iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** IX **Month of publication:** September 2021

DOI: https://doi.org/10.22214/ijraset.2021.38290

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue IX Sep 2021- Available at www.ijraset.com

Application of Industrial Engineering Techniques for Continuous Improvement in Plastic Industry

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Abstract: Industrial engineering is a specified field of engineering that deals with the design, improvement, and installation of integrated systems such as of people, materials, and energy in industry. Industrial engineers use specialized knowledge and skills in the mathematical, physical and social sciences, together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results obtained from systems and processes. As the present condition of the company is capable to some extent, but it is not sufficient as it looks. But it also faces some problems due to some improper arrangement like no proper storage system, proper material handling component, improper layout and improper arrangement of working tools. So to overcome these problems in the company, industrial engineering and its techniques can be used. By applying industrial engineering and its techniques there is improvement in companies existing situation and it helps to improve productivity and profit of the company. Problems identified in the company Atharva Moulds Pvt. Ltd. are storage department problem, company layout, material handling problem, 5s and safety issues.
This problems are sort by using various engineering techniques such as, 5s, layout improvement, material handling, maintenance, safety, etc tools and productivity is improved.
Keywords: Industrial Engineering, Productivity, Engineering Techniques,

I. INTRODUCTION

A. Industrial Engineering

Industrial engineering is an specified field of engineering that deals with the design, improvement, and installation of integrated systems such as of people, materials, and energy in industry. It can be also defined as an engineering profession that is concerned with the optimization of complex processes, systems, or organizations by developing, improving and implementing integrated systems of people, money, knowledge, information, equipment, energy and materials.

B. Industrial Engineering Techniques

The tools and techniques of industrial engineering aim at improving the productivity of an organisation by optimum utilisation organisations resources i.e. men, materials, and machines. The various tools and techniques of industrial engineering are as follows:-

1) *Method study:* To establish a standard method of performing a job or an operation after through analysis of the jobs and to establish the layout of production facilities to have an uniform flow of materials without back tracking.
2) *Time Study (Work measurement):* This is a technique used to establish a standard time for an operation.
3) *Motion Economy:* This is used to analyze the motions employed by the operators to do the work. The principles of motion economy and motion analysis are very useful in mass production or for short cycle repetitive jobs.
4) *Financial and Non-Financial Incentives:* These helps to evolve at a rational compensation for the effort of workers.
5) *Value Analysis:* It ensures that no unnecessary costs are built into the product and it tries to provide the required functions at the minimum costs. Hence, helps to enhance the worth of the product.
6) *Production, Planning and Control:* This includes the planning for the resources(like men, materials and machines), proper scheduling and controlling production activities to ensure the right quantity, quality of product at predetermined time and pre-established cost.
7) *Inventory Control:* To find the economic lot size and the recorder levels for the items so that the item should be made available to the production at the right time and quantity to avoid stock out situation and with minimum capital lock-up.
8) *Job Evaluation:* This is a technique which is used to determine the relative worth of jobs of the organization to aid in matching jobs, personnel and to arrive at sound wage policy.
9) *Material Handling Analysis:* To scientifically analyse the movement of materials through various departments to eliminate unnecessary movement to enhance the efficiency of material handling.
10) *Ergonomics (Human Engineering):* It is concerned with study of relationship between man and his working conditions to minimize mental and physical stress. It is concerned with man-machine system.

Following industrial techniques are considered in this project for solving the existing problems in the industry are as follows:

- 5S
- Layout Improvement
- Material handling equipment's
- Maintenance
- Other safety

The above techniques are described as follows:

a) 5S: 5S was created in Japan. The 5S method of workplace organisation is based on a list of five Japanese words: seiri, seiton, seiso, seiketsu, and shitsuke. These are translated as "Sort," "Set In Order," "Shine," "Standardize," and "Sustain." The list explains how to organise a work environment for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order. [2]

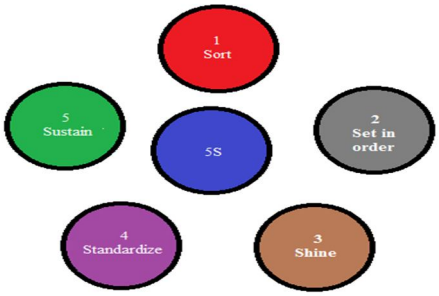


Fig.1.1 Simple Representation of 5S

- *Key benefits of 5s*

The key benefits of 5S are given as follow:

- Improve floor space utilization
- Reduce non value added activities.
- Improves employee safety and morale.
- Reduce mistake made by employee or suppliers.
- Improves standardization, process control, product quality and life.
- Reduce time for employee training.
- Improves equipment reliability through frequent cleaning and inspection.
- Reduce time searching for tools, parts, supplies and changeover time.
- Improves visual control.

b) Layout Improvement: The physical arrangement of production facilities is referred to as plant layout. In the conversion process, it is the configuration of departments, work centres, and equipment. Moore defines a plant layout as "a plan of an optimum arrangement of facilities including personnel, operating equipment, storage space, Material handling equipment, and all other supporting services, as well as the design of the best structure to contain all of these facilities." The overall goal of plant layout is to design a physical arrangement that meets the required output quality and quantity in the most cost-effective manner.

- *Objectives of Layout Improvement*

The following are the layout improvement goals:

- The primary goal of the plant layout is to maximise profit by arranging all of the plant facilities to maximise total manufacturing of the product.
- Another objective is to reduce transportation time on the shop floor.
- Streamline the material flow through the plant.
- Make the manufacturing process easier.
- Keep in-process inventory moving at a high rate.
- Reduce material handling.

c) *Material Handling Equipment:* In order to convert raw material into finished product, one of the three basic elements of production, namely material, men, and machines, must move. Material handling refers to the movement of goods or materials within a storage area over short distances. Material handling adds no value to the product but increases the cost of the product, costing the customer more. Material handling accounts for 15 to 25% of total product cost.

