MANPOWER OPTIMIZATION AND PROCESS EFFICIENCY IMPROVEMENT AT A TEXTILE MANUFACTURING COMPANY

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Abstract- Manufacturing needs to constantly nurture a system that optimizes the coordination of input, process and output. The ability to fully utilize the resources especially the labor and equipment in the assembly line has always been an important factor to achieve high productivity. A textile company packaging area is a highly manual operation and the management is facing a problem finding the effective way to utilize the operators and improve the processes. Thus, productivity analysis needs to be done at this area to determine the standard time and the types of wastes occurring at this area for the purpose of improving the efficiency and effectiveness of the packaging operations. In addition, the purpose of this project is to provide the company management with recommendations on improved manpower planning and methods to perform the work by the operators. Specifically, the research has applied the Work Study method especially Process Mapping, time study with stop watch and MOST Predetermined Time Standards (PTS). Results include the operator standard time and the current utilization of the packaging operator. Based on the results, recommendations such as reducing the number of operators to improve labor utilization, sequencing of jobs and changing the methods to perform the pin packaging through scoop and sticker dispensing design were made to the management. Consequently, the outcomes of this project are advantageous for the company to improve the packing area's productivity and for the company to be cost efficient in meeting the ever demanding customer expectation while still paying attention to the employee's well being.

Keywords: *Productivity, Work Study, Process Mapping, MOST Predetermined Time Standards*

I. INTRODUCTION

Generally, manufacturing is defined as the process of converting raw materials into products that involves activities in which the manufactured product, itself, is used to make other products [6]. Manufacturing is constantly facing challenges for cost reduction without jeopardizing the service and quality to the customers [3]. As such, manufacturing needs to continuously focus on improving its productivity. Productivity measure refers to the ratio of output divided by the inputs such as resources, capital and labor [9]. Lean tools and techniques such as Just-In-Time (JIT), Kaizen and Standard-Work is among the many philosophies, techniques and also tools that used by a business operation to identify the problems or wastes in the effort to improve the productivity [1], [2]. Lean manufacturing is highly regarded to provide significant reduction in inventory, improved delivery performance, better resource utilization, enhanced productivity and quality of products or services to the customer [7], [5], [8].

The packing department is the most labor intensive area in the factory and issues arise regarding the man power planning and operator's utilization which was affecting the labor productivity. Among the manual packing activities done here are packing material in bulk pack or blisters, sorting, arrangement of material into boxes and sticking label on the packing boxes. Since there was no proper study done to establish the standard time of the workers and to improve the efficiency of the workers, the management faces issues with determining the right number of workers to hire permanently and temporarily at this area based on the demand fluctuation. Thus, the objectives of the study are to:

i. Perform work study analysis at the packing area and establish the standard time.
ii. Identify area of opportunities at packing area to increase the productivity.
iii. Propose improvement of packing processes to improve the labor efficiency.

Basically, this project focuses on performing productivity analysis in packaging area at a selected textile manufacturing company. This project will use the work study technique to determine the current standard time and the type of wastes existing at the material packaging operation. Data from the floor were collected and analyzed to establish the work standard by considering the operator work method, activity time, job sequencing, allowance and rating.

II METHODOLOGY

According to Grunberg [4], the three keys to any problem solving is the identification of major factors to be improved, selection of method that specifically focus on the factors and the measurement of the results. Thus, the first step to this productivity study was to perform an initial assessment at the production line. Information regarding the layout plan, the process flow, product information and other general information (shift pattern, demand, customers, etc) were gathered during this stage.

Standardized work at each manufacturing and assembly process also ensures high level of productivity, quality, and safety to the employees [10]. To establish standard work at the packing area, Work Study method using Process Mapping, Maynard Operational Sequence Technique (MOST) and stop watch time study were used as primary tools. The intent was to examine the way the manual packing work was being carried out, simplifying or modifying the method of operation to reduce unnecessary or excess work, or the wasteful use of resources and setting up a time standard for performing the manual packing activity by the operators. The standard times of the processes were calculated using this formula:

Standard time = process time x rating factor x allowance factor

The standard time data obtained was then analyzed to determine the methods to perform man power planning and job sequencing to improve the labor utilization at the packing area. The detail operator work methods were also analyzed to identify the different types of wastes occurring at the operation for the purpose of identifying opportunity for improvements through job redesigning.

