through ONEWAY ANOVA. In addition to the difference in production, the difference in other variables associated with production was also taken into account. They are the quality of the soap cake, electric power consumption, bulk manufacturing time, breakdown time and frequency, and excess giveaway.

The result showed that there was no change in the quality of the soap cake and electric power consumption after modificationsHowever, the results revealed that the bulk manufacturing time, breakdown time, and frequency decreased. More importantly, the results show that the level of excess giveaway was considerably reduced. All these changes resulted in an increase in soap production. The increase is calculated as 12.63%. This increase in the production of soap cake helped to meet the demand of dish wash cake during post COVID-19 pandemic which satisfied the customers in time. Also, the project ended within the project budget. Hence the project management adopted in this study was successful. Thus the present study lends support that project management techniques can be helpful in industrial setups to increase production.

6.2 Implications

The implications of the study on product development in a dish wash cake manufacturing industry using project management techniques are as follows:

1. Effectiveness of project management: The study demonstrates that project management techniques can be successfully applied in industrial settings to improve production outcomes. This implies that other industries could benefit from adopting similar approaches.

2. Importance of team collaboration: The success of the project highlights the significance of forming a skilled, cross-functional project management team. This suggests that effective collaboration among different departments is crucial for achieving project goals.
3. Potential for production increase through machinery modifications: The study shows that significant production increases (12.63% in this case) can be achieved through targeted modifications to existing machinery, without necessarily investing in entirely new equipment.
4. Quality maintenance during production increase: The results indicate that it is possible to increase production quantity without compromising product quality, implying that efficiency improvements and quality control can be simultaneously achieved.
5. Cost-effectiveness: The project was completed within budget, suggesting that project management techniques can lead to cost-effective solutions for industrial challenges.
6. Crisis management: The study demonstrates that industries can respond effectively to increased demand (such as during the post-COVID-19 pandemic period) by implementing strategic changes in their production processes.
7. Applicability to other industries: The success of this project implies that similar approaches could be beneficial in other manufacturing sectors, such as detergent powder, bath soap, food products, and essential commodities.
8. Importance of continuous improvement: The study suggests that there is potential for further production increases beyond the achieved 12.63%, implying that continuous improvement efforts can yield ongoing benefits.

9. Multifaceted benefits: The project not only increased production but also improved other aspects such as reducing bulk manufacturing time, breakdown time, and excess giveaway. This implies that well-executed project management can lead to comprehensive improvements across various operational metrics.

6.3 Recommendations for Future Research

- Extend the study to other manufacturing sectors (e.g., food, medicine) to validate applicability.
- Use larger sample sizes for increased statistical power and generalizability.
- Explore strategies to further increase production beyond 12.63%.
- Examine production increases through administrative, infrastructure, or machinery changes.
- Conduct longitudinal studies on the sustainability of improvements.
- Analyze the cost-benefit ratio of implementing project management techniques.
- Study impact on employee satisfaction, skill development, and workplace safety.
- Investigate integration of advanced technologies (IoT, AI) with project management.
- Examine the environmental impact of increased production efficiency.
- Explore the applicability of specific modifications in other contexts.

6.4 Conclusion

In conclusion, this study demonstrates the successful implementation of project management techniques in the dish wash soap cake manufacturing industry in Puducherry, South India. The formation of a skilled project management team, comprising personnel from various departments, played a crucial role in the project's success. The team's collaborative efforts led to significant modifications in seven key areas of the manufacturing process, including batch mixing, cutting and embossing systems, ejection systems, packing conveying, soap tilting, and heat treatment. Data pertaining to production and other variables associated with production from a sample of 66 shifts were obtained before and after the modification. The data were analyzed through ONEWAY ANOVA using the SPSS statistical package.

These modifications resulted in notable improvements in production efficiency and output. The study observed a 12.63% increase in soap production, which helped meet the increased demand for dishwash cakes during the post-COVID-19 pandemic period. Additionally, the project achieved reductions in bulk manufacturing time, breakdown time and frequency, and excess giveaway, without compromising the quality of the soap cake or increasing electric power consumption.

The success of this project underscores the importance of effective team collaboration, strategic modifications to existing machinery, and the application of project management principles in enhancing manufacturing processes. This case study serves as a valuable example for other manufacturing industries seeking to improve their production outcomes through the adoption of project management techniques.