Objectives of Material Handling Equipment:

Objectives of material handling equipment are as follows:

- Minimise cost of material handling.
- Minimise delays and interruptions by making available the materials at the point of use at right quantity and at right time.
- Maximum utilisation of material handling equipment.
- Prevention of damages to materials.

d) *Maintenance:* It is critical to keep the facilities and equipment in good working order in order to achieve a certain level of quality, dependability, and efficiency. Maintenance, in its technical sense, entails performing functional checks, servicing, repairing, or replacing necessary devices, equipment, machinery, building infrastructure, and supporting utilities in industrial, commercial, governmental, and residential settings. Plant maintenance is an important service function of a well-functioning manufacturing system. It aids in the maintenance and improvement of plant facility operational efficiency.

- *Objectives of Maintenance*

➢ To improve the functional stability of manufacturing facilities.
➢ To extend the equipment's useful life.
➢ Reduce total production or operating costs directly attributable to equipment service and pairing.
➢ To reduce the frequency of production interruptions by reducing breakdowns.
➢ Maximize the production facility using the available equipment resources.
➢ To improve manpower safety.
➢ To reduce the frequency of machine malfunctions.
➢ To extend the life of the machine.

- *Types of Maintenance*

Types of maintenance are mentioned in the below diagram:

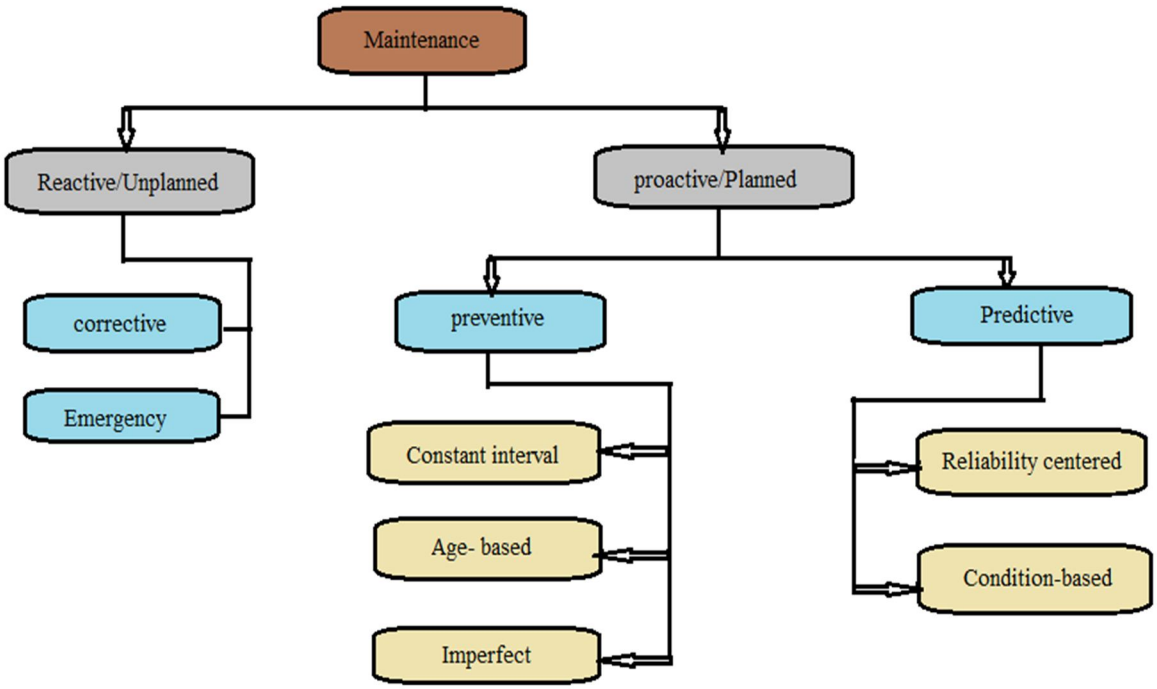


Fig.1.2 Types of maintenance

- *Planned Maintenance:* It is an organized maintenance work carried out as per recorded procedures having control.
- *Corrective Maintenance:* This is an organized maintenance work intended to restore a failed unit. It includes different types of actions like typical adjustments to redesign of equipment's. Efforts are made to identify and eliminate the cause by activities such as improving maintenance practices, changing frequency of maintenance services and improving process control procedures.
- *Preventive Maintenance:* Preventive maintenance is a planned maintenance of plants and equipment's in order to prevent or minimize the breakdown.
- *Predictive Maintenance:* Predictive maintenance as the name implies simply means predicting the failure before it occurs, identifying the root causes for those failure symptoms and eliminating those causes before they result in extensive damage of the equipment.

II. PROBLEM STATEMENT

Industrial engineering seeks to maximize the performance of interactive man-machine material system. As the present condition of the company is capable to some extent, but it is not sufficient as it looks. The company also finds out some problems or they may face some problems due to which the efficiency of the company may get decreased. By applying applications of industrial engineering for continuous improvement in the company it can reduce some time, costs, improve labour safety and also improve productivity of the company. Nowadays it is essential to improve some small changes in the company which can increase efficiency of the company. While observing the different elements of the company, we identified some problems which can be overcome by continuous improvement. By analysing, modifying and separating things properly we can solve the problems. Now we will see the problem statement and their suggestions by applying applications of industrial engineering for continuous improvement and how the techniques of industrial engineering can help to understand and solve the problems.

A. Storage System (Problem Statement-1)

In this company, their is a raw material and finished goods storage department in which problem found out of improper storage system arrangement. which causes some difficulties for the production.

Boxes of finished components are place randomly. No proper storage system(racks/compartments) is provided for them. It results in any accidents while carrying boxes from one place to another.

Floor space is not utilized properly. Due to which storage department environment is not effective.

1) Existing Storage Department

The existing storage department photos are as follows:

Fig.2.1 Existing storage department

Storage department needs a proper space management else staff is not looking to utilize space efficiently and this can cause unnecessarily long travel times between locations, causing additional fuel costs, labour costs, and delays in loading or unloading trailers. As seen in current situation, there is no any proper arrangement of finished and non-finished components boxes. The boxes are placed one over another. Due to this the finished components may get damaged. Also there is a huge chances of collapsing the boxes causes minor or major accidents.

