

Study Analysis of Productivity Improvement Micro, Small And Medium Enterprises (MSMEs) Hand Craft With Line Balancing Method To Improve and Enhance Sustainable Economic In Depok, Indonesia

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Abstract

Micro, Small and Medium Enterprises or commonly known as the SMEs is one of the supporting pillars of economic Pharmaceutics among the middle class. SMEs are high productivity levels in the villages which have massive labor absorption. Currently, Indonesia has faced the AEC (Asean Economic Community) and the effects will be felt at the beginning of the year 2016 (Directorate General of Trade and Industry, Small and Medium Industry, Ministry of Industry of Indonesia, Euis Saedah, 2015). Therefore, SMEs as the key to the economy of the community should be good developed and structured in order to be ready to face global competition. Handkerchief Our team consists of students of Industrial Engineering, Mechanical Engineering, and Accounting University of Indonesia interested in conducting research on the use of methods of Line Balancing in the production process carried out by SMEs Crafts in the city of Depok. Line Balancing methods have been tested and applied in large corporations that system of division of labor is balanced so the level of productivity increased the production. Therefore, we want to implement this method Line Balancing-Six Sigma on SMEs usually have the classic problem that is Out of Stock & Order every order in large numbers, in other words SMEs we have not been able to meet the global demand that the number would not be very much. We chose Crafts for SMEs is one of the largest home-based commodity production is quite a lot in the city of Depok, Indonesia. but less well-known, wellstructured and not very productive. Depok city itself is a nearby town in which all of our team members live and learning in the lecture. Thus the distance to carry out research on SMEs in the city of Depok is not an issue. The economic condition of the people in Depok is also not so good because it is a suburb of the capital Jakarta city. Therefore, the Micro, Small and Medium Enterprises Crafts Industry in Depok city should be developed in order to improve the economy of their communities well. The solutions we offer are using Line Balancing in the production process that previously we would do some research first about the application of methods, systems, mechanisms, and management. Expected future, the results of this study can be used as a model to be applied to applicable and tested that can be applied to SMEs which are run directly by the people in all regions of Indonesia. With the development of SMEs is expected the economy of small communities can grow and be strong to face the world economic turmoil.

Keywords

Implementation of Line Balancing, Six Sigma, Enterprise, Craft

1. Introduction

Small Scale Medium Enterprises (SMEs) have an important role Indonesian economic (Bhasin, 2010; Gunawan 2012; Hamdani, 2012; Indrawati, 2012; Pawitan, 2012; Setyaningsih, 2012). Sharman and Wadhawan (2009) stated that the importance of the SMEs sector is even recognized around the world because it can significantly improve the social and economic systems in a variety purposes. The increasing number of SMEs can support the economic to be stronger. In Indonesia, SMEs have contributed over 75% of national income and occupied 97% national employment (National Cooperative Department, 2011). This number reflects that SMEs prosecute to be carefully developed due to wide variances of labor skill and technology adopted in contrast to the customer requirements over the products of food (Setyaningsih, 2012)

The question is what about Indonesia SMEs situation and how the performance work out. Taking into account this problem, it needs the best production process to be considered. Hence, a Line Balancing System and Lean Six Sigma approach proper to be applied. A line balancing model has been widely applied to solve many multi criteria problems (Tsai et al 2011). Yang et al (2008) said if a line balancing is more suitable for evaluating and improving production process problems in the world than previously available methods. According to Pribadi and Kanai (2011) the government of Indonesia needs to reformulate their policy in strengthening and regulating the small firms in Indonesia. The government should dedicate more effort to eliminate SMEs boundaries and decide the effective way for helping SMEs to develop their strengths and potentials (Irfayanti and Aziz, 2012). This statement briefly shows that there are several criteria that should be incorporated to delegate more productive SMEs in Indonesia. Therefore, this study is aimed to identify factors that significantly influence the performance of line balancing and Lean Six Sigma which responsible to increase the productivity of SMEs to enhance sustainable economics. This research mainly focused on improvement of production process of the SMEs on handicraft products located at Depok City, West Java Province, Indonesia.