APPENDIX A

STUDY PERMISION OF THE EMPLOYER

Jyothy labs

03-Jan-22

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Mr.D.Rozinadane, Emp.No.10001350, S/o Mr.Divianathan is working in this organization from 01/02/2003 to till date as a "Senior Manager - Engineering & Project" in our Jyothy Labs Limited Puducherry.

This certificate is issued for the purpose of registration at Global Doctor of Business Administration and it is issued on his own request.

For Jyothy Labs Ltd.

Babu Chowalloor
(Deputy General Manager

JYOTHY LABS LIMITED PUDUCHERRY

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(Via) Vazhuthavur, Suthukeny P.O., Puducherry - 605 502.
Tel : 0413-2260800

APPENDIX B

INFORMED CONSENT

Jyothy labs

Date: 12/01/2022

To :

Rozinadane, D (Employee No: 10001350).
Senior Manager – Engineering & Project
Jyothy Labs Ltd., Engineering Division,
Thethampakkam, Puducherry 605 502.

Sub : Conduct of research work in our company permission granted – Reg.

Ref : Your letter dt. 12. 01. 2021.

With reference to the letter cited on the subject mentioned above **Thiru. D. Rozinadane, Emp No. 10001350, Senior Manager – Engineering & Project** is permitted to conduct the research work in our company and collect data for his study of Global Doctor of Business Administration in Swiss School of Business Management in Geneva, Switzerland country in Europe.

We wish him all success.

For JYOTHY LABS LTD.,

Babu Chowallor
(Deputy General Manager)

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APPENDIX C

INTERVIEW GUIDE

{Sample Text Sample Text Sample Text Sample Text Sample Text Sample Text Sample Text }

REFERENCES

Aghania, V., Ramzani, S., & Raju, V. (2019). *The Impact of Communication through Collaboration on Building Project Performance in Indonesia*. International Journal of Mechanical Engineering and Technology, 10(3), 1773-1780. http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=10&IType=3.

Ahn, M. J., Zwikael, O., & Bednarek, R. (2010). *Technological invention to product innovation: A project management approach.* International Journal of Project Management. Vol. 28(6), 559-568. https://doi.org/10.1016/j.ijproman.2009.11.001.

Alsohybe, N. T., & Sabrah, N. (2019). *Agile Project Management in Non-Software Sectors during Turbulent Times*. International Journal of Software Engineering & Applications (IJSEA), Vol. 10(1), DOI: 10.5121/ijsea.2019.10104 51.

Amade, B., Ogbonna, A., & Kaduru, C. (2012). *Determinants of Successful Project Implementation in Nigeria*. International Journal of Management Sciences and Business Research, Vol. 1(6), http://dx.doi.org/10.2139/ssrn.2701678.

Ansari, M.S.A., Abouraia, M.K., Morsy, R. E., Thumiki, V.R.R. (2024) *Influence of transformational and transactional leadership on agile project success. Project Leadership and Society*. Vol.5, 100136. https://doi.org/10.1016/j.plas.2024.100136.

Bahrami, M., Bazzaz, D. H., & Sajjadi, S. M. (2012). *Innovation and Improvements in Project Implementation and Management; Using FMEA Technique*. Procedia -

Social and Behavioral Sciences Vol. (41), 418-425. https://doi.org/10.1016/j.sbspro.2012.04.050.

Belassi, W., Kondra, A. Z., & Tukel, O. I. (2017). *New Product Development Projects: The Effects of Organizational Culture*. Project Management Journal, Vol. 38(4), 12–24. https://www.academia.edu/7868591.

Bergmann, T., &Karwowski, W. (2019). *Agile Project Management and Project Success: A Literature Review*. In book: Advances in Human Factors, Business Management and Society. Advances in Intelligent Systems and Computing. DOI: 10.1007/978-3-319-94709-9_39.

Blaskovics, B. (2014). *Aspects of Projects Success* – The Case of a Multinational Company. PMUni Conference Vienna, 14 May.

Blaskovics, B. (2016). *The Impact of Project Manager on Project Success – The Case of ICT Sector*. Society and Economy. Vol. 38 (2), 261–281 DOI: 10.1556/204.2016.38.2.7.