2) Disadvantages

The disadvantages of existing storage department are mentioned below:

1) Floor space is not fully used.
2) Boxes are placed over one another. In case upper box falls on the ground,it can damage finished components.
3) Boxes of finished components are not arranged properly.

B. Layout Improvement (Problem Statement-2)

The Atharva Moulds pvt ltd company's current plant layout is not productive enough.

Plant layout refers to the arrangement of physical facilities such as machines, equipment, tools, furniture, and so on in order to have the quickest flow of material at the lowest cost and with the least amount of handling in processing the product from raw material receipt to final product delivery.

The process plant layout problem focuses on the spatial arrangement of equipment items in plants as well as the necessary connections between them. Plant layout has been identified as one of the most critical issues in the design stage of process plants as a result of increased competition in the process industries, as well as strict environmental regulations and product specifications.

In the industry only the ground floor layout is available. As the raw material department, inspection department and training department is located on first floor. Due to this any one new person coming in the industry do not find this departments early. It can affect the productivity and also the time required to find these departments is more.

1) Existing Plant Layout

The existing plant layout is as shown below:

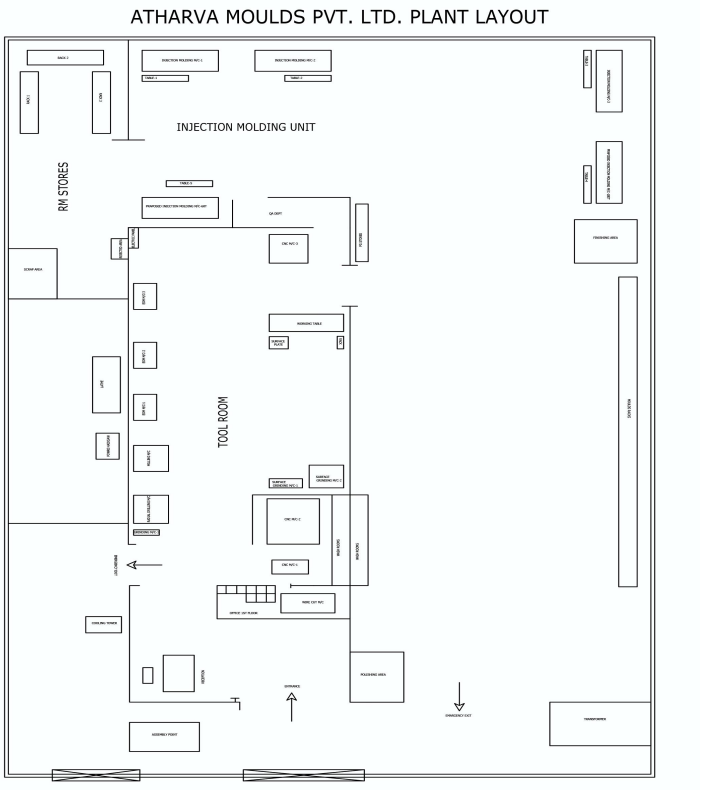


Fig.2.2 Existing plant layout

2) Disadvantage

The disadvantages of existing layout are as follows:

a) Time Required is More: The company having two floors out of which only ground floor layout is available. Storage department and quality department of the company is at first floor. So due to unavailability of floor layout workers or any new person may found difficulty during working. Hence due to unavailability of plant layout the searching time, traveling time time required is more.

C. Material Handling Equipment (Problem statement-3)

In the company material handling equipment is not available for the transportation of raw material as a well as for finished components at required destination.

The need of material handling equipment for the transportation of raw material, finished goods to their destination is very important as for the safety of worker, to avoid the excessive efforts, to reduce the raveling time.

1) Existing Situation Of Material Handling

Fig.2.3. Existing material handling situation

As shown in the above picture, the industry has no any proper material handling equipment available like trolley. The workers lift the boxes of raw material or finished components by their own. Due to this there are chances of minor or major accidents during carrying the boxes. Also the finished components can be damaged.

2) Disadvantages

a) Unnecessary time is consumed in the transportation of raw material from the raw material store to the plastic injection moulding machine.
b) Workers get frustrate by lifting only one or two boxes repetitively by their own hands.
c) More manpower is required for lifting the raw material and boxes of finished components.
d) More time is consumed in the transportation of finished goods to the storage department.
e) Frequent interruption in production due to delay in handling and supplying materials to the machine.
f) Crowded floor space with finished components.

There is chances of minor or major accidents during carrying the boxes.

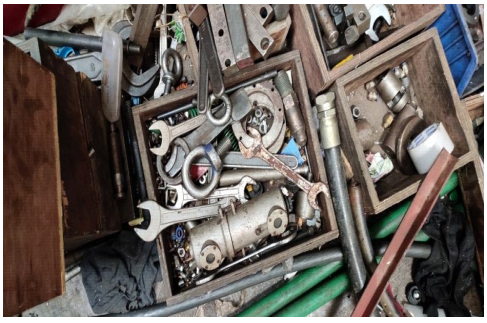
Back pain, fatigue during working and the health issues may noticed in workers due to lifting of heavy jobs and finished goods boxes.

D. Maintenance (Problem Statement)-4

In the company the tool arrangement is not proper. For the continuous and effective working the tools which are required for the daily basis must be available in the hand and should be arranged properly but in the company it found that the tools and the equipment's are places in a tool box without any proper management.

As there is no proper arrangement or proper board available in the industry for working tool, so it is difficult for workers to find the working tool at the time of operation. Also the working tools are mixed in one box. Due to this it is difficult to find the proper tool in minimum time it causes a delay during the operation.

1) Existing Situation of Working Tools



Fig,2.4 Existing Working tool arrangement

2) Disadvantages

Disadvantages of existing working tool situation are as follows:

a) Too much time is consumed for the searching of tool for the operation.
b) Tools may be damaged.
c) Injury during searching tools.

E. Safety (Problem Statement 5)

In the company after the thorough observation of shop floor, storage department, quality checking area there are so many safety problems are found out in the industry. Due to these there is chances of minor injury to workers or minor accidents can be happened. The safety problems are mentioned below:

Manpower shortage in department, chances of increase in workload.

No proper facility for safety of employees.

