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IMPROVEMENT OF RAW MATERIAL PICKING PROCESS IN SEWING MACHINE FACTORY USING LEAN TECHNIQUES

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Abstract

This study demonstrates application of Lean techniques to improve working process in a sewing machine factory, focusing on the raw material picking process. The value stream mapping and flow process chart techniques were utilized to identify the value added activities, non-value activities and necessary but non-value added activities in the current process. The ECRS (Eliminate, Combine, Rearrange and Simplify) in waste reduction was subsequently applied to improve the working process by (i) adjusting the raw material picking procedures and pre-packing raw material as per demand, (ii) adding symbols onto the containers to reduce time spent in picking material based on visual control principle, and (iii) developing and zoning storage area, identifying level location for each row and also applying algorithms generated from a solver program and linear programming to appropriately define the location of raw material storage. Improvement in the raw material picking process was realized, cutting down six out of 11 procedures in material picking or by 55%, reducing material picking time from 24 to 4 min or by 83%. The distance to handle material in the warehouse can be shortened by 120 m per time or 2,400 m per day, equal to 86% reduction. Lean techniques proved to provide significant improvement in sewing machine company operations.

Keywords

Value stream mapping, warehouse improvement, lean logistics, productivity.

Introduction

Various industries need to survive during recent economic downturns, including machine manufacturing companies. Therefore, they need to improve their competitive advantage by reducing cost and increasing profits. Lean techniques are among the prominent techniques that can be used to analyze and improve the operation processes. The techniques have been used widely in large manufacturing industries such as automotive and electronics. However, reports on application of Lean techniques to labor intensive assembly line and manufacturing SMEs are quite rare. Valuable insights may be obtained from experiences in applying and practicing these Lean techniques to an SME that may be useful to other SMEs.

In this work, a sewing machine company located in Lamphun, Thailand was used as a case study. Its working process was studied. Its key products are household sewing machines and accessories. Its sales offices are located worldwide and quality control was among the top priorities of the company. Moreover, the company puts top priority on product cost controlling and enhancing logistics efficiency that broadens the competitive opportunity to the markets nowadays. Thus, the efficiency improvement in factory warehouse process was initiated. The staff working in raw material picking process accounted for 42% of the entire employees. The raw material picking was one of the core processes of warehouse management which can affect the production process immediately when the staff picked the wrong material or delayed the process. Therefore, improvement of the raw material picking process is among the top priorities for enhancing company performance which can potentially eliminate wastes or non-value added activities (NVA) in the warehouse, hence, it can effectively reduce the production cost as well as logistics cost. High performance raw material picking process is therefore necessary for expansion plan for production in the future.

The objectives of this study were therefore to apply Lean techniques in reducing complication and time in the raw material picking process of an SME, and to discuss practicality issue of the techniques to general manufacturing firms.

Literature review

Various research works concerning warehouse operational process optimizations have been investigated and studied to develop the raw material picking process in sewing machine factories. Relevant tools such as Lean Techniques, Value Stream Mapping (VSM), Flow Process Chart Analysis, Continuous Improvement based on ECRS principles, ABC Classification to classify raw materials, Linear Programming application to position the raw material locations have been applied. Simplex and Dual Simplex Algorithm by applying Microsoft Excel Solver have been adopted to decide best location of raw material on shelves.

Recently, logistics improvement techniques have been proved that they can actually reduce significant logistics cost for SMEs as demonstrated in those cases from northern Thailand [1]. The improvements have been reported in terms of the modification of physical layout to reduce internal logistics distance [2], or adjusting the management policies both in operation process or warehouse practice. Lean techniques have been found to be intensively implemented in SMEs operational processes for minimizing costs, using poor quality materials or overloading workers with work [3].