Carbonell, P., & Rodríguez-Escudero, A. I. (2011). *The effects of managerial output control and team autonomy on new product development speed: The moderating effect of product newness*. International Journal of Product Development 13(4) DOI: 10.1504/IJPD.2011.042026.

Cohen, S. G., & Bailey, D. E. (1997). *What Makes Teams Work: Group Effectiveness Research from the Shop Floor to the Executive Suite*. Journal of Management, Vol. 23(3), 239-290.

Cooke-Davies, T. (2002). *The ‘‘real’’ success factors on projects*. International Journal of Project Management Vol. 20, 185–190. https://www.researchgate.net/publication/222689147.

Ciric Lalic, D., Lalic, B., Delić, M., Gracanin, D., Stefanovic, D. (2022). *How does a project management approach impact project success? From traditional to agile* Int. J. Manag. Proj. Bus., Vol.15 (3), 494-521

Danchenko, O. B., Palchynska, M. V., Azhaman, I. A., Telichko, N. A., & Sadova, M. A. (2020). *Psychological Means of Theoretical Modeling of the Optimum Number of Project Staff*. International Journal of Management, Vol. 11 (4), 414-426. http://www.iaeme.com/IJM/issues.asp?JType=IJM&VType=11&IType=4.

Duale, A.J., & Kaumbulu, A.K. (2023). *Project Team Competence and Project Success of Local Non-Governmental Organizations in Borama District, Somaliland* (2023). Asian Journal of Economics, Finance and Management Vol. 5(1), 411-418, Article no.AJEFM.1428.

Fung, H. P. (2014). *Relationships among Team Trust, Team Cohesion, Team Satisfaction and Project Team Effectiveness As Perceived By Project Managers in Malaysia*. International Journal of Management and Sustainability, Vol. 1(1), 1-15.

Fung, H. P. (2021). *Moderating Effects of Project Management Experience, Project Team Size, Project Duration and Project Value Size on the Relationship between Project Manager’s Leadership Roles and Project Team Effectiveness in Malaysia*. Journal of Empirical Studies, Vol. 2(1), 17-33 Journal homepage: http://pakinsight.com/?ic=journal&journal=66.

Fung, H. P., & Cheng, S. (2015). *The Influence of Team Building & Participation on Team Trust, Team Cohesion and Project Performance among Project Managers in Malaysia*. Asia e University Postgraduate Research Conference 2015 (AeU-PRC 2015).

Fung, H. P., & Ibrahim Ali, A. (2011). *Factors Influencing Project Team Effectiveness as Perceived By Project Managers in Malaysia – A Pilot Study*. Annual Summit on Business and Entrepreneurial Studies (ASBES 2011) http://www.internationalconference.com.my/proceeding/asbes2011_proceeding/001_056_ASBES2011_Proceeding_PG0001_0020.pdf. Volume: ASBES 2011.

Fung, H. P., & Ramasamy, S. (2015). *The Impact of Leadership Roles on Team Satisfaction, Team Effectiveness and Project Performance – A Study of Project Managers in Malaysia*. Asia e University Postgraduate Research Conference 2015 (AeU-PRC 2015). DOI: 10.13140/RG.2.1.1809.9280.

Gharaibeh, H. (2019). *Project Team Building: Case Study Investigation in the Construction Industry in Jordan*. International Journal of Engineering and Management Research Vol. 9(4), e-ISSN: 2250-0758 | p-ISSN: 2394-6962. www.ijemr.net https://doi.org/10.31033/ijemr.9.4.10 61.

Gomes, J., & Romao, M. (2016). *Improving project success: A case study using benefits and project management*. Procedia Computer Science 100, 489 – 497. https://doi.org/10.1016/j.procs.2016.09.187.

Hoevemeyer, V. A. (1993). *How effective is your team? Training and Development*, 47(9), 67-71.

Hueni, G., Gardner, R., & Stadig, W. (2022). *Computerized system saves $500,000 / yr in reduced product giveaway*. Research gate https://www.researchgate.net/publication/239875510.

Kapsali, M. (2011). *Systems thinking in innovation project management: A match that works*. International Journal of Project Management. Vol. 29(4), 396-407. https://doi.org/10.1016/j.ijproman.2011.01.003.

