Productivity Improvement – A Case Study of Hindustan Polymer Products

Akhil S K1* and Narendran A K1

1Dept of Mechanical engineering, Adi Shankara Institute of Engineering and Technology Mattoor, Kalady, Ernakulam, India

*akhilsankark050394@gmail.com

Abstract. In India, a large fraction of industries are labor intensive in nature which requires a large amount of labor for work and the productivity depends on the performance of workers that vary according to many facts. By proper implementation of various techniques and methods, productivity can be improved and this article suggests a methodology that can be implemented in any labor intensive industry to improve productivity, carefully examining various aspects and making the necessary adjustments. The methodology begins with the analysis of the work environment and work study in a labor intensive industry and the results are systematically analyzed using appropriate tools such as 5S, Pareto Analysis etc. to provide better alternatives and solutions. A significant percentage of time is saved after the implementation of solutions and standardization of the operations in the company and these recommendations may be extended to other forms of industry by making suitable changes.

1. Introduction
Labor intensive industries are very common in developing countries like India. The productivity and output of these industries are strongly related to the performance of the human resources. An industry may be fully automated, semi-automated or fully labour intensive and the later demands maximum skill from the labourers. Major concern related to these types of industries is that human resources will not be as efficient as machines in automated industries. Because unlike machines, humans get tired and experiences fatigue and there may be unnecessary motions and activities associated with the work, reducing the efficiency of the work done. Improving the performance of human resources is a prime concern in improving productivity, whichever the industry considered.

In the past, considerable amount of research has been performed in the area of improving productivity and efficiency in industries. Generally small scale industries are labor intensive industries and many authors investigated different methods to improve productivity and efficiency in these industries. Venugopal discussed the needs of TPM implementation in Indian SMEs and its effects on productivity, quality of product, culture of the organization, maintenance activity etc. He concluded that the process can be improved based on method study, work procedure and proper utilization of machine and material and will improve the current process by reducing the number of workstations, transportations, combining the operations and reducing the workers fatigue [1]. Azid et al. (2020) proposed a process improvement model that is enhanced by integrating motion time study and quality tools. The model suggested that by integrating two approaches to investigating motion time study and quality tools, the main causes of the bottleneck problem and the solution to production shortages can be identified and
analyzed at the same time. A case study carried out showed that production improved significantly by ten percent thanks to the reduction of times and processes to complete assembly work [2]. Ricondo Iriondo et al. (2016) examined how the concepts of takt time and flow can act as levers for the introduction of lean production into the SME machine tool manufacturing sector. The implementation of a system based on takt time in a pilot company confirmed that production efficiency, delivery time reliability and productivity have been increased [3]. Gunasekaran et al. (2000) analyzed problems of productivity and quality in a small company and the study indicated that the manufacturing techniques typically used by large enterprises can be implemented in a small scale industry also for productivity and quality improvements. The study also suggested that non-value adding activities can be considerably reduced by making minor improvements in SMEs [4].

Braglia et al. (2016) researched further about Single minute exchange of die (SMED). The proposed proposal saw a significant reduction of wasted time (in certain cases up to 87% of the original set-up time) with limited costs and very short return periods [5]. Braglia et al. (2017) also presents a new methodological approach to effectively integrate the 5 - Why Analysis - a root cause analysis tool to identify causes of problems - in a more general context to reduce installation time in general SMED programs [6]. Canan Aglan et al. (2019) suggested a four-step design method, from the parts line side presentation through in-plant vehicle routing and a continuous improvement scheme of the proposed project was developed [7]. Aliabouni et al. (2007) conducted a study about factors affecting employee productivity in a UAE construction industry and the results of the investigation of significance revealed the 14 factors that influence productivity, out of which the seven most important factors as work schedules, process control, salaries, supervision, group dynamics, climate and equipment [8]. A study by Karthick et al. (2016) presented the application of lean tools in minimizing the lead time in gear manufacturing process. The study showed that implementation of Kaizen, VSM in the industry reduced the time required for different operations and hence increasing the production rate [9].

