Improving the Changeover Performance of a Manufacturer A Case Study

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ABSTRACT

Improving manufacturing performance has become a salient factor for any firm. It is vital for personal product manufacturers due to intense competition which arises from various grounds including the cost. Therefore manufacturers concern on the ways and means by which productivity can be improved. The study focuses on the productivity problem of a department of a leading manufacturer in Sri Lanka, which produces personal products. The loss time analysis reveals that the changeover time is one of critical factor which adversely affect productivity of the selected department. Therefore the research attempts to identify the barriers to improve productivity by analyzing technical factors which result the high changeover time and suggest solutions with the aim of improving manufacturing performance.

KEYWORDS: Changeover performance, Productivity, Personal Product, Technical Factors, Change over time

INTRODUCTION

The need for productivity improvement in the manufacturing industry is due because of the high level of competition in this sector. Organizations have discussed, analyzed, planned and attempted the productivity revivals through the implementation of productivity improvement programs. Normally industry considers the productivity enhancement as process to achieve higher levels of output while consuming same or lesser amount of input resources. Also, they believe that if the same output level is reached in a shorter time period, it indicates improved productivity. Thus today's global competition requires increased throughput levels over lesser time horizons (Hoffman, et. al, 1998).

Using the knowledge and personal experience of the productivity personnel and existing literature, the studies on improving productivity have identified the possibility of improving productivity (Lecture notes, 2008., Pritchard, 1990, Hugo, 2008). The list of possible factors, which increase the productivity, can be noted below (Lecture notes, 2008).

- Increase the capital investments
- Reduces wastages
- Improve the performances of machines
- Achieve the safety environments and safety behaviors
- Increase the incentive payments
- Minimize setup and adjustment time
- Improve the management commitment and leadership
- Design the workplace as productive environment

The key important factor for any productivity improvement program in manufacturing sector is set up and adjustment time or changeover time. Producing make-to-order products to demanding customer quality, price and delivery requirements can be achieved successfully if manufacturing is efficiently geared up for wide variety, small batch production. This is applicable for the multi-product manufacturers. With wide variety-small batch production, the impact of set up times becomes significant in overall production performance. To meet competitiveness in the market, the organization must regularly change their products from one to another. Therefore it is essential to make necessary adjustment in the machines. Thus setup and adjustment time should be minimized as possible.

The study focuses on the productivity problem mainly with high changeover time of a department of a leading manufacturing company in Sri Lanka, which produces personal products such as shampoo toothpaste, cream etc. The company was formed in 1938 and it operates in three sites. It is one of the world's most culturally diverse companies, with top leadership from 32 nations. It is manufacturing fast moving consumer goods and today it is home to 20 strong brands. This Personal Product (PP) department is the largest department in the site. It is manufacturing and packing more than 26 products under 7 brands with 51 Stock Keeping Units (SKUs).

In order to gain competitive advantage, the company has implemented a Japanese production method, Total Productivity Maintenance (TPM) in 2006. Inefficient of productivity, working individually and no team work, law machine efficiencies, dirty, dangerous machines, lack

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of motivation and commitment and poor reliability were main reasons to implement TPM in the company. The PP department evolves with the TPM and initially introduced the 5S to the department. And along with the company they implemented other pillars of TPM too in the department. A kaizen event under the continuous improvement pillar had reduced changeover time in NM700 model line. With TPM the PP department created pleasant environment to work, workers were highly motivated and achieved its production targets. According to the table 1.1 at that time Overall Equipment Efficiency (OEE) of the department was around 75%- 80%.

	OEE (%)
PP Department (2006)	75 -80
NM700(2008)	57.84
PP Department(2008)	59.17

Table 1.1 OEE data

Currently the PP department is facing severe problems with the production targets and productivity. According to the table 1.1 the current OEE of the department reduce up to average 50%. The loss time analysis (Figure 1.1) revealed number of factors which adversely affect productivity of the department. According to the Figure 1.1 the main down type is the no demand. No demand indicates the low plans and no plans. Therefore it cannot be controlled by the pp department. The second major down type is equipment failures and they are spread on a vast area. Therefore analyzing those data covers a large area and it is necessary to have a specialized knowledge of mechanical and electrical engineering. Setup and adjustment time is the next highest effective factor of the performance of the PP department.

