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Waste Identification in A Pipe Manufacturing Industry through Lean Concept–A Case Study

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ABSTRACT

This study addresses the application of the lean manufacturing philosophy to the mass production sector with a focus on the plastic piping section of a selected plastic pipe manufacturing industry. In this study, the different weakness and waste of the piping section are measured by using the specific lean tools, such as Cause–Effect diagram, Pareto analysis, Time Base Mapping, and 5S. The Cause-Effect analysis shows the various root causes of the waste time and rejection of the pipes. The Time Base Mapping measures the required time needed from the raw material to finish the product dispatch. The time has reduced approximately 17 hours by eliminating or reducing the non-value added work activities. The 5S analysis is done to focus on the effective workplace organization and standard work procedure. It also simplifies the work environment, reduces all possible waste and non-value added activity while improving quality, efficiency, and safety. In this study, we have found out the various types of waste (value-added activities and non-value added activities) exist in the piping section and the possible causes behind these activities that also have proposed some recommendation for the studied process industry in order to improve the performance of the piping section.

1. Introduction

Generally, an industry gives more focus on profit but the non–value added activities known as waste, increase the product manufacturing cost. It also decreases the company's profit. So, the waste elimination or reduction is one of the foremost activities for an industry. There are two types of wastes in the manufacturing industry: Obvious wastes and hidden wastes. The value added activities are that for which the customer is willing to pay for the product or service. The non-value-added activities are those that do not add value to product or service, spend the time and increase the cost. However, some non-value-adding activities are necessary because of the current design of our processes, but they still represent a cost and should be minimized. The plastic materials are used to produce the various types of domestic products. Among them, the use of plastic pipe is increasing day by day in Bangladesh. The pipe manufacturing processes are one of the most important processes where the various value-added and non-value added are carried out to get the finished product. In this study, we try to show the common scenario of the pipe manufacturing process industry in Bangladesh by describing the existing condition

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of the piping section. To conduct our study, we have selected a plastic pipe manufacturing industry (Shamim metal industry. Ltd) which have situated at Jessore, Bangladesh to find out the root causes of the various types of waste and have proposed a possible solution. With the help of different injection molding machine, equipment, logistics processes, and worker, the final pipe product is produced. During this process, some waste is produced. It also produced due to the poor layout, long set up time, incapable processes, poor maintenance practices, poor work method, lack of training, ineffective production planning, lack of the workplace in the organization, etc. A manufacturing industry can maximize their profit by reducing or eliminating all types of waste with the help of different kinds of tools and techniques. In this study, we have used the various lean tools to identify waste and eliminate them. The lean philosophy has developed by the Japanese in the mid 50's and is nowadays worldwide used by companies. The term 'lean thinking' encloses a set of lean practices and is first proposed by Womack at 1992 [1]. The main objective of the lean concepts is to identify the waste and reduce or eliminate them. It also helps the industry to improve productivity by reducing cost. In this paper, the different weakness of the piping section of the selected industry is measured by using the specific lean tools, such as Caused–effect diagram, Time Base Mapping, 5S, Pareto analysis, etc. The Cause–effect diagram finds the root causes of waste. The Time Base Mapping measures the required time needed from the raw material to finish product dispatch. The 5S analysis is done to focus on the effective workplace organization and standard work procedure. It also simplifies the work environment, reduces all waste and non-value added activity while improving quality, efficiency, and safety.

2. Literature Review

Researchers implemented the lean production principles and tools in a carton manufacturing company to improve the quality of production processes. They found their result from the study that an average reduction of 47% in the setup time and the corresponding monthly profit is €10114 [2]. A case study carried out in a foundry division of an auto parts manufacturing industry to improve system performance. In this study, the two lean tools, namely Kobetsu-Kaizen and value stream map are implemented for improving the production performances. The implementation shows the improved performance in terms of average core rejections, sand leakage, air lock problem, reduced lead time, non-value-added time, set-up time, and the number of operators are required [3]. Mostafaa and Dumrakb used the lean tools for elimination the waste in a manufacturing company and identified nine types of waste [4]. They also suggested a framework which contains three consecutive phases: Waste documentation, waste analysis, and waste removal as an approach for sustainability in manufacturing environment [4]. A case study was conducted in an automotive industry for productivity enhancement through the implementation of the lean tools. In this study, researchers have reduced the total cycle time for manufacturing the differential housing unit about 40% through the proposed Value Stream Mapping (VSM). They have also reduced the non-value added time about 15% and increased the percentage of the process cycle efficiency to 81.18% from 71.24% [5]. Hossen et al. [6] used the Pareto analysis and Cause-Effect diagram studied on lamp production process for minimization of defects. Zero waste and zero defects were the main objectives of their works. They found that single LIW, exhaust tube broken, crack in Flange, and double LIW is responsible for 87.27 % of the total defects [6]. Vendan and Sakthidhasan [7] implemented the lean manufacturing concepts on the motor manufacturing industry with a focus on continuous production sector. The objectives of the research were to investigate how the lean manufacturing tools could be adapted from the discrete to the continuous manufacturing environment and reduce the wastes [7]. Researchers addressed the lean six sigma in a cigarette industry to separate value-added activities and non-value added activities. They found that the time for value added activity was 1119.75 minutes with 20 work processes while the non-value added activities were

525.30 minutes with 28 works. With the help of the lean approaches, they proposed the total cycle time of 1479.13 minutes which increased the process efficiency about 12.64% [8]. Nallusamy [9] made a study on gas stove burner manufacturing unit adopting the lean manufacturing techniques to enhance the productivity by reduction of the lead time. He used the visual study and time study for individual processes to analyze the existing process flow system and increased the production by 20% [9]. A case study conducted on the implementation of lean manufacturing techniques in the sewing industry. Five types of the waste as defects, inventory, overproduction, transportation, and waiting time are identified and analyzed in the sewing line with the aid of value stream mapping. An improved future-state value stream map is developed by applying several lean manufacturing techniques. During this study, results show that the production wastes reduce approximately 96% in addition to 43% reduction in the lead time [10].