2. Method

The manufacturing assembly line was first introduced by Henry Ford in the early 1900's. It was designed to be an efficient, highly productive way of manufacturing a particular product. The basic assembly line consists of a set of workstations arranged in a linear fashion, with each station connected by a material handling device. The basic movement of material through an assembly line begins with a part being fed into the first station at a predetermined feed rate. A station is considered any point on the assembly line in which a task is performed on the part. Once the part enters a station, a task is then performed on the part, and the part is fed to the next operation. The time it takes to complete a task at each operation is known as the process time. The cycle time of an assembly line is predetermined by a desired production rate. This production rate is set so that the desired amount of end product is produced within a certain time period (Baybars 1986). If the sum of the processing times within a station is less than the cycle time, idle time is said to be present at that station (Erel et al. 1998). One of the main issues concerning the development of an assembly line is how to arrange the tasks to be performed. This arrangement may be somewhat subjective, but has to be dictated by implied rules set forth by the production sequence (Kao 1976). For the manufacturing of any item, there are some sequences of tasks that must be followed. The assembly line balancing problem (ALBP) originated with the invention of the assembly line. Helgeson and Birnie (Helgeson et al. 1961) were the first to propose the ALBP, and Salveson (Salveson 1955) was the first to publish the problem in its mathematical form. However, during the first forty years of the assembly line's existence, only trial-and-error methods were used to balance the lines (Erel et al. 1998). Salveson (Salveson 1955) provided the first mathematical attempt by solving the problem as a linear program. Gutjahr and Nemhauser (Gutjahr et al. 1964) showed that the ALBP problem falls into the class of NP-hard combinatorial optimization problems. Therefore, heuristic methods have become the most popular techniques for solving the problem (Fonseca et al. 2005). The remainder of the paper is organized as follows: in Section 2 selected assembly line structure are presented, heuristic methods are discussed more precisely in Section 3. Section 4 includes popular in assembly line balancing problem quality measures of final results. Numerical example is reported in section 5. Finally, conclusions are given in section 6.

3. Selected Assembly Line Balancing Structures

In practice we can find different structures of assembly lines Balancing (serial line, with parallel workstations line, two-sided line, uline, etc.). All of them can be classified into two general types: type I with constant cycle time and minimization of workstations' number and type II with constant number of workstations and minimization of cycle time. All of them can be used in single or multi/mixed model production. A lot of methods and procedures were introduced for solving the assembly line balancing problem what can satisfy in the future production rates and utilization of tools in real companies. The first described assembly line structure was serial assembly line (Fig. 1). A traditional line organizes workstations and the tasks that comprise them sequentially along straight line. Nowadays, many products are produced not only from simple parts but very often from complex elements (earlier assembled) are used. It causes that even complex products need limited number of assembly operations. Therefore serial layout is still popular in assembly of final products.

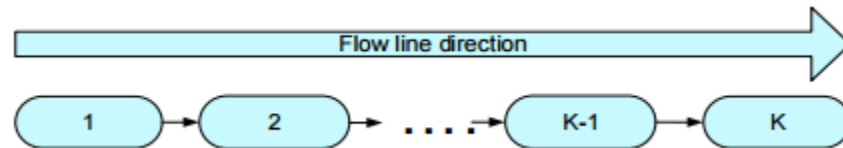


Fig. 1. Two-sided assembly line balancing

The U-line structure was introduced first time in 1994. In a U-line layout, workstations are arranged around U-shaped line (Fig. 2). Operators work inside the U-line. The U-shaped assembly line has become an alternative for assembly production system since operator may perform more than one task located to different places of assembly line. Moreover, U-line disposition allows for more possibilities on how to assign the tasks to the workstations and therefore the number of workstations needed for U-shaped line layout is never more than the number of workstations needed for the traditional straight assembly line. In the traditional assembly line balancing problem for a given cycle time, the set of possible assignable tasks is confirmed by those tasks whose predecessors have already been assigned to workstations, whereas in the U-line balancing problems, the sets of assignable tasks is determined by all those tasks whose predecessors and successors have already been assigned (Miltenburg 1998, 2001). One of the important characteristics that make U-shaped structures different from straight assembly lines is that the entrance and the exit of these lines are at the same position (Shwetank et al. 2013).