The workers do not follow safety measures like safety shoes while operating machines and during heavy working, no hand gloves used while handling and doing quality checking work.

Shop floor area is not clean properly.

Machine area also not clean properly.

Some of the pictures from the Atharva Moulds showing the safety issues are as follows:

Fig.2.5 No safety gloves while finishing the products

Fig.2.6 Uncleaned machine surface area

Fig.2.7 Unsafe working condition while packaging

III.DESIGN SOLUTIONS TO IDENTIFIED PROBLEMS

In this chapter, the design solutions are suggested and provided for the problem such as 5s (storage system arrangement), layout improvement, material handling equipment, maintenance and safety.

The suitable solution related to this problems are discussed as follows.

A. Storage System: Rack design

The problem described in the previous chapter of storage system arrangement, as there is no proper storage system available in the industry for the storage of raw material, finished and non-finished components. So, the suggestions to overcome this problem suggestion given is to implement the rack storage system in the industry.

The following suggestions given for the improvement of storage department:

Sorting of boxes of different finished components should be done firstly.

A proper rack storage system should be implemented. So that it will help us to manage all floor space.

A proper rack storage system will help to arrange the boxes of finished components properly.

Boxes should be place compartment wise in the rack storage system, so that it will be easy to find them.

To design the suitable rack for storage system in company the box dimension is important for design purpose. The available box dimensions are as follows:

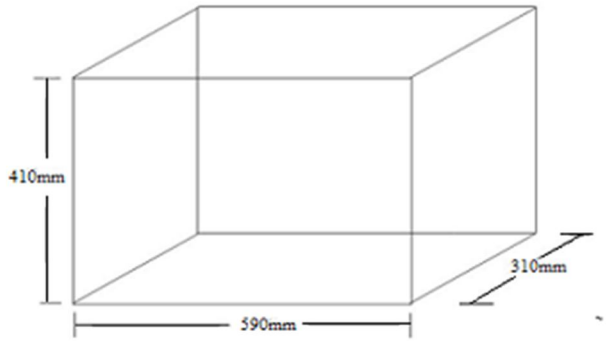


Fig.3.1 Dimensions of Box

The various suitable designs of the rack are suggested as follows:

1) Rack Design-1: Some ideas are collected from various sources. One of the idea proposed for rack design.

Fig. 3.2 Proposed rack design 1

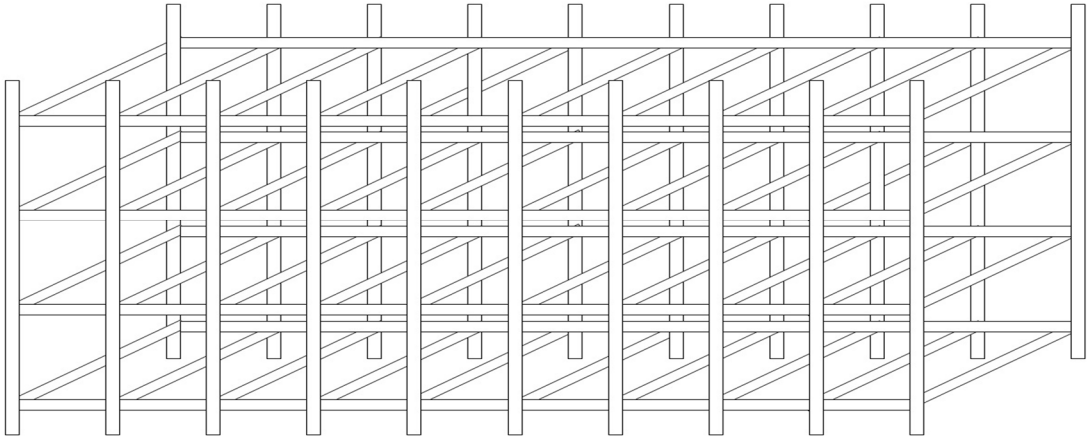


Fig. 3.3 3D view of rack design 1

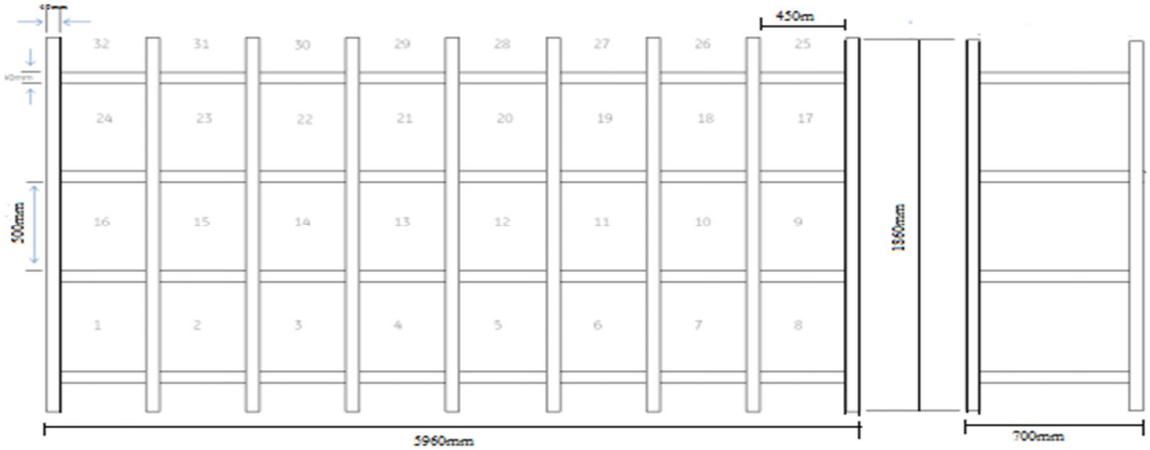


Fig.3.4 Front and side view of rack design 1

a) Specifications: Specifications of rack design 1 are mentioned below:

Table 3.1 Specifications of rack design 1

Model	Heavy duty storage rack
Loading Capacity	Per layer: 200-400 kg(2 box/compartment
Height	1860mm or customized
Length	5960mm or customized
Width	800mm

The manufacturing cost of this rack is Rs.12000/-

Features

- High tensile strength.
- Resistance Smooth finishing.
- Resistance to corrosion.

