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STUDY OF PRODUCTIVITY IMPROVEMENT OF MANUAL OPERATIONS IN SOYA SAUCE FACTORY

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ABSTRACT: Today with a rapidly changing world and markets, SMEs are facing a critical challenge to remain competitive in the business market. In this paper, a case study of the SMEs food industry is presented. Work study methodology was embedded in the strategy to improve the productivity of the soya sauce enterprise. The sample size required for the study was calculated and random observations were determined through a work sampling technique to achieve a 95% confidence level. The result from this study reveals that work sampling data can be used as a reliable estimation for identification of any potential bottleneck as well as idle time in the factory. The process flowchart at the filling and capping terminal were examined and the travelling distance was optimized to 12.5 feet from original distance of 17 feet. The modified plant layout significantly improves the people flow, production material handling, work safety, space utilization, and better working conditions. The survival of SMEs is critical as this sector contributes 38.3% to Malaysian‘s gross domestic productivity (GDP). Thus, these findings demonstrated that enhancing the productivity of SME food industries is effective through a work study. However, the successful adoption of this approach is mostly because of top administrative involvement and the participation of all staff members.

ABSTRAK: Pada hari ini, dengan perubahan pesat dunia dan pasaran, SMEs berhadapan cabaran getir bagi terus tetap berdaya saing dalam pasaran perniagaan. Kajian ini membincangkan berkaitan kes kajian SMEs dalam industri makanan. Kaedah kajian kerja telah diguna pakai dalam strategi bagi meningkatkan pengeluaran sos soya. Saiz sampel yang diperlukan bagi kajian ini dikira dan pemerhatian rawak diperoleh melalui teknik persampelan bagi memperolehi 95% tahap yakin diri. Hasil keputusan kajian menunjukkan data persampelan boleh digunakan sebagai anggaran boleh percaya bagi mengklasifikasi kemungkinan kesesakan dan juga masa terbiar dalam kilang. Proses carta alir pada terminal isian dan penutup telah diperiksa dan jarak perjalanan dioptimumkan pada 12.5 kaki dari jarak asal iaitu 17 kaki. Ubah suai susun atur kilang dapat memperbaiki dengan ketara aturan pekerja, pengendalian bahan pengeluaran, keselamatan kerja, pengunaan ruang tempat kerja dan persekitaran tempat kerja yang lebih bagus. Kemandirian SMEs adalah sangat kritikal kerana sektor ini menyumbang 38.3% kepada Keluaran Malaysia Dalam Negara Kasar (KDNK). Oleh itu, hasil kajian menunjukkan peningkatan produktiviti industri makanan SMEs adalah berkesan menerusi kajian ini. Walau bagaimanapun, keberhasilan kaedah ini berpunca daripada keterlibatan pentadbiran dan seluruh anggota pekerja.

KEYWORDS: *food industry; work study; sustainability; time study; productivity*

1. INTRODUCTION

Small and medium enterprises (SMEs) in Malaysia are regarded as the growth engine that drives the local economy as this sector contributed 38.3% to the gross domestic product (GDP) of this country. To completely realise their potential, the government has given high importance to supporting the development of SMEs. However, as per the statistics released by the Malaysian Productivity Centre (MPC) 2014/2015, even though the government has put efforts to increase productivity, SMEs' productivity growth (3.5%) has only slightly improved in Malaysia, [1]. Currently, with the establishment of the Trans-Pacific Partnership Agreement (TPPA), SMEs in Malaysia are expected to face higher competition due to free trade. To stay competitive, the SMEs have to be a lot more effective and thus yield a higher productivity. It is therefore of great importance not only to the individual enterprises but also for the country's economic sustainability as a whole. Deploying work study is a key strategy to boost SMEs' growth and enhance productivity. Managers often fail to recognise early the need to change their management practices and execution of production operations. They lack knowledge and professionalism. They are hampered by high production costs. Because of capital shortage, these firms are weak in market niche researches and R&D activities. Hence, there is an urgent need to respond to the challenges facing the SMEs. To alleviate this problem, deploying work studies is key strategy to achieving high yields and efficiency. This project will assist the entrepreneur to implement work study techniques through training and consultation efforts.