Kobetsu-Kaizen and value stream map were addressed in a foundry division of an auto parts manufacturing industry which are showing the results in the improved system performance [11]. Joshi and Pritam [12] worked in a manual foundry shop to find out the root causes and corrective issues to improve the quality level and productivity of the organization. They used Pareto and Cause and Effect diagrams to an analysis of these defects that leads to rejection for this organization [12]. In 2013, researchers applied the lean manufacturing in the Apparel Industry to improve productivity. They showed that the lean can helps to visualize the different types of wastes generated in the organization. This paper focuses on the outcome of this observation reflecting that an industry may gain higher productivity and profitability by proper application of the lean manufacturing [13]. Researchers implemented the lean manufacturing in transport and logistics section in Thailand. They designed the questionnaire to collect the data. Analyzing data, also provide some approaches and tools to find out the waste in the transport and logistics sectors [14]. A research work was carried out to improve the rejection rate of the manufacturing industry by implementing six sigma DMAIC phases. Authors found that there are 3.34 defectives per million produced parts. However, at end of the study, they found that the rejection rate of the selected manufacturing industry is brought to 1.2% from 5.3% through the implementation of DMAIC [15]. A survey of 77 automobile industries in India was done to identify the major lean production waste. Authors identified that Most of the firms have eight types of industrial muda, namely waiting time in processes, transportation of raw material, unnecessary motion of products, over production, over processing, improper inventory management, defects in finished goods and lack of knowledge. They found that transportation is major muda and over processing is minor muda [16]. A comparison was carried out between Waste Identification Diagram (WID) and Value Stream Mapping (VSM) to know the capacity of information representation and easiness of interpretation. They conclude that the WID is more effective than the VSM to identify the waste [17]. A study was carried out in an apparel industry to identify the bottleneck areas through Value Stream Mapping (VSM). They reduced the cycle time by 48.7% and increased the value-added percentages from 0.39% to 0.431% through lean approaches [18].

3. Study Methodology

Different kinds of lean tools, such as Pareto analysis, Cause-Effect Diagram, Time Base Mapping, Five S (5S) are used to find out the existing situation and waste of the selected pipe manufacturing industry through the overall production process. The overall steps in the case study are presented below with the help of the flow chart.

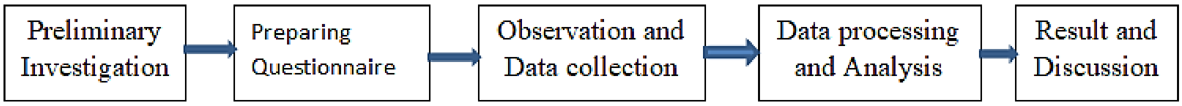


Fig. 1. *Overall steps involved in research.*

3.1 Lean Tools

The lean concept known as lean tools used in this study are described in below:

3.1.1 Pareto analysis

In early, the nineteenth century, the famous Italian Economist Vilfre do Pareto stated that about 80% of the country wealth is occupied by about 20% of the population. This observation was later on the named as '80-20' rule. This concept is now applied to the material management and quality control and also stated as such about 20% causes are responsible for 80% defect in a shop. It is generalized as only a few reasons are responsible for the majority of the problem. These 'few' (say, 20% reasons) are known as' vital few', where the rest many (say, 80% reasons) are known as 'trivial Many'. When the vital few occurs frequently, the trivial many occurs infrequently. Thus, one should concentrate on vital few, not on trivial many.

3.1.2 Cause and effect analysis

There are many potential reasons or 'Causes', which eventually lead to creating an adverse 'Effect'. 'Effect' is called the quality problem. Cause-Effect analysis is a tool which analyzes and illustrates a process by showing all root causes and sub-causes leading to an effect (Symptom). Kaoru Ishikawa developed it so it is also called the 'Ishikawa Diagram'. In this diagram, the causes as branches from the main arrow and it is called Twigs. And the sub-branches are called Twiglets. The fishbone diagram is easy to construct and invites interactive participation. The purpose of this diagram is to represent the relationship between an effect and the potential or possible causes in it. A Cause–Effect diagram for non-value-added time is shown in Fig. 2.

3.1.3 Time based mapping

The purpose of time-based mapping is to generate visibility of the process within the manufacturing processes. If this visibility has been achieved, it is possible to benchmark similar processes. The map is a snapshot which is taken during a given time period. The map records the total time when the raw material is into the industry until the finished product is dispatched. During the operation period in all sections, the value added and the non-value added works are separated. The main target of the Time Base Mapping process is to visualize the value added and non-value added work through the map and tries to eliminate or reduce the non-value added work from the process. This tool is used to improve efficiency and effectiveness throughout a business cycle or process.

