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Design, Development and Evaluation of Plant Layout for Optimized Material Movement

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Abstract: This paper is based on a case study about improvement inmaterial movement and plant layout design so as to increase the productivity.*Plant layout is often designed to reduce material movement and manufacture or produce components at greater speed with desired accuracy. Small layout changes can affect the* **production rate drastically. The main objectives of this paper are to study material movement and evaluate its impact on the manufacturing as a whole, also to recommend and implement suggestions based on present layout and material movement to achieve higher efficiency for the whole plant layout.**
Keywords: plant layout, material movement, efficiency, manufacturing, Sequencing.

I. INTRODUCTION

Owner wants to redesign the shop floor so as to improve productivity by reducing material movement. A detailed material movement is studied and suitable changes are suggested based on real time calculations on distance , time, cost and efficiency of the work or and component.

A. Company

High Tensile Fastenuts India Pvt. Ltd. Pune.

B. Product

Manufacturer of all types of Fasteners, Bolts, Rivets, Nuts.

C. Background

Plant layout is one of the most important factors that affectperformance and efficiency of the plant in the long run. Layout is often considered the base of the business. It determines the distance to be travelled by inventory, cost related to inventory holding and processing. Different plant layouts are accepted and implemented by the companies according to their product, manufacturing processes and varieties of machinery required. Hence location of each machinery and sequencing plays crucial role in the company's production capacity. In this paper a real life example on plant layout design and its effects is evaluated and analyzed. It shows how small improvements in the plant layout make major changes in the performance and production.

D. Material Movement Inside the Plant

The thin sheets or coils of raw materials are received from the supplier by a local transport system. This raw material is then unloaded in the store area.

Upon the requirement of the raw material, the coil is loaded onto the machines using overhead cranes. The production of bolts occurs on two machines namely forming and threading machines. Initially the raw material is loaded on the forming machine where the raw material gets cold forged into the size of the bolt. Later on after the forging of entire coil; the entire barrel of formed bolts are transferred to the threading machine.

Here the threading of the bolts is done through a die of required pitch specifications. A sample of these bolts is then checked and verified for the dimensions.

Later on the bolts are sent to the furnace where these bolts are heat treated and stress relieved. After hardening the batch of the bolts goes through a cleaning process. The products that have their dispatch scheduled are sent for plating whereas the remaining are stored in semi mat finish as safety stock. The plated products are then sent to the packaging department and finally to the dispatch area.

