Project Report on

"Ergonomics and Motion Study of Injection Moulding Operation for Improvement of Productivity"

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CERTIFICATE

This is to certify that **Mr. Naman Nandurkar, Mr. Shreeyash Pol, Mr. Ankush Gulhane, Mr. Mayur Lokhande has successfully completed the Project entitled "Ergonomics and Motion Study of Injection Moulding Operation for Improvement of Productivity"** under my supervision, in the partial fulfillment of Bachelor of Engineering- Mechanical Engineering, by Savitribai Phule Pune University.

Date: 02/06/2023

Place: Talegaon Dabhade, Pune

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SPONSORSHIP CERTIFICATE

TO WHOMSOEVER IT MAY CONCERN

This is to certificate that below mentioned Students of PCET'S Nutan Maharashtra Institute of Engineering and Technology Talegaon Dabhade working on the Project **"Ergonomics and Motion Study Of Injection Moulding Operation For Improvement Of Productivity"** in and Project Sponsored by Mask Polymer Pvt Ltd.

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3. **Shreeyash Pol**
4. **Naman Nandurkar**

We Wish him every success in his life and career.

For **MASK POLYMER PVT LTD**

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Declaration of Originality

It is important to note that all the figures, diagrams, graphs, photographs, videos, survey results, and any other data used in this project were not sourced from any external websites or research papers. The data used was generated by the project team through their own observations, experiments, and surveys. This was done to ensure that the data is accurate and specific to the particular context of this project. By collecting and creating the data in-house, we were able to maintain full control over the quality of the data and ensure that it is reliable for making informed decisions. This approach also allowed us to tailor our research to the specific needs and requirements of the project. We believe that this approach has led to a more robust and accurate set of results, which can be used to inform future projects in a similar context. In conclusion, all the data used in this project has been generated by the project team, and we have taken great care to ensure that it is accurate and reliable.

ABSTRACT

This project aims to identify and address ergonomic issues faced by machine operators in an injection moulding company. Through a first phase observation report, various concerns were highlighted, including insufficient protective gear, repeated motions, and physical strain experienced from standing for long hours on rigid surfaces. Possible solutions were suggested, such as providing better protective gear, introducing varied work tasks, and implementing ergonomic tools and equipment. Additionally, the project aims to improve communication between the company and its machine operators to better understand their needs and suggest improvement through feedback for improving comfort and safety in the workplace. Overall, the project aims to enhance the well-being and productivity of machine operators and promote a healthier work environment in the injection moulding industry.

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

Injection moulding is a complex manufacturing process that involves the production of parts and products by injecting molten material into a mould. This process is used in several industries, including automotive, aerospace, medical, and consumer goods. Injection moulding operations require skilled workers who are responsible for operating and maintaining the machinery, monitoring the quality of the products, and ensuring that the production process runs smoothly.

However, injection moulding operations can be physically demanding and expose machine operators to various safety hazards. The repetitive nature of the job, combined with long working hours and exposure to hot materials, can cause musculoskeletal disorders, fatigue, and discomfort. Furthermore, the use of complex machinery and the presence of moving parts and high temperatures can lead to accidents and injuries.

Therefore, it is essential to ensure the safety and well-being of machine operators while improving the productivity of injection moulding operations. One approach to achieving this goal is to apply ergonomic and motion study principles.

Ergonomics involves the study of how people interact with their environment and the design of products, systems, and processes to optimize human well-being and overall system performance. Ergonomic principles can help to minimize physical strain, reduce fatigue and discomfort, and increase efficiency in injection moulding operations. Examples of ergonomic principles that can be applied in injection moulding operations include adjusting the height of the work surface, providing adequate lighting, and optimizing the layout of the work area.

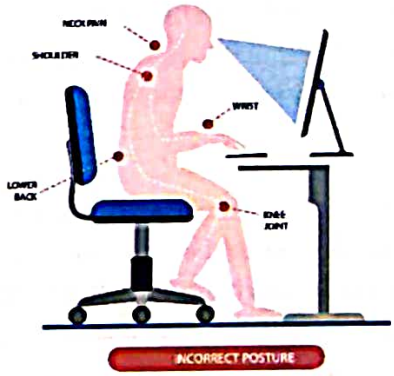


Fig. 1.1 Incorrect Posture

Fig 1.2 Correct Posture

Motion study involves the analysis of human motion to identify and eliminate unnecessary movements, reduce fatigue and discomfort, and increase efficiency as shown in fig. 1.1. Motion study principles can be applied to injection moulding operations to improve the overall efficiency of the production process. Examples of motion study principles that can be applied in injection moulding operations include optimizing the sequence of movements, reducing the number of steps required to complete a task, and minimizing the distance between workstations.

Several studies have investigated the application of ergonomic and motion study principles in various industries, including manufacturing. However, there is limited research on the application of these principles in injection moulding operations. Therefore, this study aims to investigate the application of ergonomic and motion study principles to improve the productivity of injection moulding operations while ensuring the safety and well-being of machine operators.

The study involves several steps, including observing the processes of injection moulding, conducting surveys with machine operators, and collecting anatomical data of the operators. Based on the observations, surveys, and anatomical data, the study identifies the most significant ergonomic issues faced by machine operators and proposes several solutions to address these issues.

Overall, this study provides valuable insights into the application of ergonomic and motion study principles in injection moulding operations. By addressing the ergonomic issues faced by machine operators, this study aims to improve the productivity of injection moulding operations while ensuring the safety and well-being of machine operators.

1.1 Moulding: - Moulding, also spelled moulding, is a manufacturing process in which a material, such as plastic, metal or rubber, is shaped by being poured, injected, pressed, or otherwise placed into a mould or form. The material then takes the shape of the mould and is allowed to cool or solidify, resulting in a finished product with the desired shape and features. Moulding is commonly

used in industries such as automotive, construction, and consumer goods manufacturing to produce a wide variety of products such as parts, components, and finished goods.

There are several types of moulding used in manufacturing, including:

- Injection moulding: A process in which melted plastic is injected into a mould to form a part or product.
- Blow moulding: A process used to make hollow plastic parts, such as bottles or containers, by inflating a heated plastic tube in a mould.
- Compression moulding: A process that involves placing a pre-measured amount of material into a mould and then compressing it with heat and pressure to create a part or product.
- Extrusion moulding: A process used to create plastic parts of a fixed cross-sectional profile, such as pipes or tubing, by pushing molten plastic through a die.
- Rotational moulding: A process used to create hollow parts or products, such as large containers or playground equipment, by rotating a mould around two perpendicular axes while heating and cooling the plastic inside the mould.
- Thermoforming: A process used to make plastic parts or products by heating a plastic sheet until it becomes pliable and then forming it over a mould using vacuum pressure or mechanical force.

These are just a few examples of the types of moulding used in manufacturing, and each has its own advantages and disadvantages depending on the specific application.

1.2 Injection Moulding: - It is a manufacturing process used to produce a wide range of plastic parts and products. It involves injecting molten plastic material into a mould cavity, where it cools and solidifies to form the desired shape. The process begins with the feeding of raw plastic material into a hopper, which is then melted and fed into a barrel through a heated screw conveyor system. Once the molten plastic material reaches the required temperature and consistency, it is injected into a mould cavity under high pressure using an injection moulding machine.

The mould cavity is designed to match the shape and size of the final product and is made from steel or aluminium. The mould is then clamped shut to prevent the plastic from escaping and to ensure that the mould cavity is filled completely. Once the plastic material is injected into the mould, it cools and solidifies to form the desired shape. After the part has solidified, the mould is opened, and the part is ejected.

Injection moulding is widely used in the production of various products, including automotive parts, electronic housings, medical devices, toys, and many other consumer and industrial products. The process offers a high level of precision, repeatability, and production efficiency, making it a popular choice for large-scale manufacturing operations.

1.3 Specific reason we choose Injection Moulding:

No, the decision to focus on injection moulding was not based on any specific reason. Rather, it was primarily driven by the availability of an injection moulding machine for us to use in our study. Moreover, we believed that injection moulding, being a relatively basic method of moulding with minimal operator involvement, provided an ideal starting point for our investigation into improving productivity through ergonomics and motion study.

Furthermore, we found that the injection moulding process required the least involvement from the operator, which allowed us to focus more on the ergonomic and motion study aspects of the operation. By improving the productivity of injection moulding, we could establish a foundation for improving productivity in other, more complex moulding methods.

Additionally, injection moulding is used to produce a wide range of products, from household items to automotive parts, and therefore has a significant impact on the manufacturing industry. Improving the productivity of injection moulding would not only benefit the operator and the company but also contribute to the overall growth and efficiency of the industry as a whole.

We aimed to establish a framework for improving productivity in moulding operations that could be applied to more complex moulding methods in the future. Therefore, by optimizing the productivity of injection moulding through ergonomic interventions and motion study, we can use the findings as a foundation to enhance productivity in other, more intricate moulding processes.

1.4 Help of Ergonomics and Motion study to improve productivity of Injection Moulding Operation:

In this project, ergonomics and motion study are used to identify and address the factors that affect the productivity of injection moulding operation. By studying the movements and actions of the machine operator, we were able to identify the difficulties they face and suggest ways to alleviate them. For example, we found that the machine operator was wearing single-layer gloves to protect against hot burns, but this was not sufficient. Therefore, we suggested that they wear triple-layer gloves, apply sunscreen, and avoid doing repeated motions to reduce the risk of repetitive strain injuries.

In addition, we suggested new storage areas that are easier to access and wear masks to avoid lung and breathing-related problems. We also recommended that the machine operator perform exercises and yoga asanas according to their daily actions to reduce their stress and the side effects of working continuously.

By implementing these suggestions, we aim to reduce the physical strain on the machine operator and increase their comfort and safety while performing their tasks. This, in turn, will lead to increased productivity as the machine operator will be able to work more efficiently and for longer periods without experiencing physical discomfort or injuries.

1.5 Musculoskeletal Disorders

Musculoskeletal Disorders (MSDs) are a group of disorders that affect the musculoskeletal system, which includes the muscles, bones, tendons, ligaments, and nerves. MSDs can cause pain, discomfort, and limitations in movement, which can have a significant impact on an individual's quality of life and work productivity.

Fig. 1.3 Musculoskeletal Disorder

MSDs can be caused by a variety of factors, including repetitive motions, awkward postures, forceful exertions, and prolonged static postures. These risk factors are commonly found in workplaces that involve manual labour, such as construction sites, factories, and warehouses. Office workers who spend long hours sitting in front of a computer can also develop MSDs, particularly in the neck, shoulders, and upper back.

Preventing MSDs requires a comprehensive approach that addresses both the physical and organizational aspects of the workplace. This includes implementing ergonomic solutions, such as adjusting workstations to fit the individual, providing ergonomic tools and equipment, and training workers on safe work practices. Employers can also encourage workers to take regular breaks, stretch, and perform exercises to reduce the risk of developing MSDs.

Overall, MSDs are a common and serious health issue in many workplaces, but they can be prevented through proper education, training, and implementation of ergonomic solutions.

1.6 About Industry:

Mask Polymers Pvt. Ltd. for this project is a significant support towards achieving its objectives, it's a renowned name in the manufacturing industry that has worked with leading automotive manufacturers such as Tata and Bajaj Auto. We are conducting our project at their manufacturing plant, where we are using their state-of-the-art injection moulding machine, the Desma Sigma 250,

provided to us by Mask Polymers Pvt. Ltd. The utilization of their injection moulding machine, the Desma sigma 250, has provided the project team with the necessary tools to carry out the research work. The Desma sigma 250 is a highly advanced injection moulding machine manufactured by Desma USA, a renowned brand known for its exceptional quality products. It is a state-of-the-art machine that is designed to meet the highest standards of industrial production and is widely used in various industries.

The injection moulding machine is a critical component of the project, as it is the equipment that facilitates the moulding process of the rubber parts. The Desma sigma 250 is known for its high precision, repeatability, and efficiency, which makes it the ideal machine for the project. Its advanced features, such as its energy efficiency, fast cycle time, and easy-to-use controls, have made the moulding process smoother and faster, resulting in a significant increase in productivity. Additionally, the machine's ability to handle high-temperature materials has been essential in achieving the desired results of the project.

Moreover, the sponsorship by Mask Polymers Pvt. is a testament to the company's commitment to supporting research and development in the industry. Their willingness to provide the project team with access to their advanced machinery demonstrates their confidence in the project's potential to make a positive impact in the industry. It also highlights their dedication to contributing to the advancement of the injection moulding industry. The partnership between the project team and Mask Polymers Pvt. has not only provided the project with the necessary resources to carry out the research work, but it has also created an opportunity for knowledge sharing and collaboration, which can lead to further innovation and advancements in the industry.

