CAPACITY UTILIZATION AND PRODUCTIVITY ANALYSIS OF A MANUFACTURING INDUSTRY: A CASE STUDY

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ABSTRACT

This paper deals with the application of time and motion study in the industry manufacturing the shocker seals and diaphragms. An attempt is made to improve the efficiency of various manufacturing process of the shocker seal of an industry, located in the northern part of the India. Analysis is done to decrease the transportation time, men and material movement which will increase the productivity and decrease the production cost. Capacity utilization of various machines has also been computed and recommendations have been made to increase the productivity of the industry. From the study, it is observed that the capacity utilization of machines, M1 and M2, is less than 100% while capacity utilization of trimming machine, worker 1 and worker 2 are 100%.

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1.0 Introduction

The Purpose of doing work and time study are to find the optimum and most efficient way of using the available resources which include material, machinery, men and money. As per the Industrial Engineering Terminology Standard, time study is "a work measurement technique consisting of careful time measurement of the task with a time measuring instrument, adjusted for any observed variance from normal effort or pace and to allow adequate time for such items as foreign elements, unavoidable or machine delays, rest to overcome fatigue, and personal need. In contrast to, and motivated by, Taylor's time study methods, the Gilbreth proposed a technical language, allowing for the analysis of the labor process in a scientific context. The Gilbreth made use of scientific insights to develop a study method based upon the analysis of work motions, consisting in part of filming the details of a worker's activities while recording the time. The films served two main purposes. One was the visual record of how work had been done, emphasizing areas for improvement. Secondly, the films also served the purpose of training workers about the best way to perform their work. This method allowed the Gilbreths to build on the best elements of these work flows and to create a standardized best practice. Motion and time study principles are applied in the industry manufacturing the various types of seals and diaphragms of various automobiles.

The work done in the area of motion and time study is discussed in the next section.

2.0 Literature Review

Many researchers worked in the area of motion and time study which is evident from the literature survey. But still a lot of applied research in the above field is required so as to explore the successful utilisation of work study techniques in the area of production, manufacturing and design. Some significant work in this area is summarized in this section.

Hung (1998) stated that business have different manpower needs at different times of the year and, to remain efficient, must match manpower availability with manpower needs. Common approaches are to maintain a stable workforce, allowing idle time/overtime during slow/busy periods; to maintain a basic workforce, augmenting it by temporary workers during busy periods; and to reduce workdays and pay during slow periods. Choi et al. (1999) analyzed that high labour costs and the inconsistency of manual assembly have led to the wider acceptance of the robotic assembly in products manufacturing. Planning robot assembly tasks requires a method of

estimating robotic cycle time. They identify some of the relationship between robot assembly time and manual assembly time, in order to develop a method of robot assembly time estimation based on manually assembly times. Satoko et al. (2004) observed that the time and motion study is one of various workload measurement methodologies that aim for the control of operation and has been developed in industrial engineering. In the field of healthcare, the time and motion study has been used as a workload measurement for adequate staffing, improvement of care, and a cost accounting. They describe the history of time and motion study in industrial engineering and refer to some popular methods in the healthcare field, such as stopwatch time and motion study, work sampling. Estimation based on the patient classification system and so on, and empirical estimation. As for stopwatch time and motion study and work sampling, there are observational and self-reporting approaches for data collection. They also explain some of their advantages and disadvantages.

Cheong et al. (2007) considered the unconventional way of improving labour productivity by minimizing time wastages caused by non-value added activities. This study was improvement action focuses on time wastages in queuing for metrology tools and handling of control wafers. By creating usage schedule of metrology tools across the industry, and having dispatching rules for highly utilized metrology tools, they reduced waiting time for metrology tools which increases the direct labour productivity.