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II. PRESENT PLANT LAYOUT

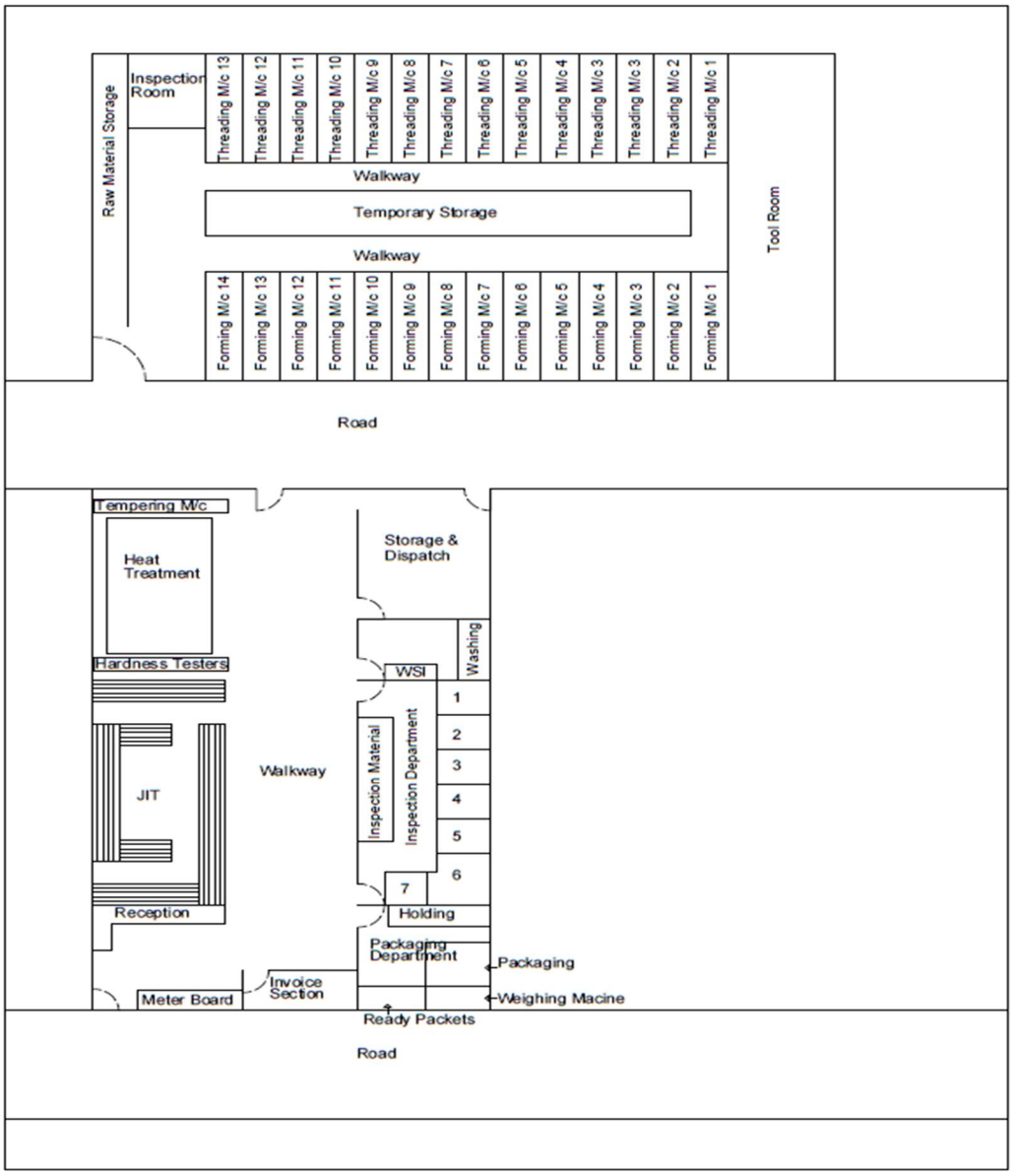


Figure 3.1 Existing plant layout [1]

A. *Plant Layout Analysis*

1) *Job Description:* For manufacturing of fasteners various people are involved. Following is the job description of all the concerned people.

a) *Worker:* To manufacture bolt from raw material.
b) *Foreman:* To supervise and direct workers with bolt specifications.
c) *Inspector:* To check whether manufactured bolt meets dimensional requirements.
d) *Production Engineer:* To plan the production so as to meet the promised delivery dates.

2) *Material Description:* Out of the many trials taken following is one bolt material description which was under study.

a) Material: SAE Boron
b) Type: Medium carbon steel
c) Raw material weight: 300 Kg
d) Average time required to complete manufacturing: 10Hrs

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III. FLOW PROCESS CHART

A flow process chart for material movement is drawn so as to understand the behavior of the material inside the plant to maximize performance efficiency. As transport and delay are non value added activities, suggestions will be given in this regard. Flow process chart gives insights about material movement as it shows distance travelled by the material and time taken for the same including delay and intangible activities which helps in calculating standard time for job.

Out of the many flow process charts for material movement that were studied, one sample has been attached below.

