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OPERATION OVERLAPPING APPROACH IN MTS PRODUCTION TYPOLOGY TO ASSIST THE ACCOMPLISHMENT OF SUSTAINABLE SUPPLY CHAIN MANAGEMENT

Chairul Saleh[a]*, Raisa Rahma Agitya[a], Huda Muhammad Badri[b], Baba Md. Deros[b]

[a]Industrial Engineering Department, International Program, Islamic University of Indonesia
[b]Department of Mechanical and Materials Engineering, Universiti Kebangsaan Malaysia, Malaysia

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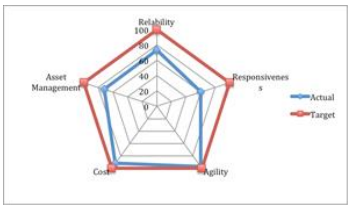
*Corresponding author
Chairul@uii.ac.id

Graphical abstract



Abstract

Sustainable supply chain management (SSCM) has appeared to be important in business practices in order to survive in the competition. Sustainable performance assessment, that includes economic, social, and environmental aspects need to be given due attention by the business players in order to understand the position of the company so that it can fulfill customer satisfaction. In this research, each of the aspects is measured using different methods. The Economic performance assessment is represented using the Supply Chain Operation Reference (SCOR) model that helps in measuring the success of a supply chain operation. It uses 15 indicators deemed relevant in the Make-to-Stock production typology that is distributed into five performance attributes. The economic assessment is then obtained through these performance attributes that result in 97.5% in agility, 92% in cost, 78.2% in reliability, 72% in asset management, and 40.67% in responsiveness. Meanwhile, the social performance assessment is directed at employee's welfare. Questionnaires are distributed to 30 employees to measure company's commitment to address their social issues. It results in a perfect score as 100% in fair salary, annual allowance, and training, while health insurance and safety equipment only cover 70% and 30%, respectively. The environmental aspect is noticed on the wastewater management, since it mainly contributes for company's waste. The assessment lies on the liquid contamination test and is compared to the maximum standard level, set by the government. Environmental assessment shows 76.8% in acidity, 71.93% in Biological Oxygen Demand (BOD), 33.15% in temperature, and 0% in both Total Suspended Solid (TSS) and Chemical Oxygen Demand (COD). While this research is focusing on improving the performance in the supply chain process (Economic aspect), which is the worst assessment in the economic aspect, which is responsiveness, it is selected to be improved to reach an optimum performance. Therefore, the operation-overlapping approach is applied in the scheduling of the production process to improve company's responsiveness, which is from 40.67% to 60.67%.

Keywords: Supply chain management, sustainable supply chain management, SCOR performance assessment, batik industry, MTS production typology, operation overlapping

Abstrak

Pengurusan rantaian bekalan yang mampan (SSCM) telah menjadi penting dalam amalan perniagaan untuk terus bertahan dalam persaingan tersebut. Penilaian prestasi yang berterusan, yang merangkumi aspek ekonomi, sosial dan alam sekitar perlu diberi perhatian penuh oleh pemain perniagaan untuk memahami kedudukan syarikat supaya ia dapat memenuhi kepuasan pelanggan. Dalam kajian ini, setiap aspek diukur menggunakan kaedah yang berbeza. Penilaian prestasi ekonomi ditentukan menggunakan model Rujukan Operasi Rantaian Bekalan (SCOR) yang membantu dalam mengukur kejayaan operasi rantaian bekalan. Ia menggunakan 15 petunjuk yang relevan