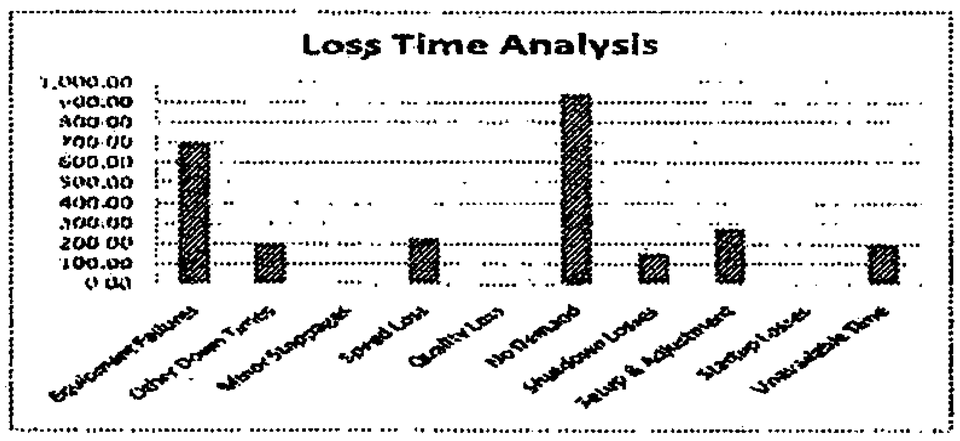

Figure 1.1- Loss Time Analysis

As shown in the figure 1.2 toothpaste section has only three tubes filling machines and a sachet filling machine. However it has five verities of toothpaste tube products with 4 SKUs.

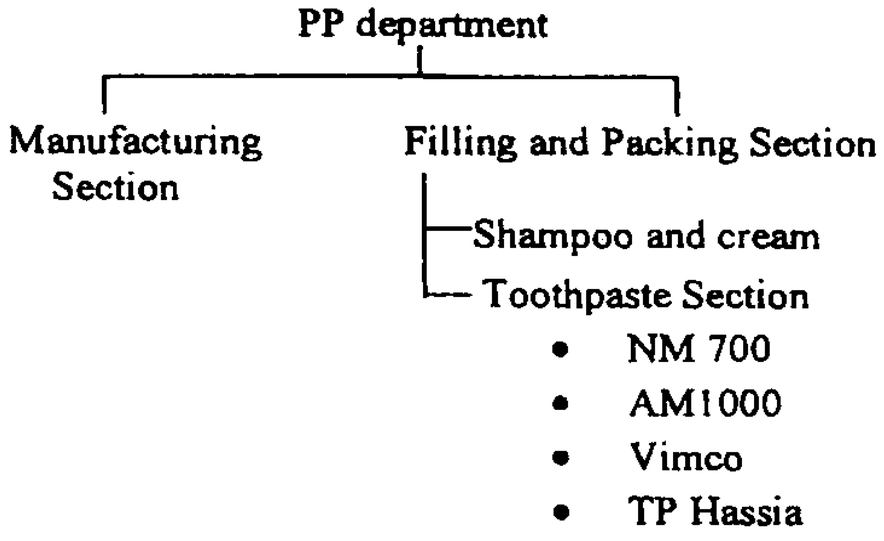

Figure 1.2 Department Structure

In 2006 with TPM they have done many projects with the aim of reducing change over time. They have applied ECRS tool (Elimination-Combination-Rearrange-Simplify) and implemented 'JIG' system to reduce changeover time but failed. According to the mean change over time (August to January) changeover time becomes major problem in the PP department.

Reduced C/O time in 2006	Mean value of C/O time in 2008
32 minutes	168.4 minutes

Table 1.2 Average Changeover Times

According to the above factors one of major problem in PP department is increasing changeover time. Therefore the main Research Question of this study is that identifying the barrier to improve productivity in PP department with special reference to the changeover time.

The study was carried out with the objective of analyzing the changeovers in PP department with the purpose of improving the changeovers and productivity. To achieve this objective, the study focused on related literature, how changeover time could be a problem, analyzing the working environment, identifying and analyzing the technical factors adversely affecting to the changeover time and finally give solutions to improve the changeover performances.

LITERATURE REVIEW

The research attempts to identify barriers to improve productivity in manufacturing organization. Basically the productivity can be defined as amount of output per unit of input (labor, equipment and capital). As discussed in the earlier section there are number of factors affecting to the productivity in direct and indirect way in manufacturing and service sector (Lecture notes,2008).