Company Name	Mask Polymers Pvt Ltd
Location	Talegaon, Pune
Certifications	IATF 16949:2016, ISO 450001:2018, ISO 14001:2015
Product Category	Rubber Moulding, Rubber Extrusion, Plastic injection Moulding (TPE/TPU), Plastic blow Moulding, Automotive Mirrors, NVH applications Parts (Sunroof Drain tubes, Insulation Foam)
Rubber Moulding	Having 62 rubber Moulding machines (Injection/Compression/Transfer), ranging from 65T to 400T
Rubber Extrusion	Having Continuous extrusion line (BIANA make) line speed of 6-7 mtrs/min for extrusion, 3 offline extruders, 2 braiding machines for high pressure hoses
Automotive Mirrors	Manufacturing facility of automotive mirrors & plastic injection products in our group company Manas automotive
CVJ boots/Bellows	Manufacturing capability of CVJ boots, bellow & cylinder head gaskets in our new group company Insit Mask Transmission Pvt Ltd (JV Company between Mask Polymers Pvt Ltd & Insit S.P.A.)
In-house Tooling/Design Capability	Having In-house tool room/Design team for manufacturing of rubber moulds (3-VMC available) & other conventional machines.
R&D	In house R&D facility with well-equipped machines to meet the testing requirements for material + products as per BS6 norms.
Mixing	Fully automated mixing plant with SCADA control system, having the capacity to produce RM of 20T/Day

Table 1.1 Industrial Information

1.7 Report on Meeting with Company Plant Head Sir Mr. Pravin Jadhav

On 5th December 2022, we had a meeting with the Plant Head Sir, Mr. Pravin Jadhav, to discuss our project and inquire about the current ergonomics of the injection moulding operation and accident rates.

Firstly, we gave him a brief overview of our project and explained how we plan to improve the ergonomics of the injection moulding operation. We also informed him about the potential benefits of improving ergonomics, such as increased productivity, reduced injury rates, and improved operator satisfaction.

We then inquired about the accident rates in the injection moulding operation before the implementation of our suggested ergonomics. Mr. Jadhav informed us that daily 1-2 minor accident happens, and they were struggling to reduce them. He also mentioned that they had implemented some basic safety measures, such as providing safety goggles and gloves to the operators.

Overall, the meeting was quite productive, and we gained valuable insights into the current ergonomics and safety measures of the injection moulding operation. We will take this information into account as we continue to develop our project and suggest further improvements to the company's ergonomics and safety measures.

1.8 Report on Company Tour with Company Guide Mr. Raju (Supervisor)

On 10th September 2022, we were given a company tour by our guide Mr. Raju, who is a supervisor in the manufacturing plant. During the tour, Mr. Raju showed us every part of the company, including the injection moulding machines, storage areas, and break rooms.

He introduced us to the machine operators and made us feel comfortable and welcome. This was very helpful for us, as we needed to interact with the machine operators for further investigation, observation, and taking surveys and operator interviews.

Mr. Raju also explained to us the manufacturing process of rubber products and how the injection moulding machines worked. He showed us the different types of machines used for different products and how they were operated.

During the tour, we observed that the working conditions in the plant were quite harsh. The temperature in the plant was quite high, and the noise level was also quite high. We also observed that the machine operators were working in a standing position for long hours, which could cause discomfort and fatigue.

Overall, the tour was very informative and gave us a good understanding of the manufacturing process in the company. It also helped us to connect with the machine operators, which was

important for our project. We are grateful to Mr. Raju for his time and effort in showing us around the company.

1.9 Report on Visited the HR Department

On the 8th of October 2022, I visited the **HR department** of Mask Polymers Pvt to inquire about their recruitment process for the Injection Moulding Operator position. In the meeting, we introduced ourself and explained our project, emphasizing the focus on improving operator productivity and safety.

I then asked the HR representative if they have any specific criteria for hiring Injection Moulding Operators, such as height, weight, or experience of working in standing positions for 12 hours. The HR representative informed me that currently, they don't have any specific criteria for hiring Injection Moulding Operators. However, they are open to considering any suggestions we may have.

In conclusion, the meeting with the HR representative was productive, and I gained insight into the company's recruitment process and work culture. I appreciated the HR representative's willingness to consider any suggestions we may have regarding the hiring criteria for Injection Moulding Operation.

CHAPTER 2

PROBLEM STATEMENT

2. PROBLEM STATEMENT

Problems faced in Mask Polymer Pvt Ltd:

1. Safety, health and comfort associated with the adopted production area.
2. Poor performance and the usability of all over manufacturing.
3. High production cost.
4. Not getting enough efforts due to ergonomical imbalance.
5. Less production due to unbalanced structural design.

CHAPTER 3

LITERATURE REVIEW

3. LITERATURE REVIEW

The extensive literature survey is carried out at certain levels by various authors. The detail review of which is given below.

[1] An Experimental Study on Productivity Improvement using Work study and Ergonomics

Author Name: -*Malashree et. al., Vinayak N Kulkarni, V. N. Gaitonde, Sahebagowda M.*

Published by: International Journal of Darshan Institute on Engineering and Emerging Technologies, 2018

Abstract: This research paper titled "An Experimental Study on Productivity Improvement using Work study and Ergonomics" presents a comprehensive investigation conducted to enhance productivity in the metal section industry by employing work study techniques and ergonomic principles. The study focuses on determining the cycle time required to produce a rolling shutter and proposes an improved method to reduce this cycle time. Additionally, the paper addresses the issue of worker fatigue and suggests ways to alleviate it through an ergonomic approach. The research aims to optimize the production process and improve the overall efficiency of operations in the metal section industry.

[2] Ergonomic analysis of an assembly workstation to identify time consuming and fatigue causing factors using application of motion study

Author Name: -*Mr. Gurunath V Shinde, Prof.V.S.Jadhav*

Published by: International Journal of Engineering and Technology, August 2012

Abstract: "Ergonomic Analysis of an Assembly Workstation to Identify Time Consuming and Fatigue Causing Factors using Application of Motion Study" investigates the impact of ergonomics on workers' productivity. The study focuses on two key factors, namely workstation layout and work design, which significantly influence the efficiency of workers. By applying motion study techniques, the authors analyze an assembly workstation to identify factors that contribute to time-consuming tasks and fatigue. The research aims to enhance worker efficiency by addressing ergonomic issues and optimizing the workstation layout and work design.

[3] A Study on the Method of Task Management Using Motion Analysis

Author Name: - *Jung-Wan Hong, Hyun-Jong Kim and Ho-Young Hwang*

Published by: International Journal of Pure and Applied Mathematics

Abstract: The research paper titled "A Study on the Method of Task Management Using Motion Analysis" explores the significance of efficient task management in improving productivity and cost savings for manufacturing industries. The study focuses on developing a method that utilizes

motion analysis to identify specific time durations for each detailed process, ultimately enhancing the overall efficiency of the manufacturing process. The research aims to address the pressing need for manufacturing companies to optimize their processes and improve productivity through the implementation of efficient task management methods.

[4] Ergonomics for Beginners- A Quick Reference Guide

Author Name: -*Jan Dul and Bernard Weerdmeester*

Abstract: The research paper serves as an informative and accessible resource for individuals seeking an introduction to the field of ergonomics. Written by Jan Dul and Bernard Weerdmeester, the paper provides a quick reference guide, offering a comprehensive overview of ergonomics, its principles, and its applications. The authors acknowledge the evolving expectations of different generations and how historical experiences shape these expectations. By recognizing the changing landscape, the research highlights the importance of adapting ergonomic practices to meet the evolving needs and preferences of successive generations. This paper is an invaluable tool for beginners looking to grasp the fundamentals of ergonomics and its relevance in addressing shifting expectations.

[5] Designing the Ergonomic Press and Moulding Machine of Cassava Chips for Sustainable Development in SMEs

Author Name: -*Silviana, Andy Hardianto, Naif Fuhaid and Dadang Hermawan*

Abstract: "Designing the Ergonomic Press and Moulding Machine of Cassava Chips for Sustainable Development in SMEs" focuses on the sustainable development of Small and Medium Enterprises (SMEs) through the utilization of technology. Authored by Silviana, Andy Hardianto, Naif Fuhaid, and Dadang Hermawan, the paper addresses the importance of SMEs competing effectively with their competitors to ensure their sustainability. The research specifically explores the design of an ergonomic press and moulding machine for cassava chips, aiming to enhance the productivity and efficiency of SMEs in the cassava chips industry. The study emphasizes the role of technology as a means for SMEs to survive and thrive in competitive markets.

Sr. No.	Name of Paper	Name of Authors and Journal Name	Published on	Remark
1	An Experimental Study on Productivity Improvement using Workstudy and Ergonomics	Malashree, Vinayak N Kulkarni, V. N. Gaitonde, Sahebagowda International Journal of Darshan Institute on Engineering and Emerging Technologies, 2018	2018	The research paper provides valuable insights into the application of work study techniques and ergonomics for enhancing productivity in the metal section industry. By determining the cycle time required for manufacturing a rolling shutter and proposing an improved method to reduce it, the authors demonstrate a practical approach to optimizing production processes. The inclusion of ergonomic principles to reduce worker fatigue further emphasizes the importance of ensuring employee well-being and efficiency. The findings and recommendations presented in this paper hold significant relevance for industries seeking to improve their productivity and worker satisfaction.
2	Ergonomic analysis of an assembly workstation to identify time consuming and fatigue causing factors using application of motion study"	Mr. Gurunath V Shinde, Prof.V.S.Jadhav International Journal of Engineering and Technology, August 2012	4 Aug-Sep 2012	The research paper sheds light on the crucial role of ergonomics in improving workers' productivity. By emphasizing the significance of workstation layout and work design, the authors highlight two major factors that directly impact the efficiency of workers. The application of motion study techniques to analyze an assembly

				workstation provides valuable insights into identifying time-consuming tasks and fatigue-causing factors. The research underscores the importance of optimizing ergonomic conditions to enhance worker efficiency and overall productivity. This paper serves as a valuable resource for industries seeking to improve their work environments and optimize their work processes.
3	A Study on the Method of Task Management Using Motion Analysis	Jung-Wan Hong, Hyun-Jong Kim and Ho-Young Hwang International Journal of Pure and Applied Mathematics	2017	The research paper highlights the pressing need for manufacturing industries to improve productivity and save costs through the implementation of efficient task management methods. By utilizing motion analysis, the authors propose a method to identify specific time dur for each detailed process, enables the optimization of manufacturing processes. The research addresses the urgent task faced by manufacturing companies and emphasizes the importance of finding efficient and effective methods to enhance process efficiency. This paper offers valuable insights and recommendations for manufacturing industries seeking to improve their productivity and streamline their operations through task management based on motion analysis.

PTO

4	Ergonomics for Beginners A quick reference guide	Jan Dul and Bernard Weerdmeester Taylor & Francis e-Library	2001	The research paper serves as an informative and accessible resource for individuals seeking an introduction to the field of ergonomics. Written by Jan Dul and Bernard Weerdmeester, the paper provides a quick reference guide, offering a comprehensive overview of ergonomics, its principles, and its applications. The authors acknowledge the evolving expectations of different generations and how historical experiences shape these expectations. By recognizing the changing landscape, the research highlights the importance of adapting ergonomic practices to meet the evolving needs and preferences of successive generations. This paper is an invaluable tool for beginners looking to grasp the fundamentals of ergonomics and its relevance in addressing shifting expectations.
5	Designing the Ergonomic Press and Moulding Machine of Cassava Chips for Sustainable Development in SMEs	Silviana, Andy Hardianto, Naif Fuhaid and Dadang Hermawan	31 July 2021	The research paper highlights the crucial role of technology in ensuring the sustainability and competitiveness of Small and Medium Enterprises (SMEs). Authored by Silviana, Andy Hardianto, Naif Fuhaid, and Dadang Hermawan, the paper emphasizes the significance of SMEs effectively competing with their counterparts. By focusing on the design of an ergonomic press and moulding

				machine for cassava chips, the research addresses the specific needs of SMEs in the cassava chips industry. The study recognizes the potential of technology in enhancing productivity and efficiency, enabling SMEs to thrive in competitive markets. This paper provides valuable insights and recommendations for SMEs seeking sustainable development through the adoption of technological advancements in their operations.

Table No. 3.1 Literature Review

CHAPTER 4

OBJECTIVES

4. OBJECTIVES

1. To observe and analyze the injection moulding process in detail and identify the ergonomic and safety issues faced by machine operators.
2. To assess the anatomy data and daily actions of machine operators to understand their physical requirements and limitations.
3. To survey machine operators to gather information about their working conditions, discomfort, and safety concerns.
4. To propose and implement changes to the work environment and work processes to reduce the physical strain on machine operators and improve their safety and well-being.
5. To evaluate the effectiveness of the proposed changes by measuring the productivity, efficiency, and quality of injection moulding operations before and after implementation.
6. To enhance overall productivity.

CHAPTER 5

METHODOLOGY

5. METHODOLOGY

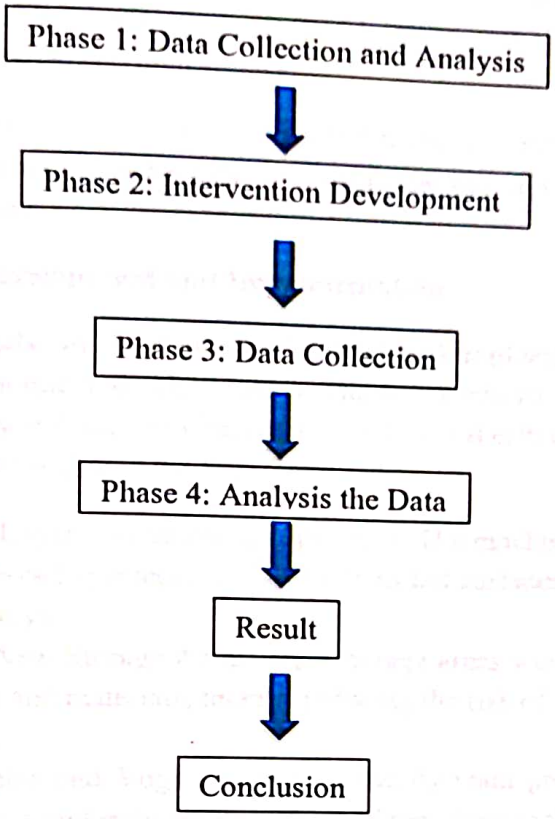


Fig 5.1 Methodology flow chart

According to above figure, the study was conducted in several phases to investigate the ergonomic and safety issues faced by machine operators in injection moulding operations and to develop interventions to address these issues. The methodology involved a combination of qualitative and quantitative data collection methods, including observation, surveys, and interviews.