b) Material Used for Rack Body: Mild steel is a type of carbon steel with a low amount of carbon – it is actually also known as "low carbon steel." Although ranges vary depending on the source, the amount of carbon typically found in mild steel is 0.05% to 0.25% by weight, whereas higher carbon steels are typically described as having a carbon content from 0.30% to 2.0%

2) Rack Design:-2

Fig.3.5 Proposed rack design 2

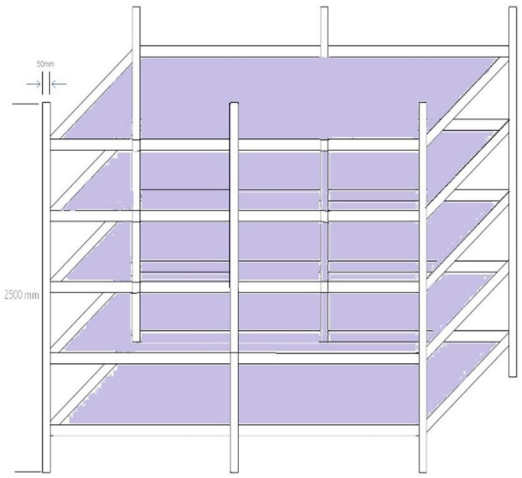


Fig.3.6 3D view of rack design 2

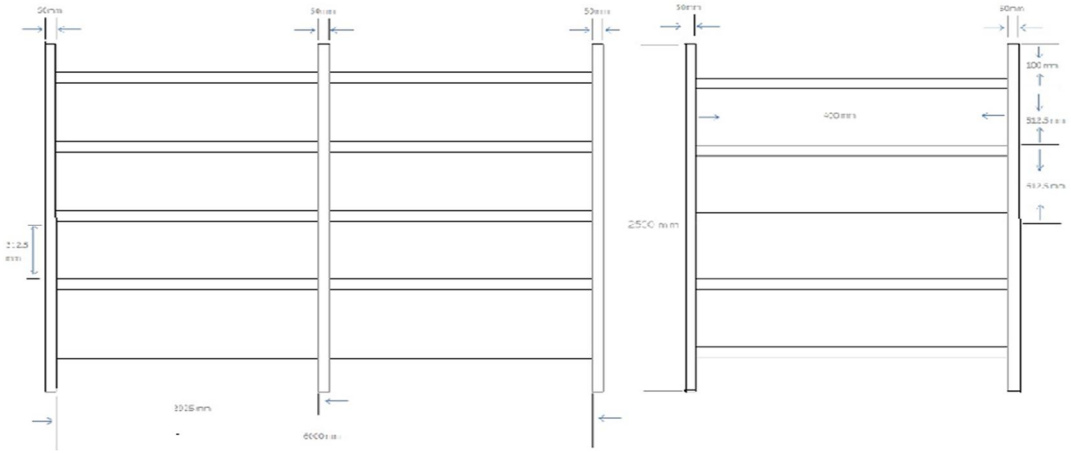


Fig.3.7 Front and side view of rack design 2

a) Specifications

Specifications of rack design 2 are mentioned below:

Table 3.2 Specifications of rack design 2

Model	Heavy duty
Loading Capacity	400-500kg (65 boxes)
Height	2500mm or customized
Length	6000mm or customized
Width	500mm

The manufacturing cost of rack is Rs 18000/-

- *Material used for rack body: Steel*

Steel is an alloy of iron and carbon. The carbon in typical steel alloys may contribute up to 2.14% of its weight. Varying the amount of carbon and many other alloying elements, as well as controlling their chemical and physical makeup in the final steel slows the movement of those dislocations that make pure iron ductile, and thus cont54rols and enhances its qualities. Because of its high tensile strength and l54ow cost, it is a major component used in buildings, infrastructure, tools, ships, trains, automobiles, machines, appliances, and weapons.

- *Material Used For Rack Body: Cold Rolled Steel*

Cold rolling occurs with the metal below its recrystallization temperature (usually at room temperature), which increases the strength via strain hardening up to 20%. It also improves the surface finish and holds tighter tolerances. Commonly cold-rolled products include sheets, strips, bars and rods; these products are usually smaller than the same products that are hot rolled. Because of the smaller size of the work-pieces and their greater strength, as compared to hot rolled stock, four-high or cluster mills are used. Cold rolling cannot reduce the thickness of a work-piece as much as hot rolling in a single pass.

B. Modified Design of Plant Layout

Following are the designs of modified plant layout as per the floors, as the existing layout is only for ground floor. The 1st floor layout is not present at plant. Means where raw material department, inspection area and training department is located.