Lean concepts proved to be popular for developing production and enabling continuous improvement [4]. Moreover, from a lean production point of view, inventory management required a reduction in inventory wastes in terms of costs, quantities and time of non-added value work [5]. It could further reduce cycle time in complex production environment through the application of Value Stream Mapping (VSM) [6]. VSM could be drawn for the entire supply chain, a process or a single sub-process. The VSM have also been used in a non-detailed way to analyze processes and sub-processes to visualize improvement potentials [7], and decrease production lead time [8, 9].

KAIZEN is a concept of continuous improvement. This philosophy seeks to improve all factors related to the process of converting inputs into outputs on an ongoing basis. It covers equipment, materials, methods, and people [10]. Impact from the VSM approach have been shown to reduce time in raw material preparation process, eliminate non-value added travelling activities in automobile part warehouse since those activities were considered as waste processes [9]. To improve warehouse operations, pick up process should be initially improved because it is the most time-consuming activity in the warehouse. De Koster and co-workers [11] demonstrated that there were four ways to reduce travel distance in the warehouse for an order-picker, by optimizing (1) storage location assignment, (2) warehouse zoning, (3) order batching, and (4) pick-routing method. Location assignment in the warehouse was modified by Zhang [12], where correlated storage assignment strategy was implemented to reduce the travel distance in the packing process. Meanwhile, Schweitzer [13] proposed the optimized model or order sequencing and order picking system to improve the average turnaround times and improved flow of containers in the automatic container warehouse. Picking improvements by different techniques have been reported in various industries such as automotive [9], beverage [14], health care product retail distribution [15]. Different techniques were required for heavy and light weight cargos. Reduction of distance and processing time had important influence on the total time for picking since they were considered having major contributions in the warehouse picking process [9]. Investigation on waste processes in the picking activity can bring about improving work method and eliminating excess processes, leading to better productivity in the warehouse.

Based on previous reports, many approaches could potentially be adopted to improve the raw material picking process in this sewing machine factory. The picking process was the most expensive activity in warehousing operations. It was considered a top priority to increase productivity [9]. However, it should be pointed out that the best improvement method is to observe the actual process, identify root causes and effects, and listen to employees' feedback to understand the expectation of internal customers. These practicality issues are important and can shine some lights in successful applications of similar Lean techniques to other SMEs.

Methodology

This work focused on the improvement resulting from elimination of raw material picking processes and time. The research approach consisted of three following steps.

Step 1: Focus areas for improvement were selected by brainstorming among warehouse and head of production staffs to identify initial areas for improvement in the warehouse department. The problems from warehouse activity were listed, and decision were made herein using the Pareto concept. From this stage, it was identified that the picking process should be improved since this activity consumed the highest time among other warehousing activities. The ideas and inputs from operators were very important during this stage.

Step 2: The raw material picking flow process was sketched through VSM. The purpose of creating this diagram was to identify sequence of activities, time, distance of overall picking process at a current stage. The value added (VA), non-value added (NVA) and necessary but non-value added (NNVA) activities could also be identified from the current flow. At this stage, changes in work procedures to improve VA and NNVA activities were introduced and real implementation to the factory to eliminate NVA activities was proposed and carried out.

Step 3: The implementation of appropriate improving process was put in place. KAIZEN or continuous improvement technique was implemented herein as the idea of changing and process continuous improvement. This guideline was widely utilized in institutes or organizations focusing on three concepts; Eliminate, Reduce and Change. Kaizen can be referred to as action to reduce and eliminate unnecessary processes by slowly changing working methods step by step to optimize the working efficiency. Continuous improvement and employee's participation were the core concepts of the Kaizen principle. ECRS is one of the prominent techniques of KAIZEN, which was implemented in this study. E is referred to Eliminate, C is to Combine, R is to Rearrange and S is to Simplify, respectively. This principle was employed with the ultimate aims at employee participation to reduce 7 wastes discovered from current process [4].