Majority of researches done in the past contributes to improving productivity by applying various scientific tools and methods, but were implemented in studies based on a particular type of industry. A general methodology which can be applied commonly to any industry is not proposed in these works. The present work deals with proposing a methodology for the enhancement of productivity in a labour intensive industry. The approach involves systematic implementation of a series of scientific techniques to investigate the issues that hinders productivity and proposing appropriate recommendations based on industry to improve productivity. A case study is conducted at a small scale industry which is labor intensive to validate the effectiveness of the methodology.

The industry selected for the study is Hindustan Polymer Products, Kottayam, who produces 'roto gravure and flexo printed multilayer plastic pouches, sheets, covers and rolls'. The average production in the firm is about 145MT per annum with a workforce of 25 people. From the pilot study, it was evident that, the firm was facing serious productivity issues. Lack of performance standards for measuring productivity, non-streamlined methods and lack of a proper organization of resources in the firm contributed to the low productivity. In this analysis the firm is examined to investigate how change can be implemented to enhance productivity in a labor intensive industry. The productivity improvement can be achieved only when there is a real change in the mind-set of people at work in the way they look at the global business, the technology and the organizations. This change can be made only by proper implementation and utilization of technology and human resource development practices. The changes must become a company-wide cultural change and not just a process change for the productivity gains to last.

The main objective of this paper is to propose a methodology to improve the productivity in a labor-intensive industry and investigate the results to understand the applicability of the methodology in similar industries. The framework will be used to see, how modifications can be made to improve the output and the objective is to suggest methods for improving the productivity by the direct involvement of employees. Scientific tools like SMED, 5S, Kaizen etc. is used to identify the major issues in the firm and appropriate alternatives or improvements are recommended based on the feasibility and effectiveness by considering the views of the human resources in the firm.
2. Methodology

The performance of labour intensive industries is highly dependent on the efficiency of the human resources. All the industries require human resources, but the performance of human resources mostly affects semi-automated and fully labour intensive industries and the methodology that is proposed here can be implemented in these industries.

Low productivity and efficiency of workers has been a major problem in Hindustan Polymer Products and this constrained them from meeting the demands and on time product deliveries. From the pilot study it is found that they lacked a worker performance measurement standard and the operations are not streamlined. The methodology proposed as shown in Figure 1 aims to achieve an improvement in productivity and efficiency of workers with minimum costs.

A key factor that is associated with the performance of workers is the availability of a well-defined performance measurements standard based on scientific techniques. The first step in improving productivity is to analyse whether there is a well-defined system for measuring the performance of the workers. The standards used to measure performance of the workers can be based on production cycle time or quantity of products produced in a shift and should be selected based on the type of industry.

For Hindustan Polymer products there are no standards for measuring performance of workers. Though work study, the standards is fixed for future references. Work study involves detailed analysis of all the activities of the human resources and helps to identify the drawbacks and scope for improvement. Information is also collected through onsite observations and brainstorming with workers and management. A sophisticated questionnaire survey for worker is also used to investigate problems which were not identified from onsite observations.

To identify the root causes of the problem, pareto analysis is used and a cause and effect diagram is prepared. The Pareto analysis helps to categorise the problems into major causes and minor causes which affect productivity.

In this paper, implementation of SMED, 5S concepts and Kaizen tools is applied to improve the efficiency of workers which in turn contributes to the productivity. Implementation of SMED reduces

![Diagram](image-url)
the changeover time or setup times of machines. Using SMED operations related to machines is highly streamlined by eliminating unnecessary activities. 5S is an important technique which can enhance the smoothness of workflow in the firm and helps to organize a work space for efficiency and effectiveness by identifying and storing the items used, maintaining the area and items, and sustaining the new order. Kaizen tools like Kanban, 5W+1H is also implemented to improve the productivity. By implementing these concepts, performance of the workers and productivity is improved without any additional cost. Also allocation of workers and machine time utilization are studied to analyse possibility of work rotation and combination of workers in machines to maximize the time utilization.

The most notable limitation of this study is that it is based on a single small industry investigation. The most interesting results could be obtained if more similar industries were considered. Factors such as working conditions, norms, culture, and social values, as well as the level of development of the city in question, have an individual impact on the productivity and efficiency of workers in the enterprises. Another important limitation of the study was the time restriction. The study was conducted in three months (January 2019 to March 2019). As a result, the seasonal factors that could affect the production of the company were not taken into account. Future research may include data from different time periods (seasons) to analyze the variations in productivity and efficiency.