Kumar et al. (2009) presented a detailed comparison of two major airlines (American Airlines and Southwest Airlines) and identified key differences and to confirm the areas on which airlines need to focus improvement efforts. Cause and effect diagrams were used to identify the factors triggering the issues. Process analysis was also used to offer improvements to reduce costs and improve customer service. Analysis is based on publicly available airline and industry information. They found that revenue, costs, growing economic concerns and an extremely competitive environment are the major areas on which airlines need to focus to be successful. Cocca and Alberti (2010) investigated the effects of stress and job satisfaction on the functioning of a company. They focused on factors affecting stress and job satisfaction such as number of work hours, good relations between management and employees, good function of the group and work related to employees' area of education. A random sample of 425 employees in the private and public sector and two stage cluster sampling is first used to collect primary data. Logistic regression was used next presenting many useful elements concerning the function of

stress, satisfaction and supportive elements on productivity. Rogerio et al. (2011) developed a methodology and a framework to assess performance measurement and generate a better understanding of the project context. They presented an application to illustrate the proposed methodology, to identify and measure the success parameters for a project. Their research method is a mixture of qualitative and quantitative and it is applied to a case study. The primary data were gathered using unstructured interviews with decision makers. Bibliographic research is used in order to construct the theoretical framework and the intervention instrument adopted is the multicriteria decision aiding methodology– constructivist (MCDA-C).

Quintana and Leung (2012) performed the study to illustrate a practical approach for industrial work process design in an integrative manner, captured essential concerns from different parties associated with manufacturing. The aim of their study was to incorporate utility expectation from the perspectives of operational managers, floor workers, and financial planners into the decision making process. Their results suggest that the proposed BBN framework is effective in modelling and solving the work design problem. Their findings may be useful in the adoption and capacity of BBN in the fields of ergonomics, worker health management, and performance improvement. Bhatti et al. (2013) examined the mediating effects of expatriate adjustment (work, general and interaction) between individual (previous international experience, self-efficacy, social network and cultural sensitivity) and organizational factor (direct and indirect support) and job performance. They collected the data from 201 expatriates working in Malaysia and analyzed by using structural equation modelling. The results of their study indicate that expatriate adjustment (work, general and interaction) mediate the relationship between individual and organizational factors and expatriate performance (supervisor rated). The findings of this study suggested that human resource managers and MNC's management should provide direct and indirect support to the expatriates and their families in terms of language and cultural training, career development, logistical assistance, family mentoring, psychological counselling, job search, self-development and social activities. Furthermore, recruitment managers and MNC's management should consider these factors before appointing any employee for international assignment.

3.0 Introduction of the Industry

It is the collaboration of three industries in August, 2001 and production started in November, 2001. It has been awarded quality standardization certifications like ISO/TS 16949:2002; ISO 14001; OHSAS 18001 & ISO 9001. Its present turnover is more than 250 crores.

The main components manufactured by this firm are:

(i) Different types of seals:

1. Shaft seals 2. Shock Absorber/Rod Seals 3. Cassette seals 4. Wiper and rod seals 5. Hydraulic seals 7. Oil seals 8. Radial shaft seals 10. Differential seals etc.