III RESULT

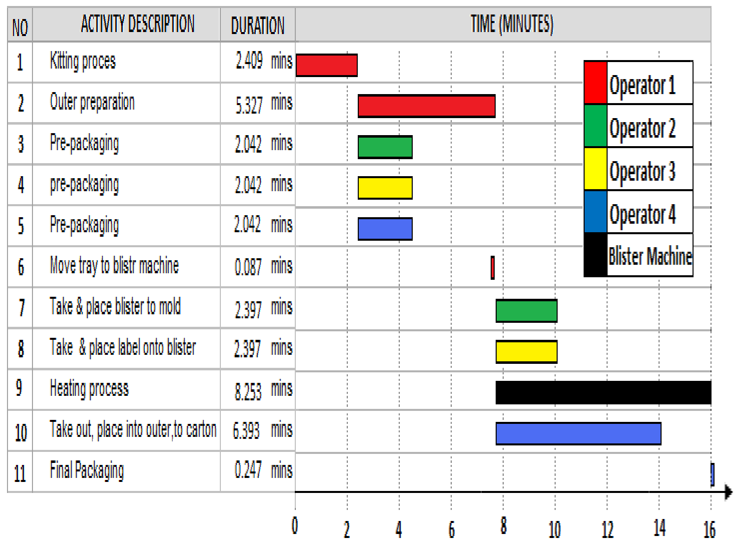
Productivity analysis is conducted to identify areas for potential productivity improvement projects based on statistical data collected during the data gathering and analysis stage. The analysis also pinpoints areas of delays and interruptions that cause loss of productivity.

The first step in any productivity improvement initiative is to understand the current state of the operation. Productivity analysis provides baseline indicators that will also yield data which will be used to determine possible productivity improvement objectives and potential cost savings.

Packing Operator Job Sequencing

The detail activities of each critical process was mapped using the Process mapping method and the time taken to perform each activities were determined using MOST standard time. Next, MOST cycle time data were used to determine the current operator's utilization and to develop proposal on ways to improve the operator's utilization. Together with MOST work study, existing job sequencing of the four packing operators was also obtained. The result of the job sequencing mapping by operator is summarized using a Gantt Chart in Figure 1.0 below.

Figure 1.0 Job Sequencing by Operator Chart



Referring to Figure 1.0, the activity starts with the first operator going to the store to prepare the raw material or called the kitting process before returning to the material packaging line. Once the first operator is back to the production line, the operator will start activity 2 until 5 together with the other three operators. Next, the first operator will move the material to the blister machine where the other three operators will resume with activity 7 until 10. Lastly, operator four will perform the final packaging of the products which is the sealing process and placing the box onto the pallet. Consequently, the cycle time for the whole material packaging process is calculated below resulting in approximately 17 minutes per cartoon.

Cycle Time = Total of working time
= 2.409 + 5.327 + 0.087 + 8.253 + 0.247
= **16.323 minutes ≈ 17 minutes per carton**

Based on observation and discussion with the packaging line supervisor, the daily output fluctuates based on customer order on selected product model. The average for current daily demand and production capacity for material packaging process is show in Table 1.0 below:

Table 1.0 Existing Production Capacity

	Capacity
Daily working hour	8 hour / 480 minutes
Number of operator	4 operator
Cycle time for each carton	20 minutes
Average daily demand (output)	24 cartons per day

However, based on the standard time established through the work study, the cycle time to pack on carton only takes 17 minutes which results in an output of 28 cartons per day. This means there is an opportunity to improve the output of the production line which can result in an increase in the productivity at this area.

Packing Operator Utilization

Based on the job activities sequencing, the four operators were responsible for various types of activity at the packaging area. Thus, the working time each of them also vary from each other depending on the types and frequency of an activity given.

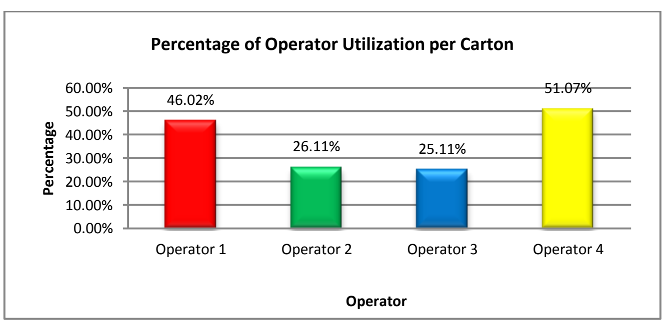


Figure 2.0 Packing Operator Utilization per carton.