Keegan, A., & Turner, J.R. (2002). *The Management of Innovation in Project-Based Firms. Long Range Planning.* Vol. 35(4), 367-388. https://doi.org/10.1016/S0024-6301(02)00069-9.

Kok, R. A. W., & Ligthart, P. E. M. (2014). *Differentiating Major and Incremental New Product Development: The Effects of Functional and Numerical Workforce Flexibility**. Journal of Product Innovation Management, Vol. 31, 30–42. doi:10.1111/jpim.12190.

Koskela, L. and Howell, G. (2002). *The theory of project management: explanation to novel methods.* Proceedings IGLC-10, Aug. 2002, Gramado, Brazil

Lewis, J. P. (1995). *An Overview of Project Management*. In Fundamentals of Project Management AMACOM Books ISBN: 0814478352 Pub Date: 01/01/95.

Magnussen, E. F., Havnelid, E., & Molléri, J. S. (2024). *The Product Owner and its Impact on Success and Challenges in Agile Scrum Projects: An Interview Study*. Procedia Computer Science. Vol. 239(2024), 1157-1164. https://doi.org/10.1016/j.procs.2024.06.282.

Majeed, M. I., Mahmood, R., Som, H. M., Munir, S. (2022). *Impact of Project Management Strategies and Project Complexity on Project Success*. The International Conference on Financial Technology and Business Analysis DOI: 10.54254/2754-1169/6/20220145.

Makarova, A., & Sokolova, A. (2014). *Foresight Evaluation: Lessons from Project Management*. Foresight, Vol. 16(1), 75–91. doi:10.1108/fs-03-2012-0017 10.1108/fs-03-2012-0017.

Malik, R. S., Ahmad, S. S., & Hussain, M. T. H. (2019). *A Review of Agile Methodology in IT Projects*. Proceedings of 2nd International Conference on Advanced Computing and Software Engineering (ICACSE). http://dx.doi.org/10.2139/ssrn.3351064.

Marnada, P., Raharjo, T., Hardian, B., & Prasetyo, A. (2022). *Agile project management challenge in handling scope and change: A systematic literature review*. Procedia Computer Science Vol. 197, 290-300. https://doi.org/10.1016/j.procs.2021.12.143.

Mehmet Saim AŞÇI, Mustafa Emre CİVELEK, Murat ÇEMBERCİ (2020). *The Role of Commitment to Learning in the Effect of Evaluation and Rewards on Project Success in R&D Teams*. International Journal of Eurasia Social Sciences. Vol. 11(39), 11-22.

Meier, A., & Kock, A. (2024). *The human factor in agility: Exploring employee dedication in agile project organizations*. International Journal of Project Management Vol. 41(7), 102527. https://doi.org/10.1016/j.ijproman.2023.102527.

Messica, A. (2008). *The effect of marketing on the optimal funding of a new product development*. SSRN Electronic Journal. DOI: 10.2139/ssrn.1210322.

Muayad, A., & Younis, H. (2021). *Conceptual Framework of Agile Project Management, Affecting Project Performance, Key: Requirements and Challenges*. International Journal of Innovative Research in Engineering & Management (IJIREM), https://ssrn.com/abstract=3912728.

Muchiri, P., & Pintelon. L. (2008). *Performance measurement using overall equipment effectiveness (OEE): literature review and practical application discussion.* International Journal of Production Research, Vol. 46(13), 3517–3535. http://dx.doi.org/10.1080/00207540601142645.

Ng, K. C., & Chog, K. E. (2018). *A Framework for Improving Manufacturing Overall Equipment Effectiveness.* International Journal of Engineering & Technology, Vol. 7 (3.13), 149-156.

Nielsen, C., Sort, J. C., & Bentsen, M. J. (2012). *Creating levers of management: Project management as an instigator of value creation in different stages of university-industry collaborations.* SSRN Electronic Journal. DOI: 10.2139/ssrn.2192349.

Pardeep Gupta and Sumit Kumar (2019) *Productivity improvements in an Indian automotive OEM using Heijunka, a lean manufacturing approach: A case study.* 6th International Conference on Production and Industrial Engineering https://www.researchgate.net/publication/333773925.