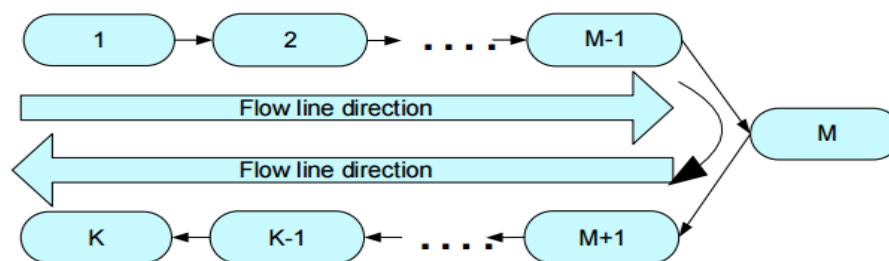


Fig. 2. U-shaped assembly line

Products enter the U-shaped assembly line at the front-side and exit from the back-side of the line. Studies on U-shaped assembly lines provide evidence for the potential to improve visibility and communications skills between operators, reduce operator requirements, increase quality, reduce work-in-process inventory, etc. (Nakade and Nishiwaki, 2008). In the same year as U-line layout was introduced, the problem of balancing parallel assembly lines was presented (Fig. 3). In the article (Gökçen et al. 2006, Ismail et al. 2011) authors studied alternative assembly line design for a single and mixed model products. The objective was to determine the number of assembly lines with minimum total manpower. In 2009 a description of parallel assembly line balancing problem (PALBP) which consists of two connected sub - problems: assigning of tasks to parallel lines and balancing parallel lines was given.

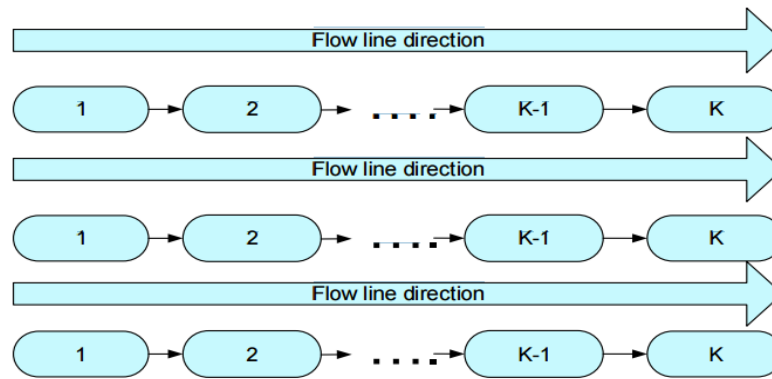


Fig. 3. Parallel assembly lines

4. Selected Heuristic Procedures

In this section heuristics which are useful in the balancing of the serial line, U-shaped line and parallel assembly lines are presented. In many papers it is possible to find different heuristic approaches (Scholl 1998). Most of the heuristics are based on genetic algorithms, tabu search and simulated annealing techniques. In each of these heuristics different strategies are used to represent assembly line balancing solutions and neighbour generation mechanism. The common assumptions of the heuristics are listed below: 1. only one product is produced on each assembly line, 2. precedence graphs for each product are known, 3. task performance times of each product are given, 4. Operators working on each workstation of the line are multi-skilled. In 1961 was proposed the well known Ranked Positional Weight procedure which bases on precedence graph and task times (Halgeson et al. 1961). The steps involved in this method are as follows: 1. Determine the positional weight (PW) for each task (time of the longest path from the beginning of the operation through the remainder of the network), 2. Rank the work elements based on the PW. The work element with the highest PW is ranked first, 3. Proceed to assign work elements (tasks) to the workstations, where elements of the highest positional weight and rank are assigned first, 4. If at any workstation additional time remains after assignment of an operation, assign the next succeeding ranked operation to the workstation, as long as the operation does not violate the precedence relationships, and the station times do not exceed the cycle time, 5. Repeat steps 3 and 4 until all elements are assigned to the workstations. Similar to straight line, U-shaped assembly line balancing problem can be solved using heuristic methods. Very often there are adopted from serial lines procedures. The difference between the original versions and the modified versions is that tasks are available for assignment to a workstation by having all successors or all predecessors previously assigned to a workstation, and when solving for the simple line balancing problem, tasks are available for assignment by having all successors previously assigned only. The Modified Ranked Positional Weight procedure was introduced by Miltenburg and Wijngaard (Miltenburg et al. 1994).