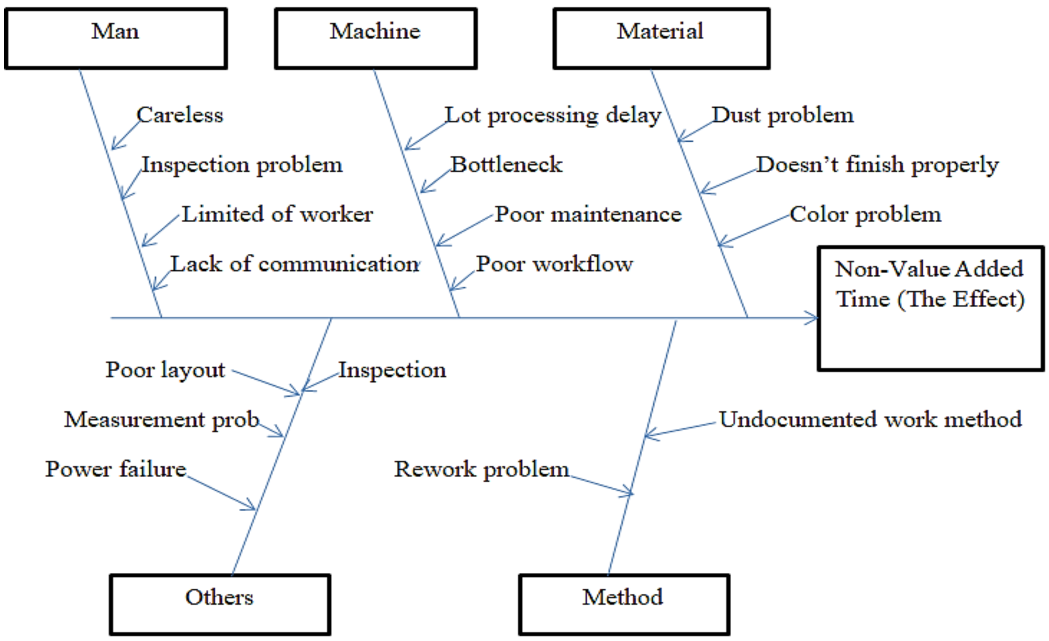


Fig. 2. *Cause and effect diagram for non-value added time.*

3.1.4 Five S (5S) in workplace organization

The Japanese word which begins with 'S' known as 5S. The 5S philosophy focuses on the effective workplace organization and standard work procedure. 5S is a system to reduce waste and optimize cost through maintaining an orderly workplace and using the visual signals to achieve more consistent operational results. It simplifies the work environment and reduces the waste and non-value added activity while improving quality, efficiency, and safety as shown in Table 1.

Table 1. *5S program.*

Terms	**Features**
Sort (seiri)	*Sort means removing all items from the workplace that are not needed for the current activity or production operation.*
Set in order (seiton)	*It refers to that as arranging needed items so that they are easy to use and labeling them so that they are easy to find out and put away.*
Shine and clean (seiso)	*The third S shine refers that sweeping the floor, wipes off machinery and generally makes sure everything on the floor stays clean.*
Standardize (seiketsu)	*Establish procedures and schedules to ensure the repetition of the first three 'S' practices.*
Sustain (shitsuke)	*The sustain may make the habit of the properly maintaining correct procedures. Without sustain the others four pillars will not be last longer.*

4. Result and Analysis

This case study has conducted from 1st May 2018 to 30th June 2018 on the selected industry. Here, the various types of waste in the existing piping section of the selected industry have identified and analyzed. All the information is gathered through the observation, questionnaires, and interview. Some data are collected through the observation and from the past records of the production department. Finally, all these data are analyzed by using various tools such as Cause and Effect diagram, Pareto diagram, Time Base Mapping and Five S (5S).

4.1 Cause-Effect Diagram for Waste of Time in the Piping Section

The following figure represents the Cause-Effect analysis showing the various root causes of time waste.

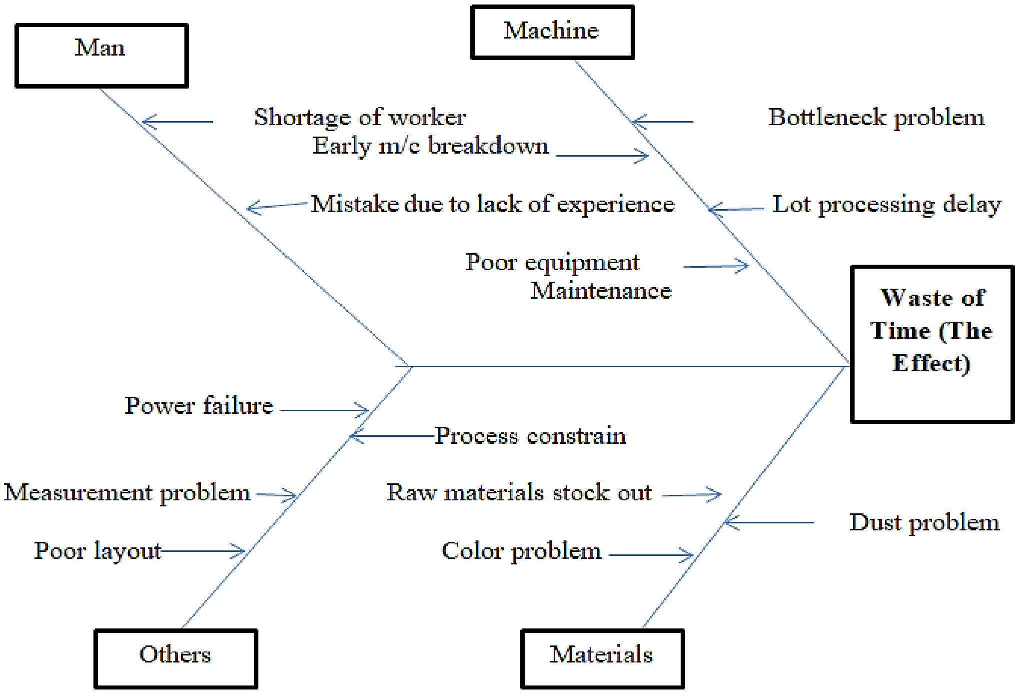


Fig. 3. *Cause-Effect diagram for the waste of time.*

In piping section, production is hampered by different types of problem. Man, machine and materials are responsible for such kinds of problem. When a shortage of the worker in the production line makes silly mistakes due to the lack of knowledge and experience of the worker, they are the mainly responsible for waiting waste. The bottleneck, poor equipment maintenance in the production line, and more time to process a lot of products are also responsible for waiting waste. Stock out of the raw material, dust on raw materials, and the process constraint are also the causes of waiting. On the other hand, the workstation are stopped due to mistakes of the operators. There is a variation of operator likes some of the operators are experienced, few are newly appointed, and these new operators make mistakes during the operation: Failure of power, wrong measurement, and poor layout responsible for the lost time.

4.2 Cause-Effect Diagram for Rejection of Pipes

The following figure represents the Cause-Effect analysis showing different root causes of rejection of the pipes in the piping section.