Flow Process Chart of Material 15B25SAEboron in Old Plant							
Sr. No.	Operation	Symbol				Distance (m)	Time min
		O	→	□	**D**		
1	Move the Crane to the Raw Material		•			11	1.5
2	Pick the Raw Material		•			0	1
3	Move the Crane to Actual Machine		•			14.7	2
4	Align the raw material with respect to machine	•				0	4.3
5	Load the Material on the machine	•				2	0.25
6	calibrate the machine				•	0	4
7	Conversion of raw material into bolt shape (for entire barrel)	•				1	240
8	waiting for threading machine to finish its first job				•	0	45
9	Movement of barrel from Bolt Machine to threading machine		•			7.4	1
10	calibration of threading machine				•	0	4
11	Threading of bolt (entire barrel)	•				0	285
12	transport to the furnace		•			34	3
13	waiting for furnace to become free				•	0	25
14	heating in furnace	•				0	90
15	Movement of few bolts from furnace to inspection		•			8	1
16	waiting for inspection				•	0	5
17	Inspection	•				0	5
18	transport to the packaging department		•			2	2
19	Packaging	•				0	15
20	transport to the storage		•			12	4
21	Storage			•		0	0
	TOTAL					92.1	738.05
							12.30083

Legend:	
Operation	**O**
Transport	→
Storage	□
Delay	**D**

Table 1: Flow process chart for 15 B 25 [4]

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A. Job Drawing

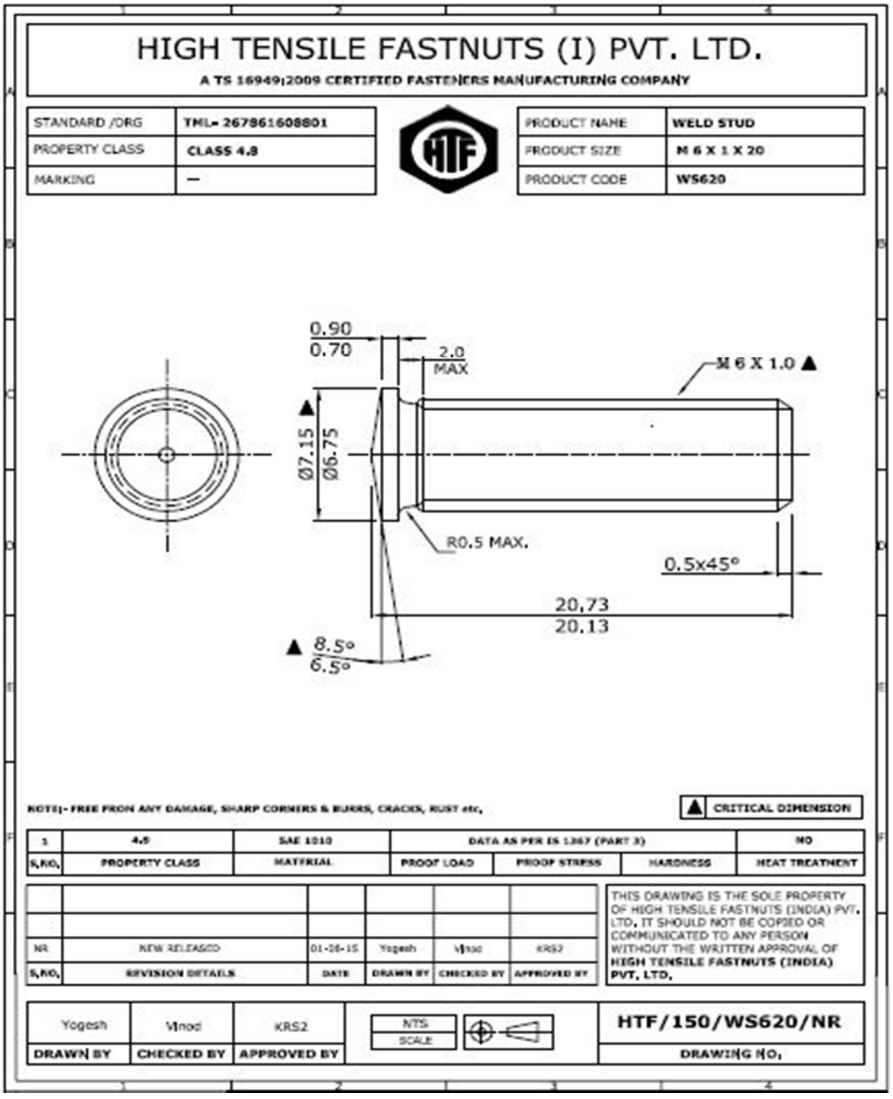


Fig 4.2 Drawing of the job.