dalam tipologi pengeluaran *Make-to-Stock* (MTS) yang diedarkan kepada lima ciri-ciri prestasi. Penilaian ekonomi kemudiannya diperolehi melalui sifat-sifat prestasi, yang menunjukkan keputusan berikut- 97.5% dalam ketangkasan, 92% dalam kos, 78.2% dalam kebolehpercayaan, 72% dalam pengurusan aset, dan 40,67% menerusi tindak balas. Sementara itu, penilaian prestasi sosial ditujukan kepada aspek kebajikan pekerja. Borang soal selidik diedarkan kepada 30 pekerja untuk mengukur komitmen syarikat dalam menangani isu-isu sosial mereka. Ia membawa kepada markah penuh 100% gaji yang adil, elaun tahunan, dan latihan, manakala insurans kesihatan dan peralatan keselamatan hanya merangkumi 70% dan 30% masing-masing. Penilaian ini terletak pada ujian pencemaran cecair dan dibandingkan dengan tahap piawaian yang maksimum, yang ditetapkan oleh kerajaan. Penilaian alam sekitar menunjukkan keputusan 76.8% dalam keasidan, 71.93% Permintaan Oksigen Biologi (BOD), 33.15% dalam suhu dan 0% dalam kedua-dua Jumlah Pepejal Terampai (TSS) dan Tuntutan Oksigen Kimia (COD). Walaupun kajian ini memberi tumpuan kepada meningkatkan prestasi dalam proses rantaian bekalan (aspek ekonomi), penilaian yang paling teruk adalah dalam aspek ekonomi, yang responsif, dipilih untuk diperbaiki untuk mencapai prestasi yang optimum. Oleh itu, pendekatan operasi-bertindih digunakan dalam penjadualan proses pengeluaran untuk meningkatkan daya respon syarikat dari 40,67% kepada 60,67%.

Kata kunci: Pengurusan rantaian bekalan, pengurusan rantaian bekalan mampan, penilaian prestasi SCOR, industri batik, MTS tipologi pengeluaran, pertindihan operasi.

1.0 INTRODUCTION

The need to manage supply chain processes in effective and efficient way has been rising more than ever before. Competitions, either domestically or globally, have risen to be the major purpose for manufacturers to deliver the best products or services in every possible way. Several studies have shown that in order to operate a firm in effective ways, it would be better to start taking a close look into its overall chain, since each party is highly sensitive to any changes, whether at the upstream or downstream level [1,2].

There are some external factors that have contributed to the adoption of sustainable supply chain practices, e.g. market forces, policy and regulations, product development and social issues [3]. These factors require development from traditional supply chain management practices towards the sustainable supply chain management (SSCM). The term SSCM is defined as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business process for improving the long-term economic performance of the individual company and its supply chains" [4].

SSCM is not only focusing on addressing economic issues, but also on meeting environmental and social standards along all stages of the supply chain [5]. Moreover, to achieve sustainability in the supply chain management, the performance of a company is very important to be measured. The Supply Chain Operation Reference (SCOR) appears to be a popular tool for all practitioners and academics to conduct the performance assessment of a company. SCOR is a management tool used to address, improve, and communicate supply chain management decisions within a company and with suppliers and customers of a company [6].

Kain Batik as the product of the Batik process, one of the Indonesian cultural heritage, has turned from historic-art to the manufacturing business. It has marketed from the domestic to the international market and potentially created a bigger segmentation in the upper-medium level of the textile industry. Batik manufacturing, on the other hand, has a unique production typology, whereupon based on classification, there are 5 types of production type, e.g. Make-to-Stock (MTS); Make-to-Order (MTO); Engineer-to-Order (ETO); Hybrid MTS-MTO; Hybrid MTO-ETO; and Hybrid MTS-MTO-ETO. This study will investigate the suitable Indicator for the Batik industry suited along the characteristic of the MTS production typology. Not only determining the SCOR metrics, SSCM practices will also be measured in this Batik industry by also including social and environmental assessments.

Since the feasibility of a firm to compete with other competitors lies on its current performance, the awareness of an efficient and effective production process is highly required in order to assist the accomplishment of SSCM inside a company. Therefore, an evaluation of the production activity control inside the shop floor production needs to be applied. Operation overlapping as the scheduling activity at at initial stage of the process series appears to be compatible in order to give an implacable role for the firm's efficiency. It is therefore improving the company's performance by reducing the make span, in order to minimize the production cycle time. Based on the latest literature studies, no studies have

discussed the implementation of this SSCM performance assessment in accordance with the MTS typology of the Batik manufacturing practices along the supply chain.