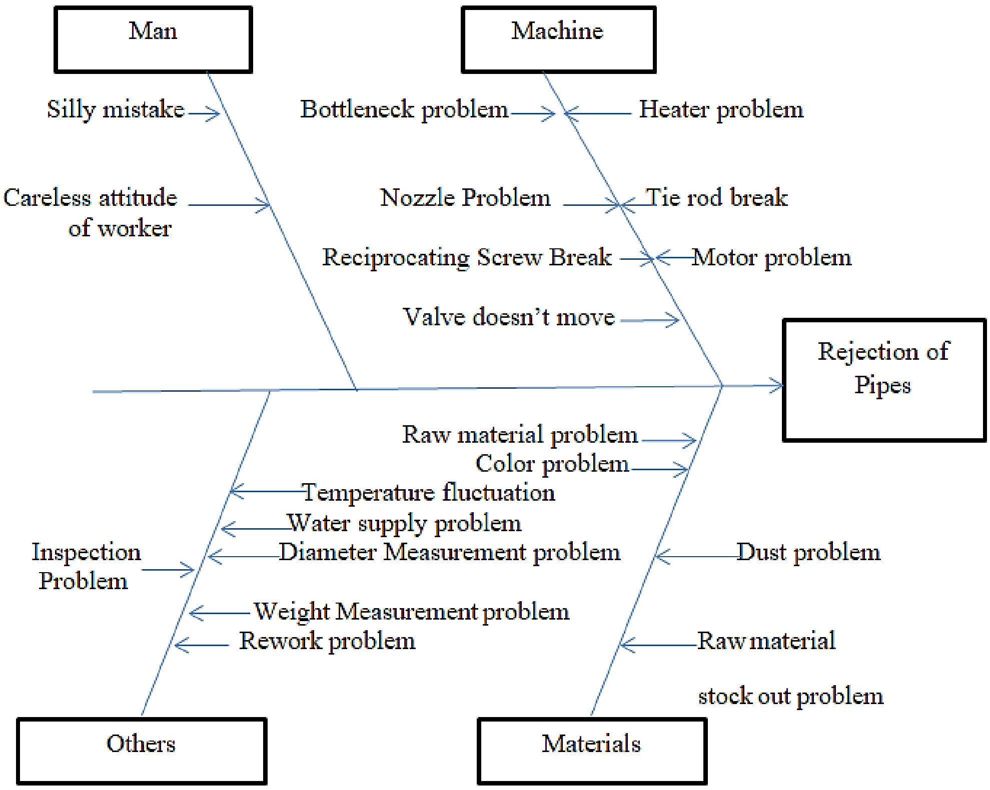


Fig. 4. *Cause-Effect diagram for rejection of pipes.*

From this figure, it has been noticed that workers, machine, and raw materials are responsible for the creation of pipe rejection. The reasons and responsibilities behind the various types of wastes are represented in Table 2 and Table 3.

Table 2. *Profile waste of time to piping section.*

Types of Wastes	**Possible Reasons**	**Which / Who is Responsible?**			
		Man	**Machine**	**Materials**	**Others**
Defective Parts	*Replace production*	√	√		√
	Low skill experience	√			
	Busy in other jobs	√			
	Temperature goes on ups and downs		√		√
	Remain dust in raw materials			√	

Types of Wastes	Possible Reasons	Which / Who is Responsible?			
		Man	Machine	Materials	Others
Waiting	*Stock out*	√			
	Lot processing delay	√	√	√	√
	Equipment downtime	√	√		
	Bottleneck	√	√		
Excess motion	*Poor workflow*	√	√		
	Inappropriate location of tools and parts	√			
	Undocumented work methods	√			
Unnecessary transportation	*WIP long distance*	√			
Non-value added process	*Rework*	√	√	√	
	Inspection	√			
	More processing steps	√	√		
Processing waste	*Improper color*	√	√	√	
	Early breakdown		√		√

The following table represents the reasons which are belong to others.

Table 3. *Others reasons behind waiting.*

Types of waste	Reasons behind this waste
Waiting (Lot Processing Delay)	*When a big lot is produced, time is different for a different process in a specific production line.*
Waiting (Silly Mistake)	*When the workers make a silly mistake because of the lack of knowledge/proper education and training.*
Waiting (Stock Out)	*Raw material is not delivered on time from grinding section to piping section because of delay in grinding operation.*
Waiting (Replace Production)	*When shrinkage of material occurs.*

From the Table 3, it is shown that producing a big lot, silly mistake of workers, stock out of raw materials, and defect products are responsible for waste**.**

4.3 Pareto Analysis: Impact of Man, Machine, Materials on Various Wastes in the Piping Section

With the help of Table 2 the Pareto chart is drawn. This Pareto chart shows the effect of various elements on waste.

From the Pareto chart, it can be found that man is responsible for most of the wastes as much 45.45% of total reasons. Machine breakdown also creates the second highest wastes as 30.31% of the total reasons. On the other hand, materials and the others factors create the lowest waste as only as 12.22% of the total reasons.

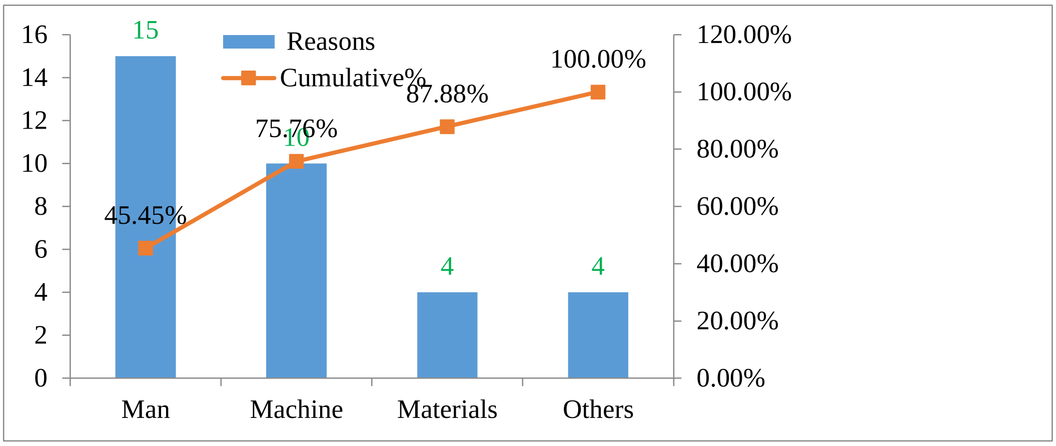


Fig. 5. *Pareto chart for different types of wastes caused by man, machine, materials and others.*

4.3.1 Some major reasons behind the failure of production in piping section

In piping section, production is interrupted for various reasons. All these types of waste are analyzed through Table 2 (Check Sheet) and the Fig. 5 (Pareto analysis). We have found some other reasons for all this failure of production: (i) Raw material input problem, (ii) Failure of power, (iii) Pipe manufacturing machine problem, (iv) Management problem, (v) Manpower problem, and (vi) All types of shading (raw material dust).