IV. SCOPE FOR IMPROVEMENTS

A. Upon observing the flow process chart we can clearly reduce the delay time before threading operation starts. For this the company has to plan the forming of the bolt in such a way that the threading operation is performed in coordination with the forming to avoid any delay for threading operation. [1]

B. The cost related to inventory is reduced as formed bolts need not to be in queue for threading or idle waiting for operation due to inappropriate sequencing. For this operator must load raw material 45 minutes after threading operation starts.

C. To reduce movement of material during forming and threading operation, we can situate these machines together. In the later stages of the paper you will see in new plant layout, there is abrupt reduction in material movement due to grouping of the machines. This methodology is known as group technology (GT). [3]

D. Various departments can be added in the existing plant to aid the production.New plant layout design consists of implementation of various production control, inventory control and industrial engineering technologies which enhances efficiency and productivity.[4]

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V. RESULTS AND DISCUSSION

A. *Results*

1) Proposed solution for new plant layout.

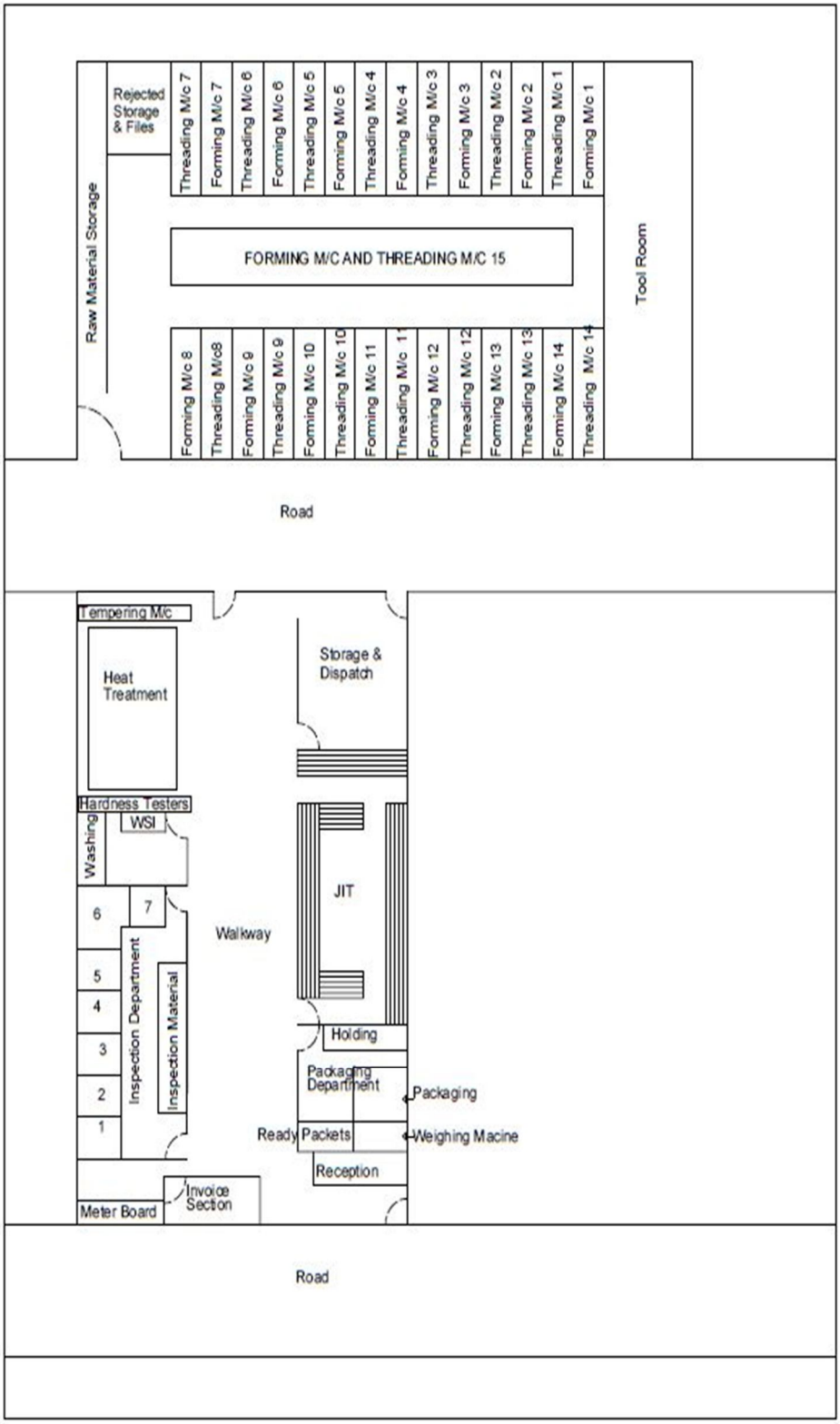


Fig. 6.1 Modified plant layout. [1]

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Table 2 Modified flow process chart for 15 B 25 [4]

Upon implementation of the new plant layout, the flow process chart of SAE Boron was again done and following observation was obtained.

Flow Process Chart of Material 15B25SAEboron in Renovated Plant							
Sr. No.	Operation	Symbol				Distance (m)	Time min
		O	→	□	**D**		
1	Move the Crane to the Raw Material		•			11	1.5
2	Pick the Raw Material		•			0	1
3	Move the Crane to Actual Machine		•			14.7	2
4	Align the raw material with respect to machine	•				0	4.3
5	Load the Material on the machine	•				2	0.25
6	calibrate the machine				•	0	4
7	Conversion of raw material into bolt shape (for entire barrel)	•				1	192
8	waiting for threading machine to finish its first job				•	0	0