Inventory management in this study was basically managed by ABC Classification similar to that in [11]. Those inventories were classified into A, B and C types, based on picking frequency. Pareto Diagram, one of 7 QC tools, was used to analyze and classify data of materials in the warehouse to seek for data arranging problems. The data was arranged from high to low, left to right to highlight the biggest problem or most common sources of defects. ABC Classification, applied in this study, was used to categorize inventory into 3 types. A was the highest order demand or fast moving, typically accounted for 20% of total inventory items. B was inter-class items, with a medium consumption value; and C was low order frequency but high inventory value. Subsequently, linear programming was integrated to assign most appropriate location for each item. Linear Programming (LP) is widely known technique and applied to warehouse allocation problems in previous research works. Basically, LP applies mathematical model to provide optimize results based on limited resources. The resources could be represented in terms of manpower, time, space, number of materials, or machine capacity. In this study, best location of each spare part was calculated from (1) with the constraints from (2) and (3)

$$\text{Min} \sum_{i=1}^{M}\sum_{j=1}^{N} f_i e_{ij} x_{ij}, \tag{1}$$

$$\text{Subject to} \quad \sum_{i=1}^{N} x_{ij} = q_i, \tag{2}$$

$$\sum_{i=1}^{M} x_{ij} \leq 1; \quad x_{ij} = (0,1), \tag{3}$$

where the variables are defined as: f_i – picking frequency of material i, e_{ij} – distance between material i to location j, q_i – space need to store material i, $x_{ij} = 1$ – accept to store material i in location j, 0 unaccepted to store material i in location j, M – material lists, N – levels to store raw materials.

The new warehouse layout was subsequently proposed from the output of the calculation. The layout was re-arranged, dependent on assembly line and picking frequency. Meanwhile, the vertical storage shelf was re-assigned, based on picking frequency and ergonomic concept. Several actual implementations were conducted in sewing machine manufacturing site. Evaluation was conducted. The number of processes, times, and distance in warehouse operations were expected to improve.

Results

Analysis results of current state

Improvement of raw material picking processes was outlined after brainstorming with the section head and seven warehouse staff. The staff evaluated the process in the raw material warehouse by scoring the key processes that needed to be improved to meet the production demand more speedily and accurately. The raw material picking process was scored the highest point of 3,800 or equivalent to 41.7%.

The raw material picking process was studied using VSM by examining the working process. The primary data was collected to draw the overview of the raw material picking process in a current state VSM, as shown in Fig. 1. There were 11 activities, with average picking time of 24 min. Only one VA activity was found, which was the raw material picking activity that accounted for about 8% of the total time.

After the current state VSM was sketched, overall picking processes became more comprehensible. The wastes could be detected from each stage. The flow process chart appeared to identify one VA, four NVA and six NNVA activities from the material picking process. Actual implementation was subsequently carried out in the factory warehouse. For the resulting improvement, NVA activities were eliminated and NNVA activities were combined and rearranged.

Improvement of raw material picking process

Improvement of the raw material picking process was initiated from adding pre-packing method in the receiving area. This method was started from unpacking the material box and pre-packing into the required number specific part into a plastic bag (Prepack). The key issue was that the number required parts in the plastic bag must be equal to the production demands. Thus, the materials were readily prepared for the future demand once they were received. This improvement was achieved with no additional operation cost. The pre-packaging was found to meet the production demand with flexibility in terms of responding to change in quantity. The pre-packing process is shown in Fig. 2.

Moreover, line balancing was also applied in the pre-packing process. One out of 11 material picking staffs was assigned to pre-pack the materials after incoming inspection process. The pre-pack was undertaken prior to storing those parts into the warehouse. This rearrangement appeared to shorten the raw material picking process in the way that no part had to be counted before the picking. The delivery of the packed parts to the production line was quicker. The improvement was found to eliminate NVA activities, wastes from transportation and overproduction, summarized as follows:

- the raw material picking activities reduced from 11 to 6 activities or equivalent 45%,
- the raw material picking time reduced from 24 to 6.48 min or equivalent to 72%,
- the raw material picking distance reduced from 140 to 50 m or equivalent to 64% of raw material storage area.