The following table represents the check sheet for different causes and result of the failure of production of the piping section over a month.

Table 4. *Check sheet.*

<table>
<tr><th>No</th><th>Causes</th><th>Tally (No of Defects)</th><th>Total Defect</th></tr>
<tr><td>1</td><td>Raw material input problem</td><td>||||</td><td>5</td></tr>
<tr><td>2</td><td>Failure of power</td><td>|||| |||| |||| |||| |||| |||| |||| |||| ||||</td><td>45</td></tr>
<tr><td>3</td><td>Pipe manufacturing machine problem</td><td>|||| ||||</td><td>10</td></tr>
<tr><td>4</td><td>Measurement problem</td><td>|||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| ||||</td><td>60</td></tr>
<tr><td>5</td><td>Man power problem</td><td>|||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| ||||</td><td>90</td></tr>
<tr><td>6</td><td>All types of shading</td><td>|||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| ||||
|||| |||| |||| |||| |||| |||| |||| |||| |||| |||| |||| ||||</td><td>150</td></tr>
<tr><td></td><td>Total No. of Occurrence</td><td></td><td>360</td></tr>
</table>

By using Table 4, Pareto chart is being constructed which is given below.

From the Pareto chart, it is cleared that all types of shading create the major effect as much as 41.67% of total defects. Man creates the second most problems as much as 24% of the total defects. Measuring problem, failure of power, and machine create 16.66%, 12.5%, and 2.78% of the total defects, where the raw materials creates the lowest defect as only 1.39% of the total defects.

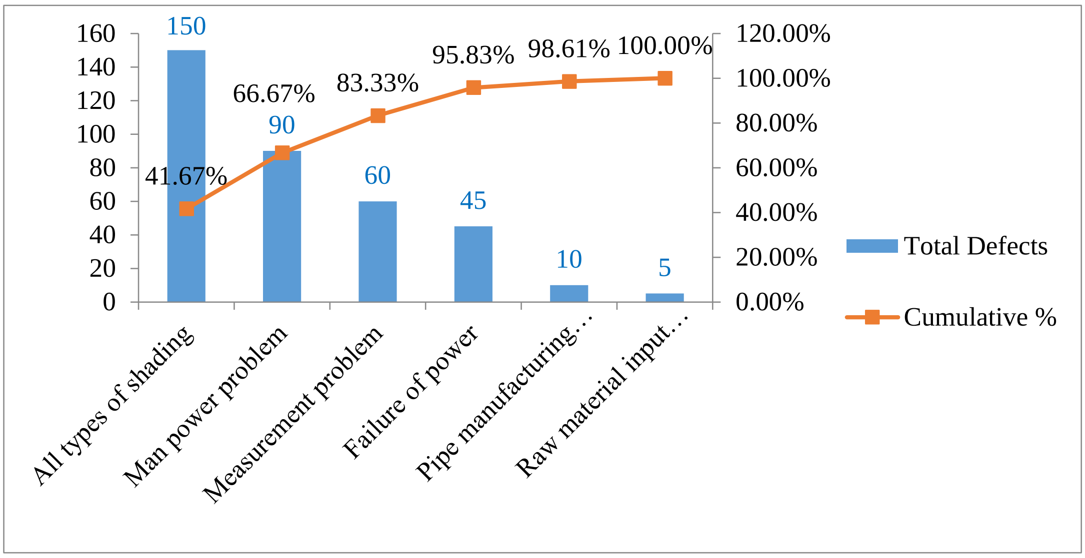


Fig. 6. *Pareto chart showing some major reasons behind the failure of problems.*

4.3.2 Some minor reasons behind the failure of production in piping section

During our study, we have identified some minor reasons that are responsible for the failure of production in the production floor: (i) Lack of experience in operating the material handling equipment, (ii) Careless in his own job, (iii) Air cooling machine problem, (iv) Discontinuous supply of water, (v) Raw material does not finish properly, (vi) Keep tools and parts in inappropriate location, (vii) Poor layout in production floor, (viii) Inspection (doesn't use statistical process control), (ix) Supporting system is not good, (x) Noisy environment, (xi) Grinding problem, (xii) Sometimes electric motor fails to run, (xiii) Weight doesn't measure accurately, and (xiv) Poor equipment maintenance.

4.4 Time-Based Mapping

The flowing flow chart represents the map of the process from entering the raw materials to dispatch the finish product in the selected industry.

4.3.5 The current time based map in the existing industry

Both the activity time and the waste time are shown in Table 5. Activity time means the required time needed to process the job and the waste time is called the non-value added time. Our desire target is to identify the non-value added time and to reduce it as much as possible or if possible to eliminate it.