Figure 2.0 shows that the percentage of operator utilization in order to pack one unit of carton based on the standard time of 17 minutes per carton. Operator 4 shows the highest utilization at 51.07% followed by Operator 1 at 46.02%. Meanwhile, Operator 2 and Operator 3 have the same utilization which is 26.11% respectively. Based on this result, the current manpower allocation method is not efficient to fully utilize the operator. Labor input is a critical productivity measure that requires focus in order to improve productivity. Thus, improvement is needed to increase the utilization of the operator while still meeting the customer requirements.

Packaging Pin

Another activity occurring at the packaging area is the pin packaging process. Basically, the manual process starts with the operator weighing the pins using the digital weight or the manual weight balance, loading the pins into boxes manually or using the shaker machine, putting the cover and outer until placing the outer into the carton. Figure 3.0 shows the flow of the pin packaging process.

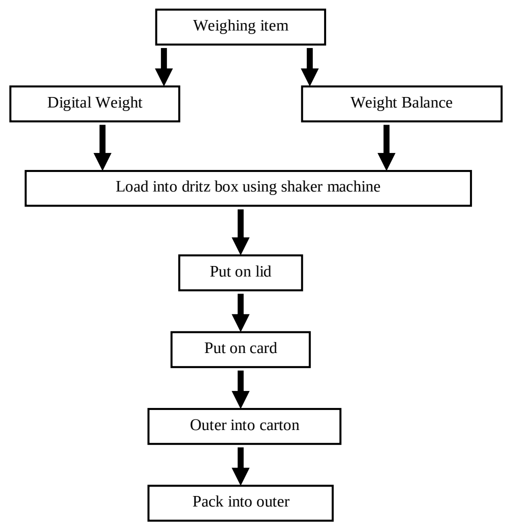


Figure 3.0 Pin Packaging Process Flow

During the observations at the pin packaging process, some activities that had the opportunity to be redesigned were identified.

a. Manual Balance Weight

The usage of manual balance weight is to weigh the pins for the purpose of estimating the amount of pins per packet. Figure 4.0 illustrates the use of the manual weight balance for the pin packaging process.

Figure 4.0 Manual Balance Weight

b. Manual Bulk Packing

Bulk packing safety pins into the polybag using hands. The process involves:

- Load items on table.
- Load items into polybag/bulk pack and weighing:
  Load estimate value of item into
  polybag using hand.
  Weight the filled polybag.
  Add/reduce item in the polybag to get desired weight according to specification.
  Put into box.
- Move to shrink wrap machine
- Shrink wrap 6 outer per wrap.
- Put into carton.

Figure 5.0 illustrates the manual bulk pin packing process.

Figure 5.0 Manual Bulk Pin Packing Process

c. Manual Box Labeling

Another observation made was on the sticking label on box activity. The operator was observed to have some difficulty to remove the sticker from the paper. There is an opportunity to design a sticker label dispenser to improve the time the operator needs to spend on removing the sticker from the paper and sticking the label on the box.

IV RECOMMENDATIONS

Based on the standard time established using MOST work measurement system, the cycle time for each carton using four operators is 17 minutes resulting in an output of 28 cartons per shift. However, the data analysis showed that the four operators utilization were not at the optimum level. Analysis on the Process Mapping data on the operators' activity revealed the occurrence of many non value added activities in the preparation of the product. For example, kitting process is done by the same operator who was doing the packaging process. Thus, the other operators will have to wait for the material to arrive before being able to start the packaging process together with operator 1. As, a result, the cycle time to pack one carton is affected.

The recommendation made to the management is to allocate one operator to specifically focus on the kitting operations for all the eight workstations at the packaging area. His or her job will be to transfer all the related material based on daily demand to the packaging line. He or she will also be responsible for each inventory material from store.

a. Utilization for Three Operators

With one operator being allocated to focus on kitting the material, the other three operators will only be concentrating on the material packaging process which now starts from the outer preparation to the final packaging.