3. Results and discussion

3.1 Work study

Work study is conducted for the major product manufacturing activities. Each operation is broken down to the simplest elements to study the methods and time requirements (Figure 2 and Figure 3). After analyzing the work study results, the time standards for performance measurement for workers in each machine are fixed. Flexo printed covers and Roto gravure printed covers are the main revenue earning products in the firm and hence work study is mainly conducted for operations related to producing these products. In these products 1kg variants, which contributes to the major demand, are considered for work study.

Cycle times corresponding to cycles with and without machine setup activities are found from the work study and in the cases were setup activities are considered, Roto gravure printing machine showed significant increase in cycle time (Table 1) [10].
Table 1. Time study details of 1kg products

| No | Machine type               | CWOT in min | CWT in min |
|----|----------------------------|-------------|------------|
| 1  | Extruder                  | 45.8        | 109.60     |
| 2  | Flexo printer              | 65.1        | 99.90      |
| 3  | Cutting and sealing machine| 83.2        | 93.80      |
| 4  | Roto gravure printing machine | 74.1      | 216.70     |
| 5  | Two layer lamination machine | 115.4     | 162.60     |
| 6  | Three layer lamination machine | 220.3     | 283.50     |
| 7  | Trimming machine           | 59.7        | 65.20      |
| 8  | Pouching machine           | 63.6        | 66.90      |

CWOT Cycle time without setup activities; CWT Cycle time with setup activities.

3.2 Implementation of SMED

From the work study it is evident that setup activities contribute a significant percentage of cycle time for each product manufacturing line. The setup activities are done by the human resources in the firm which has the potential for improvement. The SMED methodology divides the activities into internal and external activities. The prime objective of this approach is to convert internal activities into external so that, these activities can be completed without affecting the machine. This improves the time requirement for setup activities in machines and helps to eliminate unnecessary activities by the operators. The first step to implement the SMED was to divide all the activities of the company into internal and external. The second step was to analyze the internal activities to see if any of them could be transformed into external activities without affecting the total workload. The final step was to convert these internal activities into external activities. Many operations like transporting rolls into and from the storage, Acquisition of tools and materials, Arrangements of inventory materials etc. are converted to external activities which helped to reduce the total cycle time for producing the products. These activities were previously internal activities, that is, workers only performed these activities when the machines were off. Proper allocation of workforce facilitated activities while the machine was in operation. This was possible because employees had downtime while the machines were running. The results of implementation of SMED is shown in Table 2.

Table 2. Setup time saved by implementation of SMED

| No | Machine type                                           | TSTBS in min | TSTAS in min | TSTS in % |
|----|--------------------------------------------------------|--------------|--------------|-----------|
| 1  | Flexo printing process                                 | 109.2        | 79           | 27.66%    |
| 2  | Two layer laminated roto gravure printing process      | 198.6        | 106          | 46.63%    |
| 3  | Three layer laminated roto gravure printing process    | 214.6        | 117          | 45.48%    |

TSTBS Total Setup time before implementation of SMED; TSTAS Total Setup time after implementation of SMED; TSTS Total setup time saved.

3.3 Implementation of 5S Concept and Kaizen tools

By having a systematically organized facility, a company increases the likelihood that production will occur exactly as it should. 5S concept is employed in a manufacturing firm for the purpose organizing the work environment to improve the workflow and efficiency. The work environment in the firm is not properly organized, which is evident from the work study. From the information collected by various sources like onsite observation, the major problems identified in the firm are:
1. Tools and materials were not properly arranged and hence a considerable time is wasted for finding the appropriate tools.
2. Storage area of inventory materials are at a considerable distance from the production machines, which contributes to long transportation time.
3. The pathways through which materials travel is not clear and smooth.
4. The inventory flow is not streamlined in the firm
5. A considerable time is taken for insertion and removal of inventory to and from the machines.
6. The tools, raw material, die etc. are not labelled and inventory materials are not tagged
7. No boards for showing the status production near the machines.
8. Difficult to distinguish between the WIP inventory and finished goods
9. There is inventory build-up near some machines and unavailability of inventory in some other machines at various times.