(ii) Different types of diaphragm

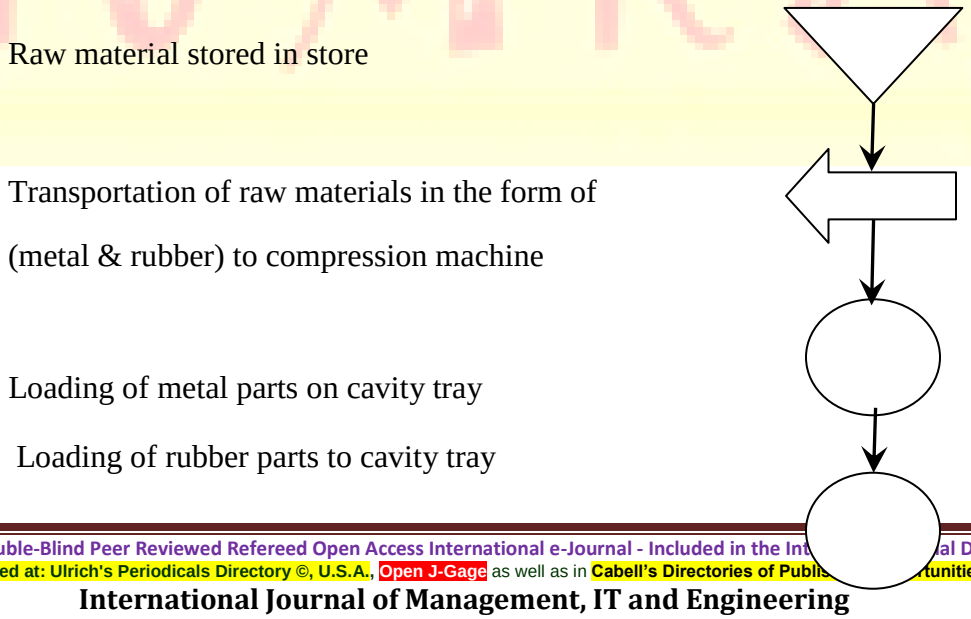
1. Package Solution for Automotive Construction 2. Pump Diaphragms 3. Rolling Diaphragm 4. Turbocharger Diaphragm 5. EGR Diaphragm etc.

3.1 Customers of the company

1. L & T 2. LML 3. Lincon hellious 4. Mahindra & Mahindra 5. New Holland 6. Eicher motors 7. Escorts Ltd. 8. Hindustan hydraulics 9. Ashok Leyland 10. Bosch 11. BHEL 12. Bajaj tempo 13. Brakes India 14. Delphi automotive systems etc.

3.2 Manufacturing processes

The complete process of manufacturing of Shock Absorber/Rod Seals is presented in the form of flow process chart as shown in Figure 1.