Parallel assembly lines are considered in literature rather seldom. Süer and Dagli (Süer et al. 1994) suggested heuristic procedures and algorithms to determine the number of lines and the line configuration dynamically. Gökçen (Gökçen et al. 2006) presented heuristic procedures and mathematical model for multiple or parallel assembly line balancing problem. They divided their study problem of parallel lines balancing in two cases: passive (same products are assembled with the same cycle time in two different assembly lines) and (the products assembled at each line should be different or similar models of a single product and their cycle times should also be the same). For passive case, the following steps should be carried out: 1. balance each assembly line using any single model assembly line balancing method, 2. compute the idle times for each workstation of each assembly line, 3. find the workstation k with an idle time that is equal to or greater than the half of the cycle time, and assign the task(s) in workstation k of another assembly line to the operator of the related workstation. Repeat this process for all workstations. For an active case procedure, the product assembled at each line should be different or similar models of

single product and their cycle times should be also same. In some practical, even though the product is same on both lines, the cycle times can be different.

5. The concept of Lean Six Sigma:

The Enterprise Management called Lean (literally thin) can be translated as (agile company) or (flexible company) links performance (productivity and quality) with the flexibility of an enterprise should be able to optimize and maintain all of its processes. Proponents of Lean want performance through continuous improvement and continuous improvement by waste elimination, Figure 4.

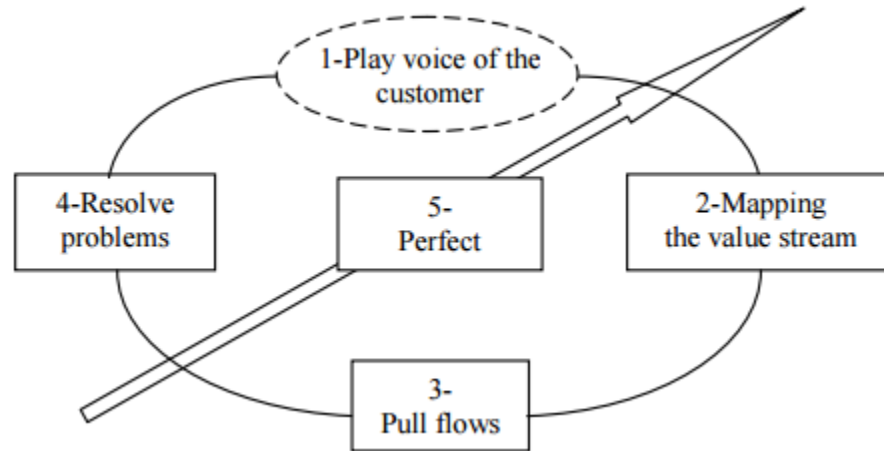


Fig 4: Technology (Lean) to drive the waste.

The concept of six sigma: An industrial process includes a number of repetitive tasks, the most grotesque example being the production of a room in high volume. A room is compliant if it meets a number of criteria. However, all the exhibits can't be strictly identical. One of major concern of quality management is how to master the conditions of production so that there is as little waste, the least possible customer dissatisfaction.

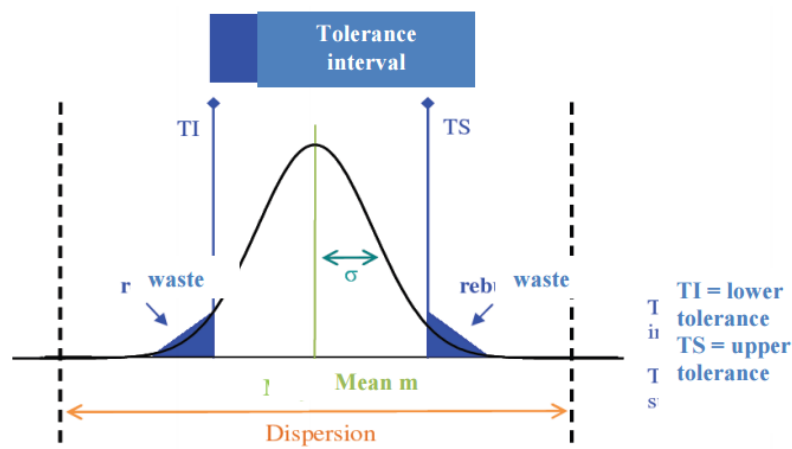


Fig 5: Representation of areas of waste on a normal dispersion.

Six Sigma represents the idealized goal of a defect rate of 3.4 DPMO² (defects per million opportunities), or 3.4 defective products on a sample of 1 million, which corresponds to a quality rate of 99.9997% [10],

Table 1. Table 1: Sigma performance levels.