The concept of OEE goes with the technique TPM. There is direct relationship between productivity and OEE. Improve Overall Equipment Efficiency means improve of productivity (TPM text book, TPM centre OEE is taken as the most common and important

sources of manufacturing productivity loss (as TPM there are 8 major losses), places them in to three primary categories; availability, performance and quality. OEE is a calculation which focuses on individual items of process or manufacturing equipment and allows their 'effectiveness' to be measured individually or in groups. Overall Equipment efficiency can define as,

OEE = Availability x Performance Rate x Quality products rate

Availability takes into account Down Time Loss, which includes any events that stop planned production for an appreciable length of time. Examples include equipment failures, material shortages, and changeover time. Performance takes into account Speed Loss, which includes any factors that cause the process to operate at less than the maximum possible speed, when running. Examples include machine wear, substandard materials, misfeeds, and operator inefficiency. Quality takes into account Quality Loss, which accounts for produced pieces that do not meet quality standards, including pieces that require rework. (Inconics, 2006)

TPM is a companywide strategy to increase the effectiveness of production environments, especially through methods for increasing the effectiveness of equipment. TPM implementation involves applying continuous improvement methods to reduce losses. Because the actual process of adding value to products usually involves machines and equipment, TPM focuses its improvement activities on equipment-related losses. The difference between the ideal and the actual situation is caused due to losses. Equipment operators face the results of these losses on a daily basis. TPM gives them the tools to identify the losses and make improvements. According to the TPM there are six types of waste that can refer as losses as they reflect lost effectiveness of the equipment. These six losses can also group in three categories: downtime, speed losses, and defect losses.

As discussed in earlier OEE is calculated using availability, Performance Rate and Quality product rate. Availability takes in to account down time losses. There are many down time losses. Down time losses includes any events that stop planned production for an appreciable length of time. But machine should be running. Downtime includes two major losses, equipment failures and set up and adjustments (Mc Carthy,*et al*, 2004)

Under setup and adjustment most machine changeovers require some period of shutdown therefore that internal tools can be exchanged. The time between the end of production of the last good part and the end of production of the next good part is downtime (TPM text book, 2006). Changeover in manufacturing is the process of converting a line or machine from running one product to another. Changeover times can last from a few minutes to as much as several weeks.

There are number of factors which influence the changeovers. They include skills of workers, poor maintenance of machines such as worn parts, worn tooling (Strategos Consultant), Location and Adjustments such as eliminate on-machine adjustments; provide intelligent adjustments and monitoring and easy delivery of tools. (McCarthy, et al, 2004)

Therefore for the high changeover time, lack of technical knowhow, layout of the machine and lack of tools and equipment are affected and these factors affect to the production time, breakdowns, wastages and equipment efficiency. And finally these factors result to the productivity, profit, quality and OEE.

METHODOLOGY

The research is basically done to solve the organizational problem. Therefore this research is also based on the problem in selected department. The research is an applied research since it is undertaken to answer a specific industry problem and give solutions to it. The research is mostly based on qualitative data and applied deductive reasoning. The basis of this research is identification and analysis of the factors affecting to increase changeover time. The Research is flowing with answering the research questions. If the research is divided in to three phases, the first one is identification of the research and research problems. Second phase is the data collection and analysis. The third phase is identification of solutions and evaluation. This research executed two main data collection methods: primary data and secondary data. Primary data were collected through observations and informal discussions. Because of the worst situation in department, it was difficult to apply other sophisticated primary data collection methods. Although primary data collection methods such as formal interviews or questionnaire are effective in similar research, the research could not use them due to prevailing unfavorable situation of the organization. Therefore informal discussions with workers, managers and supervisors were used to collect data. The research uses secondary data too. The production and machine breakdown data were taken from the production sheets. The details of loss tree data and OEE of the department were taken from the information system. To get past data, project boards, charts, reports, and magazines were used. The user manual of NM 700 toothpaste filling machine was used as a secondary data source. TPM text book was used to gather information that relevant to the research. As data collection tools the time study, the stopwatch technique was applied. And also digital camera was used to take photographs as data and a table format was used to mark changeover activities and time durations of each

activity. Use the mean and standard deviations as statistical methods.

DATA COLLECTION & ANALYZING

Initially the manufacturing process was identified. After manufacturing the white paste (Lleal I) and color paste (Hobal or Thompson mixer) they were piped to the storage tanks that connect in NM700. There are two storage tanks in the NM700 filling machine that situated in high point related to the filling machine and the storage tanks are connects to the NM700 machine with pipe lines.

Filling machine fills the toothpaste into the empty toothpaste tubes. Empty toothpaste tubes are kept in tube cassette and tubes are placed in tube holders and fill the paste and seal the tube. In the carton Machine, tubes are transported to the carton machine using product transport chain and put tubes into carton boxes and pack them. Finally stack them on pallets.