Loading of cavity tray to compression machine

Beginning of pressing operation

Waiting by worker to check the closure of machine

Start curing

Unloading of work piece from compression machine

Transportation of work piece to cooling machine

Placing of work piece on conveyor cooling belt for cooling

Transportation of work piece to trimming machine

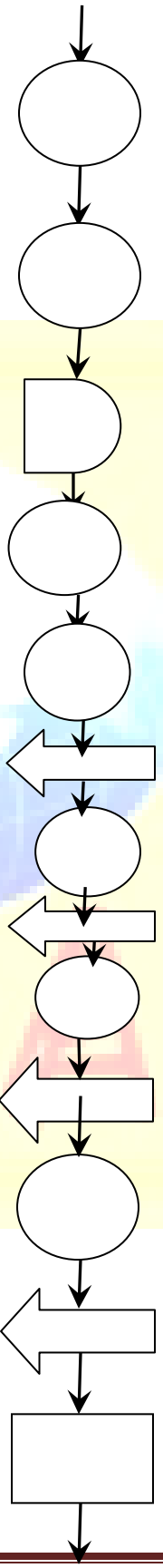
Starting of trimming on work piece

Transportation of work piece to spring loading table

Spring loading on work piece

Transportation of work piece to Inspection table

Starting of inspection on work piece



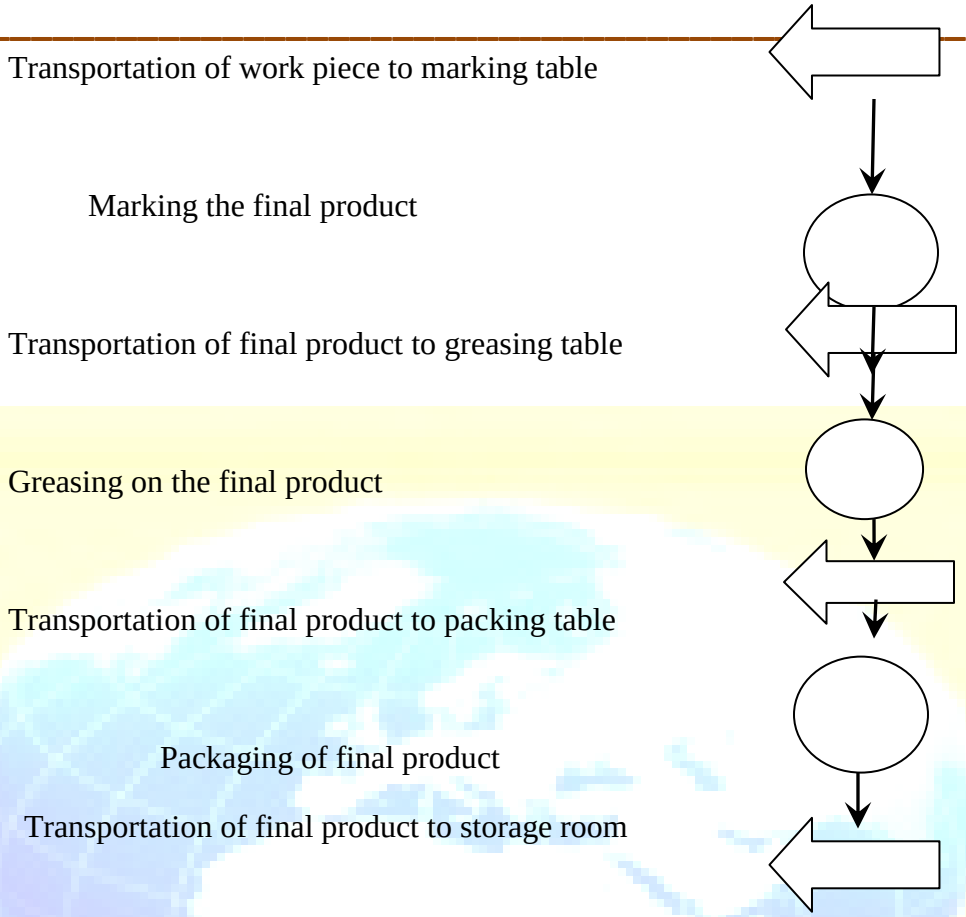


Fig. 1 Flow Process chart of manufacturing of shocker seal

3.3 Existing layout analysis of the industry

Fig. 2 shows the existing layout of the manufacturing area of shocker seals along with the distances between various work stations. Work study techniques may be applied to reduce this material handling time (transportation time) to increase the productivity of the product.