2.0 LITERATURE REVIEW

To answer the increasing demand for environmental friendly business nowadays, it is important for a firm to apply sustainable supply chain management. The concept of sustainability was first defined by the United Nations World Commission on Environment and Development (WCED) that describes "sustainability means being able to satisfy current needs without compromising the possibility for future generations to satisfy their own needs" [4]. Along with the development, its meaning has been developed through numerous practices in real world systems and therefore creating a broader context. SSCM thus, is defined as ''the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements'' [1].

Forum for the Future Organization defines sustainable development as a dynamic process, which enables every individual to realize their potential and improve their quality of life in ways that simultaneously protect and enhance the Earth's life support systems [8]. It could be seen that those definitions are related to several aspects that include the environment, human, and economy, as have been elaborated by [7], who provided a comprehensive definition of the concept by defining it in terms of the triple bottom line, which are economic prosperity, environmental quality and social justice. In relation to corporate performance, sustainability means operating a business in a way that causes minimal harm to living creatures [8]. The importance of sustainability as the integration of the triple bottom line has been proven by maintaining equitable balance among those three aspects that will therefore support a firm for long-term competitiveness [9, 10, 11]. Sustainable development is applied in almost all business industries nowadays, as the overall view of sustainable development is seen as becoming increasingly strategic because it affects the core business of the firm and its growth, profitability and even survival [12].

Operation overlapping has been known for decades as an optimization tool for scheduling in any production system. It is either used for minimizing the lead-time, machine idle, the weighted total stock or simply for minimizing the carrying cost. Many tools have been applied to optimize, those mentioned factors using Ant Colony Optimization (ACO) [13]. There is also Overlapping Strategy Matrix (OSM), a tool used to make a framework to optimize project schedule with minimum rework [14].

As one of the scheduling optimization approaches, operation overlapping is the core idea of building our proposed model for the integration of process planning and group shop scheduling by developing a constructive O-algorithm [15]. Although it is beneficial for lead-time reduction, operation overlapping also requires additional costs for rework. An analytical model has also been developed to improve the project performance by balancing its negative and positive effects [16].

3.0 RESEARCH METHODOLOGY

Company GS is chosen as a case study for this research, as considered relevant to represent any similar typology of the production system. This research aim is to conduct an assessment of the SSCM performance in Batik manufacturers who implement MTS Typology. This research will be focusing on the assessment of triple bottom line of sustainability; economic, social, and environmental. SCOR 11.0 is used to assess the performance of the economic aspect. Observation is done to collect data of information and material flow inside the business practices. The assessment encompasses five process attributes, which are Reliability, Responsiveness, Agility, Cost, and Asset Management, which cover all business processes. Questionnaires are distributed to 30 workers to measure the social welfare. In order to measure the environmental effect of Batik process to the surroundings, liquid waste is tested in a laboratory to seek the composition of bacteria and any other aspects by comparing it to the national standard of wastewater management in Surakarta, Indonesia.

3.1 Economic

SCOR has identified over 200 key performance metrics to monitor the overall supply chain performance. These metrics are used to build performance trends for areas under improvement, or to compare against industries' best practice performance. In this research, the SCOR metrics used is set up according to company's practices, giving more specialization to the practices of the Make-to-Stock typology.

3.1.1 Reliability

Reliability is defined as the percentage of orders meeting delivery performance with complete and accurate documentation and no delivery damage. Components include all items and quantities on-time using customer's definition of on-time, and documentation – packing slips, bills of loading, invoices, etc. The reliability in this study uses six level 2 operations; namely forecast accuracy, schedule product deliveries, schedule achievements, yield, fill

rate, and return rate. Forecast accuracy lies on the Plan process. Data of the sum of variances and forecast sum are needed to process the accuracy of forecasting. The number of schedules changed and the total number of schedules are used to set the schedule product deliveries. The SCOR model for reliability is as shown in Figure 1.