Sigma	% Quality	% Defect	DPMO
1	30.9%	69.1%	691462
2	69.1%	30.9%	308538
3	93.3%	6.7%	66807
4	99.38%	0.62%	6210
5	99.977%	0.023%	233
6	99.9997%	0.00034%	3.4

The Lean Six Sigma is a method of improving the quality and profitability based on statistical process control. It is a management style that relies on a tightly controlled organization dedicated to project management.

6. Measures Of Final Results

Some measures of solution quality have appeared in line balancing problem. Three of these are presented below (Scholl 1998). Line efficiency (LE) shows the percentage utilization of the line. It is expressed as ratio of total station time to the cycle time multiplied by the number of workstations:

$$LE = \frac{\sum_{i=1}^K ST_i}{c \cdot K} \cdot 100\% \quad (1)$$

where:

K - Total number of workstations,

c - cycle time.

Smoothness index (SI) describes relative smoothness for a given assembly line balance. Perfect balance is indicated by smoothness index 0. This index is calculated in the following manner:

$$SI = \sqrt{\sum_{i=1}^K (ST_{max} - ST_i)^2} \quad (2)$$

where:

ST_{max} = maximum station time (in most cases cycle time),

ST_i = station time of station i.

7. Numerical Example

In this section a numerical example is calculated and discussed. Table 1 includes the processing times of 30 tasks. The graph of the single product is presented in Fig. 6.

Table 1. Processing times

Task	t_i	Task	t_i	Task	t_i	Task	t_i
1	4	9	3	17	4	25	1
2	2	10	7	18	9	26	2
3	7	11	9	19	4	27	3
4	6	12	2	20	3	28	5
5	1	13	7	21	6	29	4
6	5	14	10	22	5	30	1
7	9	15	1	23	4		
8	5	16	6	24	3		

Next a u-line shaped assembly line was considered. Similar to serial line, value of cycle times changed from 10 units of the time to 20 units of the time every 2 units – 5 steps. As a last step of the experiment, parallel assembly lines (only 2 lines) were studied as a possible configuration of assembly system. Some results are shown in Fig 5 - 10. Detailed solutions in serial and u-shaped line are presented in Table 2. Additionally, the quality measures were calculated and also added to the final knowledge of balance process.

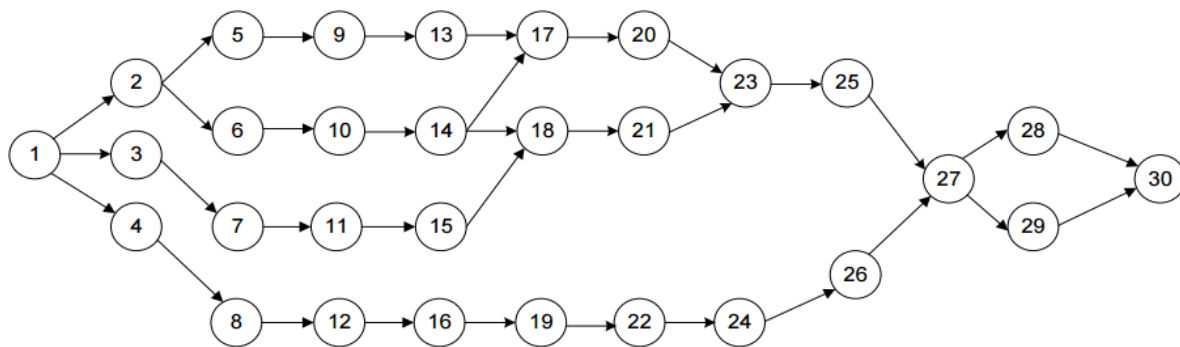


Fig. 6. Precedence graph of a numerical example

8. Applied in Small Medium Enterprise in Depok City, West Java, Indonesia (SMEs)

In the production activity of SMEs Curug Gentong in Depok City, West Java, Indonesia progressing from year to year. The fastest development occurred padatahun 2004 when production volumes reach 50-100 pieces perbulan.Namun today volume production has started bekurang hinggamencapai average of 40 pieces per month. The increase in volume occurred after an exhibition like demand which increased production volumes could reach 30% .To fill the order recruited empatkaryawan that each generate six barrel-shaped waterfall-thirds of the day. You can imagine how the production of barrel-shaped waterfall Mr. Ricoper year. This does not include the order if there is a third anakmaupun his wife is involved in manufacturing. Mr. Rico doing manufacture curug this keg on his wife and three children. Third active role in the activities of production, while IbuRitta involved in material procurement manajemennya. Discussed about waterfall keg, Rico said, so far found no significant constraints. This is because materialyang used

instead of domestic origin also mudahmendapatkannya. The material among other rocks, pumice dan semen while gentongnya obtained from village in Sawangan village, Depok.