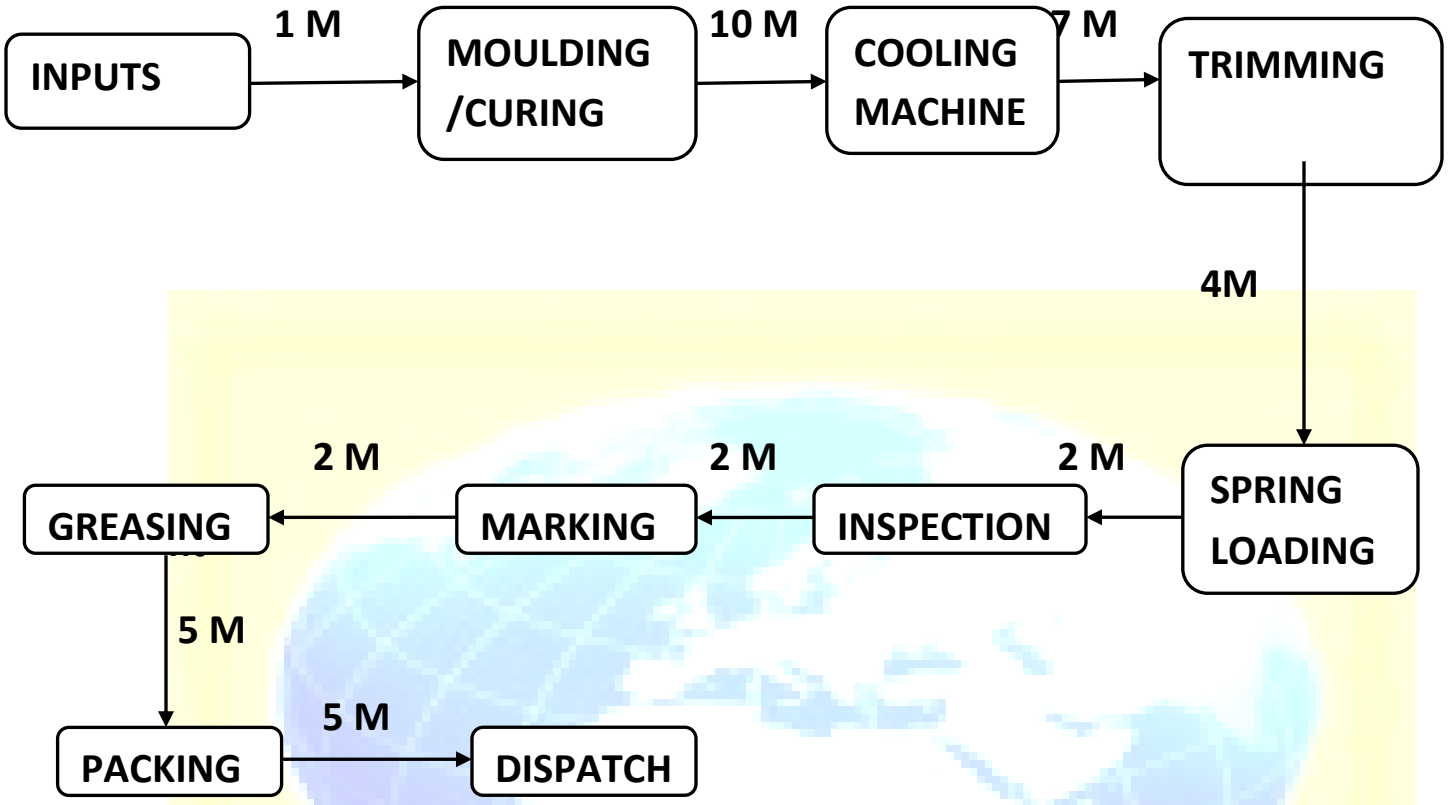


Fig. 2 Existing layout of manufacturing area of shocker seals

3.4 Proposed layout analysis of the industry

After analysis, it is found that some changes are required in the existing layout of production area of the shocker seals. The proposed layout is shown in Fig. 3.