5S concept is then implemented in the firm. The tools and materials required for each of the machines are arranged near the machines, so that operator can easily acquire them. The storage area is rearranged to enable easy storage and retrieval of inventory and to reduce the distance from the working machines. Results of implementing Kanban and 5W+1H are reflected in the final standard time measurements. A significant time difference is seen in the cases of transportation time (Figure 4). All the inventories are tagged with relevant details using cards attached to them and all the tools, die etc. are properly labeled to eliminate the uncertainty in operators mind. Inventories are rearranged in storage area separating WIP materials and finished good using multi coloured tags.

3.4 Time utilization of man and machine
From Table 3, it is evident that operators in the Lamination machines and trimming machines are idle for a large part of the cycle time and they can be assigned to cutting machines and pouching machines. From the study it is evident that cutting and sealing machines and pouching machines are part of bottlenecks to the maximum output. There are two machines each for cutting and sealing and pouching processes (according to the product size requirement), but only a single operator is controlling both of them. This reduces the output of the firm due to the lack of continuous outputs from both machines. The workers from the Lamination machines and trimming machines can be assigned to this during their idle time, if proper trainings are given. With proper planning, the use of combination of workers in machines can improve the output of these machines up to 150%.

3.5 Questionnaire survey results
A questionnaire survey was conducted among the workers and management of the Hindustan Polymer Products. A total of 25 people responded to the survey. Since the sample size was less than 30, the survey

| Time taken for operations | Flexo printing | Two layer laminated roto gravure printing | Three layer laminated roto gravure printing |
|---------------------------|----------------|------------------------------------------|-------------------------------------------|
| Transportation time for inventory before 5S | 22.5 | 47.6 | 47.6 |
| Transportation time for inventory after 5S | 14.7 | 33.4 | 33.4 |
| Acquisition of tools and materials before 5S | 3.9 | 0.3 | 1.7 |
| Acquisition of tools and materials after 5S | 0.3 | 1.5 | 0.7 |

*Figure 4. Results of implementation of 5S and Kaizen*
Table 3. Time utilization in present situation for 1kg products (with setup)

| No | Machine type                   | N | MWT in min | MIT in min | MMWT in min | MMIT in min | CT in min |
|----|--------------------------------|---|------------|------------|-------------|-------------|------------|
| 1  | Extruder                       | 2 | 69.6       | 40         | 40          | 69.6        | 109.60     |
| 2  | Flexo printer                  | 2 | 43.9       | 56         | 56          | 43.9        | 99.90      |
| 3  | Cutting and sealing machine    | 1 | 93.8       | 0          | 73          | 20.8        | 93.80      |
| 4  | Roto gravure printing machine  | 3 | 151.7      | 65         | 65          | 151.7       | 216.70     |
| 5  | Two layer lamination machine   | 2 | 64.6       | 98         | 98          | 64.6        | 162.60     |
| 6  | Three layer lamination machine | 2 | 87.5       | 196        | 196         | 87.5        | 283.50     |
| 7  | Trimming machine               | 1 | 21.2       | 44         | 44          | 21.2        | 65.20      |
| 8  | Pouching machine               | 1 | 66.9       | 0          | 49          | 17.9        | 66.90      |

N: No of operators; MWT: Man working time in min.; MIT: Man idle time in min.; MMWT: Machine working time in min.; MMIT: Machine idle time in min.; CT: cycle time in min.

is only considered as quick response survey, to identify major problems which were not identified through other methods and no statistical analysis was carried out. Major problems identified from the questionnaire are:

- Lack of backup generators for electrical power failure
- Lack of performance monitoring system
- Inefficient use of IT system in organization
- Organization doesn’t take effort to provide training
- Lack of goals and standards
- Inefficient transportation facility for inventory
- No regular supervisions conducted
- Unsatisfactory arrangement of plant layout
- Improper arrangement of tools and equipment
- Lack of well-defined storage areas

Most number of negative feedbacks were obtained for Backup generators for electrical power failure, Performance monitoring system, IT system in organization, Organization take effort to provide training, Setting of goals and targets, Transportation facility for inventory and Regular supervisions. All the people who attended the survey responded poor or average for these items.