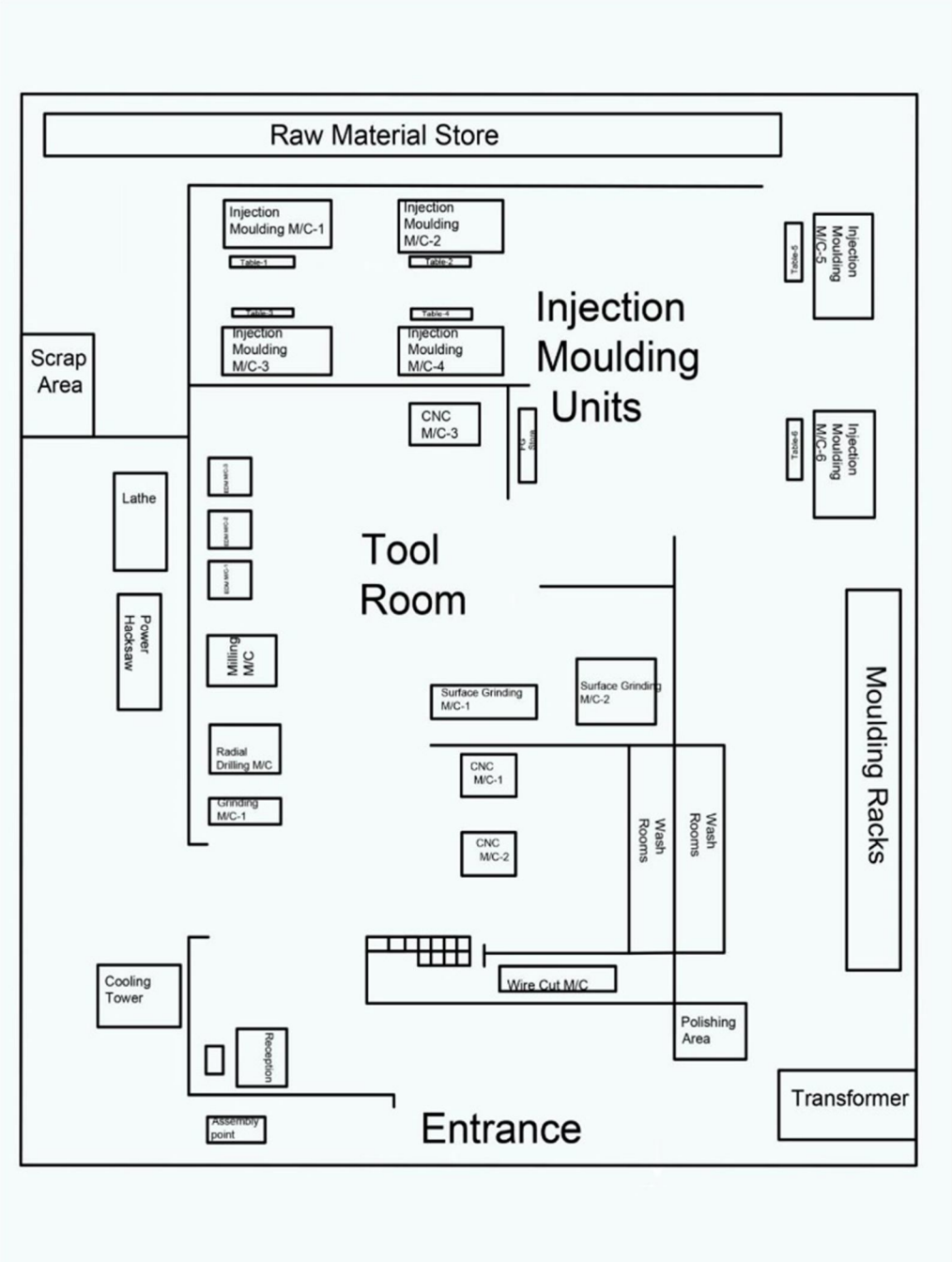


Fig.3.8 Modified layout of ground floor

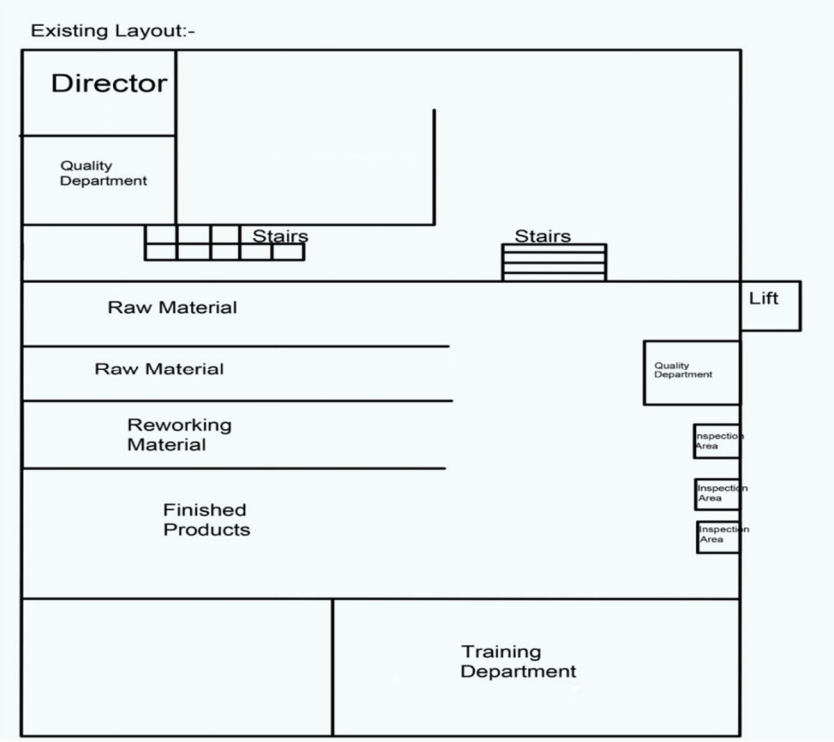


Fig.3.9 Modified layout of 1st floor

1) Advantages

Following are the advantages of suggested modified layout:

a) Flexible material handling system.

b) Traveling time is reduced.

c) Shorter cycle time.

C. Design of Trolley for easy Material Handling

As there is no any proper material handling system for transferring the boxes of finished and non-finished components and also for raw material boxes. So we design trolley for the safe transferring of boxes.

The suggestions for the material handling system are given as follows:

Material movement does not add any value to the product, it only add cost to that product. So the material handling should be kept at minimum though not avoid it. The productive time of workers will go without production if they are required to travel long distance to get the raw material. Hence, a good material handling equipment should available.

1) Trolley Design-1

Fig. 3.10 Proposed Trolley Design-1

a) Specifications

Following are the specifications of trolley design 1:
Material used: Mild steel
Load capacity: 100kg-500kg (4Boxes)
Base dimension: 1000mm length,700mm breadth

b) Material used for Trolley

Mild steel is a type of carbon steel with a low amount of carbon – it is actually also known as "low carbon steel." Although ranges vary depending on the source, the amount of carbon typically found in mild steel is 0.05% to 0.25% by weight, whereas higher carbon steels are typically described as having a carbon content from 0.30% to 2.0%.

c) Wheel Material

Nylon Wheel
Nylon is manufactured by reacting Amino molecules with Carboxylic Acid Molecules and the addition of fibers.
The resultant material provides excellent mechanical properties.
It's used in all manner of equipment in the Industrial, Commercial and Domestic Environments.
Provides high load capacities, excellent wear and tear resistance and can cope with occasional impact without fracture.
Ideal for applications that require regular wash down and cleaning.
The two most common grades of Nylon are Nylon 6 and Nylon 66. It provide excellent properties, whilst maintaining their low cost, compared to some other Nylons.
Nylon 6 and Nylon 66 have a melting temperature of 220°C and 265°C respectively. Nylon Wheels can also be used in Low temperature of -30°C.

d) Advantages

The advantages of trolley design are as follows:
Raw material is receive without delay by operator of injection moulding machine.
Less manpower is required.
More than 4 boxes or sacks of raw material can be carry at one time.
Decrease in repetitively distance travel by the workers.
Safety of the operator is increased.
Security of the product is increased with the help of this trolley.