Patanakul, P., Chen, J., & Lynn, G. S. (2010). *Autonomous Teams and New Product Development*. Journal of Product Innovation Management Forthcoming. North-western University, Evanston, Illinois USA.

Peeters, K., Adan. I., & Martagan, T. (2019), *Throughput Control and Giveaway Minimization of a Poultry Product Batcher*, Winter Simulation Conference (WSC), 2019, pp. 2131-2141, doi: 10.1109/WSC40007.2019.9004780.

Pirotti, A., Keshavarzsaleh, A., Rahim, F. A. M., & Zakaria. N. (2020). *Effective Factors on Project Success in Malaysian Construction Industry*. Journal of Engineering, Project, and Production Management. Vol. 10(1), 1-10. DOI 10.2478/jeppm-2020-0001.

Pirotti, A., Rahim, F.A.M., & Zakaria. N. (2022). *Implementation of Project Management Standards and Project Success: The Mediating Role of the Project Management Office*. Journal of Engineering, Project, and Production Management, Vol. 12(1), 39-46. DOI 10.32738/JEPPM-2022-0004.

Pokharel, S., Yeo, K. T., & Wang, T. Y. (2006). *Value of Project Management in High-Tech and Manufacturing*. Journal of the Chinese Institute of Industrial Engineers, Vol. 23(6), 443-448. https://www.researchgate.net/publication/228638331.

Project Management Institute (PMI) Global Standard (2017). *A Guide to the Project Management Body of Knowledge* (PMBOK) (6^{th} ed.). Published by: Project Management Institute, Inc. 14 Campus Boulevard Newtown Square, Pennsylvania 19073-3299 USA. ISBN: 978-1-62825-184-5.

Quinn, R. E. (1988). *Beyond Rational Management: Mastering the Paradoxes and Competing Demands of High Performance*, Jossey-Bass, Inc., San Francisco.

Radhakrishnan, A., Zaveri, J., David, D., & Davis, J.S. (2022). *The impact of project team characteristics and client collaboration on project agility and project success: An empirical stud*y. European Management Journal Vol. 40(5), 758-777. https://doi.org/10.1016/j.emj.2021.09.011.

Ragazzini, L., Negri, E., Fumagalli, L., & Macchi, M. (2024). *Digital Twin-based bottleneck prediction for improved production control*. Computers & Industrial Engineering. Vol. 192, 110231. https://doi.org/10.1016/j.cie.2024.110231.

Ramachandran, K.K., & Karthick, K. K. (2019). *Gantt Chart: An Important Tool of Management*. International Journal of Innovative Technology and Exploring Engineering (IJITEE). ISSN: 2278-3075, Vol. 8(7C).

Ramesh, E., Ramesh Babu. D., & Ramchandar Rao. P (2018), *the Impact of Project Management in Achieving Project Success- Empirical Study*. International Journal of Mechanical Engineering and Technology, Vol. 9(13), 237–247 http://www.iaeme.com/IJMET/issues.asp?JType=IJMET&VType=9&IType=13.

Ridgway, J. S., Henthorn, K. S., Hull, J. B. (1999). *Controlling of overfilling in food processing*. Journal of Materials Processing Technology. Vol. 92–93(30), 360-367.https://doi.org/10.1016/S0924-0136(99)00114-4.

Rijsdijk, S. A., & Van, D. E. J. (2011). *Control Combinations in New Product Development Projects.* Journal of Product Innovation and Management, 28, 868–880. https://www.researchgate.net/publication/227732165.

Royce, W.W. (1970). *Managing the development of large software systems*. In: Proceedings of the 9th International Conference on Software Engineering. IEEE. Computer Society Press, pp. 328–338, URL: https://dl.acm.org/doi/pdf/10.5555/41765.41801.

Shameem, M., Nadeem, M., & Taha Zamani, A. T. (2023), *Genetic algorithm based probabilistic model for agile project success in global software development*. Applied Soft Computing, Vol. 135, 109998.

Shandilya Sumit, Surendra P. Tiwari, Gyanabrata Lahkar (2020). *A Study on New Product Development in Indian Manufacturing Industries*. International Journal of Scientific Research and Engineering Development—Vol. 3(6), 601- 607. https://www.researchgate.net/publication/348649589.