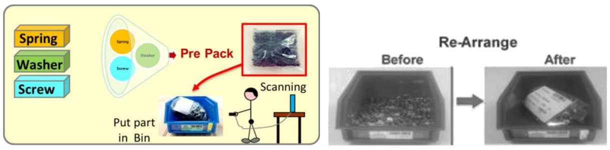

Fig. 2. The pre-packing process in raw material picking process.

Apart from improving the picking process, rearrangement of the raw material storage area was also important that could enhance the picking process. The storage location was initially arranged to suit suppliers, facilitating the storing material process and space utilization, but not particularly useful to the picking process. The working staff had to walk around the warehouse to pick the materials, resulting in long picking time and distance. To reduce the picking time and unnecessary movement, the storage area was re-arranged accordingly.

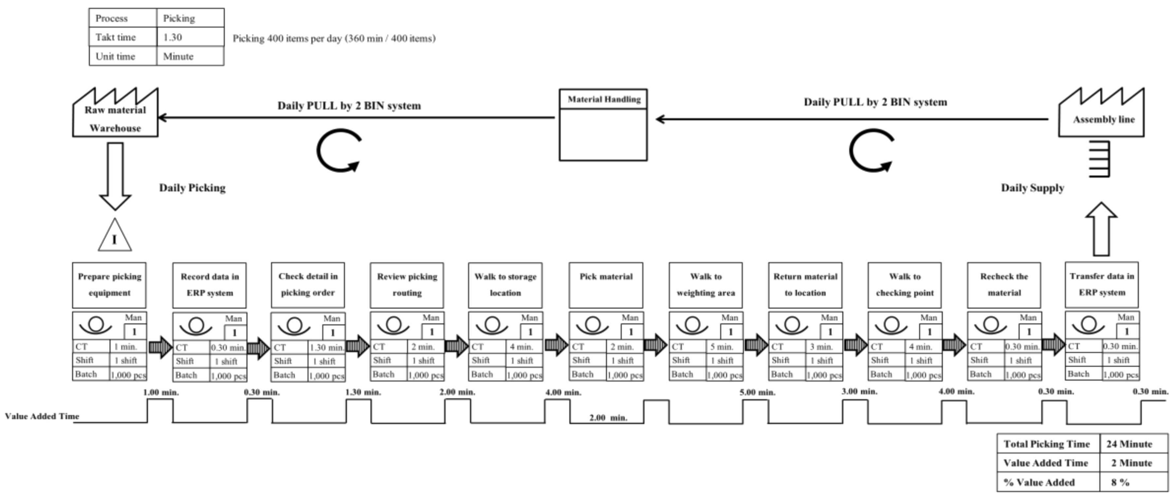

Fig. 1. Current state VSM of picking process.

Improvement of storage location in warehouse

The data from the preceding one year picking of approximately 14,000 records were accumulated from the material picking department. The data were analyzed in terms of picking frequency and rearrangement from fast to slow movement. The picking data was again divided by production line of each sewing machine model. The ABC classification was subsequently applied to assist in allocating the storage area of each part based on the corresponding production line and the frequency of part picking. The allocation result was described in the later section.

Zone picking or pick by line area allocation

The storage area was adjusted using the data categorized from the previous ABC classification. New storage area was arranged as follows; (i) the area was alternated from storage by supplier to storage by assembly line, and (ii) parts/ materials were allocated on the shelf by fast moving rule. The fast moving materials/ parts were located at the front line of the shelves, close to the door where materials were delivered to the production (fastest turning closest to the door). The new warehouse arrangement is displayed in Fig. 3.

Fixed location storage

One shelf contains five levels whose level should be assigned to each material subsequently. In the previous zoning storage, it was suggested only what materials needed to be kept in the shelf close to the door, but no further information was obtained. Therefore, the storage shelf was subsequently classified into three levels; X, Y, and Z. The shelf position is shown in Fig. 4

- Level X allowed the position staff to pick the materials easily and comfortably.
- Level Y required the position staff to stand on tiptoe or bend down to pick the materials.
- Level Z required the position staff to kneel down to pick the materials.