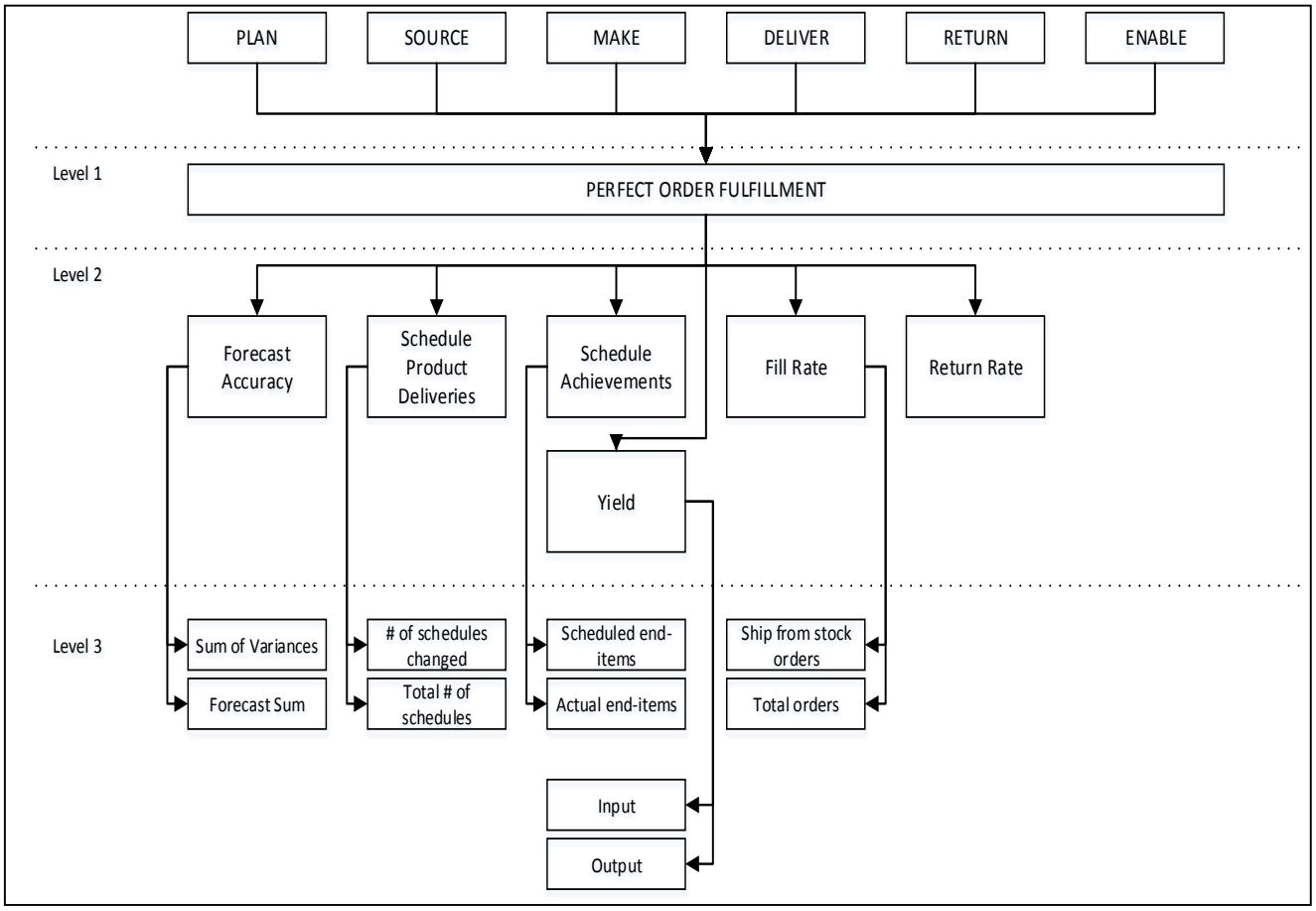


Figure 1 SCOR model for reliability

3.1.2 Responsiveness

The average actual cycle time is consistently achieved to fulfill customer orders. For each individual order, this cycle time starts from the order receipt and ends with customer's acceptance of the order.