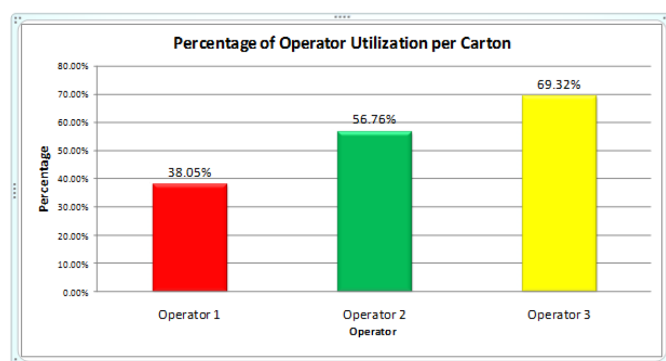


Figure 6.0a Percentage of Operator Utilization per Carton

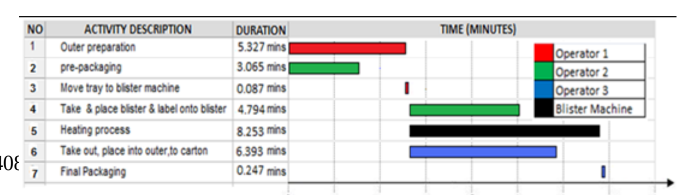


Figure 6.0b Activity Sequence for Three Operators

Figure 6.0a shows that by reducing one operator, the utilization of each operator has improved. The utilization of operator 3 is now 69.32% and followed by operator 2, 56.76%. The lowest utilization is operator 1 with 38.05%. The summary of the three operator's activity sequence is illustrated in Figure 6.0b.

Cycle Time = Total of working time
= 5.327 + 0.087 + 8.253 + 0.247
= **13.914 minutes ≈ 14 minutes per carton**

Consequence, by removing the kitting process will result in the reduction of the time to pack one unit of carton from 17 minutes to 14 minutes. Thus, the maximum output can be increased to 34 cartons per day from 28 cartons per day. The productivity increase by allocating three operators to perform the packing operation is:

$$\text{Productivity increase (\%)} = \frac{(34 \text{ cartons} - 28 \text{ cartons})}{28 \text{ cartons}} \times 100\% = 21.4\%$$

b. Utilization for Two Operators

Since the utilization of the three operators working on the material packaging process are still considered very low, the researchers went another step by trying to remove another operator from the packaging process. This time operator 1 will focus on the preparation of the outer and placing the completed outer into the carton. Operator 2 will perform the pre packaging operation and preparing the blister before the heating process.

Figure 7.0 illustrates the utilization of two operators in packing one unit of carton continues to increase to 78.13% and 75.05% respectively.

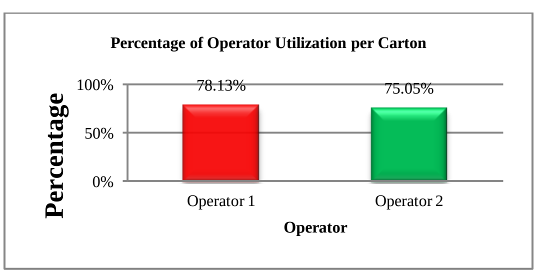


Figure 7.0 Percentage of Operator Utilization per carton

Figure 8.0 shows the chart for the two operator activity sequence and time line.

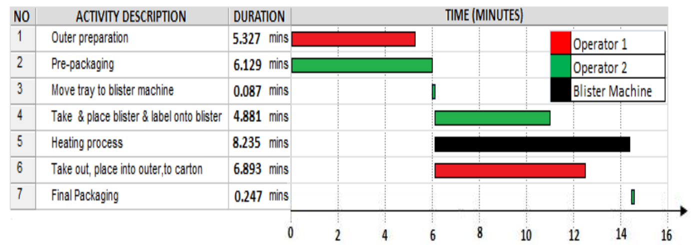


Figure 8.0: Activity Sequence for Two Operators

Cycle Time = Total of working time
= 6.129 + 0.087 + 8.253 + 0.247
= **14.718 minutes ≈ 15 minutes per carton**

However, by using only two operators for the material packaging, the cycle time has increased by 1 minute compared to using three operators which means short of two carton for every shift or 32 cartons per shift. Using the partial productivity measure, the productivity for the two options are:

Productivity (Three operators) = Output/ Input (labor hours)
= 34 / (3 x 8)
= 1.42 cartons / labor hour

Productivity (Two operators) = 32 / (2 x 8)
= 2 cartons / labor hour

Thus, in order for the material packing area to improve the production line efficiency, the recommendation is to allocate two operators for each of the material packing workstations. By implementing the two operator option, the manufacturing company will be able to enjoy a productivity increase of 33% as compared to the existing four operator allocation.

$$\text{Productivity increase (\%)} = \frac{(32 \text{ cartons} - 24 \text{ cartons})}{24 \text{ cartons}} \times 100\% = 33.3\%$$

Based on the International Labor Organization standards, the operators are allocated with 15% personal, fatigue and delay (PFD) allowances and the ideal utilization that the management should target for the packing operator is 85%. By knowing the utilization of the operators at the packing area, the management can now work towards establishing the output target or goal for the operators.

c. Operator Work Planning Schedule

Work planning schedule is one of the methods for allocating the number of operator on each specific job. By understanding the utilization based on daily working hour in the pursuit to achieve target, work planning schedule is able to illustrate the differences in working time for each operator. In this study, there is a number of activity sequences that each operator need to follow to pack one unit of carton.