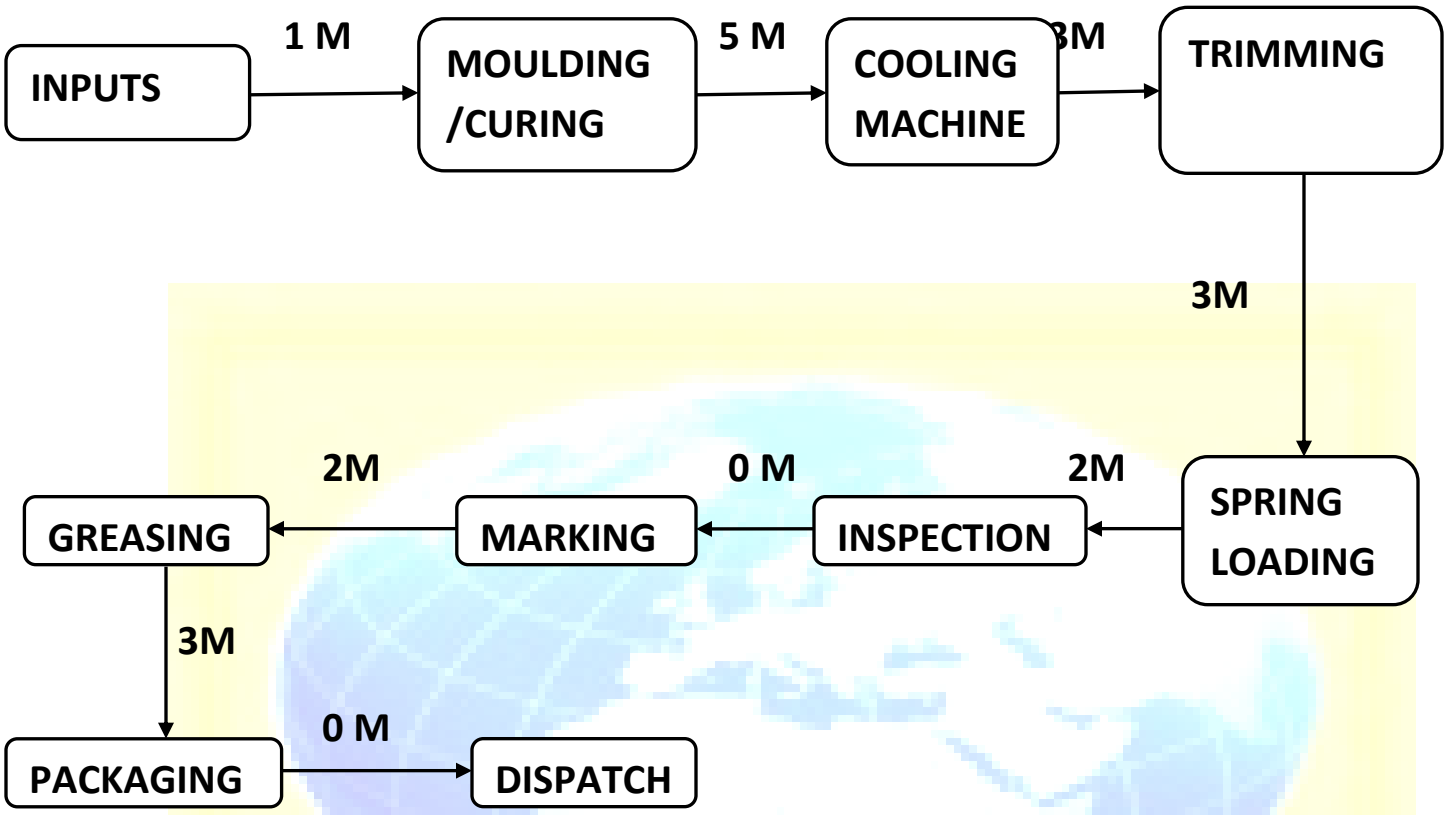


Fig. 3 Proposed layout of shocker seal

Following changes are required to in the proposed layout:

1. Moulding machine to cooling machine = reducing distance from 10 to 5 metres

2. Cooling machine to Trimming machine = reducing distance from 7 to 3 metres

3. Trimming machine to Spring loading machine = reducing distance from 4 to 3 metres 4. Combining marking and Inspection operation

5. Marking and Greasing tables = reducing distance from 5 to 3 metres

6. Combining packaging & dispatching

Existing distance = 38 meters

Proposed total distance = 19 meters

Total distance saved = 19 meters

As per the above analysis, it is found that productivity can be increased by reducing the distances among various machines and combining some operations. Manufacturing cycle time will be reduced due to change in the layout which will increase the productivity and reduce the manufacturing cost.

3.5 Analysis by using Man-Machine (multiple activity) chart for shocker seals manufacturing area

Where a number of workers perform the various tasks in a group or an individual operator handles two or more machines, their activities have to be co-ordinated for achieving maximum outputs. A multiple activity chart records the activities of all the workers and machine on a common time scale simultaneously and thus shows inter-relations between them. Various symbols for man machine charts are shown below:

M 1 = Machine 1 (compression moulding machine 1)

M 2 = Machine 2 (compression moulding machine 2)

M 3 = Machine 3 (Trimming machine)

W 1 = Worker I

W 2 = Worker II

Fig. 4 shows the man-machine chart for manufacturing of shocker seals for 288 minutes activities. Black boxes show the working portion and blank boxes show the idle activities in the part of either workers or machines.