In Japan, soya sauce production occurs on a small scale. Since 1950, the manufacturing process has been studied and modernized using modern production control methods such as using microorganisms in the fermentation process [2]. However, in Malaysia, most soya sauce factories operate on a small scale partly due to the factors mentioned earlier.

This work study is comprised of method study and work measurement. The former involves minimisation of the work content and setting a single best way to execute a job. It is implemented to decrease manufacturing costs by saving on cycle time pertaining to the operation [3-6]. The latter deals mostly with investigation of ineffective time associated with a job, and setting time standards to execute an operation by conforming to the standard method [7]. This also results in a systematic investigation pertaining to all factors that can impact the production efficiency and economy pertaining to the case being studied, which effectively allows achieving productivity gains [8].

Productivity enhancement can be achieved by getting rid of inefficient methods, decreasing work content as well as effectively making use of manpower, machines, and materials. Also, it can be realised in multiple ways, such as by decreasing the production unit cost or decreasing the production work content, by increasing the products' value-added content [8-14], by line balancing with respect to the production line, or via combination of all of these [9-10,15]. Enhancement of productivity can be defined as a continuous improvement process that is applicable to many kinds of activities [7-8,11,16-17]. When harnessing more profit via the same types of resources, increasing productivity is regarded as a key issue [18]. Enhancing productivity also results in customer satisfaction, time and cost reduction, as well as delivery of products [19]. Productivity involves an effective relationship in order to determine method output, product prices, method utilisation, work in process, on-time delivery, and inventory levels [4]. Vergeer [5] regarded productivity as a driver for profit.

Assessing the entire process allows for the establishment of further best practices as well as optimum productivity, which also helps to decrease the cycle time. Since the bottom line is affected by cycle time, assessing the process and determining consistency in best practices will aid in enhancing the overall business operations [9]. As per [6-10], decrease in cycle time has a cascading impact on the value as well as worth. With decrease in cycle times, there is equally an increase in output. It has been shown that there is considerable enhancement in production throughput with decrease in order-to-delivery cycle time. Seemingly, long cycle times result in higher cost, high inventory as well as poor customer service. Because of these facts, this study focuses on manpower utilisation and production cycle time. These days, a key element to successful management is reduction in cycle time [10].

The work study has been extensively employed in the manufacturing industry and in various other fields [11,14,18-19]. As per the literature, work study's application is not limited to manufacturing industries and can also be used in service sectors such as the hospitality sector [20-21]. Some recent works have considered new areas pertaining to improvement in productivity and layout planning with regards to SMEs food industry as well as the hospitality sector [20-24].

This study recommends a work study approach that can be used to devise an efficient strategy to attain sustainability in SMEs, which in turn can function as a means to improve both process efficiency and product quality, thereby enhancing productivity.

The factory setup comprises a manual assembly system, in which the work in progress (WIP) item undergoes manual transportation through its processes. The scope of the research includes the general factory layout at the filling area and the manual operation line of the 630 ml soya sauce bottle. The problems that the enterprise runs into include the unbalanced operation at each workstation that impacts the smooth functioning of the production line. The objectives of the study are to (a) assess the work performance of the existing operations with regards to manpower utilisation and production cycle time; (b) recommend a new operational layout design; and (c) analyse and compare the performance of the new and current operations.

2. METHOD

In this research, the work study technique was employed at the soya sauce 630 ml bottle operation line where the problems occurred. Cycle time reduction, manpower utilization, and plant layout were the main focus in this study as they impact the bottom line of the company.