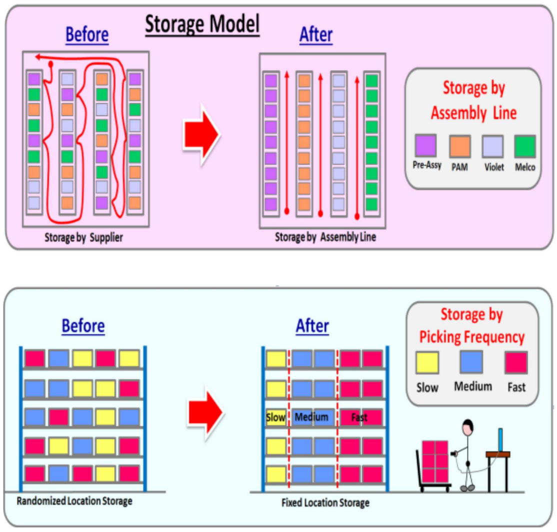

Fig. 3. The storage re-arrangement by assembly line and picking frequency.

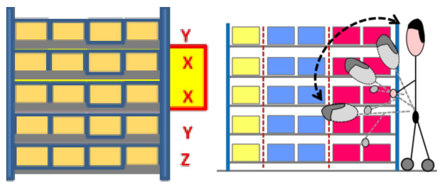

Fig. 4. The vertical storage re-allocation by picking frequency and ergonomics concept.

From the analysis of picking data for each production line zoning, the most frequent pick materials were to be stored at Level X, followed by Y and the less frequent pick parts were to be stored in Level Z. Once the most suitable location of each part was assigned and implemented, the resultant picking time was then evaluated and found to be reduced from 6 to 1 min or equivalent to 83% in time reduction. The distance travelled required by the staff was also found to be collectively shortened from 50 to 10 m, which was 80% saving. The corresponding improvement of the raw material picking process using ECRS is summarized and can be seen in Table 1.

Table 1
Value analysis of picking raw materials before and after improvement.

Description	Before improvement	After improvement	Amount reduced	Percent reduction
Value added (VA)	2 min	1 min	1 min	50%
Non-value added (NVA)	14 min	0 min	14 min	100%
Necessary but non-value added (NNVA)	8 min	3 min	5 min	62.5%
Picking flow	11 flow	5 flow	6 flow	55%
Picking lead time	24 min	4 min	20 min	83%
Picking distance	140 m	20 m	120 m	86%

A limitation may be noted here that using Microsoft Excel Solver combined with Linear Programming to find out the best location for raw materials can only be applied when the exact storage size is available. This calculation is best suited for small workpieces and with fixed location storage.

Conclusion

In this work, Lean techniques were applied to improve working process of a sewing machine factory where the raw material picking process was focused. Material picking process is one of most important tasks in internal supply chain operations which play a major role in meeting manufacturing target. Picking activity is the most expensive activity in warehouse operations which could be more than 55% of total warehousing operating cost. It was necessary to implement the strategy and tools that can help to analyze the process flow. This was performed to eliminate waste in the form of processes, time and distance. This research implemented Value Stream Mapping tool to picture the current stage, then applied practical ECRS tool to improve those material picking activities.

From the findings, it was conclusive that the picking by Zone method was more productive than by routing method. In this study, increased productivity was realized in terms of reduction time by more than 22%. The total time of picking process was affected by the distance traveled by the picker, hence analyzing the flow process was needed. The role of VSM pointed out the need to modify the picking from heuristic to zoning method. In warehouse management, more effective and improved picking process could be achieved via periodic movement and part requirement by product in response to ever-changing customer demand.

This work demonstrated that KAIZEN and Lean techniques were successfully implemented in the raw material picking process. Six NVA procedures were eliminated and the picking time was saved by 83%. Total picking distance was shortened up to 2,400 m per day which was 86% reduced. The finding from this study may be applied to other processes in the factory.

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