Figure 6 : Handicraft from Depok, called Curug Gentong

SMEs Curug Gentong have a development plan as follows: 1. Short-term development plan is terusmenemukan innovations by making the latest creation in accordance with changing consumer tastes and continue to expand its marketing. 2. The medium-term plan of SME owners Curug this Gentong want this creativity can be new business opportunities for young people, one way to make the whole training. 3. Long-term plan was to have a showroom and branches in various regions in Indonesia.

Table 2. Results of assembly balancing problem for a given numerical example

C	Serial line				U-shaped line			
	K	SI	LE	LT	K	SI	LE	LT
10	17	10,58	81,19	165	15	6,16	92	150
12	14	10,78	82,14	161	13	8,72	88,46	156
14	11	6,63	89,61	154	10	1,41	98,57	140
16	10	6,32	86,25	154	9	4,24	95,83	144
18	8	3,17	95,83	142	8	3,47	95,83	144
20	8	11,49	86,25	150	7	1,41	98,57	140

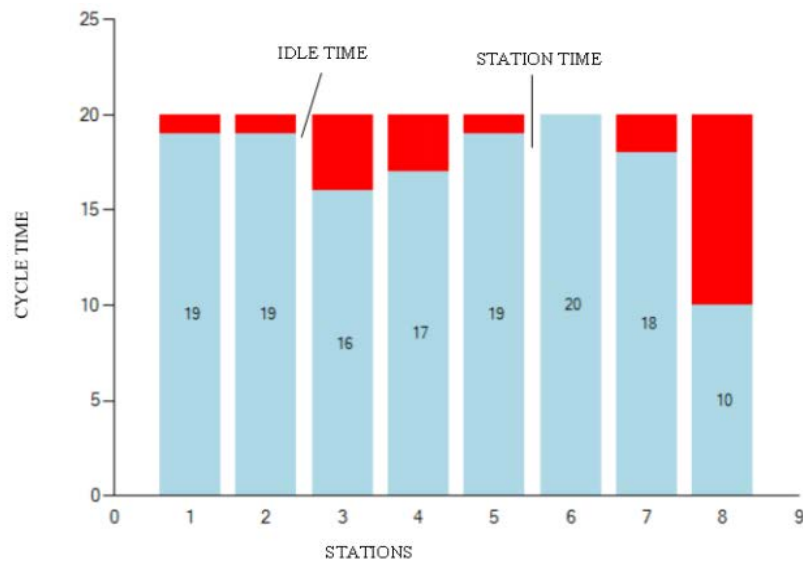


Fig. 7. Station times of serial assembly line for $c=20$

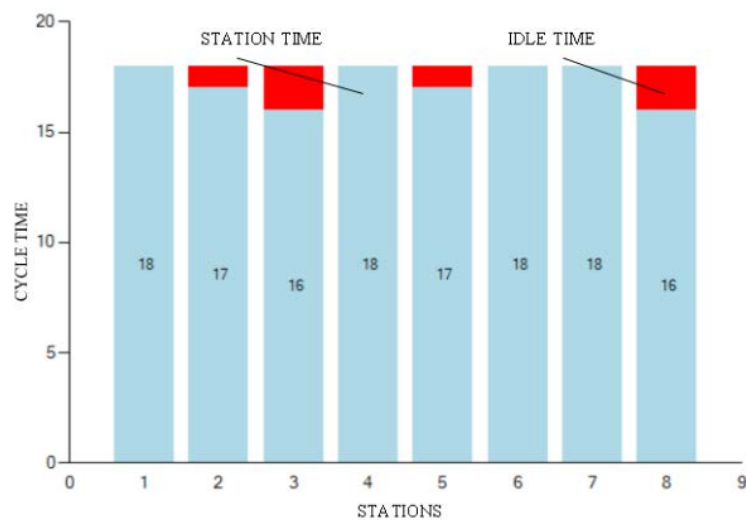


Fig. 8. Station times of serial assembly line for $c=18$

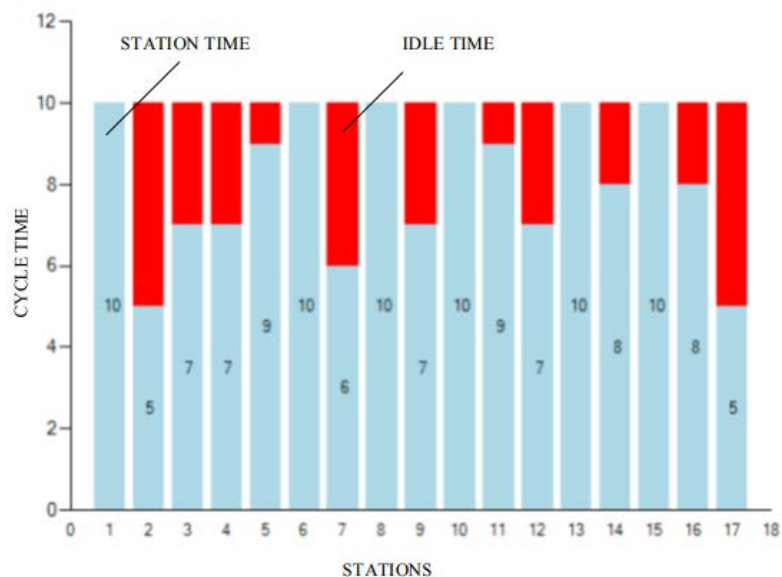


Fig. 9. Station times of serial assembly line for $c=10$

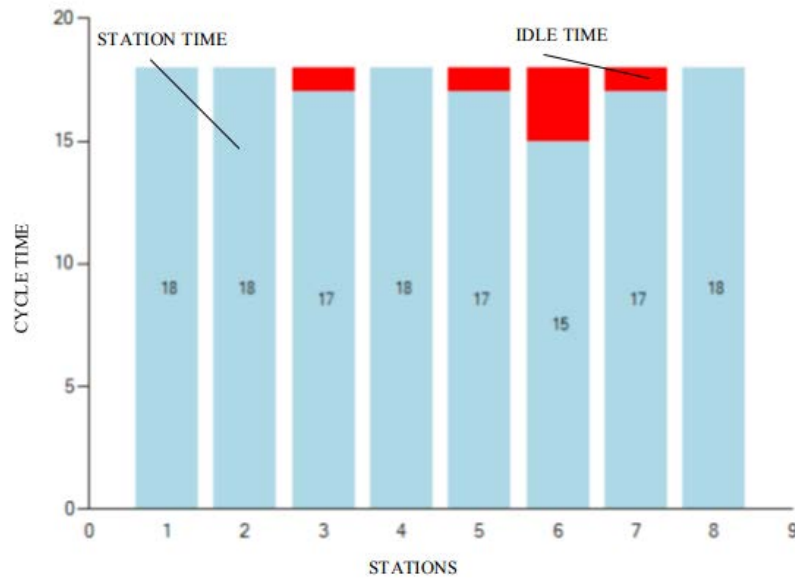


Fig. 10. Station times of U-shaped assembly line for $c=18$

Comparing this solution to serial line balance from Fig. 5 we can notice that the station times are almost perfect. In this case transforming serial line into U-shaped line gave a much better result. We obtained less 1 workstation (instead of 8 workstations we have only 7 now). The quality of balance is much better, too. But it is no rule in assembly line balancing problem. We can only be sure that the number of workstation can't exceed the number of workstations of existing serial assembly line balance solution. The quality of the final result of u-shaped line can be worse than for serial line. In Fig. 9 we can observe such case. Comparing to serial line solution for $c=18$ we have still 8 workstations but the smoothness index and line time are a bit higher than for the same conditions for serial line.

9. Conclusion

The traditional assembly line is characterized by high efficiency or good value of smoothness index but due to its high specification and division of labor it has disadvantages in other areas. The assembly line has poor flexibility and can't adapt easily to either changes in product design or product demand changes. Almost any changes in product design by line balancing & Lean Six Sigma, affects the entire system, requiring rebalance of the line and reallocation of resources. Problem of reducing number of workstations was discussed in this paper. Fluctuation of market demand cause changes in production systems. It was presented that even single product can lead to rebalance of assembly line in case of new market demands (new cycle time). SME business in handicraft Curug Marketing Gentong pretty good run so far, even though Curug Gentong not pay much attention these aspects in developing a business. Curug Gentong has focused on production activities than pemasaran. Curug Gentong tends to relax in promoting its products because it usually does not do the waterfall Gentong significant marketing efforts. For example, in terms of advertising, Curug Gentong indeed a lot to advertise its products in various media such as newspapers, tabloids, television, and so on, but not the waterfall Gentong who spend on advertising, it is precisely those media requesting Curug Gentong to advertise their products on their media. In terms of efficiency, Curug Gentong more emphasis on word of mouth marketing over other marketing strategies, which costs quite a lot but not too big impact in driving sales