Phase 5.1: Data Collection and Analysis

The first phase of the study involved data collection and analysis to identify the key ergonomic and safety issues faced by machine operators in injection moulding operations. The data was collected through the following methods:

- Observation: The injection moulding process was observed to identify the tasks performed by machine operators, the equipment used, and the environmental factors affecting the process.
- Surveys: Surveys were administered to machine operators and supervisors to gather information on their perceptions of ergonomic and safety issues in the workplace. The surveys focused on topics such as work practices, equipment, training, and injury history.

- Interviews: Interviews were conducted with key stakeholders, such as machine operators, to gain an in-depth understanding of the issues affecting injection moulding operations.
- Document Review: The study team reviewed injury and accident reports to identify common types of injuries and their causes.

Data collected through these methods were analyzed using a combination of qualitative and quantitative techniques. The results were used to identify the key ergonomic and safety issues in injection moulding operations.

Phase 5.2: Intervention Development and Implementation

The second phase of the study involved the development and implementation of interventions to address the identified ergonomic and safety issues. The interventions were based on the findings of the first phase of the study and aimed to improve the safety and efficiency of injection moulding operations. The interventions included the following:

- Provision of Triple-Layer Gloves and Suns Cream: The machine operators were provided with triple-layer gloves to protect their hands from hot surfaces and suns cream to protect their skin from UV rays.
- Implementation of New Storage Areas: New storage areas were implemented to improve accessibility to tools and materials, thereby reducing the risk of injury from handling heavy or awkward objects.
- Promotion of Exercise and Yoga Asanas: The study team promoted exercise and yoga asanas to reduce stress and mitigate the effects of repetitive motion.

Phase 5.3: Data Collection

The third phase of the study involved the collection and analysis of data to evaluate the effectiveness of the interventions. The data was collected through the following methods:

- Measurement of Productivity: The productivity of injection moulding operations was measured before and after the implementation of the interventions to determine the impact of the interventions on productivity.
- Measurement of Quality: The quality of the injection moulding products was measured before and after the implementation of the interventions to determine the impact of the interventions on quality.
- Measurement of Operator Satisfaction: The satisfaction of machine operators was measured through surveys to determine the impact of the interventions on their job satisfaction.
- Measurement of Injury Rates: The injury rates were measured before and after the implementation of the interventions to determine the impact of the interventions on injury rates.

Data collected through these methods were analyzed using statistical techniques to determine the impact of the interventions on the outcome measures. The results were compared to the findings of the first phase of the study to identify areas for improvement.

Phase 5.4: Analysis the Data Collected in Phase 3

The final phase of the study involved an analyzing of the data collected in phase 3 on measurement of productivity, quality, operator satisfaction, injury rates of ergonomic and safety practices in injection moulding operations. The analysis was conducted to identify best practices in other industries and to identify areas for further research.

CHAPTER 6

ANALYTICAL WORK

Company Visit and Work Calendar

6.1 Work Calendar:

24/08/22	Started the project and had initial meetings with the plant head and guide
27/08/22	Further meetings with company guide to understand the company environment
28/08/22	Meeting with company HR
04/09/22	First observation visits to the plant
11/09/22	Second observation visit to the plant
18/09/22	Third observation visit to the plant
25/09/22	Fourth observation visit to the plant
02/10/22	Fifth observation visit to the plant
09/10/22	Sixth observation visit to the plant
16/10/22	Seventh observation visit to the plant
23/10/22	Eighth observation visit to the plant
30/10/22	Ninth observation visit to the plant
06/11/22	Tenth observation visit to the plant
13/11/22	Eleventh observation visit to the plant
20/11/22	Twelfth observation visit to the plant
27/11/22	Thirteenth observation visit to the plant
04/12/22	Fourteenth observation visit to the plant
11/12/22	Fifteenth observation visit to the plant
18/12/22	Operator survey conducted
08/01/23	Interviews conducted
15/01/23	Document review and study
22/01/23	Understanding the problem and brainstorming solutions
29/01/23	Data collection started
05/02/23	Provision of Triple-Layer Gloves and Sun Cream implemented
12/02/23	Implementation of New Storage Areas
19/02/23:	Promotion of Exercise and Yoga Asanas
26/02/23	Implementation of an Ergonomic Assessment Checklist
05/03/23	Phase 3: Data Collection and Analysis started
12/03/23	Measurement of Productivity
19/03/23	Measurement of Quality
26/03/23	Measurement of Operator Satisfaction
02/04/23	Measurement of Injury Rates
09/04/23	Combining these data and coming to the result and conclusion
16/04/23	Report writing started
26/04/23	Report writing continued
28/04/23	Project completed and report submitted to the Guide for review and suggestion

Table 6.1 Work Calendar

6:30pm	Ashok takes his final 10-minute break. He seems to be more relaxed after the break.
7:00pm	Ashok finishes his shift on time and shuts down the injection moulding machine. He seems tired but relieved that his shift is over.

Table 6.2 Observations of Daily Operations

We conducted daily observations of the operator during his 12-hour shift. We recorded various aspects of his behaviour and performance, including the frequency and duration of breaks he took for tasks such as using the restroom or taking a drink of water. We also noted any instances of repeat motions or facial expressions, as well as any changes in performance before and after lunch breaks.

In addition to these physical observations, we also monitored the operator's mood, attention level, stress, and tiredness throughout the shift. We recorded any instances of water breaks or time spent talking to other operators, as well as the seriousness with which he approached his tasks.

Overall, these daily observations provided us with valuable insights into the operator's working conditions and the factors that may be affecting his productivity. By identifying areas of improvement, such as reducing the frequency of repeat motions or providing more frequent breaks, we were able to develop targeted interventions to help improve the operator's overall efficiency and reduce the risk of injury or fatigue.

6.1.3 Actions of a machine operator in the x, y, and z axis for an Injection Moulding machine:

- . X-Axis:
  - Reaching for raw materials and supplies
  - Adjusting controls on the machine
  - Inserting and removing moulds
  - Removing finished products from the machine
  - Transporting finished products to a storage area or packaging station
  - Cleaning and maintaining the machine
- Y-Axis:
  - Moving raw materials and supplies to and from the machine
  - Adjusting the height of the work surface or machine controls
  - Positioning moulds in the machine
  - Removing and replacing safety guards on the machine
- Z-Axis:
  - Bending or stooping to reach low areas of the machine
  - Reaching to access supplies or finished products
  - Standing on a platform to access higher areas of the machine
  - Adjusting the angle of the mould or machine controls

Conducting a thorough motion study can help identify which actions are most frequently performed and where ergonomic improvements can be made to reduce the risk of injury or strain.

6.1.4 List of actions in which the operator is involved in an injection moulding operation:

- Loading raw material into the machine
- Starting the machine and setting the parameters for the injection process
- Monitoring the machine during the injection process
- Observing the injection process to ensure proper flow and formation of the moulded parts
- Removing the moulded parts from the machine after the cycle is complete
- Inspecting the moulded parts for defects or imperfections
- Trimming excess material from the moulded parts using hand tools
- Cleaning and maintaining the machine to ensure proper functioning

These actions involve a combination of movements in the x, y, and z axes, as well as various body positions such as standing, bending, reaching, and lifting. Analysing these movements and positions can help identify any ergonomic issues that may be causing discomfort or injury to the operator, and allow for improvements to be made to the work station to reduce the risk of injury and improve overall efficiency.

6.1.5 Some noted points after observation

- Work surface: The work surface should be designed in such a way that it is easy for the operator to remove the finalized moulded parts without any difficulty. The surface should also be resistant to high temperatures.
- Lighting: Adequate lighting should be provided to the work station to ensure that the operator can see clearly and avoid making any mistakes while handling the moulded parts.
- Ventilation: The work station should have proper ventilation to prevent the build-up of heat and fumes, which can cause discomfort and health issues for the operator.
- Ergonomics: The work station should be designed with ergonomic principles in mind to reduce the risk of musculoskeletal disorders and fatigue. The height of the work surface should be adjustable to accommodate operators of different heights.
- Storage: Adequate storage space should be provided near the work station for storing raw materials, finished products, and tools. This will help in reducing the clutter in the work area, making it more organized and efficient.
- Safety: Safety measures such as emergency stop buttons, safety guards, and warning signs should be installed in the work area to ensure the safety of the operator and other workers.

By incorporating these design considerations into the work station, the manufacturing plant can improve the productivity of the operation and ensure the safety and comfort of the operators.

6.1.6 Machine Operator's Survey

One of the team members conducted a survey for the ergonomics and motion study project using Google Forms. The questions in the survey were translated into the local language and then read out to the machine operator by the team member. The operator provided answers to the questions, and the team member filled in the responses on behalf of the operator. This process was used to gather feedback from the machine operator about their experiences and to identify areas for improvement in the injection moulding operations. The survey results were then analysed to help inform the interventions implemented in the later phases of the project.

6.1.7 Repeated Motion

During the first phase observation of the injection moulding operation, it was noted that the machine operator is required to repeat the same motion for a minimum of 72 times in a 12-hour shift. The repetition of the same motion for such a long period can result in musculoskeletal disorders (MSDs), which can cause long-term damage to the operator's health. To avoid the harmful effects of repeated motions, it is recommended that the operator works on different machines that involve different motions after the half or lunch break. This will help the operator to stretch and move different muscles, which will reduce the risk of developing MSDs.

Apart from this, other possible solutions to avoid repeated motion could be to rotate the job of the machine operator among different machines, allowing them to work in a different work environment, and the opportunity to use different muscles. Additionally, providing ergonomic training to the machine operator can help them learn how to avoid repeating the same motion, thereby reducing the risk of developing MSDs. It is crucial to monitor the machine operator's movements and make necessary changes to their work environment to minimize the occurrence of repetitive motion injury.

In conclusion, it is essential to identify and address the issue of repetitive motions to ensure the safety and well-being of the machine operator. The suggested solutions, such as working on different machines, rotating jobs, and ergonomic training, can help prevent the risk of developing MSDs. The company should take necessary steps to implement these solutions and ensure the health and safety of its employees. By implementing these measures, the company can reduce the risk of work-related injuries and increase productivity.

6.2.1 Single Layer Hand Gloves:

During the first phase of our observation report, we noted that the machine operator working on the injection moulding machine was only provided with single layer hand gloves and a cloth apron as protective gear. It is worth noting that these safety measures are insufficient to protect the operator from the high temperatures generated by the machine, which operates at 300 degrees Celsius. As a result, the operator is at a high risk of heat burns and other related injuries, which can negatively impact their productivity and well-being.

To address this issue, we recommend that the company provide additional safety gear to the operator, such as triple-layered gloves and heat-resistant aprons, which are specifically designed to protect workers in high-temperature environments. The triple-layered gloves will provide better insulation against the heat, while the heat-resistant aprons will ensure that the operator's clothing is not affected by the high temperatures. By providing these safety measures, the company can significantly reduce the risk of heat burns and related injuries, as well as improve the overall safety and well-being of the operator.

In conclusion, the provision of suitable safety gear and the implementation of preventive measures are essential for ensuring the safety and well-being of the machine operator working on the injection moulding machine. By adopting these measures, the company can significantly reduce the risk of heat burns and related injuries, as well as improve the overall productivity and efficiency of the operation.

a) Before b) After

Fig 6.1 Before and after safety hand gloves for worker

6.2.2 Final product analysis:

During the first phase of our observation report, we noticed that the operator had to manually fill bags with finished products once the storage area was full. This was a time-consuming and physically demanding task, which required the operator to pick up and place each product into the bag manually. This process was repeated several times during the 12-hour shift, which resulted in physical strain on the operator and also reduced the productivity of the process.

To avoid this, several possible solutions can be implemented. One solution could be to install an automatic bagging system that would fill bags with finished products automatically. This would

eliminate the need for manual labor and reduce the risk of injury for the operator. This would reduce the time required for the operator to fill bags manually and increase the efficiency of the process.

Another solution could be to increase the storage capacity of the storage area to avoid the need for frequent manual bag filling. This would also reduce the physical strain on the operator and allow for more uninterrupted production time. The storage area could be expanded or replaced with a larger one to accommodate the increased product volume.

Furthermore, training could be provided to the operator to ensure proper handling of finished products to reduce the risk of damage or contamination during the bagging process. This would also increase the quality of the final product and improve the overall efficiency of the process.

In conclusion, the manual bag filling process observed during the first phase of our observation report is a time-consuming and physically demanding task. However, several possible solutions can be implemented to improve the efficiency and safety of the process. An automatic bagging system could be installed, the storage area could be expanded, and proper training could be provided to the operator. These solutions would not only reduce the physical strain on the operator but also increase the productivity and quality of the final product.