2.1 Analysis method

This section outlines a systematic approach for recording, observing, and critically analysing the existing linked problems and processes. The approach also serves as a means for improving productivity, as shown in Table 1. Process charts were created after identification and selection of the operations or activities. A process chart provides an outline of the process and records the key events in a sequence, as well as captures all aspects of the job. Every operator's movement was recorded against time measured. This approach helps to identify the best pattern of movements for an operator that leads to minimum effort and optimum time consumption. It also enables finding the most economical route of movement.

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Table 1: Analysis method

Item	How	Analysis
Line balance	Time study	Time analysis
Method study	Work improved	Work sampling
No proper Layout	Process flow and material flow	Routing analysis

In order to balance the work team, the line balancing approach was implemented, so that the idle time on the filling machine and workers could be detected. This in turn resulted in the optimisation of work distribution between machines and workers. To improve the performance at the 630 ml bottle operation line, the layout was also redesigned.

Figure 1 shows the process flow of the soya sauce 630 ml bottle operation line. Table 2 presents the breakdown of the operators based on the operation. In this assembly line, the total number of operators engaged was seventeen.

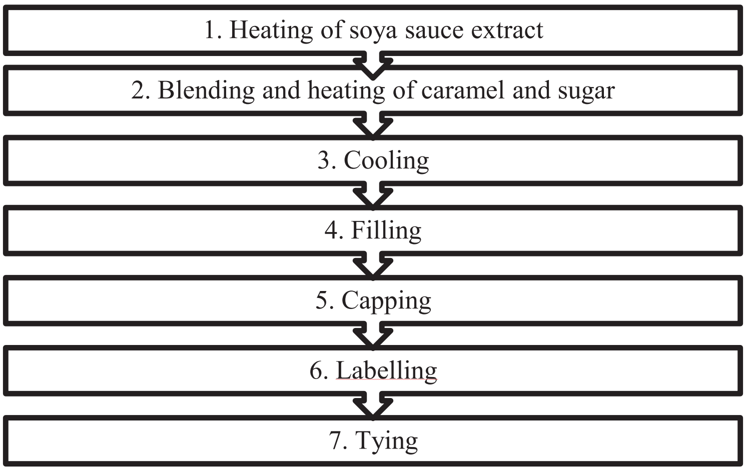

Fig. 1: Flow process chart of soya sauce 630 ml bottle line.

Figure 2 presents the flow diagram of the existing manual operation line. Trolleys were used for transportation between workstations. The workstations were about six feet apart. At the filling workstation, there were three filling barrels with one trolley between the filling barrels on which to place the filled bottle. Once the trolley was filled, it would be transported to the capping workstation. The capped bottle was placed back on the trolley on completion of the capping operation. Thereafter, it goes through a manual labelling operation.

Table 2: Breakdown of the operator based on the operation

Workstation	Number of Operator
Filling	6
Capping	2
Labelling	6
Tying	3
Total	17

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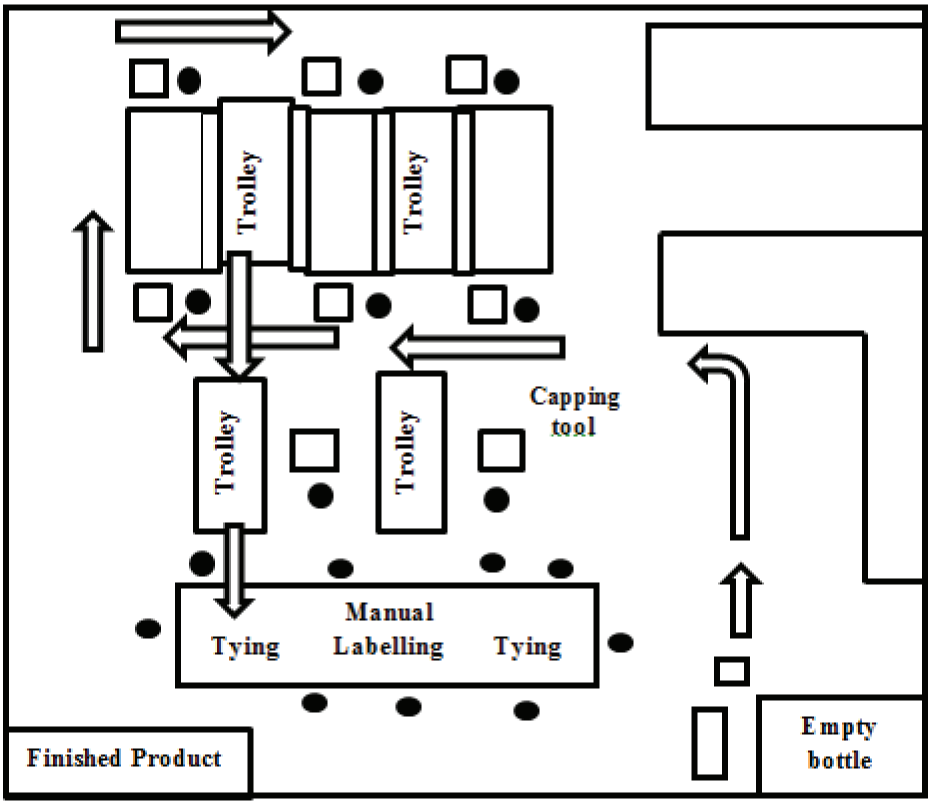