References

- Adiningsih, S., 2005. Regulasi dalam Revitalisasi Usaha Kecil dan Menengah di Indonesia. Laporan Tim Perencanaan Pembangunan Hukum Nasional Kelompok Bidang Hukum Ekonomi dan Industri.
- Anggadwita, G., Mustafid, Q. Y., 2014. Identification of Factors Influencing the Performance of Small Medium Enterprises (SMEs). *Procedia Social and Behavior Sciences* 115 page 415-423.
- Assarlind, M., Gremyr, I., Backman, K., 2012. Multi-faceted views on a lean Six Sigma € application. *Int. J. Qual. Reliab. Manag.* 29 (1), 21e30.
- Baybars, I., (1986). A survey of exact algorithms for simple assembly line balancing problem, *Management Science*, 32, 11-17
- Erel,E., Sarin, S.C., (1998). A survey of the assembly line balancing procedures, *Production Planning and Control*, 9, 414-434
- Fonseca, D.J., Guest, C.L., Elam, M., Karr, C.L., (2005). A fuzzy logic approach to assembly line balancing, *Mathware & Soft Computing*,12,57-74
- Bae, J.W., Kim, Y.W., 2007. Sustainable value on construction project and application of lean construction methods. In: *Proceedings IGLCe15*, Michigan, USA, 2007. 18e20 July.
- Banawi, A., Bilec, M.M., 2014. A framework to improve construction processes: integrating lean, green and Six Sigma. *Int. J. Constr. Manag.* 14 (1), 45e55.
- Bendell, T., 2006. A review and comparison of six sigma and the lean organisations. *TQM Mag.* 18 (3), 255e262
- Bhasin, B. B., Venkataramany, S., 2010. Globalization of Entrepreneurship: Policy Considerations for SME Development in Indonesia. *International Business and Economic Research Journal* Volume 9 Number 4. Bhattacharjee, A.,
- Bonnet, J., Le Pape, N., Result, R., 2008. Entrepreneurial Motives and Performance: Why might Better Educated Entrepreneurs be Less Successful? The Research Laboratory Working Paper .University of Cergy-Pontoise, France.
- Bourletidis, K., Triantafyllopoulos, Yiannis., 2014. SMEs Survival in time of Crisis: Strategies, Tactics, and Commercial Success Stories. *Procedia Social and Behavioral Sciences* 148 639 – 644.
- Chowdhury, M. S., Alam, Z., Arif., M. I., 2013. Success Factors of Entrepreneurs of Small and Medium Sized Enterprises: Evidence from Bangladesh. *Business and Economic Research* ISSN 2162-4860 Volume 3 No 2.
- Hamdani, J., Wirawan, C., 2012. Open Innovation Implementation to Sustain Indonesia SMEs. *Procedia Economics and Finance* 4 223-233.
- Irfayanti, M., Aziz, A. M., 2012. Barrier Factors and Potential Solutions for Indonesia SMEs. *Procedia Economics and Finance* 4 3-12.
- Liao, C. W, Yeh, T. M, Pai, F. Y. 2014.Using a Hybrid MCDM Methodology to Identify Critical Factors in New Product Development. Springer Verlag London. *NueralComput&Applic* 24:957-971.
- Mawardi, M. K. 2011., The Factors of SME Cluster Development in a Developing Country: The Case of Indonesian Clusters ICSB World Conference. Stockholm, Sweden. Nobar, M.N, Steak, M., and Tafti, A.F., 2011.Selecting Suppliers of 2nd Layer Suppliers by Utilizing FANP Procedure. *International Journal of Business and Management* .6(2): 265 – 275.
- Pawitan, Gandhi., 2012. Characteristic of Small Medium Manufacturing Industries In the Era Of ACFTA: case Study from West Java. *Procedia Economics and Finance* 130-139.
- Rachmania, I, N., Rakhmaniar, M., Setyaningsih, S., 2012. Influencing Factors of Entrepreneurial Development in Indonesia. *Procedia Economics and Finance* 4 234-243

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