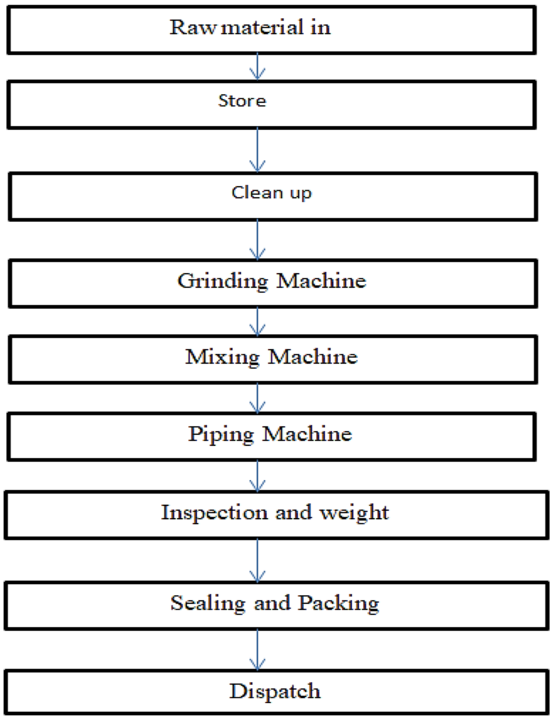


Fig. 7. *Flow chart of the time based mapping process.*

Table 5. *The activity time and the waste time (non-value added time).*

Processing Steps	Causes of non-value added time	Total Time (hrs)	Waste Time (hrs)	Activity Time (hrs)
1. Raw material in	*Wait due to a shortage of workers.*	*0.00*	*2.00*	*0.30*
2. Store the raw material	*Raw material decorates disorderly; store room is too far from the piping section.*	*2.30*	*2.00*	*1.00*
3. Clean up the raw material	*Water supply problem. Cleaning m/c problem.*	*5.30*	*4.00*	*4.00*
4. Grinding machine	*m/c problem, raw material problem.*	*13.30*	*2.00*	*6.00*
5. Colour mixing machine	*Raw material is not mixed with color appropriately.*	*21.30*	*2.30*	*6.00*
6. Piping Machine	*Air cooler/water supply problem, m/c breakdown, power failure.*	*29.60*	*3.00*	*12.65*
7. Inspection and weight	*Busy in another job, use poor tools, dia/wgt problem.*	*45.25*	*0.00*	*3.30*
8. Sealing and Packing	*Manpower problem, don't seal and pack properly.*	*48.55*	*1.00*	*3.30*
9. Dispatch	*Man power problem.*	*52.85*	*2.00*	*1.00*

From the Table 5, we can observe about how much time is needed for the activity time (value-added time) and the waste time (non-value-added time). In the current map, it is required approximately 56 hours for a selected style of pipe. The mapping time is graphically represented as follow.

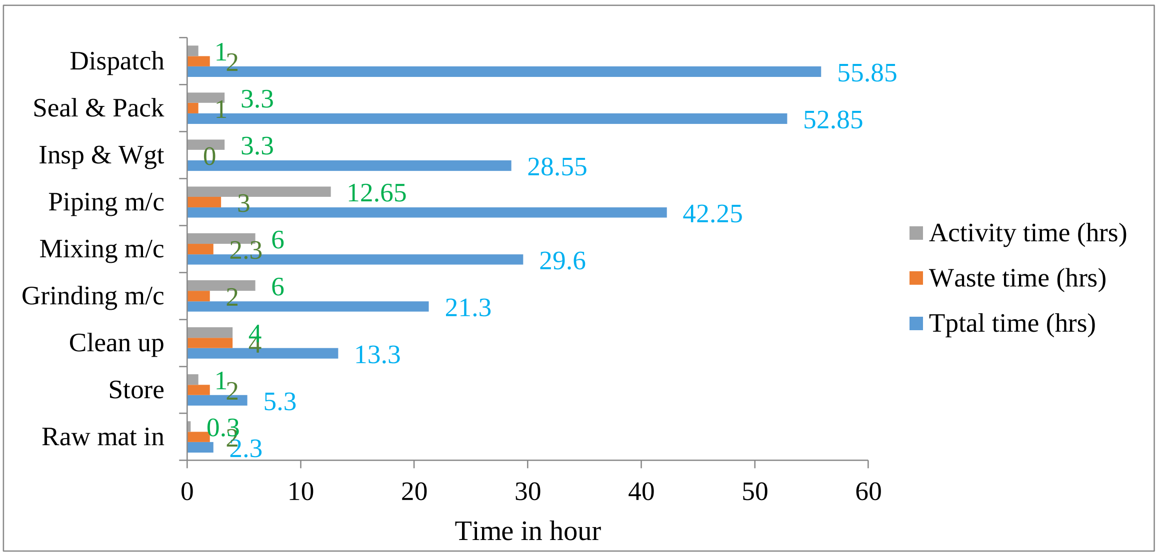


Fig. 8. *Time-based process map: current.*

From the graph, it is observed how much time is needed to complete a process in the selected industry.

4.5 Cause-Effect Analysis of the Process

The Cause-Effect represents the reasons behind the failure of production or process in the selected industry. From the Cause-Effect analysis, we can easily identify which elements or factors are responsible for the failure of production. The value added and the non-value added time are also presented here. The Cause-Effect diagram has shown in Fig. 9 below.

4.6 The Proposed Future Map for the Industry

From the above Cause-Effect diagram, we can identify all the non-value added work in the production process. The main goal of time-based mapping is to identify the non-value added time and try to eliminate that if possible or try to reduce that time as much as possible. After analyzing the current map of the existing situation, we have proposed a time map that will help to reduce the non-value added time as much as possible. The proposed time map is shown in the data Table 6.