3.6 Pareto analysis and cause and effect diagram
The information collected from the work study and interview with is used for Pareto analysis. The output of Pareto Analysis is shown in Figure 5, Figure 6, Figure 7 and Figure 8.

![Figure 5. Pareto analysis of Flexo printing operations](image-url)
From the Pareto Analysis (Figure 5, Figure 6 and Figure 7), it is evident that setup time contributes to the majority of cycle time when the machines are not operating and the same is applicable for flexo printing operations and two- and three-layered roto gravure printing operations. In the case of flexo printing, preheating time required for Extruder is also a major constraint in reducing cycle time. Transportation time for inventory materials in the firm also calls for important attentions. Electrical power failure is also another major cause of production loss (Figure 8). The cause-and-effect diagram prepared from the quantitative aspects of Pareto analysis and qualitative aspects of investigation of work environment is shown in Figure 9.
3.7 Recommendations
The major problems that affected productivity and efficiency of workers in the enterprise was found and recommendations are given and can be implemented in the real time. The feedbacks of recommendations are also collected and assessed the feasibility and effectiveness of each of the recommendations based on workers and management opinion. All the personnel were asked to rate the recommendations from 1 to 5 (1 – low and 5 – high), for both feasibility and effectiveness. Then the sum of feasibility and effectiveness is considered for ranking the recommendations (Table 4). The recommendation with highest rank is most feasible and effective and can be implemented in short time.

Table 4. Recommendations feedback survey results

| Sl. No. | Recommendations                                                                 | Average score | Total |
|--------|--------------------------------------------------------------------------------|---------------|-------|
|        |                                                                                 | Feasible      | Effective |
| 1      | Transport rolls from and to storage area during machine is working               | 4.65          | 4.2    | 8.85  |
| 2      | Use engine lifter to remove and insert rolls into the machine                    | 4.3           | 4.5    | 8.8   |
| 3      | Start the preheating of extruder as soon as plant is opened in the morning      | 4.2           | 4.35   | 8.55  |
| 4      | Use small carts to carry the rolls during production (50kg roll)                | 3.8           | 4.1    | 7.9   |
| 5      | Re-allocate idle workers into required machines                                | 3.2           | 4.5    | 7.7   |
| 6      | Promote rotation of work and give appropriate trainings to the workers         | 3             | 4.2    | 7.2   |
| 7      | Give electrical power backup to preheater in extruder and blowers in printing machines | 2.85          | 4.3    | 7.15  |
| 8      | Use combination of workers in machines                                         | 3             | 4      | 7     |
| 9      | Use the shelves near the machines to store immediate inventory                 | 3.1           | 3.75   | 6.85  |
| 10     | Arrange the tools and materials required for production near each machines     | 3.15          | 3.6    | 6.75  |
Transportation rolls from and to storage area during machine is working and Usage engine lifter to remove and insert rolls into the machine showed maximum total score in the survey. These are the recommendations that can be readily implemented.

3.8 Standardization of operations
After considering all the recommendations and solutions from different methods, all the operations are streamlined and time for completing these operations are standardized (Table 5). Implementation of solution from work study, 5S and Kaizen, allocation of workers and brainstorming significantly reduced the cycle times for operations, which in turn improves the productivity of the firm (Table 6).

| Table 5. Standard time details of 1kg product production machines |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| No. | Machine type | STWOT (min) | STWT (min) | TSWOS (%) | TSWS (%) |
|-----|----------------|--------------|--------------|-------------|------------|
| 1   | Extruder       | 39.2         | 82.3         | 14.41       | 24.91      |
| 2   | Flexo printer  | 59.3         | 78.5         | 8.91        | 21.42      |
| 3   | Cutting and sealing machine | 74.2 | 79.4 | 10.82 | 15.35 |
| 4   | Roto gravure printing machine | 67.4 | 118.5 | 9.04 | 45.32 |
| 5   | Two layer lamination machine | 100.4 | 121.1 | 13.00 | 25.52 |
| 6   | Three layer lamination machine | 202.3 | 235.7 | 8.17 | 16.86 |
| 7   | Trimming machine | 47.3 | 51.4 | 20.77 | 21.17 |
| 8   | Pouching machine | 50.4 | 53.7 | 20.75 | 19.73 |