6.2.3 Seating break for operator, suggest minimum sitting duration in break:

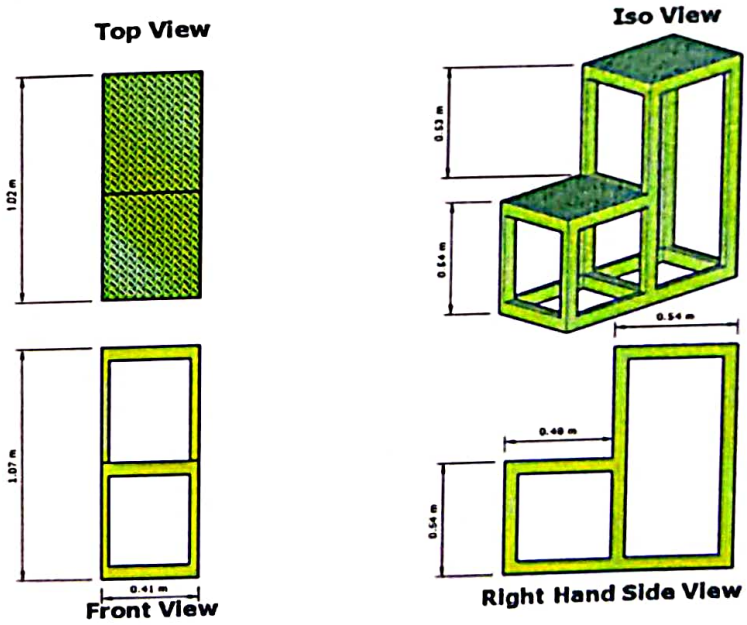


Fig 6.2 Sitting arrangement stool measurement

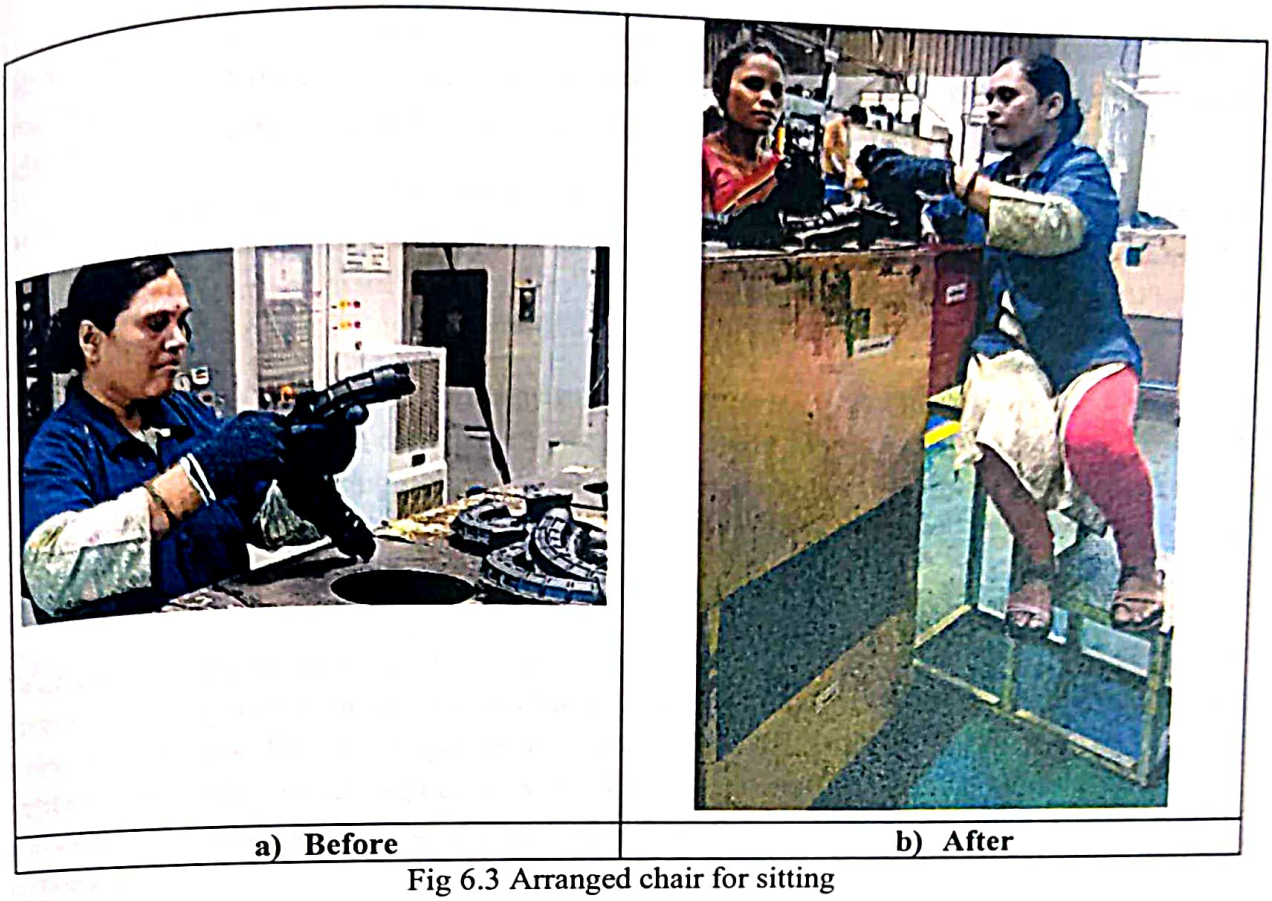
During our initial phase of observation, we noticed that there is no provision for seating or seating breaks for the machine operator who operates the injection moulding machine. This is a major

concern as the operator has to stand in the same position for 12 hours continuously, which can lead to fatigue and discomfort. This can affect the operator's productivity and even increase the risk of accidents. It is recommended that the company provides at least two 10-minute seating breaks during the 12-hour shift. These breaks will help the operator to rest and rejuvenate their body, which will lead to better work performance.

However, it is also important to consider the ergonomic impact of sitting for a long time during the work process. The studies have shown that prolonged sitting can lead to poor circulation, back pain, and other health issues. Thus, it is important to strike a balance between standing and sitting during the work process. We suggest that the company provides a seating option for the operator during the seating break, but not for the entire work shift.

Furthermore, the company should also consider providing an anti-fatigue mat for the operator to stand on while working. This will help to reduce the pressure on the feet and lower back, and can increase the operator's comfort level during the work shift. Additionally, the company should also provide proper footwear to the operator, such as comfortable shoes with good arch support, to reduce the risk of foot pain and other foot-related issues.

In conclusion, providing seating breaks, anti-fatigue mats, and proper footwear to the operator will not only improve the operator's comfort level but also reduce the risk of accidents, increase productivity, and improve work performance.



a) Before b) After

Fig 6.3 Arranged chair for sitting

6.2.4 Lack of interaction between the machine operator and the company:

The lack of interaction between the machine operator and the company about the discomfort in work is a significant issue that needs to be addressed. It is essential to ensure that the workers are provided with a comfortable and safe work environment so that they can work efficiently without experiencing any physical or mental strain. To avoid such situations in the future, the company can take various steps.

Firstly, the management should regularly hold meetings with the machine operators to discuss their concerns and suggestions for improving the work environment. These meetings can be conducted on a monthly or quarterly basis to ensure that the workers feel heard and valued. The company can also appoint a dedicated person or a team responsible for addressing the concerns of the workers.

Secondly, the management can conduct regular health and safety audits to identify any issues that the workers might be facing. The audits can help to identify potential hazards and recommend corrective actions that need to be taken. The company should prioritize the implementation of these recommendations to ensure that the workers are not at risk of any harm.

Thirdly, the company can invest in training programs that focus on ergonomics and work safety. Such programs can help workers understand the importance of proper posture, body mechanics, and stretching exercises to prevent injuries and discomfort.

Lastly, the company can also offer incentives to workers who take steps to improve their work environment. For example, workers who report safety hazards or suggest improvements can be rewarded with bonuses or extra vacation days. Such incentives can motivate workers to take an active interest in their own safety and well-being.

In conclusion, it is crucial for the company to prioritize the comfort and safety of the workers by regularly communicating with them, conducting safety audits, investing in training programs, and offering incentives for reporting safety hazards or suggesting improvements. By taking these steps, the company can ensure that the workers are healthy, happy, and motivated to perform their best.

6.2.5 Cooling Fans:

Based on the observations made during the first phase of the assessment, it was found that the operators working on the injection moulding machine were not provided with any air fans, cool water, or air coolers. This is a major issue as the machine operates at a high temperature of 300 degrees and the operators are required to work for long hours in such conditions. As a result, they are more susceptible to heat exhaustion and heat stroke, which can have serious health consequences.

To address this issue, it is recommended that air fans, cool water dispensers, and air coolers be provided to the operators. These measures will help to regulate the temperature in the working area, reducing the risk of heat exhaustion and heat stroke. The air fans will provide a cooling breeze, while the cool water dispensers will enable the operators to stay hydrated and cool. Air coolers can be used to reduce the temperature in the working area, creating a comfortable and safe working environment.

In addition to the above measures, it is also recommended that the operators take frequent breaks to rest and rehydrate. This will help to prevent fatigue and heat exhaustion. The breaks should be scheduled at regular intervals throughout the day and should be of sufficient duration to allow the operators to recover fully. It is recommended that the breaks be taken in a cool and shaded area, away from the heat of the working area.

Furthermore, it is recommended that the operators wear lightweight and breathable clothing, which will help to regulate their body temperature. Clothing made from natural fabrics such as cotton or linen is highly recommended as they are more breathable than synthetic materials. It is also important to provide the operators with sun protection, such as hats and sunscreen, to protect them from the harmful effects of the sun's rays.

In conclusion, the lack of air fans, cool water dispensers, and air coolers in the working area is a significant issue that needs to be addressed. By providing these measures, along with frequent breaks, lightweight and breathable clothing, and sun protection, the operators can work in a safe and comfortable environment, reducing the risk of heat exhaustion and other health problems.

6.2.6 Temperature of production area:

Based on the observation report, the machine operator is working in a high temperature environment, which can lead to several health problems such as dehydration, heat exhaustion, and heat stroke. These problems can have serious consequences, including organ damage and even death. Therefore, it is crucial to take steps to prevent such problems and ensure the safety of the machine operator.

One possible solution is to provide adequate hydration to the machine operator by making drinking water easily accessible in the work area. Additionally, providing electrolyte drinks and encouraging the operator to take frequent breaks to rehydrate can help prevent dehydration.

Another solution is to improve the ventilation system in the work area. Good ventilation can help regulate the temperature and humidity levels, which can reduce the risk of heat-related health problems. Installing fans or air conditioning can be effective in this regard.

It is also important to provide the machine operator with personal protective equipment (PPE) such as heat-resistant gloves, aprons, and face masks. These items can help protect the operator's skin from burns and reduce the risk of inhaling harmful fumes or particulate matter.

Finally, regular health checks can be conducted to monitor the machine operator's health and detect any potential health problems early. This can include monitoring vital signs such as blood pressure, heart rate, and body temperature. If any problems are detected, the operator should be given adequate rest and medical attention to prevent further complications.

In conclusion, working in a high-temperature environment can have serious health consequences for the machine operator. Therefore, it is important to take steps to prevent heat-related health problems, such as providing adequate hydration, improving ventilation, and providing PPE. Additionally, regular health checks can help detect any potential health problems early and prevent further complications.

6.2.7 Wearing Shoes for safety:

During our observation, we noticed that the operators were not wearing shoes while operating the injection moulding machines. This is a major concern as it puts the operator's feet at risk of injury from falling objects, sharp edges, and hot surfaces. Moreover, working without shoes can lead to foot strain and fatigue, which can eventually lead to reduced productivity and an increase in sick days.

To address this issue, it is important to provide suitable footwear for the operators. The footwear should be designed to provide adequate protection and support to the feet while also being comfortable to wear for long hours. The ideal footwear would have a non-slip sole to prevent slipping on wet or oily surfaces, a steel toe cap to protect against falling objects, and a padded insole for cushioning and comfort.

Another measure to consider is providing mats or anti-fatigue floor coverings on the work area. These floor coverings can help reduce the pressure on the feet and legs, which can reduce the risk of leg pain, back pain, and other problems caused by prolonged standing on rigid surfaces.

Finally, it is important to educate the operators on the importance of wearing appropriate footwear and taking regular breaks to rest and stretch their legs and feet. This can help prevent injuries and improve the overall health and well-being of the operators, leading to improved productivity and reduced absenteeism.

6.2.8 Working for long hours in a standing position

The observation report clearly indicates that the machine operator is working for long hours in a standing position on a rigid surface, which has resulted in various physical problems like leg pain, back pain, and other problems. This can lead to serious health issues if not addressed properly. To avoid these problems, there are various possible things that can be done.

One solution is to introduce seating options for the machine operator. This can provide a much-needed break for the operator and allow them to rest their legs and back for a short duration during work. Studies have shown that providing short breaks for seated rest can significantly reduce musculoskeletal disorders in workers. Thus, introducing a seating option with a minimum duration of 10-15 minutes in every two hours shift can help to prevent leg pain, back pain, and other related problems.

Another solution is to introduce anti-fatigue mats on the work floor. These mats can help to reduce the impact of standing on the rigid floor by providing cushioning to the operator's feet. This can significantly reduce the strain on the leg muscles, resulting in less fatigue, and ultimately less pain. It has been observed that the use of anti-fatigue mats can significantly reduce leg pain, back pain, and other musculoskeletal disorders in workers who work in standing positions for extended periods.