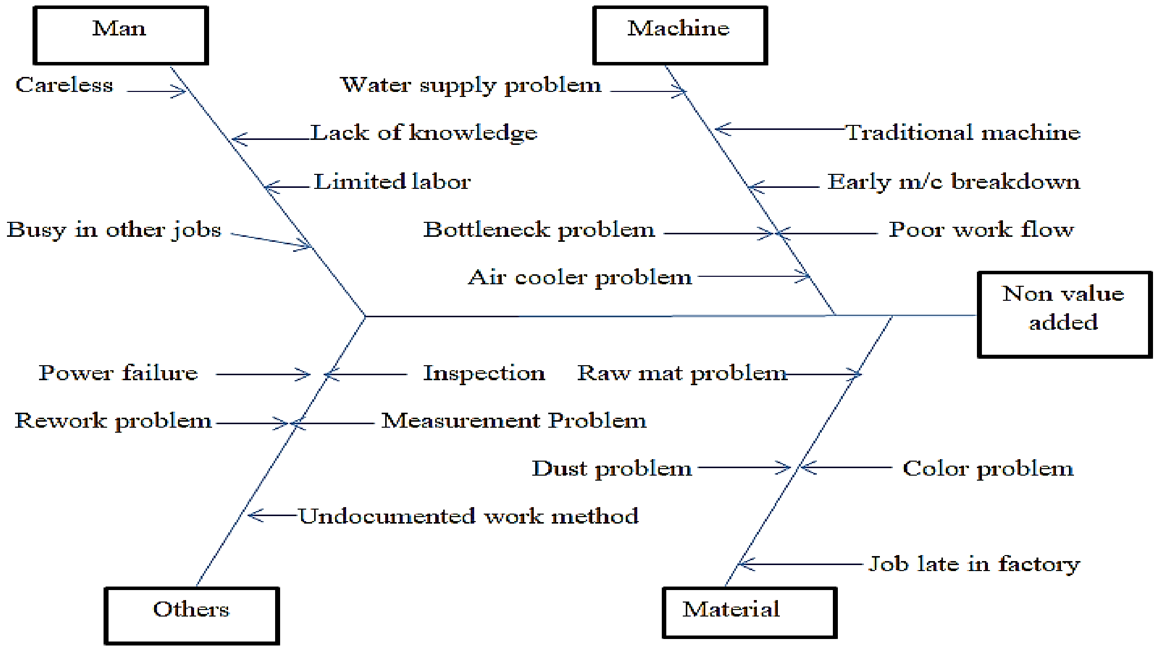


Fig. 9. *Cause-Effect diagram of non-value added work in production process.*

Table 6. *Proposed data table for future map.*

Processes/Steps	Solutions to reduce non-value added time	Total Time (hrs)	Waste Time (hrs)	Activity time (hrs)
1. Raw material in	*Involvement of sufficient workers.*	*0.00*	*0.50*	*0.30*
2. Store raw material	*Arrange raw material properly and establish the store room near to piping section.*	*0.80*	*0.50*	*1.00*
3. Clean up	*On time supply of water.*	*2.30*	*1.00*	*3.00*
4. Grinding machine	*Replacement of old m/c by new m/c and careful monitoring of finish raw material.*	*6.30*	*0.50*	*5.5*
5. Color mixing machine	*Monitor carefully to ensure that color is mixed with raw material granules properly.*	*12.30*	*0.50*	*5.5*
6. Piping machine	*Introduction of preventive maintenance in piping section.*	*18.30*	*0.50*	*12.65*
7. Inspection	*Arrange training facilities for unskilled inspectors and improve the performance of inspectors.*	*31.45*	*0.20*	*3.00*
8. Sealing and Packing	*Involvement of sufficient skill workers.*	*34.65*	*0.00*	*3.30*
9. Dispatch	*Involvement of sufficient workers.*	*37.95*	*0.20*	*1.00*

From the data in Table 6 it is noticed that the required time is taken to process a specific style of pipe, approximately 39 hours. The time has reduced approximately 17 hours by eliminating or reducing non-value added work which helps to reduce the production cost. Time Based Map for the future production process for a specific style of pipe where includes the possible solution to reduce the non-value added time are shown in Fig. 10.

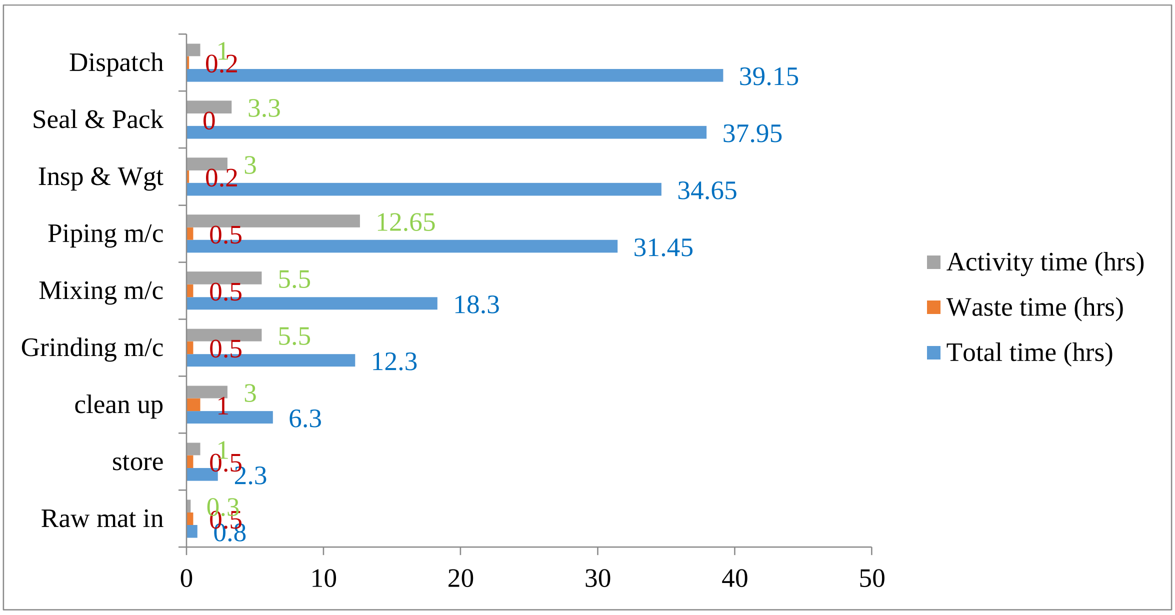


Fig. 10. *Time-based process map: future.*

4.7 Findings and Analysis of Five S (5S)

The philosophy of 5S focuses on effective workplace organization and it also standardizes the work procedure. It simplifies the work environment and reduces waste and non-productive time while improving quality, safety, and efficiency. 5S has the most important impact on the safe working place while getting clean up and better organization. The result of 5S is that everything be visible at inside and outside of the industries.

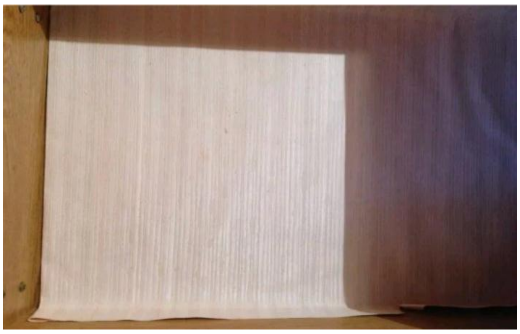
4.7.1 Identifying unnecessary items based on sort

The first 'S' focuses on the unnecessary item, removing broken tools, getting rid of dust, etc. from the workplace. The effective visual method is used to identify the unneeded items. All unnecessary items exist in the floor are marked by a red tag. These items are then moved to a central holding area. We sorted all unnecessary items from the area and kept those which are needed. Fig. 11 shows the before and after implementation of 5S. From the figure, it is observed that extra material, basket, box, unnecessary tools, and work parts exist on the floor.

Before sort process.

After sort process.

Set in order process.



Shine process.

Before 5S implementation.

After 5S implementation.