Fig.2: Flowchart of soya sauce 630 ml bottle line.

3. DATA COLLECTION AND ANALYSIS

Work sampling is one of the work measurement techniques employed in this study to find the percentage occurrence of a certain activity by statistical sampling and random observations. An established standard procedure was adopted before the study was performed. Various authors [24-26] recommended that the use of the sampling method is an effective way to detect idle time or unproductive work. According to [20] now more than 40,000 mainly industrial engineers are trained in work sampling due to its effectiveness and accuracy.

3.1 Estimation of Number of Observations Required

The method of work sampling was employed at the filling terminal to determine the ineffective time/idle time of the operator. A pilot study was performed with 80 observations to measure the idle time of the operators and processes. From the result of this primary examination, it was found that 7.5% of the time was idle time, 92% of the time was filling time and 0.5% of the time was for other work. Determining the number of observations entailed assigning a limit of precision of ± 5% at 95% confidence level to the percentage of operation idle time. The following formula was employed.

$N = [4P\ (100\text{-}P)] / L = [4 \times 7.5\ (92.0)] / 25 = 111$

Where,

P (% of idle time) = 7.5; L (limits of accuracy) = 25;

111 actual observations were made and the following results were obtained.

Filling = 66.66%

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Idle time = 16.27%

Other work = 17.12%

N = [4 x 16.27 (66.66)] / 25 = 385

Therefore, required observations needed are 385 to achieve the desired level of accuracy. One of the basic foundations of statistical sampling theory is the concept that the larger the sample size, the results will be more accurate [20, 26-27]. [28] reported that work sampling as a method improves plant efficiency and increase productivity.

Filling = 68.57%

Idle time = 23.38%

Other work = 8.05%

Hence the % of idle time was 23.4 ± 5.

Work sampling technique was also used at the capping workstation to determine the operator idle time. Causes of idle time at the capping workstation are waiting for the bottle, transfer of trolleys, transfer of bottles, talking/looking, and not at working place.

The preliminary results are as following:

Observation, N = 27

Capping = 55.56%

Idle time = 37.01%

Other work = 7.41%

To determine the number of observations required to give a limit of accuracy of ± 5% at 95% confidence level in the percentage of operation idle time.

N = [4 x 37.03 (63)] / 25 = 373

Actual observation of N = 373

Capping = 65.19%

Idle time = 29.35%

Other work = 5.46%

Hence the % of idle time at the capping workstation was 29.35 ± 5.