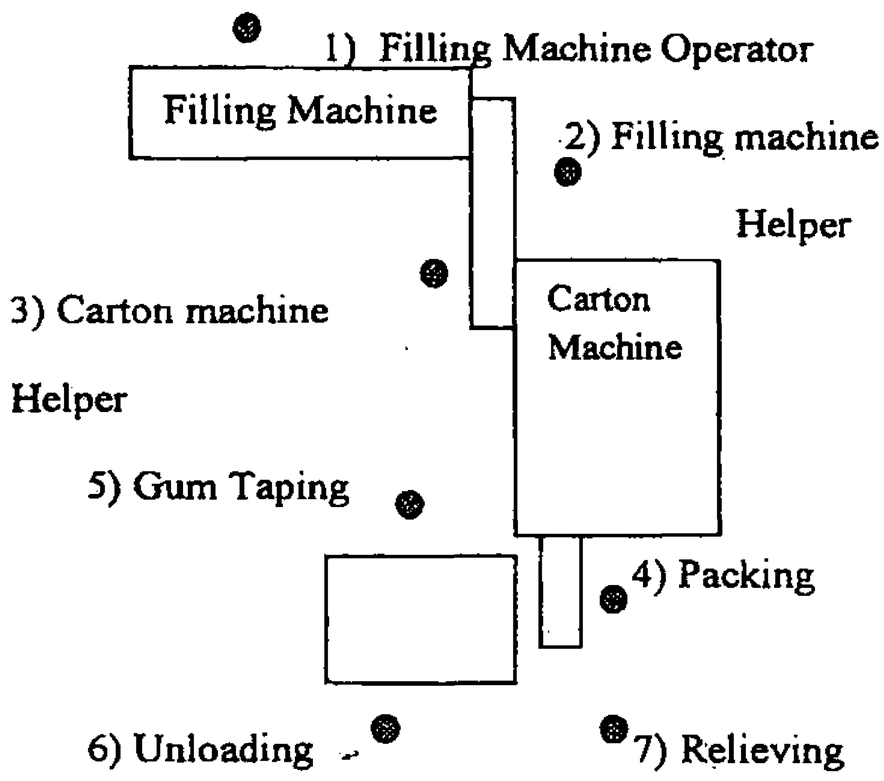

Figure 1.3 Layout of the NM 700 Machine

Initially the manufacturing process and layout of the NM700 machine was identified.

As shown in the layout (Figure 1.3) there are seven workers assigned for the machine. The changeover time starts when the last product of the batch is produced until the moment that the first product of the next batch is produced. All the changeover activities are identified and changeover time durations for each activity are taken

No	Activity
1	Change Tube cassette
2	Change and adjust rocker plate
3	Adjust overhead guide plate
4	Adjust lateral guide plate
5	Adjust and Change tube tilter
6	Adjust and Change side wall
7	Adjust and Change tube infeed depressor
8	Adjust sealing unit
9	Adjust tube ejector
10	Change tube holders
11	Adjust and Change white filling unit
12	Adjust tube registration photocell
13	Adjust and Change red filling unit
14	Change hot air unit
15	Adjust product transport chain
16	Adjust product pushes
17	Adjust overhead guide rail
18	Adjust carton transport bed
19	Adjust carton transport chain
20	Adjust carton magazine
21	Adjust & change carton erection
22	Adjust side flap folding swing arm
23	Adjust end flap guide rail
24	Adjust front flap folding bar
25	Adjust triangular folding rail
26	Adjust tuck-in flap guide plate
27	Adjust horizontally rotating carrier plate
28	Adjust flap closing finger
29	Cleaning the environment & machine
30	Replace carton & empty tube boxes for new product
31	Testing & re-adjustments

Table 1.3 Changeover steps in filling machine

The changeover time starts when the last product of the batch is produced until the moment that the first product of the next batch is produced according to the product specifications at nominal production rate. Therefore table 1.3 shows the identified activities of SKU changeovers in NM700 filling machine.

When changeover is started, necessary tools for the changeover have not been arranged. Therefore, the fitter has to spend extra time and energy to find them. The same problem is noticed by the researcher eight times out of 12 times of observation. The needed tools for the changeover are following.

- Allen key – 2.5
- Allen key – 4
- Allen key – 5
- Allen key – 5 (long Tee)
- Allen key – 6
- Allen key – 6 (long Tee)
- Allen key – 8
- Box wrench – 10
- Box wrench – 13
- Box wrench – 19
- Hammer
- Open-ended wrench – 13
- Pipe wrench
- Socket wrench - 17
- Socket wrench - 19

There are no sufficient tools available for the changeover. When doing a changeover there must be relevant tools. But without tools the changeover can be inefficient and finding tools is time consuming. As discussed in Literature review there should be an easy delivery of tools. Therefore the tools are key factor that affecting to the changeover.