Fig. 11. *Implementation of 5S program.*

The list of equipment in the piping section are represented in Table 7.

Table 7. *The list of equipment in the piping section.*

Line	**Machine**		**Table**	**Basket**		**Inventory Storage Self**
	Used	**Unused**		**For Scrap**	**For Unused Tools**	
1	*5*	*2*	*4*	*4*	*4*	*4*
2	*5*	*3*	*2*	*6*	*3*	*3*
3	*5*	*2*	*3*	*4*	*4*	*4*
4	*5*	*3*	*4*	*5*	*5*	*3*
Total	*30*		*13*	*19*	*16*	*14*

The following data represent the existing condition of the industry. Here, all the used and unused machine, remaining number of table, basket for scrap and unused tools are in the floor space. We shortened the existing condition of the floor space. Table 8 represents the existing condition after sorting.

Table 8. List of needed equipment according to sort.

Line	Used Machine	Table (remain 2 in each line)	Basket For Scarp	Basket For Unused Tools	Inventory Storage Self
1	5	2	2	2	2
2	5	2	2	2	2
3	5	2	2	2	2
4	5	2	2	2	2
Total	20	8	8	8	8

Many unneeded tables, basket, storage shelf have decorated in the production floor which create an obstacle to improve productivity, improve product quality, and minimize wastes. Fig. 12 shows the comparison between existing and needed equipment.

From Fig. 12, we find that the number of unneeded machines, tables, baskets for scrap, baskets for unused tools, and inventory self are 10, 5, 11, 8, and 6. Therefore, the total number of unused equipment is 40, which is a vast amount that creates more product cost.

4.7.3 Some proposed guideline to maintain shine

To keep the production floor net and clean we proposed some important guidelines for the both management and workers: (i) In order to maintain shine, everyday worker should practice cleaning activities, (ii) assign an owner to each area or machine, (iii) combine cleaning with the inspection, (iv) cleaning tools are arranged properly, and (v) organized a cleaning day once or twice a month.

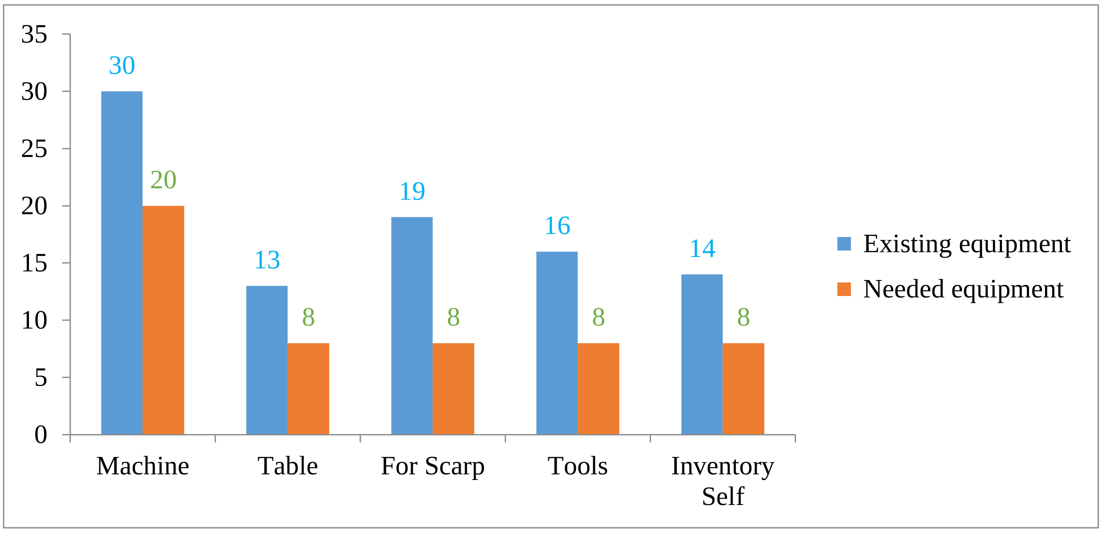


Fig. 12. Existing equipment's vs needed equipment's.

4.7.4 Proposed guidelines to maintain standardize

To make a standard work procedure to implement the above-mentioned 3S, we have proposed some crucial guideline that helps the process as a standard level as follows: (i) Integrated before 3S duties into regular duties, (ii) maintenance of 3S must become a natural part of everyone's regular works, (iii) the score should assign for areas of responsibilities, (iv) have to maintain and monitor the first 3S, (v) 5S team has to make the standardized level checklist to evaluate the maintenance level, (vi) introduce checklist for all cleaning and maintenance of man, machine, and materials, and (v) have to fix limit of inventory.

4.7.5 Proposed guidelines to maintain sustain

For long-term practice 5S program, we have proposed some key guidelines for both management and workers: (i) The worker should have good working knowledge about 5S, (ii) the worker should be trained up on 5S, (iii) 5S checklist should be followed, (iv) everyday 5S pillars should be followed, (v) communicate the theme of the five pillar campaign in a company such as a poster, flag or stickers, (vi) 5S slogans descriptions of activities can be posted through the workplace, (vii) uses different 5S photos or visual display in the workplace, and (viii) the campaign should be designate two or three months in every year as '5S month'.

5. Conclusion

The case study research was extracted an overall representation of the piping section of the selected pipe manufacturing industry; lean manufacturing concept was applied as an effectively and efficiently. In this study, through Cause-Effect diagram root cause of the various wastes produced in the workplace, the reasons were identified and showed which are mainly responsible for that problem. This analysis showed that most of the time, the human resource was responsible for the creation of waste. The time-based map was also constructed by the analysis of the existing process flow of the selected industry. Different non-value added works were done in the process and for these reasons, excess time was required to produce a lot of product. In this research paper, it was clearly visible how much time was needed to produce a specific lot of product in the existing situation and a proposed map was also given for the future by eliminating or reducing all non-value added work. From the 5S analysis, it was also found that there was a lot of unnecessary elements exist in the piping section of the selected industry such as the unused machine, underutilized table, excess scrap, and excess inventory shelf. Unneeded items were removed from the workplace and only the items remained which were needed. Then the needed items were decorated as a way that it helped to improve productivity, product quality, minimize all kinds of waste, reduce production cost, and create a better working environment.

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