4. RESULTS AND DISCUSSION

The work sampling approach was employed at both the filling and capping workstations to determine the productive and non- productive element or idle time in the operation. It is basically a statistical technique where large numbers of observations are made. The purpose of this analysis is to take action to eliminate the problem. At the filling workstation, a sample size of 385 total observations was made to achieve 95% accuracy. The result of the examination indicated that the idle time of the operator was 23.4% with bounds of accuracy of 5%. Similarly, 29.35% idle time of the operator was found at the capping workstation based on a sample size of 373 observations made as discussed in section 3.1. This study discovered that the root causes were mostly attributed to the general factory layout at the filling area and the manual operation line of the 630 ml soya sauce bottle and it results in wasted time and unnecessary movements such as transferring the trolleys from one workstation to another, which cause a delay or slow down the production line. The manual operations demand intensive engagement of manpower however, the extent of manpower engagement and utilisation is still low. In addition, documentation of any standard operating procedure was not in existence and as a result, the operators perform work based on their individual styles, which results in added work content that were not value added activities. Hence, the productivity could potentially be increased by an enormous amount based on the above factors. A study by [18, 25, 27-28] revealed that the use of work sampling enhanced the production capacity. A study by [26] also showed that it is simple and inexpensive to perform.

Based on the data collected, the idle time is higher at the capping workstation as compared to the filling workstation. The cycle time of these processes were measured and calculated. These analyses automatically confirmed where the bottlenecks or capacity constraints are in the process line. This bottleneck causes delay or slows down the operation system so it needs to be solved urgently. This is a major obstacle faced by this enterprise as most of the jobs are performed manually. According to [12] a bottleneck is one of the significant problems encountered by most SMEs. Subsequently the improvement action has been established and implemented using a semi-automatic filling machine having 6 nozzles, which is essential. Only a single worker was needed to work at this workstation compared to the existing operational conditions. The bottleneck is eliminated by the installation of the semi-automatic filling machine. Thus, the time of one processing cycle was decreased, which in turn increases the efficiency of the whole system and improves the earnings. The small investment for this semi-automatic filling machine was recuperated in 3 months.

The quantity of sauce loaded in the bottle was more consistent and easy to control and monitor. This improvement leads to better product quality and quantity. Underutilisation of the human resources was reduced. Using a semi-automatic process will benefit the firm with respect to productivity and will also solve the issue of manpower employment since the labour turnover is fairly high. Hence, the imbalance between the capping and the filling workstations was eliminated. This result was parallel with the result obtained by [11,19,29].

The existing process flowchart was critically studied. The layout was rearranged by minimising the transit time between each workstation. Using systematic layout planning a modified process flowchart was presented and the travel distance was reduced to 12.5 feet which was originally 17 feet. The cycle time for each operation is very much related to the transit times from one workstation to the next workstation. The number of trolleys involved was reduced from 5 to 3. Figure 3 displays the proposed new process flowchart of the soya sauce (630 ml) operation line. [18,24,28,] reported that increasing productivity by reducing cycle time in the assembly lines of the automotive industry.

The modified design layout and simplified process flowchart minimised the unnecessary movements of the operators, as shown in Fig. 3. It also improved the safety and the flow of the material on the workstation floor. Similar findings were also revealed by [8,18]. [29] reported that systematic layout planning and design layout is an influential factor in a company's performance to support the streamlined process of production. Furthermore, it provides better working conditions for the operators. These workstations are now connected to each other through a conveyor belt. The work elements at both workstations were reduced. Thus, time required to complete the final product was substantially reduced in comparison to the time taken in the current operational conditions. Thus, there was an increase in the output in less time and the results of this study support the findings of [26].