The introduction of ergonomic workstations is another possible solution. Ergonomic workstations can be designed to provide the operator with an adjustable height work surface that can be easily adjusted to the operator's individual needs. This can significantly reduce the strain on the legs and back muscles by allowing the operator to work in a more comfortable and natural position. The ergonomic workstation can also be equipped with other features, such as adjustable footrests, armrests, and lumbar supports to further enhance the comfort level of the operator during work.

Lastly, the introduction of job rotation can also help to reduce the risk of musculoskeletal disorders. This involves rotating the operator's tasks between different machines or tasks after every two hours of work. This can reduce the strain on specific muscle groups and prevent the accumulation of muscle fatigue. By rotating the tasks, the operator can avoid repeating the same motion for extended periods, thereby reducing the risk of developing musculoskeletal disorders.

Overall, the above solutions can significantly reduce leg pain, back pain, and other related problems that arise due to continuous standing work on rigid surfaces. The implementation of these solutions can create a safer and healthier work environment for the machine operator, resulting in a more productive and efficient workforce.

6.2.9 Lifting of Raw Material:

Based on the observation report, it is clear that the manual lifting of raw material to supply it to the injection moulding machine is a potential hazard for the operator. Lifting heavy loads can lead to a number of musculoskeletal disorders, which can be both acute and chronic in nature. These disorders can affect the muscles, tendons, ligaments, and nerves, causing pain, stiffness, and reduced mobility. In addition, the repeated lifting of heavy loads can also lead to fatigue, which can increase the risk of accidents and injuries.

To avoid these potential hazards, there are a number of possible solutions that could be implemented. One option would be to provide a mechanical lifting aid, such as a hoist or conveyor belt, to lift the raw material to the injection moulding machine. This would eliminate the need for manual lifting, reducing the risk of injury and increasing productivity. Alternatively, the raw material could be stored at a higher level, so that it can be fed directly into the injection moulding machine without the need for lifting.

Another solution would be to modify the design of the injection moulding machine itself. For example, the machine could be designed to have a lower feeding height, so that the operator does not have to lift the raw material as high. This could be achieved through the use of a platform or other mechanical aid. Additionally, the machine could be designed to have a built-in lifting mechanism, such as a hydraulic lift, which would allow the operator to easily lift and move the raw material.

It is important to note that whatever solution is implemented, it should be done in consultation with the operators themselves. This will help to ensure that the solution is practical and effective, and that it meets the specific needs of the operators. Additionally, regular training and education should be provided to the operators to ensure that they are using the lifting aids correctly and safely. By implementing these measures, it is possible to reduce the risk of injury and improve the overall safety and efficiency of the injection moulding process.

6.2.10 Nose Mask:

During our initial observation phase, we noticed that the machine operators at the injection moulding facility were not provided with any masks to protect their lungs from the fumes and odors generated by the molten rubber. The operators are the first ones to come in contact with the molten rubber smell, and they are exposed to it for long durations, which can lead to respiratory problems. This is a serious concern as the long-term effects of exposure to such fumes can be damaging to their health.

To address this issue, we recommend that the management should provide appropriate respiratory protection equipment such as masks to the machine operators. These masks should be specifically designed to protect the workers from the fumes generated during the injection moulding process. Additionally, regular training sessions should be conducted to educate the workers on the importance of wearing masks and how to use them correctly.

Apart from this, it is also important to ensure proper ventilation in the work area to minimize the number of fumes that are generated. The company can install exhaust systems and air filters to remove any harmful particles from the air. Moreover, it is recommended to conduct regular air quality testing to ensure that the air quality is within acceptable limits.

Lastly, it is important to provide workers with adequate breaks to allow their lungs to recover from prolonged exposure to the fumes. This can be achieved by scheduling frequent breaks for the workers, during which they can leave the work area and breathe in fresh air. The breaks should be of sufficient duration to allow the lungs to recover fully. By implementing these measures, the company can significantly reduce the risk of respiratory problems among its workers.

6.2.11 Suns Cream and Body Lotion:

During our observation in the injection moulding plant, we noticed that no sun cream or body lotion was provided to the machine operators. As the operators are working in an environment that operates at a high temperature of 300 degrees, it is essential to protect their skin from the heat and prevent any skin damage. The exposure to such high temperatures for prolonged periods can lead to skin burns and long-term skin damage, which can be prevented by providing proper protective measures.

One possible solution to avoid skin damage is to provide sunscreen lotions with a high SPF factor to the machine operators. This will protect their skin from the harmful UV rays that can cause sunburns and other skin-related problems. Additionally, providing moisturizing body lotion can help to prevent skin dryness and reduce the risk of skin damage due to prolonged exposure to high temperatures. It is recommended to choose products that are specifically designed for use in high-temperature environments and provide adequate protection against heat and UV rays.

Another possible solution to avoid skin damage is to encourage operators to wear full-sleeve shirts and pants that cover their skin while working. These clothing items can act as a barrier and prevent direct contact of the skin with the high-temperature environment. Moreover, it is essential to provide clean and breathable work clothes to the operators that can absorb sweat and prevent skin irritation.

Furthermore, providing regular training to the operators on how to protect their skin from the heat and prevent any skin damage can be helpful. The training should include information on the correct use of protective equipment, such as sunscreen, body lotion, and clothing, and the signs and symptoms of skin damage. The operators should be encouraged to report any skin-related issues immediately to the management.

In conclusion, it is crucial to take adequate measures to protect the machine operators' skin from the high-temperature environment in the injection moulding plant. Providing proper protective equipment, such as sunscreen and body lotion, and encouraging the use of full-sleeve clothing can help prevent skin damage. Additionally, regular training on skin protection can help operators to take better care of their skin and avoid any long-term skin-related problems.

Implementation of New Storage Areas: New storage areas were implemented to improve accessibility to tools and materials, thereby reducing the risk of injury from handling heavy or awkward objects.

6.2.12 Small capacity storage box for raw material:

During our first phase observation at the injection moulding plant, we noticed that the storage box for raw material had a small capacity. As a result, the operator had to refill the storage box three times in a single shift. This caused a significant amount of downtime and reduced productivity. The small capacity of the storage box also created a potential safety hazard as it required the operator to frequently access the area around the machine, which increases the risk of injury.

To address this issue, we suggest increasing the capacity of the storage box for raw material. This would reduce the amount of time the operator spends refilling the box and increase the efficiency of the injection moulding process. Additionally, a larger capacity storage box would reduce the need for the operator to access the area around the machine, which would help to prevent accidents and injuries. It is also important to ensure that the new storage box is located in a safe and convenient location for the operator to access.

Furthermore, to improve the overall efficiency and safety of the injection moulding process, it may be beneficial to implement a system for automatically refilling the storage box. This would reduce the amount of manual labor required by the operator and increase the consistency of the raw material supply, leading to improved product quality. This can be achieved by installing a hopper and feeder system that can transfer the raw material to the storage box automatically.

Another solution to consider is increasing the frequency of raw material delivery to the plant. By ensuring a more regular supply of raw materials, the storage box can be kept consistently full, reducing the need for frequent refilling. This solution would require close coordination with the supplier to ensure that the required quantity of raw material is delivered on time, but it would significantly improve the efficiency of the injection moulding process and reduce the operator's workload.

6.2.12 Machine operator have to bend 45 degrees to throw the waste material:

During our first phase observation of the injection moulding process, we noticed that the machine operator has to bend down at a 45-degree angle to dispose of the waste material produced during the production process. This bending motion can lead to several musculoskeletal disorders and can cause physical strain on the operator's lower back muscles.

To avoid this, we recommend that a separate disposal system be installed in the work area, which will not require the operator to bend down or move away from the machine to dispose of the waste material. This system could be in the form of a chute or a conveyor belt, which will allow the waste material to be easily transported to a designated waste disposal area.

Another possible solution would be to adjust the height of the waste disposal bin to match the operator's height, so that he does not have to bend down to dispose of the waste material. This will help to reduce the risk of musculoskeletal disorders and injuries caused by repetitive bending motions.

In addition to these solutions, we suggest that the operator be provided with proper training on ergonomic work practices and techniques that can help to reduce the physical strain on their body. This can include training on proper posture and lifting techniques, as well as regular stretching exercises to keep their muscles relaxed and prevent stiffness.

Overall, the implementation of these solutions can help to improve the working conditions for the machine operator and reduce the risk of musculoskeletal disorders and injuries caused by repetitive bending motions. It is important to prioritize the health and safety of the workers in any production process, and these solutions can go a long way in achieving that goal.

a) Before | b) After

Fig 6.4 Before and after rejection box

6.2.13 Raw material storage box:

During the first phase of observation, it was noted that the operator had to refill the raw material storage box multiple times in a single shift due to the small capacity of the storage box. To refill the box, the operator had to pull and drag the box from the work area to the refill section and back, which required a considerable amount of physical effort. It was observed that the empty box weighed around 0.5 kg while the full box weighed around 15 kg, which made the task even more challenging for the operator.

To avoid this problem, there are several solutions that can be implemented. One possible solution is to increase the capacity of the storage box so that the operator does not have to refill it as frequently. Another solution is to relocate the storage box closer to the work area to reduce the distance that the operator has to drag it. This can be done by installing a conveyor system that can move the raw materials from the storage area to the work area without any manual effort.

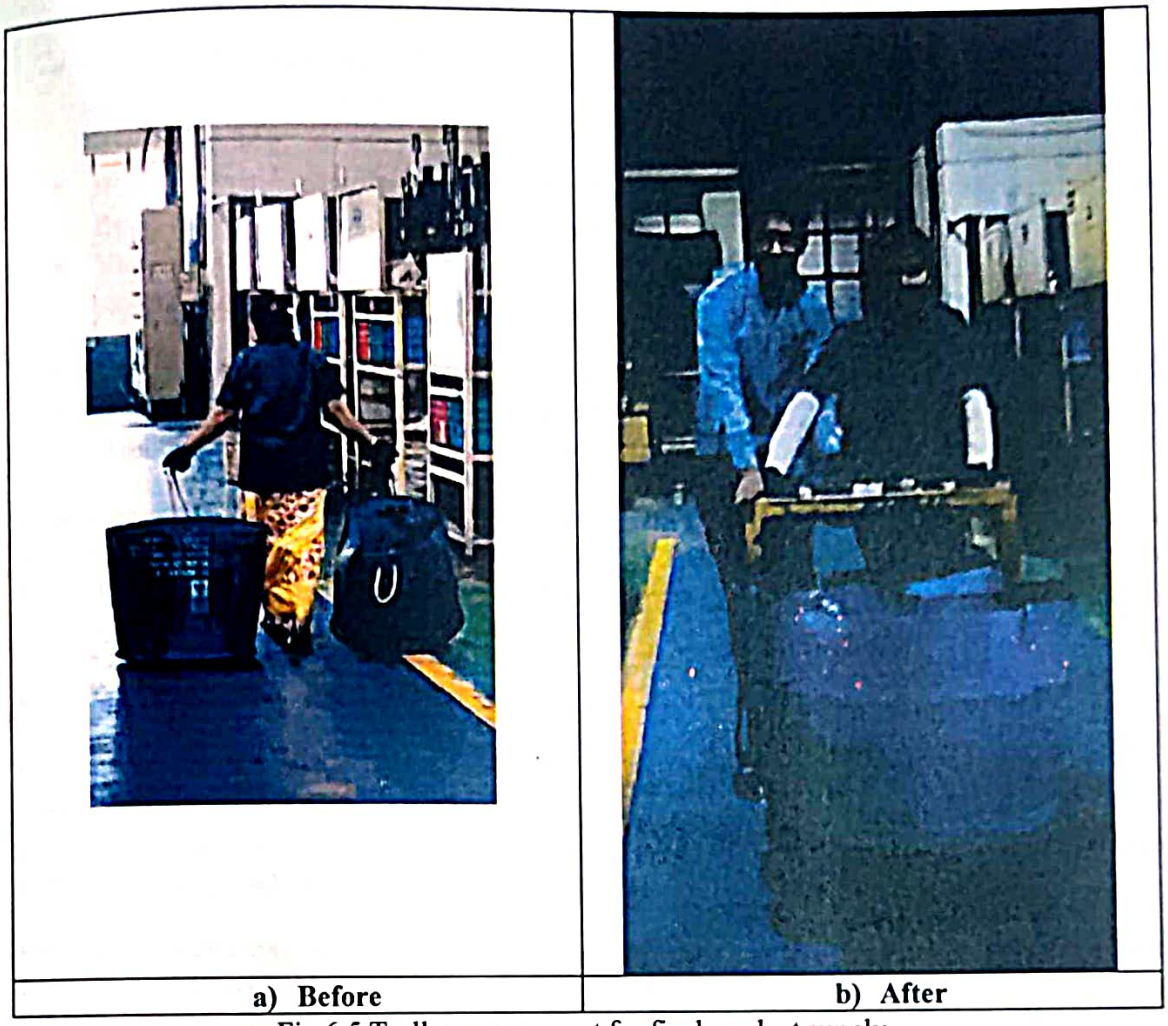
Additionally, introducing a trolley or a cart that can carry the box would be another effective solution to reduce the physical effort required to transport the box. The trolley or cart can be designed to have wheels and a handle for easy mobility, and can be placed near the work area to facilitate quick and easy access. This would not only reduce the physical strain on the operator but also increase the efficiency of the process.

Moreover, the use of automation technology can be considered to eliminate the need for manual transportation of the raw material storage box. This can be achieved by incorporating a robotic arm or a conveyor belt that can transport the raw material box to the work area automatically. This would significantly reduce the physical strain on the operator and improve the overall efficiency of the operation.