2) Trolley Design 2

Fig. 3.11 Proposed Trolley design-2

Given below is the table of the components used for designing the trolley [fig.4.16] as per their requirements and specifications.

Table 3.4 Specifications of parts assembled to form a trolley

Sr No.	Components	Quantity	Specification
1	Ball bearings	4	Bearing 6205ZZ
2	shaft	1	Diameter 25mm
3	Axial rod	1	66.04mm
4	Bush	2	Outer diameter of 65mm, Inner diameter of 25 mm
5	M S sheet	4	3mm Thickness
6	Angular shafts	6	1x35mm
7	Mesh sheet	1	91.44x66.04mm
8	Square rod	2	66.04mm
9	Axial shaft	1	66.04mm
10	Wheels	6	Outer diameter is 222mm
11	Rear wheel	2	64.46mm
12	washer	12	25mm

Given below is the table for the cost estimation of trolley [fig.3.3(b)] as per the components requirements.

Table 3.5 Cost estimation for trolley components

Sr No.	Components	Quantity	Cost
1	Ball bearings	4	4x300=1200
2	Axial rod	1	1x500=500
3	Red oxide and color	1	1x500=500
4	Bush	2	2x650=1300
5	M S sheet	4	4x300=1200
6	Angular shafts	6	1x500=500
7	Mesh sheet	1	1x450=450
8	Square rod	2	2x300=600
9	Angular rod	1	1x700=700
10	Wheels	6	6x800=4800
11	Rear wheel	2	2x350=700
12	washer	12	12x10=120
13	Round pipe	1	1x300=300
	Total rupees		12,870

D. Proposed Design of Working Tool Board

As there is no proper working tool board present in industry for the easy and quick handling of working tools at the time of operation. So, we suggest them to implement the proper board for the tools arrangement so that worker can find the tools easily at the time of operation. It helps to reduce the time of operation.

The suggested tool board is as shown in fig.4.17

Fig.3.12 Suggested Tool Board

1) Advantages

The advantages of suggested tooling board are as follows:
Tool searching time is reduced.
Chances of tool damage is less.
Chances of injury during searching tools is overcome.
Easy to find the tools at right time at right place.

E. Other Safety Solutions

Provide proper safety hand gloves while finishing the non-finished products.
Keep machine area clean.
Shop floor area clean.
Also provide safety gloves while packing the finished products in the boxes

Fig.3.13 Rubber hand gloves for finishing components and Cotton hand gloves for heavy work.

IV. RESULT AND CONCLUSION

This project deals with problems observed at Atharva Moulds, Ambad such as rack storage system, design layout improvement, material handling equipment, working tool board and other safety. These problems are discussed with details in chapter 3 whereas the design solutions for these problems are given in chapter 4. The result and conclusion related to these problems are discussed below. By implementing all the proposed design, the following result and conclusion occurs:

A. Rack Design

In this company, there is a raw material and finished goods storage department in which problem of improper storage system arrangement was seen which causes some difficulties for the production, there as shown in fig 3.1 (a) and fig 3.1(b). After identifying this problem and working on it, solution of rack design for arrangement of the boxes and finished good products is suggested as shown in fig 4.2 and fig.4.9.

1) *Percentage improvement in Time :* Before implementing the solution of the rack design, the time required to search a box or the finished good product is about 1 min. to 2 min. and after implementing the solution of the rack design, the time required to search the boxes or finished good product is about 30 sec. to 1 min. Here,by comparing both searching time (before and after), there is about 50% of the time reduction takes place.

Formula used for percentage improvement in time:

$$\text{Percentage Improvement in Time} = \frac{(\text{Original time} - \text{New time})}{\text{Original time}} * 100$$

Table 4.1.1 Result for the suggested rack design

Suggested Design	Searching Time		Percentage Improvement in time
	Before	After	
Rack Design.	1min. to 2 min.	30 sec. to 1min.	50%

Here the percentage improvement is about 50%.

Percentage of space utilization :-

Before implementing the solution of the rack design, all the surface area of storage department (12m*8m) was covered with boxes of raw material and finished goods without proper arrangement.

After implementing the solution of the rack design, arrangement of all racks occupy the area of 9m*8m.Hence the remaining area of 3m*8m can be used for other purpose.

2) *Formula used to find Percentage of Space Utilization*

$$\text{Percentage of space utilization} = \frac{\text{Utilized surface area}}{\text{Total surface area}} * 100$$

Table 4.1.2 Result for the suggested rack design

Suggested Design	Space utilization		Percentage of space utilization
	Before	After	
Rack Design.	96m^2	72m^2	75%

From table 4.1.2, it can be observed that there is 75% of total space is utilized and remaining 25% space can be used for other purposes.

B. Layout Improvement

By studying the plant layout of the industry, it was noticed that time required to find a department is far more as shown in the fig. 3.2. After working on the plant layout design and by arranging all departments at the proper position, new plant layout is proposed as shown in the fig. 3.13 and fig. 3.14.

Before implementation the new design of plant layout, the time requires to find the department is about 1 min. and after implementing the modified layout design the time required is 25 sec. Here about the 58.33% of the time improvement takes place.

Formula used for percentage improvement in time:

$$\text{Percentage Improvement in Time} = \frac{(\text{Original time} - \text{New time})}{\text{Original time}} * 100$$

Table 4.2 Result for layout improvement

Suggested Design	Travelling Time		Percentage Improvement in time
	Before	After	
Layout Design	1min.	25sec.	58.33%

C. Trolley Design

Again the third problem which observed that the time required for the transportation of the material from one station to the station. Here the transportation of the materials done by manually or the workers lift the material and transport from one place to the another place as shown in the fig. 3.3. To avoid this the trolley design solution suggested as shown in the fig. 3.3(a) and fig. 3.3(b).

