Measurement of TPM Losses Due To Skill Level Difference of Workers: Case Study of A Pharmaceutical Company

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Abstract

Total Productive Maintenance, TPM, has been proven to be a very effective tool for the improvement of productivity and efficiency of employees and equipments, and the overall environment of a company. From the TPM perspective, 16 losses have been identified to exist in an organization, of which some are attributed to human error. Among these, Operating Motion Loss and Multiwork loss are directly related to deficiency in both skill and work allocation. The study was conducted in a pharmaceutical company to find out a relative scenario of these losses in different sections of the tablet manufacturing facility. The losses were quantified in terms of loss of productive time and labor.

Keywords
Total Productive Maintenance (TPM), Multiwork loss, Operating motion loss, Skill level difference.

1. Introduction
One of the recently developed concepts in industrial engineering that has been gaining popularity over the past few decades is Total Productive Maintenance or in short, TPM [1]. The basic idea is to adopt the best practices for maintenance of equipments and plants while making no compromise with productivity. TPM fosters an environment where improvement efforts in Safety, Quality, Delivery, Cost and Creativity are encouraged, through the participation of all employees. Employee involvement is one of the main catalysts of TPM [2]. One of the eight pillars of TPM, Kaizen [2], pursues efficient equipment, operator, and material and energy utilization. To achieve these goals, 16 major losses have been identified to exist in an organization, of which 5 major losses are the ones that hinder human work efficiency. Of these, two losses namely, Operating Motion loss and Multiwork loss are directly related to human skill level difference and scheduling inefficiency and thus are attributed to ineffective management of human resources [3]. Therefore, the losses thus quantified can be deemed as effects of worker allocation from a TPM perspective. The study was conducted in the tablet section of a well reputed pharmaceutical company of Bangladesh. Losses due to human activities are often taken as qualitative losses and their effects are not quantified. In this study, the delays and impedances caused by human inefficiencies were measured and their effects were quantified.

2. Literature Review
McKone, Schroeder and Cua [1] presented a contextual approach to TPM where they recognized that the environment and employee involvement characteristics of an organization are crucial factors for TPM implementation. Venkatesh [2] identified and defined 16 major losses in an organization from the TPM perspective of which 5 were attributed to human inefficiency or erroneous activities. Pfeffer [3] examined different companies and concluded that effective management of workforce led to more success. He also emphasized on training and cross utilization of workers, which coincides with the basic idea of TPM. Some literatures regarding the implementation of TPM in different industries were helpful for this study. Seng and Ramayah [4], while developing a framework for implementing TPM in a Malaysian manufacturing industry, recognized that both human – oriented and process- oriented strategies were equally crucial. Ramayah, Jantan and Hassan [5] made a comparison of different industries implementing TPM on the basis of several factors and found out empirical evidence that the factors related to what they termed "Change Management", such as managements' commitment, employee empowerment and training etc, significantly enhanced TPM implementation. OH, Park, LIM and LEE [6] studied TPM implementation factors in Korea and they also emphasized on personnel and organizational management. Lemma [7] presented a case study of TPM implementation in a textile industry of Ethiopia. A way of looking into human errors in organization was presented by Rasmussen [8] where task analysis was given importance. Pessan,

Moreneau and Neron [9] solved a multi- skill scheduling problem using the basic theories of project management. This gave the idea of solving the multiwork loss problem using a simulation similar to Gantt chart [10].

3. Problem Definition

3.1 Study area

The study was conducted in an eminent drugs manufacturing industry of Bangladesh. The Tablet section was the chosen sector of study. The tablet manufacturing facility consisted of the following steps. The processes starting from raw material mixing to the production of tablets in a compressed form were under the scope of this study.

In the Tablet section, tablets are manufactured in 2 ways:
Dry mass tablet manufacturing and Wet mass tablet manufacturing. From the Pharmacy (Store), raw materials go to rapid mixer (wet mass room) in case of wet mass manufacturing. From there it goes to Fitz mill and from there materials are taken to the dryer. In case of Dry mass Manufacturing the materials from pharmacy are sent to Compactor. Now after these steps the materials from the Fitz mill or from compactor are sent to the blender. After being blended the materials are then carried to different compression machines to get the desired tablet shapes. From there the tablets are sent to the coating machine room if coating is required. Here Quality Checking is done in many steps and without being confirmed from the Quality Assurance Department the materials can not proceed from one step to another step.
The machines involved were:

1. Coating machine, 2. Drier, 3. Wet Mass Mixing, 4. Fitz Mill, 5. Blender, 6. Compression machine, 7. NC Compression machine (Sejong).