TIME (in Min.)	M1	M2	M3	W1	W2
0-4					
4-6					
6-8					
8-12					
12-22					
22-29					
180					
29-43					
43-68					
68-71					
71-76					
76-78					
78-80					
80-84					
84-94					
94-101					
180					
101-114					
114-150					
150-213					
213-216					
216-218					
218-222					
222-224					
224-226					
226-230					
230-239					
239-246					
246-257					
257-281					
281-284					
284-288					

Fig. 4 Man machine chart of manufacturing of shocker seals

3.5.1 Percentage utilization of workers and machines

On the basis of Fig. 4, Table 1 shows the calculations of Idle and working times of various machines and workers.

Table 1 Calculation of Percentage utilization of workers and machines

TIME	Machine 1	Machine 2	Machine 3	Worker I	Worker II
Idle Time (in minutes)	57	29	0	0	0
Working Time (in minutes)	231	259	288	288	288
Total Cycle Time (in minutes)	288	288	288	288	288
Percentage Utilisation	80 %	90%	100%	100%	100%

3.5.2 Summary of Capacity Utilisation

Capacity utilization compression moulding machine 1 (M1) = 80%

Capacity utilization compression moulding machine 1 (M2) = 90%

Capacity utilization of Trimming machine (M3) = 100%

Capacity utilization of worker I (W1) = 100%

Capacity utilization of worker II (W2) = 100%

From the Table 1, it is observed that the capacity utilization of machines, M1 and M2, is less than 100% while capacity utilization of trimming machine, worker 1 and worker 2 are 100%.

4.0 Conclusions

Purpose of doing work and time study is to find the optimum and most efficient way of using the available resources which include material, machinery, men and money. As per analysis, it is found that by combining some operations and reducing the distances among the various work

stations will improve the productivity of the industry. Manual transportation should be replaced with conveyors and these changes will lead to increase the productivity of the firm.

The limitation of the work is that the time and motion study could be applied in the other manufacturing area/section of the industry.

References:

- Cheong, W. K, Look, S.O. and Mohamed, H. (2007), "Improving direct labour productivity through minimizing time wastage approach", *International journal on semiconductor manufacturing*, Vol. 4 , Issue, 15 – 17, pp. 1 – 4.
- Choi, C. K. (1999), "A comparison of MTM and RTM " *Journal on Work Study*, Vol. 48, No. 2, pp. 57- 61.
- Bhatti, M. A., Battour, M. M. and Ismail, A. R.(2013), "Expatriates adjustment and job performance: An examination of individual and organizational factors', *International Journal of Productivity and Performance Management*, Vol. 62 Issue 7, pp. 694 – 717.
- Cocca, P. Marco Alberti, M. (2010), "A framework to assess performance measurement systems in SMEs", International Journal of Productivity and Performance Management, Vol. 59, Issue: 2, pp.186 – 200.
- Hung, R. (1998), "Novel ways to deal with seasonal manpower needs ", *Journal on Work Study*; Vol. 47, No. 3, pp. 87-89.
- Kumar, S., Kevin L., Johnson, K. L. and Lai, S. T. (2009), "Performance improvement possibilities within the US airline industry", International Journal of Productivity and Performance Management, Vol. 58, Issue: 7, pp.694 – 717.
- Quintana, R. and Leung, M. T. (2012) "A case study of Bayesian belief networks in industrial work process design based on utility expectation and operational performance", *International Journal of Productivity and Performance Management*, Vol. 61, Issue 7, pp.765 - 777
- Rogerio, T. O.L., Leonardo, E. and Ensslin, R.(2011), "A performance measurement view of IT project management", International Journal of Productivity and Performance Management, Vol. 60 Issue: 2, pp.132 – 151.
- Satoko, K., Atsue, I., Hodaka, N., Urarieko; Y.B., Fumiko, W. Mitsuko, Y., Suzuki, T. and Yuko, O. (2004), *Journals on Time and Motion study*, Vol.37, No. 4, pp. 297-308.