Before implementing the solution of the trolley design, the time required to lift the material from rack is about 10 sec. and after implementing the trolley, the time requires about 6 sec. Here about 40% of the time reduction takes place. At the same, time required to transport the material without trolley from one place to another is about 40 sec. and after using the trolley, the time required is 25 sec. Here about 37.5% of the time reduction is takes place.

Formula used for percentage improvement in time:

$$\text{Percentage Improvement in Time} = \frac{(\text{Original time} - \text{New time})}{\text{Original time}} * 100$$

Table 4.3 Result for suggested Trolley design (for 1 box)

Suggested Design	Activity	Time required to cover distance		Percentage Improvement in time
		Before	After	
Trolley Design	From lift to rack	80 sec.	20 sec.	75%
	From lift to exit station	120 sec.	30 sec.	75%

D. Tooling Board Design

Another problem which was noticed that the time required for the searching of a specific tool for operation is more. There was no proper arrangement for working tools. The tools are placed randomly over one another in the boxes. By developing the design of proper tooling board as shown in fig.4.17,there is reduction in searching time of tools while operating. The existing searching time for tools is about 1min. to 2min. After implementation of tool board, the time may reduce to 30sec. to 1min. So there is 50% improvement in tool searching time. Here,5S (sort) methodology can be used to arrange the tools.

Formula used for percentage improvement in time:

$$\text{Percentage Improvement in Time} = \frac{(\text{Original time} - \text{New time})}{\text{Original time}} * 100$$

Table 4.4 Result for tooling board

Suggested Design	Tool searching Time		Percentage Improvement in time
	Before	After	
Tooling board	1min. to 2 min.	30 sec. to 1min.	50%

V. CONCLUSION

As industrial engineering is very essential to maximize the performance of interactive man-machine material system, it is concluded that continuous improvement is very essential in any sector to maximize its efficiency. A small change can improve too much factors in the industry like reduce cost, time, labour cost and also improve safety and productivity, which results in increasing industry profit and demand. Also it is essential in the industry to analyse the factors affecting its progress.

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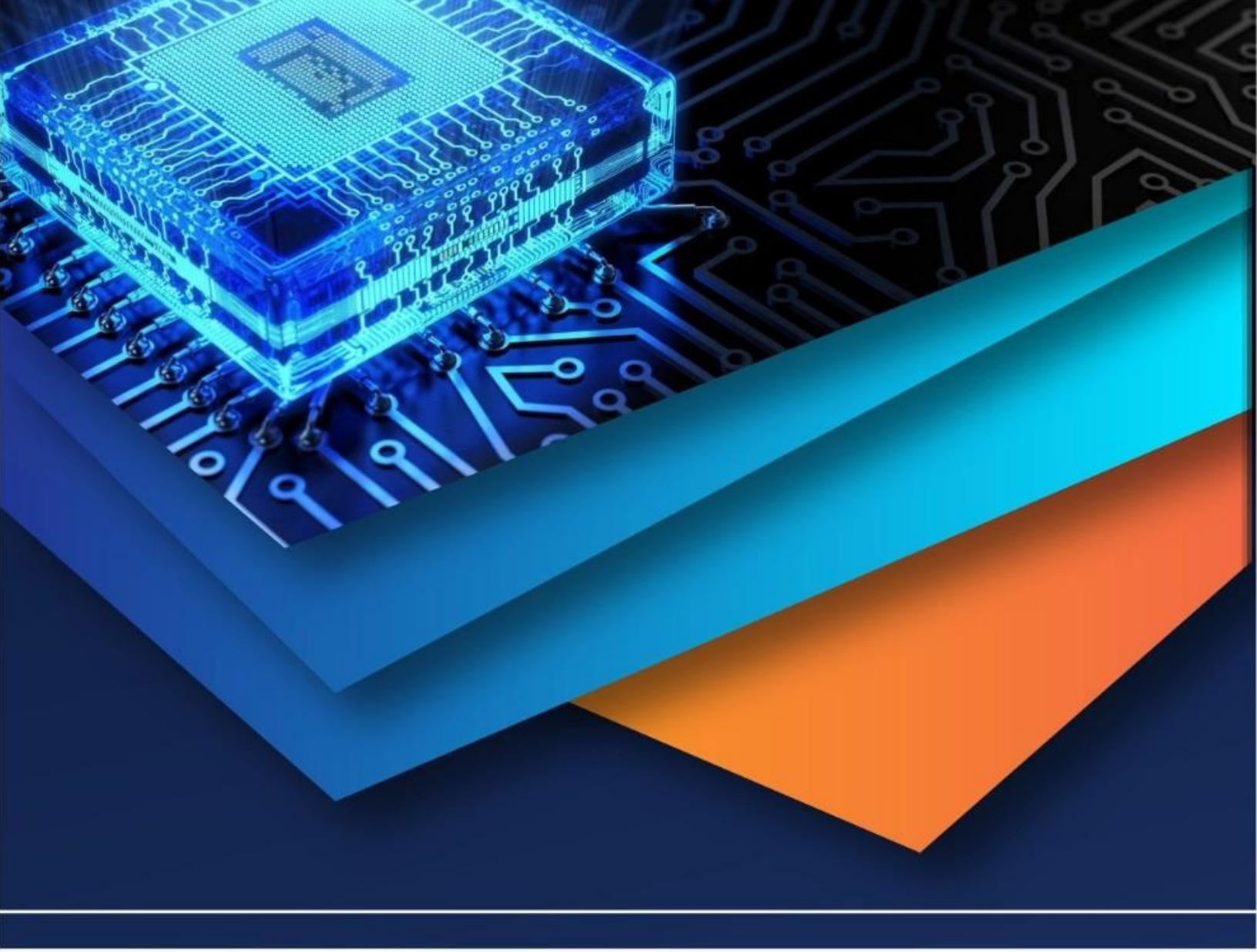

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