Referring to Figure 7.0, the utilization for operator 1 is 78.13% and operator 2 is 75.05%. The utilization for each operator is not exactly 100% due to waiting for the blister machine to complete. There is also a 3.08% difference in the utilization of operator 1 and operator 2. In order to balance the working time for both operators, a work schedule for a shift is proposed.

The work is divided into two categories which are A and B. Each operator will rotate their shift every two weeks between work type A and work type B. This will continuously ensure fair loading for both operators working on the material packaging process. Table 2.0 shows the proposed operator 1 and operator 2 working schedule by week.

Table 2.0 Operator Working Schedule

OPERATOR	**WEEK**			
	1	**2**	**3**	**4**
Operator 1	**A**	**A**	**B**	**B**
Operator 2	**B**	**B**	**A**	**A**

d. Pin Packaging

In addition to the worker's job sequencing and identifying the ideal manning configuration at the material packaging area, other potential opportunities for productivity improvements were also identified at the pin packaging process such as the weighing methods used, bulk packing and the label sticking.

Pin Packaging Weighing Method

At the Pin Packing department, there are two different types of weighing methods. One method is using the digital weight and another method is by using the balancing weight. The researchers observed that using balancing weight is more cumbersome since the measurement is easily affected by the environment such as wind. On the contrary, the digital weight is able to provide faster and more accurate result.

Figure 9.0a Manual Balancing Weight

Figure 9.0b Digital Weight

The difference in time between the two methods is summarized in Table 3.0. The result shows that using digital weight was 2.14 minutes faster than using the balancing weight. To study the feasibility of converting to the digital weight, return on investment (ROI) study was also done. Based on labor cost savings of RM 16.12 per month and the cost to purchase the digital weight of RM 2020, the return on investment is calculated to be 125 months which is more that the company set target of below 26 months and thus, the option to convert all the balancing weight to digital weight is not feasible currently for the company although the productivity is able to be improved.

Table 3.0 ROI of Digital Weight Conversion

Difference time between two method **(second per carton)** =	128.33	
Difference time between two method **(minute per carton)** =	2.14	
Total difference (saving time) per day **(minute)=**	16.12	
Saving time per month **(minute)**=	322.39	
Saving time per month **(hours)** =	5.37	
Labor cost per hour **(RM)=**	3.00	
Saving labor cost per month **(RM)** =	16.12	
Balancing weight cost **(RM)** =	220.00	
Digital weight cost=**(RM)**	2020.00	
ROI time = Investment/cost saving per month =**(month)**	**125**	**>36month**

Bulk Packing Pin Into Polybag

The normal packaging method for the pins is using the bulk. Through observation, the operators will load the pin manually using hand into the polybag. Since the pins have sharp ends, the operator will need to be careful when picking the pins to avoid from poking the hand. There is a need for a better way of picking the pins and one tool that was evaluated was the scoop.

Initially, the experiment starts with designing the scoop using only the cardboard and tested the scoop at the bulk packing process. The initial experiment worked and the scoop design was further improved with the use of Solid Work software. In addition, with the help of the design department in Faculty of Manufacturing (FKP), Universiti Teknikal Malaysia Melaka (UTeM), a prototype scoop was designed using the rapid prototyping equipment available at FKP's laboratory. Figure 10.0a and 10.0b illustrates the process from designing the scoop until the fabrication stages.

Figure 10.0a Scoop Prototype Using Cardboard

Figure 10.0b Scoop from Vendor and Rapid Prototyping

The work study time was then analyzed and the difference in the two methods time is used to calculate the time savings per month in order to determine the return on investment (ROI) to change to the scoop method.