3.1.3 Agility

Agility is the number of days required to achieve an unplanned sustainable 20% increase in the quantities delivered. In the practice of this research, the MTS company implements the upside supply chain flexibility, which is related to the source and make process. Upside source flexibility and upside make flexibility act as Level 3

3.1.4 Cost

The total cost to serve is the sum of the supply chain cost to deliver products and services to customers. The total cost to serve includes the cost to plan the supply chain, cost to source materials, products, goods, merchandize and services, cost to produce, etc. It is the sum of the Sourcing Cost, Material Landed Cost, Production Cost, and Order Management Cost.

3.1.5 Asset Management

Asset management can be inferred by cash to cash cycle time. It reflects on inventory days of supply of finished goods

3.2 Environmental

In the environmental dimension, the parameters that are measured as waste water quality indicators are

temperature, acidity (pH), BOD (biochemical Oxygen Demand), COD (Chemical Oxygen Demand), and TSS (Total Suspended Solids).

3.3 Social

Social assessment consists of five parameters, which are BPJS (health insurance), safety equipment, basic salary, extra allowance, and training given from a company to its employees.

3.4 Operation Overlapping

Operation overlapping allows the next operation to begin processing before the entire lot is completed in the previous operation. The efficiency can be measured through Manufacturing Efficiency (ME) or Value Added Efficiency (VAE).

3.4.1 Current Efficiency Measurement

Manufacturing efficiency (ME) is calculated by dividing the total setup time and operation time by the total manufacturing lead-time (MLT). Q is the total lot size, S is set-up time, O is operation time per unit, W is waiting time, N is number of operation and M is movement time.

$$MLT = \sum_{i=1}^{n} Q + S + (N \times O) + W + M \quad (1)$$

A more accurate measure of the manufacturing efficiency is obtained by dividing the processing time, the only time when value is added, by the total manufacturing lead-time of the part. It is the Value Added Efficiency (VAE).

$$VAE = \frac{O}{MLT} \quad (2)$$

3.4.2 Optimum Size Batch of Calculation

In operation overlapping, the basic idea is to divide the lot size in the current system to be two or more batches to shorten the processing time. The first batch is processed beforehand, and right after the first operation for batch one is finished, it continues with the second batch. It goes until the final operation is done, where the processing of the two batches is finally complete.

4.0 RESULT AND DISCUSSION

Data processing has shown the calculation and results obtained for each dimension. It is then elaborated in the chapter below.

4.1 Sustainable Performance Assessment

The nature of Sustainable Supply Chain Management is essential to the success of the existence in the supply chain competition. Companies need to be aware of the implementation of triple bottom line, to assure the sustainability of its economic growth, social development, and environmental protection inside the supply chain in order to meet the company's target. These current performances need to be reviewed through the company's assessment that covers those three dimensions, since it creates a reciprocal relationship with the company's performance itself, as well as to determine how healthy a company runs its business.

4.1.1 Economic

Each process has its own characteristic. The performance of the Plan process can be reflected through its reliability in the forecast accuracy, resulted in 42.85%. Meanwhile the Source process can be traced through several attributes: reliabiliity, responsiveness, agility, and cost. The summary of the economic performance assessment can be seen in Table 1 below. In Table 1, the overall performance of the MTS Company with regard to its reliability is 78.2%; the responsiveness for a company to make a product from the source to deliver takes 23.9 days; its agility is 97.5%, and costs around Rp. 43,218,750,00. Meanwhile, its asset management is turned over in 58 days.