3.2 Human losses under TPM

The objective of TPM is maximization of equipment effectiveness. TPM aims at maximization of machine utilization and not merely machine availability maximization. As one of the pillars of TPM activities, Kaizen activities try to thoroughly eliminate 16 major losses [2]. These are: 1. Failure losses - Breakdown loss, 2. Setup / adjustment losses, 3. Cutting blade loss, 4. Start up loss, 5. Minor stoppage / idling loss, 6. Speed loss - operating at low speeds, 7. Defect / rework loss , 8. Scheduled downtime loss, 9. Management loss, 10. Operating motion loss, 11. Line organization loss, 12. Logistic loss, 13. Measurement and adjustment loss, 14. Energy loss, 15. Die, jig and tool breakage loss and 16. Yield loss. Of these, losses 9 through 13 are the human losses under TPM. These are the losses that impede human work efficiency, thus adversely affecting the productivity of the organization. The goal of this study was to find out the scenario of Multiwork loss and Operating Motion loss in quantitatively in terms of loss of productive time and labor.

3.3 Operating motion loss / losses due to skill level difference

Operating motion loss is mainly the man hour loss generated by the skill level differences of workers in carrying different operations. The main objective was to find out the sections where skill level difference in different operations occurred most, and to quantify that loss. Operating motion loss occurs mainly in the following three arenas:

i. Skill Level Difference in the set up and adjustment
ii. Skill Level difference in loading and unloading
iii. Skill level difference in cleaning equipment

3.4 Multiwork loss

This loss results when workers work on more than one piece of equipment at the same time. This study tried to find out whether the number of workers needed in one room was sufficient or not.

4. Analysis of Losses Due To Skill Level Difference

4.1 Methodology

- The sections were observed for two weeks' working hours. Time measurements for skill level difference in set up and adjustment, in loading unloading, and in cleaning equipments were made.
- Data was analyzed.
- Section of most significant loss was identified and the range of loss was quantified and represented.

4.2 Data observations

For each type of skill level loss, data for concerned machines were taken. Skill Level Difference in the set up and adjustment occurred at Fitz Mill, Compression Sejong and Compression Clit Press II. Skill Level Difference for Loading and Unloading occurred at Fitz Mill, Wet mass mixing, Drier, Blender, Compression Sejong and Compression Clit Press II. Skill level difference in cleaning the equipments also occurred in all the above machines, except for the Sejong machine. For the three kinds of activities, the duration of work depending on the type of machine varied as depicted in Table1.

Table 1: Descriptive statistics of duration of work for different activities

Type of Activity	Statistics	Fitz Mill	Wet mass mixing	Compression Sejong	Copression Clit Press II	Drier	Blender
Skill Level Difference in the set up and adjustment	Maximum	42 min	X	12.5 hrs	4.5 hrs	X	X
	Minimum	21 min		8 hrs	2.5 hrs		
	No. of data	9		3	4		
Skill Level difference in Loading and Unloading	Maximum	103 sec	195 sec	212 sec	166 sec	480	12 min
	Minimum	63 sec	91sec	145 sec	128 sec	240	8 min
	No. of data		23	10	9	10	12
Skill level difference in cleaning equipment	Maximum	42 min	75 min	X	72 min	52 min	85 min
	Minimum	29 min	34 min		58 min	48 min	50 min
	No. of data	4	4		3	3	5

It is evident that skill level difference really does make a lot of difference. In most of the cases, a huge difference was found in activity completion time. Since the ranges were wide, mean values could not be taken as representative.

4.3 Data Analysis for Skill Level Difference

The most frequent data was taken as the standard time and the difference between that and each data was calculated. A positive difference indicated that the worker was more skilled and finished the work quicker. A negative difference indicated that a loss occurred due to inferior skill level of worker. Summary of three kinds of losses are shown in Table 2. In case of Set up and adjustment, skill level difference occurred most at the compression machine (Sejong), with 33% (1 out of 3 data) frequency. In Loading and Unloading, skill level difference occurred most at the Drier, with 60% (6 out of 10 data) frequency. In case of Cleaning, skill level difference occurs 50% (2 out of 4 data) of the time at both Fitz mill and wet mass mixing machine.