Overall, there are several possible solutions that can be implemented to avoid the physical strain on the operator caused by the repeated task of refilling the raw material storage box. By implementing these solutions, the operator's workload can be significantly reduced, and the efficiency of the operation can be improved.

In addition to the weight of the storage box, another concern that arises from dragging it is the strain it puts on the operator's muscles. The repeated motion of dragging a heavy load can lead to muscle fatigue, pain, and even injury over time. This can have a significant impact on the operator's physical health and overall well-being, as well as their productivity and efficiency at work.

To address this issue, there are a few possible solutions. One option is to provide the operator with a wheeled cart or trolley to transport the storage box between the work area and refill section. This would reduce the amount of dragging required and make the task less physically demanding for the operator. Another solution could be to redesign the layout of the work area and refill section to reduce the distance between them, minimizing the amount of dragging required. Additionally, providing training to the operator on proper lifting techniques and encouraging regular breaks can.



a) Before | b) After

Fig 6.5 Trolly management for final product supply

6.2.14 Promotion of Exercise and Yoga Asanas:

In the context of an injection moulding manufacturing plant, yoga can be a helpful tool for promoting the health and well-being of machine operators. Working in a factory setting can be physically demanding and mentally stressful, and yoga can help to counteract these effects by promoting relaxation, reducing muscle tension, and improving concentration and focus.

Some Yoga Asanas That Can Be Beneficial for Machine Operators:

- Tadasana (Mountain Pose) - This asana helps improve posture and relieve back pain.
- Uttanasana (Standing Forward Bend) - This pose helps stretch the hamstrings, calves, and hips, which can become stiff from standing for long periods.
- Vrikshasana (Tree Pose) - This pose helps improve balance and stability, which can be important for machine operators who are required to stand for long periods.

- Ardha Matsyendrasana (Half Lord of the Fishes Pose) - This pose helps relieve tension in the spine and improve digestion, which can be beneficial for those who work in physically demanding jobs.
- Bhujangasana (Cobra Pose) - This pose helps strengthen the back muscles and improve flexibility, which can be beneficial for those who have to perform repetitive motions.
- Virabhadrasana (Warrior Pose) - This pose helps strengthen the legs, hips, and back muscles, which can be important for those who are required to stand for long periods.

It's important to note that before starting any yoga practice, it's important to consult with a certified yoga instructor to ensure proper alignment and safety. Additionally, it's important to listen to your body and modify or skip any poses that cause pain or discomfort.

Yoga is an ancient Indian practice that combines physical postures, breathing techniques, and meditation to promote overall health and well-being. It has been shown to have a range of benefits for the body and mind, including reducing stress, improving flexibility, and increasing strength and balance.

6.2.15 Exercises:

Regular exercise and stretching can be beneficial for machine operators who have to perform repetitive motions and maintain the same position for long periods of time. It can help to improve their posture, reduce stress, increase flexibility, and prevent or alleviate musculoskeletal disorders such as back pain, neck pain, and carpal tunnel syndrome.

some exercises that may be helpful for machine operators. However, please note that it's important to consult a certified fitness professional before starting any new exercise program, especially if you have any medical conditions or injuries.

- Shoulder and neck stretches: Sitting for long periods can cause tension in the neck and shoulders, which can lead to pain and discomfort. To relieve this tension, try doing some shoulder and neck stretches throughout the day. For example, you can try slowly rolling your shoulders forward and back, or gently tilting your head from side to side.
- Wrist and hand exercises: Machine operators often perform repetitive motions with their hands and wrists, which can lead to conditions like carpal tunnel syndrome. To prevent these types of injuries, it's important to do regular exercises that help to strengthen and stretch the muscles in the hands and wrists. Some examples include finger stretches, wrist rotations, and hand squeezes.
- Back stretches: Sitting for long periods can also cause tension in the lower back, which can lead to pain and discomfort. To prevent this, try doing some simple back stretches throughout the day.

For example, you can try bending forward at the waist and reaching for your toes, or lying on your back and pulling your knees up to your chest.

- Cardiovascular exercise: Regular cardiovascular exercise, such as walking, running, or cycling, can help to improve overall fitness and reduce the risk of conditions like heart disease and obesity. Even just 20-30 minutes of moderate-intensity exercise per day can be beneficial.
- Yoga: Yoga is a form of exercise that combines physical postures with breathing techniques and meditation. It can be a great way to reduce stress, improve flexibility, and increase strength and balance. Some specific yoga poses that may be helpful for machine operators include downward dog, warrior II, and the seated spinal twist.

It's important to start any new exercise program slowly and gradually, and to listen to your body to avoid injury.

Fig 6.6 Exercise before starting shift

Fig 6.7 Exercise finger (stretching)

Fig 6.8 Exercise finger(stretching)

Fig 6.9 Exercise for back pain

Fig 6.10 Exercise for back pain

6.2.16 Suggestions to improve the operator's attention and mood while working:

Provide a clean and well-organized work environment: A cluttered and dirty work environment can lead to distraction and stress. Providing a clean and well-organized work environment can help to reduce distractions and improve the operator's mood and focus.

- Provide appropriate lighting: Poor lighting can lead to eye strain and headaches, which can negatively affect the operator's attention and mood. Providing appropriate lighting can help to reduce eye strain and improve the operator's mood and focus.
- Provide comfortable seating: Sitting in an uncomfortable chair for long periods can lead to back pain and discomfort, which can negatively affect the operator's attention and mood. Providing comfortable seating can help to reduce back pain and discomfort and improve the operator's mood and focus.
- Encourage breaks: Taking short breaks throughout the workday can help to reduce stress and improve the operator's mood and attention. Encouraging operators to take short breaks can also help to prevent burnout and increase productivity.
- Provide healthy snacks and drinks: Providing healthy snacks and drinks such as fruits, nuts, and water can help to improve the operator's mood and attention. Consuming unhealthy snacks and drinks can lead to a crash in energy levels and negatively affect the operator's attention and mood.
- Provide opportunities for social interaction: Social interaction with co-workers can help to improve the operator's mood and attention. Encouraging social interaction during breaks or lunch can also help to build a sense of community and reduce stress.
- Provide opportunities for professional development: Providing opportunities for professional development such as training or education can help to improve the operator's mood and attention. Opportunities for growth and development can also help to increase job satisfaction and reduce stress.

few additional suggestions to improve operator's attention and help them maintain a good mood while working in a standing position in high temperature:

Provide regular breaks: Regular breaks are important for allowing the operator's body and mind to recover from the physical and mental demands of the job. Short, frequent breaks can help the operator stay fresh and focused.

- Keep the workplace comfortable: The workplace should be well-ventilated and maintained at a comfortable temperature. If possible, provide air conditioning or fans to help keep the temperature down. Also, ensure that the operator has access to plenty of cool drinking water.
- Provide comfortable footwear: Wearing comfortable shoes or boots with good support can help reduce fatigue and improve the operator's mood.

- Provide anti-fatigue mats: Standing on hard surfaces for extended periods can cause fatigue and discomfort. Providing anti-fatigue mats can help reduce the stress on the operator's feet, legs, and lower back.
- Offer stress management training: High-stress jobs can take a toll on the operator's mental and emotional well-being. Providing stress management training can help the operator learn how to manage stress and maintain a positive attitude.
- Promote exercise: Encourage the operator to engage in regular exercise outside of work. Exercise has been shown to improve mood and cognitive function, which can translate to better performance on the job.

Offer healthy food options: Providing healthy food options can help improve the operator's mood and energy levels. Eating a balanced diet with plenty of fruits, vegetables, lean proteins, and whole grains can help keep the operator feeling alert and focused.

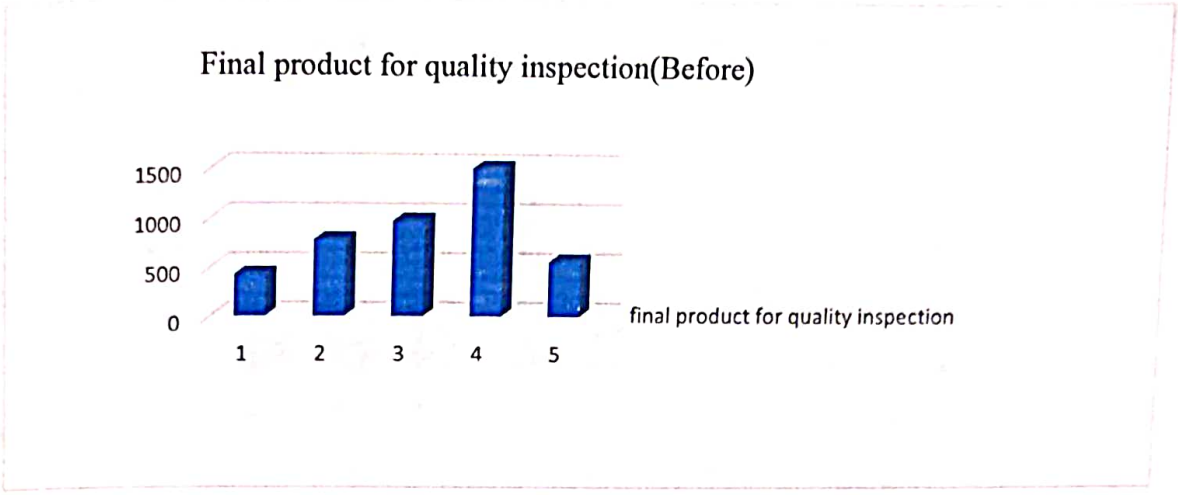
6.3 Phase 3: Data Collection

The third phase of the study involved the collection and analysis of data to evaluate the effectiveness of the interventions. The data was collected through the following methods:

- Measurement of Productivity: The productivity of injection moulding operations was measured before and after the implementation of the interventions to determine the impact of the interventions on productivity.

Sr no	1	2	3	4	5
Name of product	Duct (Hose bellow mixture)	Duct (Air filter inlet)	Bellow spiral large	Sleeve carburettor	Wheel Damper
Cavity	4	6	12	32	8
Shots in hr	10	13	8	7	9
Products in hr	40	78	96	224	72
Time in hr	10:26 to 11:26	10:52 to 11:52	8:14 to 9:14	11:00 to 12:00	9:10 to 10:10
Products(pieces) in 12 hr	480	936	1152	2688	864
Wastage in 12 hr	10	13	15	20	10
Final product for quality inspection	470	950	1137	2668	854

Table 6.3 Production data before implementation



Graph No. 6.4 Final product for quality inspection (Before)

Sr no	Name of product	Cavity	Shots in hr	Products in hr	Time in hr	Products (pieces) in 12 hr	Wastage in 12 hr	Final product for quality inspection
1	Duct (Hose bellow mixture)	4	9	36	10:26 to 11:26	432	10	422
2	Duct (Air filter inlet)	6	11	66	10:52 to 11:52	792	20	772
3	Bellow spiral large	12	5	60	8:14 to 9:14	720	25	965
4	Sleeve carburettor	32	4	128	11:00 to 12:00	1536	40	1496
5	Wheel Damper	8	6	48	9:10 to 10:10	576	22	554

Table 6.5 Production data after implementation

Graph No. 6.6 Final product for quality inspection (After)

Interview after implementation:

Fig 6.11 Interview after implementation

Interview Questions are as follow:

Q1) How do you feel after the new implementation?

Ans: -Really good and comfortable

Q2) The implement that we have done for the raw material supply to machine is comfortable?

Ans: -Yes, it's really useful it reduces the stress of back muscle

Q3) The new long hand glows are comfort?

Ans: -Yes, it's comfortable and useful for prevent heat

Q4) What about new air coolers?

Ans: - It is one off the biggest need and is fulfilled now. we are happy.

Q5) New area of sludge deposit box is comfortable?

Ans: -Now comfortable

Q6) Sitting stools and chairs are useful or not is that increase your comfort?

Ans: -Yes, Arrangement was really good better than before.

Q7) Lunch break is increasing by 10 min is it sufficient?

Ans: - now its sufficient to eat and take a 5 min rest after the lunch.

Q8) I this face masks useful to prevent rubber burnt gases?

Ans: -Yes, it's really good and comfortable because rubber has very poisons mixture and more harmful

Q9) Now how do you feel to operate the machine?

Ans: -Now I can comfortably work and my stress also reduced muscle pain after the shift finish is also reduced.

10)How do you feel after the yoga?

Ans: -Yoga is good and feels happy and increase the working power.

11)Is there any increase in productivity?

Ans: -Yes, definitely increased some machines have increased more than his one shot and many increased by 2/3 shots per hour increased.