Škorić, S., Aliti, B., & Leško, L. (2017). *Distribution of Workforce through Project Life Cycles and Analysis of the Satisfaction with the Organisation*. In: 8th International Scientific Conference on Kinesiology (eds.: Milanović, D., Sporiš, G., Šalaj, S. and Škegro, D.) 481-484.

Smits, A., Vissers, G., & De Wit, J. (2009). *Exploratory and Exploitative Market Learning in Discontinuous New Product Development*. SSRN Electronic Journal. doi:10.2139/ssrn.1579269.

Souder, W.E. (1988). *Managing Relations between R&D and Marketing in New Product Development Projects*. Journal of Product innovation and Management. Vol.5, 6-19. https://doi.org/10.1016/0737-6782(88)90029-X.

Spalek, S. (2014). *Does investment in project management pay off?* Industrial Management & Data Systems. Vol. 114(5), 832-856. https://www.researchgate.net/publication/263204118.

Sudhakar, G. P. (2013). *The Key Functions and Best Practices of Software Product Management*. Sprouts: Working Papers on Information Systems, Vol. 13(2), ISSN 1535-6078. http://sprouts.aisnet.org/13-2.

Suvi Elonen & Artto, K. A. (2003). *Problems in managing internal development projects in multi-project environments*. International Journal of Project Management Vol. 21, 395–402. https://doi.org/10.1016/S0263-7863(02)00097-2.

Tatikonda, M.V., & Rosenthal. S. R. (2000). *Successful execution of product development projects: Balancing firmness and flexibility in the innovation process*. Journal of Operations Management, Vol. 18, 401–425. https://doi.org/10.1016/S0272-6963(00)00028-0.

The Business Times (2006). *An interview with Gregory Balestrero, PMI's CEO*, in Singapore, 4, September, 2006.

Thiry, M., & Duggal, J. S. (2005) *Breaking the project management glass ceiling: barriers to organizational project management*, in PMI® Global Congress Toronto, PA: Project Management Institute.

Tingting Yan & Kevin Dooley (2014). *Buyer-Supplier Collaboration Quality in New Product Development Projects*. Journal of Supply Chain Management, Vol. 50(2).

Tufail, M.U., & Sohail Anwar, S. (2023). *The Effects of the Transformational Leadership on Project Success: Sequential Mediation of Team Building and Team Work*. Leadership and Organizational Behavioral Journal Vol. 2(1), 22-42

Un, C. A., Cuervo-Cazurra, A., & Asakawa, K. (2010). *R&D Collaborations and Product Innovation*. Journal of Product Innovation Management, First published: 07 July 2010. https://doi.org/10.1111/j.1540-5885.2010.00744.x.

Unger, Darian W., & Steven D. Eppinger. (2006). *Improving Product Development Processes to Manage Development Risk.* SSRN Electronic Journal. DOI: 10.2139/ssrn.876618.

Venkatesan, G. (2003). *Process control of product quality*. ISA Transactions Vol. 42(4), 631-641. https://doi.org/10.1016/S0019-0578(07)60011-1.

Victor P. Seidel. (2007). *Concept shifting and the radical product development process*. Journal of Product Innovation Management, Vol. 24(6), 522-533. DOI: 10.1111/j.1540-5885.2007.00269.x

Vrchota, J., & Řehoř, P. (2019). *Project management and innovation in the manufacturing industry in Czech Republic.* Procedia Computer Science 164, 457–462. https://doi.org/10.1016/j.procs.2019.12.206.

Yakovleva, A. (2015). *Methodological Aspects of Project Techniques Selection for Innovation Project*. International Journal of Innovation - IJI, Vol. 2(1), 18-31. DOI:10.5585/iji.v2i1.13.

Yukl, G. (2010). *Leadership in organizations (7th ed.)*. Upper Saddle River, NJ: Prentice-Hall.

Zhang, J. (2016). *Deadlines in product development.* Management Science Vol. 62(11), 3310-3326. DOI: 10.1287/mnsc.2015.2300.

Zhang. Y, Marquis. C, and Filippov. S, (2015). *The Challenges and Enhancing Opportunities of Global Project Management: Evidence from Chinese and Dutch Cross-Cultural Project Management*. SSRN Electronic Journal 15(063). DOI: 10.2139/ssrn.2562376.