9	Movement of barrel from Bolt Machine to threading machine	•				0	0
10	calibration of threading machine				•	0	4
11	Threading of bolt (entire barrel)	•				0	261
12	transport to the furnace		•			34	3
13	waiting for furnace to become free				•	0	10
14	heating in furnace	•				0	90
15	Movement of few bolts from furnace to inspection		•			1	1
16	waiting for inspection				•	0	1
17	Inspection	•				0	5
18	transport to the packaging department		•			1	1
19	Packaging	•				0	15
20	transport to the storage		•			1	0.5
21	Storage			•		0	0
	TOTAL					65.7	596.55
							9.9425

Legend:	
Operation	**O**
Transport	→
Storage	□
Delay	**D**

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B. Discussion

1) Total production time drops from 12.3 Hrs to 9.95 Hrs. This achievement is due to elimination of non value added activities like delay for machining and delay for inspection.[4]

2) Total material movement is also reduced by 30 percent. So we have successfully avoided almost one third of unwanted material movement within the plant. This can further be reduced but due to plant layout restrictions changes are not feasible.[3]

3) A new unit called sequencing and scheduling is installed in plant for further planning of production in large quantity with minimum disturbance in achieved values. Sequencing avoids delays and idleness of any material by planning its production according to machine availability. [2]

4) Furthermore the calculations does not account for machine failure which is often the case in industry. Minor breakdown leads to huge disturbance and uneven loading on different machines. Scheduling and sequencing absorbs such variations and ensure the production is smooth and within acceptable limit.

5) Some key features of the new plant design:

a) Additional two machines are mounted in the area where material used to get stored. But there is no requirement to store material hence space is free and is utilized by mounting additional machines.

b) Scheduling and sequencing area is merged with raw material hence operator or supervisor gets quick suggestions from sequencing and scheduling team before production starts .Ultimately this proper planning ensures timely manufacturing.