Table 1 Comparison of assessment and company's target in the economic dimension

Attribute	Assessment	Target
Reliability (%)	78.2	100
Responsiveness (days)	23.9	15
Agility (%)	97.5	100
Cost (IDR)	IDR43,218,750	IDR40,000,000
Asset Management (days)	58	45

In order to put every aspect into one frame, the conversion into percentage is implemented to see the gap in the same scale. The illustration of the comparison between the SCOR performance assessment and company's target is explained in the radar chart in Figure 2 below.

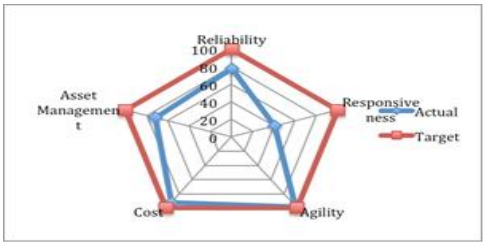


Figure 2 Radar chart for SCOR assessment

4.1.2 Social

In health insurance, there is 30% gap between the actual and target condition. A company has aimed to cover all of their employees, but certain situations do not allow them to implement this. Safety equipment is only given to 30% of workers in the production process. Based on observation, the workers who work on the dyeing or scouring process are not well-equipped with boots or gloves. Since their work involves being in contact with boiled water in high frequency, it is important to equip those workers with appropriate standard. There is 70% gap between the company's actual facility and company's commitment.

Table 2 Comparison of target-assessment in social dimension

Parameter	Assessment	Target
Health Insurance	70	100
Safety Equipment	30	100
Appropriate Salary	100	100
Reward/Extra Allowance	100	100
Training	100	100

The illustration of Table 2 is clearly explained in the radar chart in Figure 3.

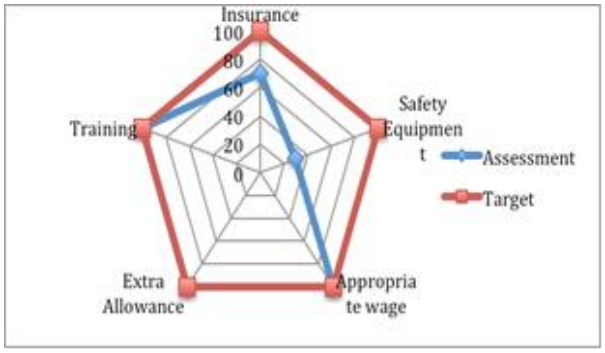


Figure 3 Radar chart for social dimension

4.1.3 Environmental Dimension

In the environmental dimension, parameters measured as wastewater quality indicators are temperature, pH, BOD, COD, and TSS. Each of the indicators has its own standard level. The comparison between the laboratory test result and government policy (target) is shown in Table 3 below. It shows that wastewater's acidity (pH), BOD, and temperature are not harmful, whle results on COD and TSS show that they are exceeding the maximum level, which means it is hazardous.

Table 3 Comparison of target-assessment in social

Parameter	Assessment (mg/L)	Standard (maximum) (mg/L)
Acidity	1.74	7.5
BOD	16.84	60
COD	632.82	150
TSS	1934	50
Temperature	25.4	38

To ease the comparison, the unit of measurement is then changed into percentage, through normalization data. Based on the environmental assessment, we are aware that the lower result obtained, the better it is for the environment. Due to the maximum standard set as the target, it means that the smaller result shows that the indicator has not even reached maximum content, and the more secure the waste to the environment. The summary of result can be seen in Table 4, showing that the worst quality of liquid waste lies on the COD and TSS levels.

Table 4 Comparison of Test Result – Limit in Environmental Dimension (%)

Parameter	Assessment	Standard (maximum)
pH	76.8	100
BOD	71.93	100
COD	0	100
TSS	0	100
Temperature	33.15	100

As seen in Table 4, the environmental assessment can be explained easier following the illustration of the radar chart below, in Figure 4.