Table 4.0 Return on Investment on Bulk Packing Method using Scoop

Diiference time between two method **(minute per carton)** =	0.24
Total difference (saving time) per day **(minute)=**	6.84
Saving time per month **(minute)**=	136.82
Saving time per month **(hours)** =	2.28
Labor cost per hour **(RM)=**	3.00
Saving labor cost per month **(RM)** =	6.84
Scoop cost **(RM)** =	12.00
ROI time = Investment/cost saving per month **(month)=**	2 <36month

Based on Table 4.0, the labor cost savings achieved through using the scoop will be RM 6.84 and the cost to make the scoop using stainless steel from the vendor will be RM12.00. Thus, the return on investment for the bulk packing using scoop was determined at 2 months. Thus, this method is a feasible alternative for the company management to increase worker's efficiency and the bulk packing process effectiveness.

Label Sticking

Another issue observed at the pin packaging area is the label sticking on one type of the boxes called the dritz box. The operator was having a problem to remove the sticker from the paper. The operator will have to have long nails before the operator is able to perform this operation well. One of the options explored was using the sticker dispenser. First, the time taken to complete one cycle of stick label to dritz box was taken. Next, a suitable sticker dispenser was searched using the internet. However, the dispensers found in the internet were mainly are single line dispensers whereby the requirement at the pin packaging process was for the double or multiple line dispenser.

The sticker dispenser equipment was designed using AutoCad and Solid Work. The sticker label dispenser equipment was fabricated using the laser cutting and the bending machine. Figure 11.0a and 11.0b shows the laboratory equipment being used for the sticker label dispensing prototype.

Figure 11.0a Bending Machine

Figure 11.0b Laser Cutting Machine

The sticker dispenser prototype was tested at the label sticking process and the design was changed three times to continuously improve the label sticking capability. The time taken for the label sticking process using the sticker dispenser was gathered for the purpose of calculating the return on investment in order to determine the feasibility to change to the new method of label sticking using sticker dispenser.

Figure 12.0a and 12.0b show the different versions of the sticker dispenser equipment from the first version which has many problems with the dispensing of the sticker until the third improved version which is working well to dispense the sticker from the paper. The application of the sticker dispenser is illustrated using Figure 12.0c.

Figure 12.0a Sticker Dispenser 1st Design

Figure 12.0b Sticker Dispenser 2nd Design

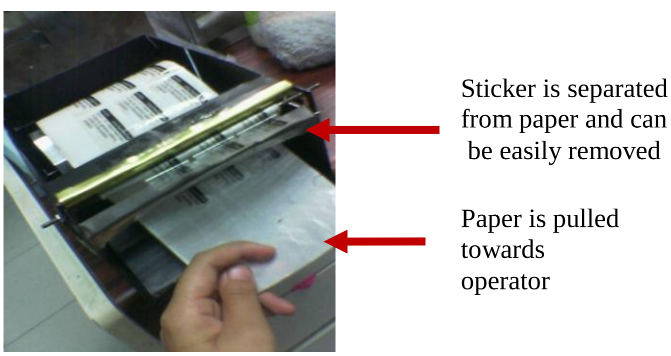


Figure 12.0c Sticker Dispenser Application

The time savings from using the label dispenser method of RM 6.22 per month is divided to the cost of fabricating the label dispenser provided by the vendor, RM 192.70 to get a return on investment (ROI) of 23 months. Since this is lower than the maximum limit of 36 months, it is feasible for the management to consider replacing the manual method of label sticking to using the label dispensing equipment.

V CONCLUSION

The project has achieved its objectives which are to:

i. Perform productivity analysis using work study methodology at the packing area in order to establish the standard time. From the work study application, the packaging area operator standard time and utilization was able to be determined.

ii. Identify area of opportunities at packaging area to increase the productivity. The information on the standard time was used to determine the ideal labor requirement at the material packaging process and to propose an efficient man power planning for the production line. The work study result had also unveiled various wastes occurring at the pin packaging process prompting opportunity for work method redesign.

iii. Propose improvement of material packaging processes to improve the resources efficiency. The existing four operator per shift work schedule was found to be very inefficient and redesigning the work sequence with only two operators has proven to be a leaner approach towards improving labor efficiency. The productivity analysis was further extended to the pin packaging process where various opportunities such as changing the work method from using hand packaging to using a simple scoop, weighing equipment evaluation and designing sticker label dispenser options were analyzed and return on investment (ROI) were calculated to determine the feasibility of each alternatives.

Although not all alternatives evaluated were feasible to be implemented due to long ROI, the experience of performing productivity analysis project at the textile manufacturing line has provided the UTeM's researchers with valuable insights and skills of actual practical applications of work study methodology in improving the productivity measures. The design of the simple scoop and the sticker dispenser prototypes using the FKP's laboratory equipment confirms that FKP has the right equipment to facilitate students in the design and development of product manufacturing.

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