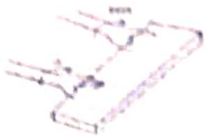
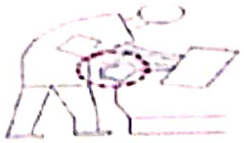
Sr No	Factors	Illustration	Description	Reasons
1	Wrong gripping and grasping of objects Effect on: wrist and hand		Left hand fingers are over the surface and thumb is underneath while vice-a- versa for right hand which is wrong activity as per ergonomics	Part design not suitable for grasp and hold, lack of awareness to hold part
2	Bending Effect on: Wrist and hand		Too much body bending for loading to station and picking parts from bin (~ 70°)	height of workstation is less
3	Frequent and long walk for material handling Effect on: leg and foot		Distance between workstation and destination like tool, bin, button etc is more	poor facility layout
4	Antigravity lifts effect on shoulders and Hands		Lifting originally not allowed in workplace design as it is antigravity task takes more time, fatigue causing even in this study lifting task seen above chest which is even more severe.	Size, Weight of parts are not suitable to handle it manually, no assistance for material handling
5	Stressed body posture Effect on: various body parts depending on posture		Improper loading of parts since workstation design causes complex and stressed body movements	Poor workplace design and less awareness of body postures
6	Eye Movements Effects on: Eye and pupil		Eye movements are frequently changed for picking parts, pressing button etc.	Poor work layout and less awareness of movements
7	Critical area working Effect on: Whole body		Working in critical area of parts and resistance due to workstation design causes complex task hence time consumption is more	Tool geometry and workstation design

Table No. 6.7 Ergonimic analysis data (Source: [4])

Sample sheet of motion study implementation data:

MOTION STUDY/BEFORE IMPLEMENT				
OPERATOR ACTIVITY DETAILS				
ORGANISATION : MASK POLYMER PVT.LTD	LINE INCHARGE NAME:	MR.RAJU NIRGUDE		
MACHINE NAME : DESMA SIGMA 250T	OPERATOR NAME:	KULDEEP SINGH		
OPRATION NAME : INJECTION MOULDING	PART NO/NAME :	C001235/RUBBER BELLOW		
S.NO	ACTIVITIES	TIME IN SECONDS		SYMBOL
1	Pushing and bringing raw material bin	15		Search
2	To insert raw material strip in injection tunnel	10		Plan
3	press the start button from control pannel	5		Position
4	product remove from cavity mould/ front side	15		Rest
5	product remove from cavity mould/ Back side	20		Inspect
6	Remove product flash and throws it the bin	10		Find
7	check visual inspection and put ok part in green bin & rejected part in r	20		Assemble
8	toilet Distance long so required more time	300		Avoidable Delay
9	cut rubber strip in continous form	50		Unavoidable Delay
10	wasted bin material fill in container	30		Preposition
11	water spray in raw material satrip	5		Use
12	operator continous bend for wasted material throws .	10		Transport Loaded
13	mould change	150		Transport Empty
TOTAL TIME IN SECONDS		640		

Table No. 6.8 Sample sheet of motion study before implementation

MOTION STUDY/AFTER IMPLEMENT				
OPERATOR ACTIVITY DETAILS				
ORGANISATION : MASK POLYMER PVT.LTD	LINE INCHARGE NAME:	MR.RAJU NIRGUDE		
MACHINE NAME : DESMA SIGMA 250T	OPERATOR NAME:	KULDEEP SINGH		
OPRATION NAME : INJECTION MOULDING	PART NO/NAME :	C001235/RUBBER BELLOW		
S.NO	ACTIVITIES	TIME IN SECONDS		SYMBOL
1	Pushing and bringing raw material bin/ After Using Wheel Trolly	10		Search
2	To insert raw material strip in injection tunnel	10		Plan
3	Press the start button from control pannel	5		Position
4	Product remove from cavity mould/ front side	15		Rest
5	Product remove from cavity mould/ Back side	20		Inspect
6	Remove product flash and throws it the bin	10		Find
7	Check visual inspection and put ok part in green bin & rejected part in red bin.	20		Assemble
8	Toilet Distance long so required more time/ After Toilet Arrangement nearby machine Sh	200		Avoidable Delay
9	Cut rubber strip in continous form	50		Unavoidable Delay
10	Wasted bin material fill in container / Using carry bag so easily putting in container	15		Preposition
11	Water spray in raw material satrip	5		Use
12	Operator continous bend for wasted material throws / After wasted & Rejection bin arrangement near left hand side & Right hand Side	10		Transport Loaded
13	mould change / After high pressure crane	100		Transport Empty
TOTAL TIME IN SECONDS		470		

Table No. 6.9 Sample sheet of motion study after implementation

Sample sheet of motion study implementation data:

MOTION STUDY/BEFORE IMPLEMENT

OPERATOR ACTIVITY DETAILS

ORGANISATION : MASK POLYMER PVT.LTD	LINE INCHARGE NAME:	MR.RAJU NIRGUDE
MACHINE NAME : DESMA SIGMA 250T	OPERATOR NAME:	KULDEEP SINGH
OPRATION NAME : INJECTION MOULDING	PART NO/NAME :	C001235/RUBBER BELLOW

S.NO	ACTIVITIES	TIME IN SECONDS	SYMBOL
1	Pushing and bringing raw material bin	15	Search
2	To insert raw material strip in injection tunnel	10	Plan
3	press the start button from control pannel	5	Position
4	product remove from cavity mould/ front side	15	Rest
5	product remove from cavity mould/ Back side	20	Inspect
6	Remove product flash and throws it the bin	10	Find
7	check visual inspection and put ok part in green bin & rejected part in r	20	Assemble
8	toilet Distance long so required more time	300	Avoidable Delay
9	cut rubber strip in continous form	50	Unavoidable Delay
10	wasted bin material fill in container	30	Preposition
11	water spray in raw material satrip	5	Use
12	operator continous bend for wasted material throws .	10	Transport Loaded
13	mould change	150	Transport Empty
	TOTAL TIME IN SECONDS	640	

Table No. 6.8 Sample sheet of motion study before implementation

MOTION STUDY/AFTER IMPLEMENT

OPERATOR ACTIVITY DETAILS

ORGANISATION : MASK POLYMER PVT.LTD	LINE INCHARGE NAME:	MR.RAJU NIRGUDE
MACHINE NAME : DESMA SIGMA 250T	OPERATOR NAME:	KULDEEP SINGH
OPRATION NAME : INJECTION MOULDING	PART NO/NAME :	C001235/RUBBER BELLOW

S.NO	ACTIVITIES	TIME IN SECONDS	SYMBOL
1	Pushing and bringing raw material bin/ After Using Wheel Trolly	10	Search
2	To insert raw material strip in injection tunnel	10	Plan
3	Press the start button from control pannel	5	Position
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7	Check visual inspection and put ok part in green bin & rejected part in red bin.	20	Assemble
8	Toilet Distance long so required more time/ After Toilet Arrangement nearby machine Sh	200	Avoidable Delay
9	Cut rubber strip in continous form	50	Unavoidable Delay
10	Wasted bin material fill in container / Using carry bag so easily putting in container	15	Preposition
11	Water spray in raw material satrip	5	Use
12	Operator continous bend for wasted material throws / After wasted & Rejection bin arrangement near left hand side & Right hand Side	10	Transport Loaded
13	mould change / After high pressure crane	100	Transport Empty
	TOTAL TIME IN SECONDS	470	

Table No. 6.9 Sample sheet of motion study after implementation

Before Implementation Time in Seconds	640
After Implementation Time in Seconds	470
Total Saving Time in Seconds	170

6.4 Phase 4: Analysis the Data Collected in Phase 3:

The final phase of the study involved an Analyzing of the the Data Collected in Phase 3 on Measurement of Productivity, Quality, Operator Satisfaction, Injury Rates of ergonomic and safety practices in injection moulding operations. The Analysis was conducted to identify best practices in other industries and to identify areas for further research.

The suggestions and recommendations made during the analytical phase were implemented in the injection moulding process to improve the working conditions for the machine operators. The first step taken was to provide the operators with triple layer gloves to protect them from the heat of the moulded plastic. Additionally, they were advised to use sunscreen to protect themselves from harmful UV radiation, which can lead to skin damage.

To reduce the likelihood of repetitive strain injuries, the operators were instructed to perform certain actions simultaneously instead of repeatedly, and were given ergonomic tips to help them maintain a healthy posture while working. For instance, operators were advised to avoid bending their necks and backs, which can cause strain on the spine, and to use footrests to ensure a comfortable seating position.

To enhance the overall safety of the workplace, operators were asked to wear masks to avoid inhaling plastic fumes, which can lead to respiratory problems, and were encouraged to take breaks to rest their eyes and reduce the risk of accidents due to fatigue. Additionally, they were provided with a new storage box area that was easier to access, reducing the need for unnecessary bending and stretching.

To reduce stress and fatigue, yoga asanas and exercises were recommended for the operators to perform during breaks. The recommended exercises were tailored to the daily actions of the operators, ensuring that the exercises were relevant and effective. The purpose of the exercises was to reduce stress levels and improve overall wellbeing, allowing the operators to work more efficiently and effectively.

Overall, the implementation of the recommendations made during the analytical phase of the project resulted in significant improvements in the working conditions of the injection moulding process. The operators reported feeling more comfortable, safe, and less fatigued while working, which ultimately led to an increase in productivity.

6.4.1 Vitamins and minerals:

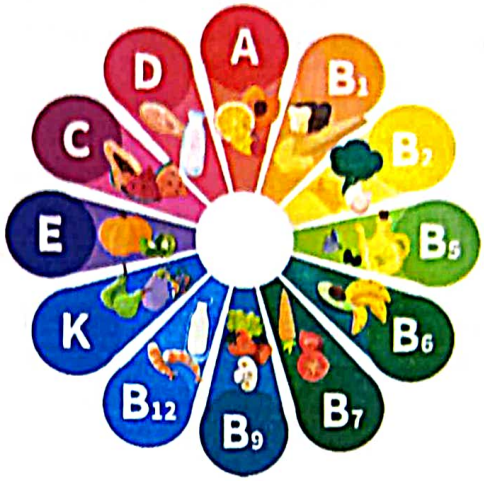

Fig 6.12 Vitamins and minerals diagram

- Magnesium: This mineral is essential for muscle and nerve function, and can help prevent muscle cramps and stiffness during prolonged standing. Foods rich in magnesium include spinach, almonds, avocados, and dark chocolate.
- Potassium: Another mineral that supports muscle function, potassium helps regulate fluid balance in the body and can help prevent swelling in the legs and feet during prolonged standing. Bananas, sweet potatoes, and leafy greens are good sources of potassium.
- Vitamin D: This vitamin is important for bone health and can help prevent the development of osteoporosis, a condition that can increase the risk of fractures from standing for long periods of time. Vitamin D is produced by the body when exposed to sunlight, but can also be found in fatty fish, egg yolks, and fortified foods.
- Vitamin C: This antioxidant vitamin is important for immune system function and can help reduce inflammation and swelling in the legs and feet during prolonged standing. Citrus fruits, bell peppers, and broccoli are good sources of vitamin C.
- Iron: This mineral is essential for oxygen transport in the body and can help prevent fatigue and weakness during prolonged standing. Red meat, poultry, seafood, beans, and leafy greens are good sources of iron.

6.4.2 Suitable height:

The suitable height for the machine operator will depend on several factors such as the task being performed, the operator's anthropometry, and the ergonomic design of the workstation. However, as a general guideline, the ideal height for the machine operator should allow for a comfortable posture that minimizes excessive bending or reaching.

If the working area of the machine is between 0.80 meters to 1.30 meters in height, a suitable height for the operator would be between 1.50 meters to 1.75 meters. This range should allow for a comfortable working posture and minimize the risk of musculoskeletal disorders caused by awkward postures.

However, it is important to note that the height of the operator is not the only factor to consider when designing an ergonomic workstation. Other factors such as the layout of the workstation, the adjustability of the equipment, and the task requirements should also be taken into account to ensure optimal ergonomic design.

Certainly, the suitable height of the machine operator for a machine with a working area between 0.80 meter to 1.30 meter in height can depend on various factors such as the height of the operator, the type of work being performed, and the available space.

6.4.3 An operator's health:

A healthy operator is essential for any manufacturing company. It is because the operator is the backbone of the production line, and their well-being is a crucial factor in determining the success of the company. A healthy operator is less likely to take sick leaves, which in turn increases the productivity of the company. Moreover, a healthy operator is more efficient in their work, which results in high-quality products. By providing a safe and ergonomic working environment, the operator's overall health and well-being can be maintained, leading to increased job satisfaction and loyalty. This can result in a higher retention rate of skilled workers, which can benefit the company in the long run. Thus, the company must prioritize the operator's health and safety as it not only benefits the operator but also the company's productivity and profitability.

Certainly! The health and well-being of an operator is crucial to the long-term success and profitability of a manufacturing company. It is well known that work-related injuries and illnesses can have a negative impact on a worker's quality of life and long-term health. These injuries can also result in costly medical bills, workers' compensation claims, and legal fees for the company. By prioritizing the health and safety of their operators, companies can create a positive work environment that is conducive to higher levels of productivity, job satisfaction, and employee retention. Additionally, healthy operators are more likely to have a higher quality of work and perform better on the job, leading to increased efficiency and profitability for the company. Investing in ergonomic improvements, safety training, and health promotion programs can help to ensure the well-being of operators and ultimately result in a more successful and sustainable business.

6.4.4 Maximum suitable temperature:

The maximum suitable temperature for the human body to work in varies depending on various factors such as humidity, physical activity, and clothing worn. Generally, the maximum suitable temperature is around 30-35 degrees Celsius. However, when working in an environment with

high temperatures, it is crucial for the machine operator to take necessary precautions to ensure their safety and well-being.

When working on a rubber injection moulding machine that operates at a temperature of 300 degrees Celsius, the machine operator must take several safety precautions. Firstly, they should wear proper Personal Protective Equipment (PPE) such as heat-resistant gloves, aprons, and shoes to protect themselves from high temperatures and prevent burns. Secondly, they should ensure that the machine is in good working condition and all safety measures are in place. Thirdly, the operator should avoid wearing synthetic or loose clothing that could catch fire or get stuck in the machine.