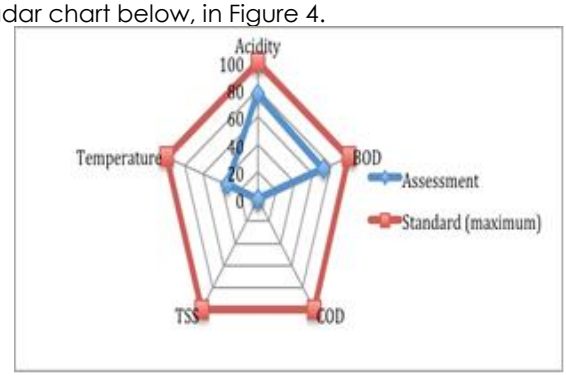


Figure 4 Radar chart for environmental dimension

4.2 Performance Improvement

While the current system applies one batch in one operation, operation overlapping proposes the batch to be divided into two, due to the consideration of implementing a feasible method in the business. Based on the assessment conducted on the economic dimension, the aspect that has the worst

performance lies on the Responsiveness attribute by only 40.67%. It highlights Make Cycle Time as the metric that hampers the productivity of company's responsiveness.

In the case of daily production, Figure 5 illustrates the Gantt Chart for Batik Cap production. In this process, each process of stamping, dyeing, scouring, and drying is done twice in sequence. Going from stamping to quality control will normally take up to 12 days (including 2 days in the weekend). Thus, the processing of the material that starts on 2 March will be expected to be complete on 13 March.

ID	Task Name	Start	Finish	Duration
1	Stamping (1)	02/03/2015	02/03/2015	,5d
2	Dyeing (1)	02/03/2015	02/03/2015	,94d
3	Scouring (1)	03/03/2015	04/03/2015	1,88d
4	Drying (1)	05/03/2015	05/03/2015	1d
5	Stamping (2)	06/03/2015	06/03/2015	,5d
6	Dyeing (2)	09/03/2015	09/03/2015	,94d
7	Scouring (2)	10/03/2015	11/03/2015	1,88d
8	Drying (2)	12/03/2015	12/03/2015	1d
9	Quality Control	13/03/2015	13/03/2015	,25d

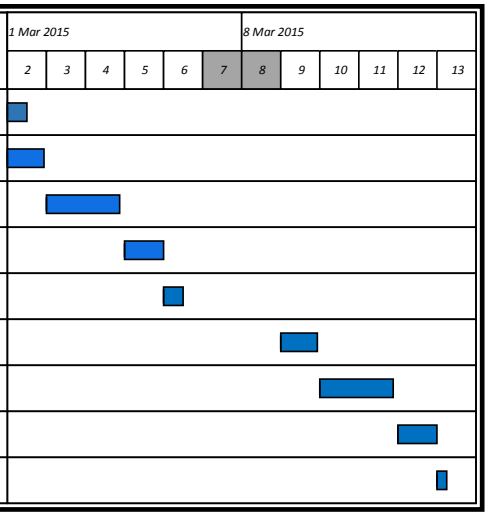


Figure 5 Gantt chart for current performance

The main idea of overlapping lies in the fact that batch 2 will be started as soon as batch 1 finishes its operation. By that, the total amount of production time can only consider the time taken in batch 1, regardless of the operation time in batch 2. In order to acquire the optimum size of batch for each operation, calculation based on equation 4.17 is undertaken. The transfer lot size for batch 1 in operation 1 to 9 is 11, 10, 20, 20, 11, 10, 20, 23, and 30 pieces consecutively. By this, a company could save up to 3 days in processing Batik Cap for two colors.

After gaining the optimum size of pieces processed with the operation overlapping, hence the improvements can be seen in Figure 6 that illustrates the gant chart, with only consideration on the time taken for the first batch.