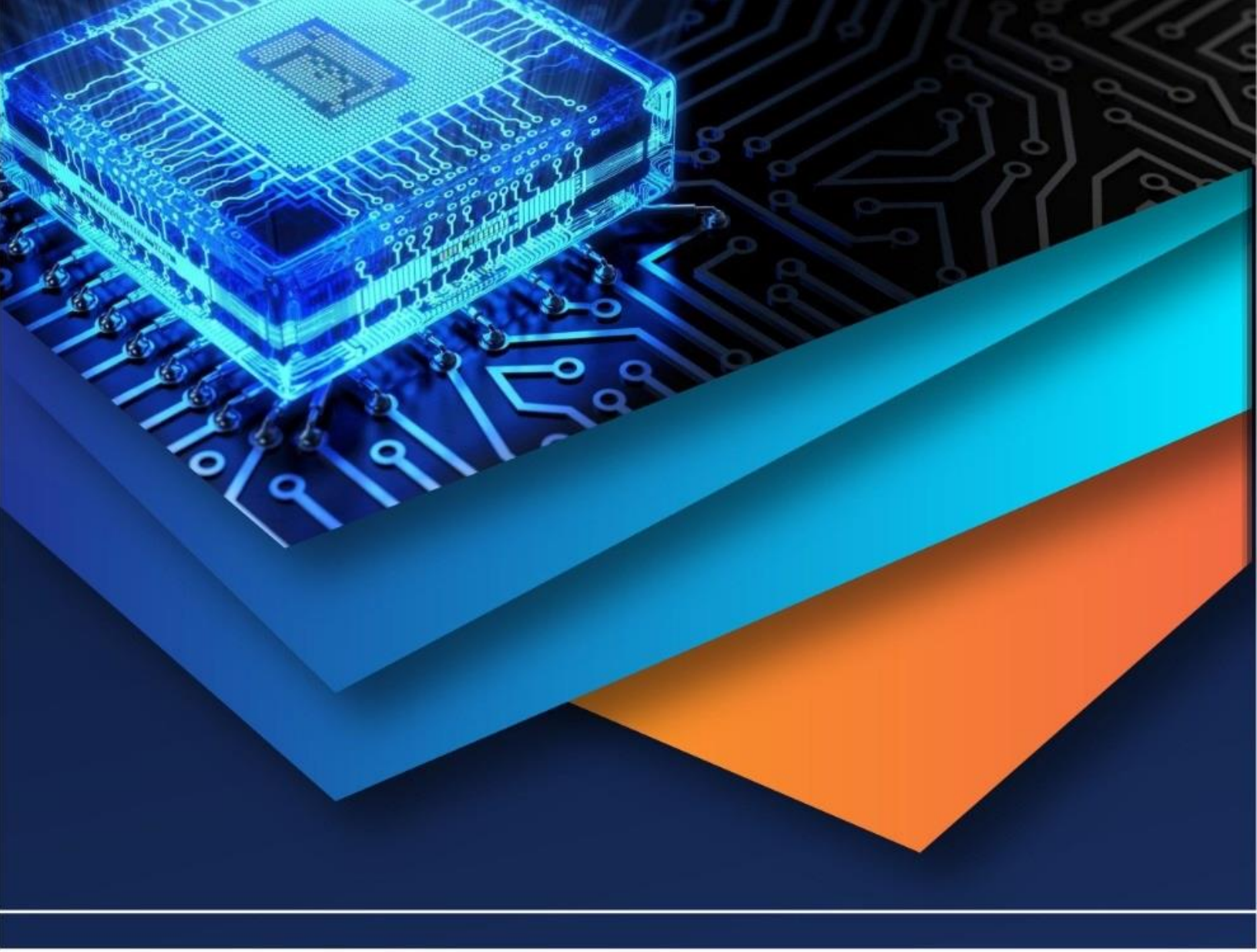
c) Storage and packaging department is in line with the other storage relating areas. Hence moves in line from packaging –just in time – storage and dispatch –transport.[1]

d) There is no need to store samples temporarily after manufacturing, since inspection is being carried out simultaneously. Hence only rejected samples will be stored from now on.

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