Because of not knowing how to do changeover correctly more time for the changeovers can be consumed. As the researcher's observations sometimes fitters do wrong adjustments and then have to readjust those parts again. In a changeover, fitter once adjusted tuck-in flap guide plate wrongly and when testing it had to be readjusted again. Therefore it took another 10 minutes to readjust tuck-in flap guide plate again. By informal discussion with technical supervisor in PP department the researcher got to know that the high percentage of breakdowns occurred in because of not doing proper changeovers. Normally the changeover is done by fitters. Fitter needs technical knowhow of way of doing the changeover. Without that the technical knowledge a proper changeover cannot be done. The results come in when the machine doing the trial for the next product. This will lead to readjust those parts again. It clearly shows the re-adjustment time in observations and also ultimately it could lead to equipment failures. The more a fitter is experienced in performing the changeover, the more efficient changeover will be done. As discussed in literature review also doing a changeover without having proper skills could be a very dangerous and risky.

There are Hard to Access Areas (HAA) and worn parts in NM700 machine. That means when doing the changeover there are difficult areas to adjust. Layout of the machine affects the changeover process. The changeover parts are kept in the Engineering workshop in the PP department. Sometime because of not keeping changeover parts in proper places it takes time to find them. Using photographs able to show that it is very difficult to put the hand in and adjust that place. Those activities are highly time-consuming.

RESULTS AND DISCUSSION

To do the changeover the fitter must have technical know-how towards the machine and skills. Otherwise it will result readjustments and equipment failures. Readjustments are a wasting of time because if it is adjusted first attempt then no need to readjust. Thus eliminating readjustments can increase changeover time and efficiency. According to the analysis changeover tools are playing major role in the changeover process. Because of absence of tools or sharing them, definitely cause to increase the changeover time. Finally there is another factor that affect the changeover time is Hard to Access Areas in the machine and worn parts. In the analysis it was discussed that hard to access areas and worn parts of the NM700 machine have increased the changeover time of the PP department.

By identifying the root causes to these factors and giving solutions the changeover time in the department can be reduced. As discussed in the Literature review, changeover time is a down time type and reducing changeover time means reducing the down time. Because of reducing down time, availability is increased. Availability is directly proportional to the OEE Therefore by increasing availability, the OEE can be increased. OEE increased in the NM700 machine indicates productivity increase in the department. Finally it can be said that changeover time is a barrier to improve productivity in the department.

As solutions to the high changeover time that identified in the above factors can be given following solutions.

As discussed in the Theoretical Background according to the TPM there ECRS tool can be applied to reduce changeover time. This can be done by eliminating, combining, rearranging and simplifying the changeover activities. Using ECRS tool in TPM the changeover time can be reduced by eliminating, combining, rearranging and simplifying the changeover activities. Elimination means skipping or removing a changeover activity without any effect to the changeover process. Combination is done in two events in one adjustment. By that the changeover time can be saved. Rearrange means to do changes of way of doing the adjustment without any effect to the changeover activity. Simplify the activities means to use changeover part without changing the changeover process. So by applying ECRS the changeover time can be reduced. By applying ECRS tool can reduce hard to access areas and by that can simplify the layout of the machine.

As another solution technical know-how of workers and fitters can be improved by organizing training and development programs for workers and fitters. There skill training to the both operators and fitters

especially to the operators should be given to perform the changeover accurately. And also there should be programs organized to change the attitudes and behaviors of the workers.

Identifying all the tools that were needed for a changeover and assigning tools to each worker. By that the time of sharing and finding the tools can be avoided. By identifying what were the tools needs for the changeover the management the necessary tools can be provided. Before starting the changeover workers can prepare the tools that need for each task. This can save the unnecessary wasting time during the changeovers.

According to the above details, solutions can be prioritized according to the importance, time constrains, sequential of the solutions, financial constraints. According to the above prioritization, immediate feasible solutions provided necessary tools that are needed for each worker to perform the changeover, give training and development to both operators and fitters. As the long term solutions, do necessary changes for identified ECRS activities.

CONCLUSION

The conclusion of the research is that changeover time is identified as productivity barrier in the PP department. The research identifies the technical factors that affect to the high changeover time and the solutions to improve the changeover performances. Therefore the objectives of this research are achieved. The technical factors that affect to the changeovers are tools problems, hard to access areas in the machine and worn parts of the machine and technical knowhow of the fitters. These factors affect the changeover time and changeover time affects the production time, breakdowns, wastages and equipment efficiency. Therefore these factors directly affect the productivity of the PP department.

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