ID	Task Name	Start	Finish	Duration
1	Stamping (1)	02/03/2015	02/03/2015	,18d
2	Dyeing (1)	03/03/2015	03/03/2015	,31d
3	Scouring (1)	02/03/2015	03/03/2015	1,25d
4	Drying (1)	04/03/2015	04/03/2015	.5d
5	Stamping (2)	05/03/2015	05/03/2015	,18d
6	Dyeing (2)	05/03/2015	05/03/2015	,31d
7	Scouring (2)	06/03/2015	09/03/2015	1,25d
8	Drying (2)	09/03/2015	09/03/2015	,76d
9	Quality Control	10/03/2015	10/03/2015	,31d

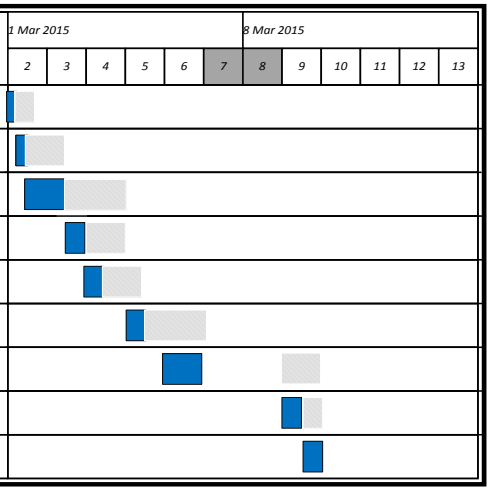


Figure 6 Gantt chart for improved performance

This is evident, as three days are added as improvement, since this production with two batch splitting starts on 2 March and ends in 10 March, saving three days from the previous production seen in Figure 4. Meanwhile the saving time for the responsiveness attribute compared to the current system can be seen in Figure 7. Hence the proposed system results in the improvement of the performance. As shown, responsiveness has increased to be 60.67%. The illustration of the overall performance attributes is explained in Figure 8.

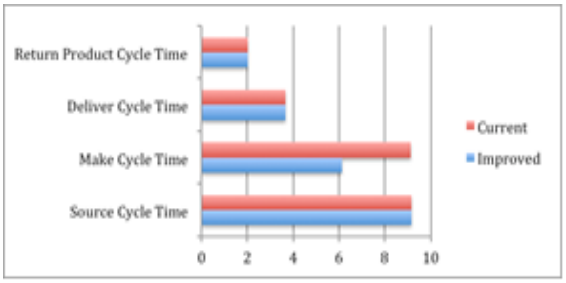


Figure 7 Comparison between Improved and Current Systems

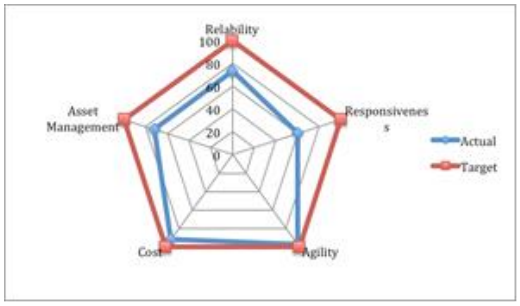


Figure 8 Radar chart for improved performance

5.0 CONCLUSION

Based on the performance assessment in the perspective of sustainable supply chain management, this result shows that the company still does not receive the much-deserving attention in safety and health insurance for their employees. Related to the environmental aspect, wastewater in this company has yet to be managed well, due to the severity level of the TSS and COD contents that are far above the maximum standard set by the government. Also, in the perspective of the economy, the company has the lowest score of responsiveness that is closely related to how fast a company responds to the market demand that leads to customer loyalty, although company's agility to market dynamics is rated as the highest score in this assessment. Firm's feasibility to compete with other competitors lies on the performance of each attribute in the assessment. Operation overlapping has been proposed to increase firm's responsiveness by 20%, by determining the optimum size of the first batch in every operation as 11, 10, 20, 20, 11, 10, 20, 23, and 30 pieces. Referring to the result of research, some points can be highlighted for future studies: the essential relationship of the whole triple bottom line has not been inspected in integration. This association can be inspected through a simulation, to seek the behavior of one variable to another. Also, the real sense of SSCM performance assessment should be covering every possible indicator that might later provide more accuracy to the assessment.

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