Moreover, the operator should be trained in proper handling of the machine and its components, such as the heating elements and injection moulding materials. They should also be trained to recognize and handle any emergencies that may arise during operation. In addition, it is important to provide a cool and well-ventilated work environment to help regulate body temperature and avoid heat-related illnesses.

Overall, working in high-temperature environments can be hazardous and requires proper safety measures and precautions to ensure the well-being of the machine

CHAPTER 7

FUTURE SCOPE

7. FUTURE SCOPE

The findings of this study open avenues for further research and development in the field of injection moulding ergonomics. Based on the results of the study, the following future scopes are suggested:

1. Implementation of Automated Systems: The study results showed that repetitive and manual tasks can cause fatigue and discomfort in the operators. Therefore, the future scope of this study involves the implementation of automated systems for monotonous tasks to reduce operator fatigue and increase productivity.

2. Smart PPE: The study identified the need for better personal protective equipment (PPE) for the operators. Future research could explore the development of smart PPE that could continuously monitor the operator's health and safety while working.

3. Further Research on Ergonomic Interventions: This study focused on the ergonomic interventions that can improve productivity in injection moulding. Future research could explore additional ergonomic interventions that could further improve the operator's health, safety, and productivity.

4. Investigation of the Impact of Product Design: The study showed that the product design can impact the operator's productivity and safety. Therefore, future research could investigate the impact of product design on the operator's safety, comfort, and productivity.

5. Implementation of Lean Manufacturing Techniques: The study identified several areas where the injection moulding process can be streamlined to improve efficiency and reduce waste. Future research could focus on implementing lean manufacturing techniques to optimize the injection moulding process.

Overall, the future scope of this study is to improve the health and safety of injection moulding operators and increase productivity through the implementation of advanced technologies and ergonomic interventions.

CHAPTER 8

CONCLUSION

8. CONCLUSION

In conclusion, this study aimed to investigate the ergonomics and motion study of injection moulding operation for the improvement of productivity. The study found that the injection moulding operators faced several challenges that impacted their productivity and well-being, such as physical strain, repetitive motions, exposure to hot surfaces, and lack of attention, among others. To address these challenges, the study utilized ergonomic and motion study techniques to identify potential improvements and implemented several changes, such as suggesting triple layer gloves, using sunscreen, avoiding repeated motions, and promoting exercise and yoga asanas.

The results of the study indicated that the proposed improvements positively impacted the productivity and well-being of the injection moulding operators. Specifically, the study found that the suggested changes resulted in increased efficiency, reduced physical strain, and improved operator safety. The study also highlighted the importance of taking an ergonomic approach to design workstations and optimize the work environment for improved productivity and worker well-being.

As a future direction, this study suggests that further research should be conducted to evaluate the effectiveness of ergonomic interventions on a larger scale and in different industrial settings. Additionally, it would be useful to investigate the impact of implementing more advanced technologies such as automation, artificial intelligence, and machine learning on the productivity and safety of injection moulding operations. These technologies could potentially further enhance efficiency, reduce physical strain, and minimize safety hazards.

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APPENDIX:

Full Name of Operator	Surekha Bhaskar Mule	Raisingh kanvar	Kamta kumar	Ashok Pal	Renuka dnyneshwar bhokre	Kuldeep singh
Age	37	18	18	40	37	23
Gender	Male	Male	Male	Male	Female	Male
Height	5 feet	5	4.8	6 fit	5.8	5
Experience of working in this field	8 yrs. total 3 yrs. in moulding	1 month	1 yr total 7 months on desma	12 years	12 years	6 yr
How many hours per day do you operate the machine?	12 Hr	12 hr	12	12	12	12
Current working position	Standing	Standing	Standing	Standing	Standing	Standing
Do you do same work every day or different-different work	Same	Same	Same	Same	Same	Same
Do you exercise Everyday	No	No	No	No	No	No
Do you experience discomfort or pain in your hands, arms, or back while operating the machine?	Hands, back, neck or shoulders	Hands, arms back, neck or shoulders	Hands, arms, back, neck or shoulders	hands;back;neck or shoulders	arms; back; neck or shoulders	back; neck or shoulders
Have you ever experienced an injury related to operating the machine?	Yes	Yes	Yes	Yes	Yes	Yes
Have you received any training on proper ergonomic techniques for operating the machine?	Yes	No	Yes	Yes	Yes	Yes

Do you have access to ergonomic equipment, such as wrist supports or adjustable chairs, while operating the machine?	No	No	No	No	No	No
Do you feel that your employer is supportive of implementing ergonomic measures to improve working conditions for machine operators?	Yes	Yes	No	No	No	Yes
Have you ever reported any ergonomic issues related to operating the machine to your supervisor or HR department?	Yes	No	Yes	Yes	Yes	No
How satisfied are you with the current ergonomic measures in place for machine operators?	Satisfied	Neutral	Satisfied	Satisfied	Satisfied	Satisfied
Are there any additional ergonomic measures that you would like to see implemented in your workplace?	12 months Cooler required, Filtered water,	Cooling fans	12-month air cooler, increase exhaust fan	chairs, air coolers, increase in break time	chairs ,12-month air coolers	air coolers, chairs

Do you have any other comments or suggestions related to ergonomics and operating the machine?	Rubber smell if rubber material changed maintain rubber material, cotton sleeves for hands for safety purpose, shoes also required from company not provided	Shift time should be less minimum 8 Hr	need chairs, filtered cooled water	decr ease the shift time as my age is 40	shift time should be 8 hr, break time should be 1 hr	
How long have you been operating the machine?	Last 3 years	Last 30 day's	7 months	Last 12 years	3yr	6yr
Do you take any breaks during your shift to rest or stretch your muscles?	No	No	No	No	x	No
Do you use any personal protective equipment (PPE) while operating the machine?	No	No	No	No	No	No
Do you find the machine controls and displays easy to use and read?	Yes	Yes	Yes	Yes	Yes	Yes
Do you have any concerns about the long-term effects of operating the machine on your health?	Yes	Yes	Yes	Yes	Yes	Yes
Have you ever experienced any mental or emotional stress related to operating the machine?	No	Yes	Yes	Yes	Yes	Yes
Have you ever received any	Yes	No	Yes	Yes	Yes	Yes

feedback from a healthcare professional regarding any physical discomfort or pain you experience while operating the machine?						
How frequently do you experience discomfort or pain while operating the machine?	4	3	3	4	3	4
Do you experience any discomfort or pain outside of work hours that you believe is related to operating the machine?	Yes	Yes	Yes	Yes	Yes	Yes
Have you ever missed work due to discomfort or pain related to operating the machine?	Yes	Yes	Yes	Yes	Yes	Yes
Do you believe that ergonomic adjustments could improve your performance while operating the machine?	Yes	Yes	Yes	Yes	Yes	Yes
Have you ever been given the opportunity to provide input on ergonomic improvements in the workplace?	No	No	No	No	No	No

Are there any external factors (such as environmental conditions or interruptions) that impact the efficiency of performing this task?	Yes	Yes	Yes	Yes	Yes	Yes
Have you ever worked with a supervisor or engineer to design a better process for performing this task?	Yes	No	No	No	No	No
Are there any tools or equipment that you use that are difficult to handle or operate?	yes; Raw material if not in proper cute they should be affected to load, to remove the final product they have issues	yes; Remove the final product, supply of raw material	yes; remove final product from die	yes; Removing final product from die	yes; removing final product	yes; removing final product
Are there any repetitive motions that you perform that cause discomfort or pain?	Yes	Yes	Yes	Yes	Yes	Yes
How do you feel at the end of your shift, and do you feel fatigued or stressed?	yes	yes	yes	yes	yes	yes
Are there any environmental factors that affect your work, such as	Yes	Yes	Yes	Yes	Yes	Yes

temperature or noise levels?						
Are there any specific tasks that you find particularly challenging or uncomfortable?	Hot surrounding and smell of rubber	Sludge removes and at the end of day collection of all sludge is difficult task	removing final product and supply raw material	Removing final product	removing final product from die	removing final product
strains or sprains, due to your work conditions?	Yes	Yes	Yes	Yes	Yes	Yes
Are there any specific changes or improvements you would like to see in your work environment to make it more comfortable and ergonomic?	yes	yes	yes	need chairs ,12-month air cooler	yes	yes
Are there any breaks or rest periods provided during your shift, and do you feel that they are adequate for your needs?	No	No	Yes	Yes	No	Yes
Have you ever received any training or education on proper posture, lifting techniques, or other ergonomic practices?	No	No	Yes	Yes	Yes	No

Have you ever been provided with ergonomic equipment, such as chairs or workstations, to help improve your work conditions?	No	No	No	No	No	No
Do you experience any discomfort or pain in your hands or arms while handling hot rubber or moulds?	Yes	Yes	Yes	Yes	Yes	Yes
How do you protect yourself from burns while working with hot rubber?	Hand gloves	Hand gloves and maintain proper gap with hot die	hand gloves	Han d glov es	hand glove s	hand gloves
Are there any specific tools or equipment that you use to handle hot rubber or moulds that are uncomfortable or difficult to use?	yes	yes	No	yes	yes	yes
Do you experience any discomfort or irritation due to the smell of rubber or burned gases in the workplace?	Yes	Yes	Yes	Yes	Yes	Yes
Have you experienced any health issues, such as headaches or respiratory problems, that you	Yes	Yes	Yes	Yes	Yes	Yes

think may be related to the smell of rubber or burned gases?						
Have you received any training or education on how to minimize exposure to the smell of rubber or burned gases while working?	Yes	No	No	No	No	No
Are there any ventilation systems in place to help control or reduce the smell of rubber or gases in the workplace?	Yes	Yes	Yes	Yes	Yes	Yes

Table: Worker Survey Data (Google form)

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Vilas Deotare for making full-time availability of all the laboratories and necessary equipment and also to all staff members for their encouragement and suggestions during the partial fulfillment of the project stage-II

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...this opportunity to express our hearty gratitude and sincere th anks towards our guide Prof Neeta karhadkar mam for her invalu able assistance for our project. We express our sincere thanks to the Project Co-ordinator Prof. Sagar Joshi sir, H. O. D. of E&TC Prof . Devtare sir and our respected Principal Dr. sir **for making full t ime availability of all the laboratories and necessary equi pment and also to all staff members for their encouragem ent and suggestions during the partial** fulfilment **of the pro ject.** 1. International Journal of Advanced Technology in Motoren ng and Science Volume No. 02, IssueNo. 05, May2014 2. Electron ic Material And elements P. C. Rao&D. V. Satrawe 3. Electronic Cir cuit& Device Millmen&Halkias 4. https://store. arduino. cc/usa/ar duino-uno-rev3 5. https://www. rakeshmondal. info/L293D-Motor-Driver 6. www. ijsr. net Volume four Issue three, March 7....

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This process is used in several industries, including automotive, aerospace, medical, and consumer goods

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Gat No. 109/110, Village Ambi, Tal. Maval, Dist. Pune - 410 507. Maharashtra (INDIA)
Phone : +912114307186, E-mail : mask@maskpolymer.com Website : www.maskpolymers.com
CIN NO. - U28920MH1999PTC111940

ISO/TS 16949 : 2009

MAY 20,2023

NO OBJECTION CERTIFICATE (NOC)

To Whom It May Concern,

This is to certify that **Mr.Ankush Gulhane, Mr.Naman nandurkar, Mr.Shreeyash Pol, Mr.Mayur Lokhande** has successfully completed his final year project titled ***"Ergonomics and Motion Study of Injection Moulding Operation for Improvement of Productivity"*** using the data and facilities of Mask Polymer pvt.Ltd. The project was completed under the supervision of **Prof.Santosh Dabhole**(Nutan maharastra institute of engineering and tech. Talegaon dahade) and in partial fulfillment of the requirements for the award of the Bachelor of Engineering (Mechanical) from Savitribai Phule Pune University.

The data used for the project was provided by Mask Polymer Pvt.Ltd and was solely used for academic purposes. The company has granted permission to **Mr.Ankush Gulhane, Mr.Naman nandurkar, Mr.Shreeyash Pol, Mr.Mayur Lokhande** to use the data and facilities required to complete the project.

We are pleased to inform that **Mr.Ankush Gulhane, Mr.Naman nandurkar, Mr.Shreeyash Pol, Mr.Mayur Lokhande** has demonstrated professionalism and commitment towards the project and has successfully completed it in a satisfactory manner. The project has been reviewed and approved by the academic authorities of the university.

We wish all the best for his future endeavors.

Sincerely,

M/S MASK POLYMERS PVT. LTD. AMBI PUNE 410507

Anuradha Sawant

[HR Manager]

[Mask polymer pvt.Ltd]

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May 20,2023

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This is certify that ***Mr.Ankush Kailas Gulhane.***Student of Bachelers of Engineering from *Nutan Maharastra institute of Engineering and Technology,* has completed the project work from *24 Aug.2022 to 20 May,2023* in our organization.

The project under taken by him was,

"Ergonomics and motion study of injection moulding operations for improvement of productivity."

During the period of the project work he was sincere,hardworking and inquisitive. He will be a valuable addition to the any team he works with the future.

We wish him success in his future endeavors.

For Mask Polymer Pvt.Ltd.

M/S MASK POLYMERS PVT. LTD. AMBI PUNE 410507

Anuradha Sawant

(HR Manager)

[Mask Polymer Pvt.Ltd]

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We wish him success in his future endeavors.

For Mask Polymer Pvt.Ltd.

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Anuradha Sawant

(HR Manager)

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Anuradha Sawant

(HR Manager)

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We wish him success in his future endeavors.

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