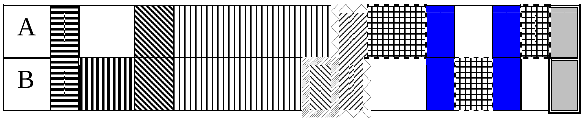
Table 2: Relative scenario of losses

Type of Activity	Attributes	Fitz Mill	Wet mass mixing	Compression Sejong	Copression Clit Press II	Drier	Blender
Skill Level Difference in the set up and adjustment	Most frequent data/ range	33 min	X	8 hrs	3.2 hrs	X	X
	No of negative differences	2		1	1		
	No. of data	9		3	4		
Skill Level difference in Loading and Unloading	Most frequent data/ range	70-85 sec	170-180 sec	160- 210 sec	160- 165 sec	228-312 sec	10 min
	No of negative differences	6	5	1	2	6	3
	No. of data	23	23	10	9	10	12
Skill level difference in cleaning equipment	Most frequent data/ range	32 min	54-55 min	X	70 -72 min	52 -54 min	72-75 min
	No of negative differences	2	2		0	1	1
	No. of data	4	4		3	3	5

5. Multiwork Loss

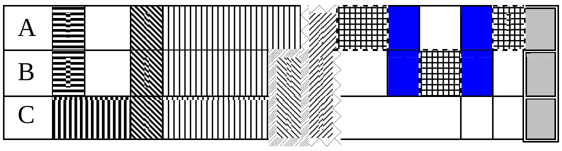
To find out this loss it was tried to figure out whether the number of workers occupied in wet mass mixing was sufficient or not, by simulation. In the wet mass section there were usually 2 workers. Occasionally, three workers were also found to work. In most of the cases, when hot water was needed, an additional worker was called up. In this analysis, we tried to find out if it would be better to have three workers assigned for that section permanently. The concept of Gantt Chart was used for the simulation.

- **Case one: Two workers**



Total time needed: (45+600+210+4380+175+1200+5+900+5+30+30) =7580 sec or 126.33min
Idle time of worker A: 1500 sec or 25 min
Idle time of worker B: 1230 sec or 20.5 min
Cumulative idle time of workers: 45.5 min

- **Case two: Three workers**



Total time needed: (600+150+4380+120+1200+5+900+5+30+30) = 7420sec or 123.67 min
Idle time of worker A: 1455 sec or 24.25 min
Idle time of worker B: 1785 sec or 29.75 min
Idle time of worker C: 2140 sec or 35.67 min

Pattern	Meaning	Time Needed for two workers(s)	Time Needed for three workers (s)
	Bringing Raw Material	45	45
	Heating water	600	600
	Mixing to make paste	210	150
	Cooling paste	4380	4380
	Loading material in machine	175	120
	Operating the machine	1200	1200
	Operating machine again	900	900
	Operating machine before unloading	30	30
	Checking	5	5
	Preparing container to collect end product	130	60
	Unloading	30	30
	Worker idle		

From the above simulation, it can be seen that if three workers are permanently assigned in the section, process time will reduce by (126.33-123.67) = 2.66 minutes, but the cumulative idle time of the workers will increase by (89.67-45.5) =44.17minutes. Therefore, the gain in process time was very small compared to the significant increase in idle time of workers. So we can conclude that, three workers should not be permanently assigned for this section; two workers could better do the job.

6. Conclusion

The skill level difference of workers was observed in this study for three different kinds of tasks. Losses are bound to occur when a skill level difference occurs, as is evident from this study. It was observed that for the three kinds of tasks, 30 to 60 % of the time, productivity loss occurred due to skill level difference among workers. Also, Worker allocation should be made only when gain in productivity is significant. The proposed simulation method can be used in this respect in similar situations. Worker allocation should be made keeping in mind the skill level differences and the number of workers needed should also be determined beforehand. The losses that occur due to skill level difference and unnecessary workers allotted at workstations are, in fact, significant, and these facts need to be addressed with proper emphasis.

Acknowledgements

This study was done as a part of the thesis work for B.Sc Engineering degree under the department of Industrial and Production Engineering of Bangladesh University of Engineering and Technology (BUET). The authors would like to thank BUET for complete support and supervision. Also thanks to Renata Limited for their support and cooperation.

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