STWOT: Standard time without setup activities; STWT: Standard time with setup activities; TSWOS: Time saved without considering setup activities in percentage; TSWS: Time saved considering setup activities in percentage.

| Table 6. Standard time details of 1kg product production processes |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| No. | Process                        | STWOT (min) | STWT (min) | TSWOS (%) | TSWS (%) |
|-----|--------------------------------|--------------|--------------|-------------|------------|
| 1   | Flexo printing                  | 172.7        | 240.2        | 11.03%      | 20.80%     |
| 2   | Two layer laminated roto gravure printing | 265.5 | 344.7 | 15.12% | 32.60% |
| 3   | Three layer laminated roto gravure printing | 367.4 | 459.3 | 12.04% | 27.36% |

STWOT: Standard time without setup activities; STWT: Standard time with setup activities; TSWOS: Time saved considering setup activities in percentage; TSWS: Time saved without considering setup activities in percentage.

4. Conclusions
The productivity of a labor-intensive industry is dependent upon the performance of human resources in the industry. By the application of different tools like SMED, 5S and Kaizen, a significant time difference is observed for various operations and the most predominant difference is for Roto gravure printing machine operations, which may be attributed to the long setup time. The major issues in the Hindustan Polymer Products are addressed and given proper recommendations are implemented in real time. The recommendations for enhancement of productivity are ranked on the basis of a feedback survey. Further, most relevant recommendations are economically justified. Electrical power failure is found to be the main external cause that affects production. A significant increase in profit is seen after standardization of the operations in the company. The framework used in this study can be implemented for similar kind of industries to enhance their productivity and efficiency. The study also encourages using advanced approaches in a competitive world, which offers significant potential for improving the productive efficiencies of small and medium business firms.
References

[1] Venugopal N S B 2015 Productivity improvement in small scale industries *International Journal of Mechanical and Production Engineering* 11(3) 113-119

[2] Azid I A, Ani M N C, Hamid S A A and Kamaruddin S 2020 Solving production bottleneck through time study analysis and quality tools integration *International Journal of Industrial Engineering* 27(1)

[3] Ricondo Iriondo I, Serrano Lasa I and De Castro Vila R 2016 Takt time as a lever to introduce lean production in mixed engineer-to-order/make-to-order machine tool manufacturing companies *International Journal of Industrial Engineering*, 23(2)

[4] Gunasekaran A, Forker L and Kobu B 2000 Improving operations performance in a small company: a case study *International Journal of Operations & Production Management* 20(3) 316-336

[5] Braglia M, Frosolini M, and Gallo M 2016. Enhancing smed: changeover out of machine evaluation technique to implement the duplication strategy *Production Planning & Control* 27(4) 328-342

[6] Braglia M, Frosolini M, and Gallo M, 2017 Smed enhanced with 5-whys analysis to improve setup reduction programs: the swan approach *The International Journal of Advanced Manufacturing Technology* 90(5-8) 1845-1855

[7] Aglan C and Durmusoglu, M B 2019 A complete design methodology for lean in-plant logistics to assembly line using ad principles *International Journal of Industrial Engineering* 26(5)

[8] Ailabouni N, Gidado K and Painting N 2007 Factors affecting employee productivity in the UAE construction industry *In Proceeding Conference for Postgraduate Researchers of the Built and Natural Environment (PRoBE)* 33-46

[9] Karthick N, Hari Prasad V, Gopi S and Balaji K 2016 Application of lean tools (VSM, SMED, KAIZEN) in minimizing the lead time in gear manufacturing process *International Journal Of Scientific & Engineering Research* 7(5) 53-71

[10] Akhil Sankar K, G Venugopal and Ajith P M 2019 Enhancing productivity by standardization of operations in a small scale industry *International Journal of Applied Engineering Research* 14 (14) 22-27

[11] Ahmed T, Ali S M Allama M M and Parvez M S 2010 Total productive maintenance (TPM) approach to improve production efficiency and development of loss structure in a pharmaceutical industry *Global Journal of Management and Business Research* 10 (2) 186-190

[12] Dogra M, Sharma V S, Sachdeva A and Dureja J S 2011 TPM – A key strategy for Productivity Improvement in Process Industry *Journal of Engineering Science and Technology* 6(1) 1 -16