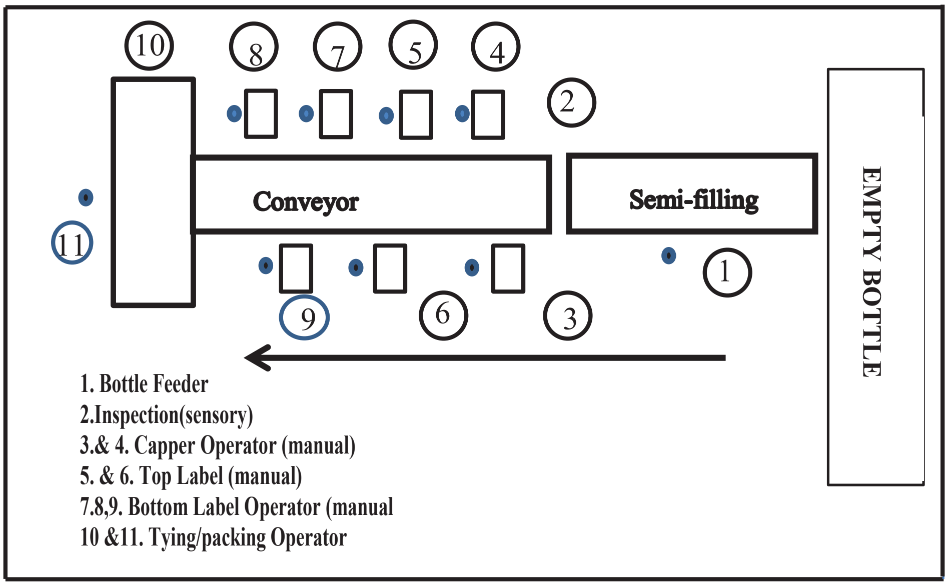

Fig. 3: Proposed improvement flow diagram of soya sauce (630 ml) operation line.

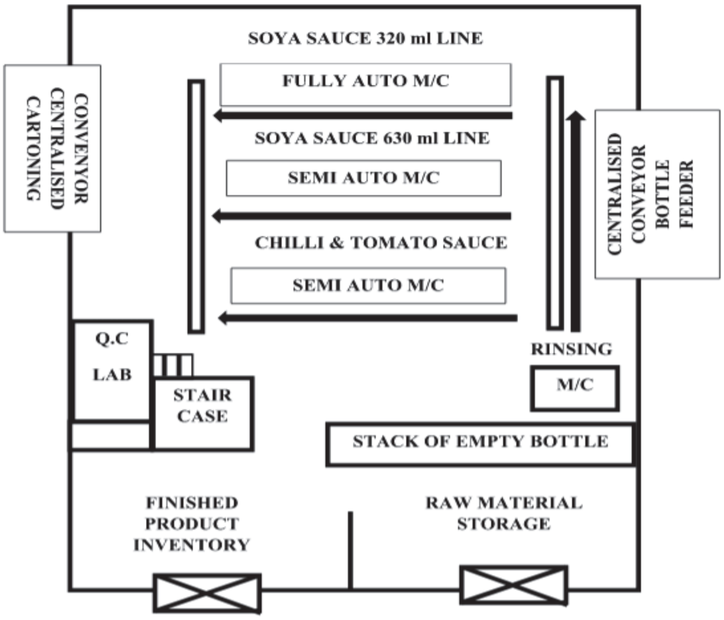

Fig. 4: The overall factory layout at the filling area.

Figure 4 presents the overall factory layout at the filling area which was quite congested due to the limitation of floor area. An improved layout was proposed so that a centralized bottle rinsing workstation could be achieved. As compared to the existing layout, the workstations were all over the factory. The improved layout design allowed feeding of the bottle to be centralized. [16, 18, 22, 27,29] also showed that the optimization of production layout was achieved and improve product flow and plant layout efficiency.

5. CONCLUSION

The deployment of the system proposed in the study at the capping and filling workstations have a significant impact on the productivity of the soya sauce factory. The

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layout of the factory was optimised, the bottleneck was eliminated, the production capacity was improved, and the return on investment (ROI) was 3 months. Moreover, even the transportation was decreased from 5 to 3 trolleys with no delay in the assembly line. The standard operating process was well established by using the new proposed outline. New policies and observation schedules were introduced to keep up the improvement in the process. Thus, this study demonstrated that work study techniques are suitable tools to be implemented for productivity improvements. However, the successful adoption of this approach is mostly because of the top administration involvement and the participation of all the members of the staff.

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