Application of ranked positional weights method in springbed production line balancing

Ikhsan Siregar*
Department of Industrial Engineering, Faculty of Engineering, Universitas Sumatera Utara

*Email: Ikhsan.siregar@usu.ac.id

Abstract. In the current era of globalization, business competition demands industries in manufacturing to improve their business strategies are increasingly. The company that produces spring beds of various sizes has experienced rapid development. Spring bed 180 cm x 200 cm size has the longest process and research on the springbed production line is 180 cm x 200 cm. The company has 9 work stations with 19 work elements with time variation of work elements which are 50 seconds to 2737 seconds. The problem experienced by the company is the bottleneck at the assembly station because it has the longest cycle time of 2737 seconds. One method used in assembly line balancing is the RPW method (Ranked Positional Weights). The RPW method is an approach to solving problems in line balance and finding solutions quickly by the number of workstations determination at a minimum by giving weight to each work elements that has been placed on all work elements. Using the RPW method, obtained line efficiency, balance delay and smoothing index were 86.09%, 13.91% and 1418.45 with the number of work stations is 8.

1. Introduction
In the current era of globalization, business competition demands industries in manufacturing and services to improve their business strategies are increasingly. Industries are expected to increase the efficiency of production process time so that there is no waste of time that harm the company in achieving the expected level of production. Competition between companies does not cover regional and global regions, therefore every company competes continuously in business and ways capable to compete and have a competitive advantage in order to survive and develop. This is globalization and consequently in competition. This competition must be supported by the smooth production process by the company itself [1].

The company is one of the manufacturing companies that produce spring beds have 3 product specifications, namely 100 cm x 200 cm, 140 cm x 200 cm and 180 cm x 200 cm. The problem of inaccuracy in the order delivery schedule is caused by an improper production schedule or an under-optimal production scheduling system. Of the three sizes that will be examined is the spring bed with a size of 180 cm x 200 cm because it requires the longest assembly time compared to the other specifications. Observations were made on the making of springbed mattresses and bottlenecks occurred at per beam assembly stations because the assembly time of per beam is too long. Therefore it is necessary to balance the line to increase productivity, increase line efficiency, balance delay and smoothing index. The production line balancing focuses on improving line efficiency, which is aim to increase productivity. Line balancing uses a work elements assignment balancing approach from production lines to workstations to minimize the number of workstations and minimize idle time at all stations for a certain level of output [2] [3]. Process planning is mainly relevant to generating line balancing set of steps required to approach specified aims, with given constraints, as an attempt to enhance a part of the criteria [4]. Balancing assembly lines becomes one of the most important parts
for an industrial manufacturing system that should be supervised carefully. Since then, many industries and for sure researchers, attempt to find the best methods or techniques to keep the assembly line balanced and then, to make it more efficient. Furthermore, this problem is known as an assembly lines balancing [5] [6].

Line balancing is an analysis process that tries to equally divide the work to be done among workstations so that the number of workers or workstations required on a production line is minimized [7]. In an assembly line, the balancing of workload at different workstations is necessary to avoid the idle time occurred between them. The time taken for the completion of task in a workstation should match the task time of next workstations to balance the assembly line [8]. Line Balancing means balancing the production line or any assembly line. The main aim of line balancing is to distribute the task evenly over the work station so that the idle time of man or machine can be minimized. Parts included in the system transfers from one workstation through the other and at the end leaves the system as a completed product. Transfer lines uses manpower very little when compared to assembly lines. The certain properties of Transfer lines are transfer and process of a product automatically through a line. Objectives that should be gained balancing an assembly line are regular material flow, maximum usage of man power and machine capacity, minimum process times, minimizing slack times, minimizing workstations, distribute slack times to workstations and reduce production costs [9]. Line balancing consists of a series of work stations that comprises of work elements. A set of work element having tasks which have a defined cycle time or operating time with a set of interrelated activities in a certain order. Each work element possesses a task time which is a standard time to complete the elemental task. The collective time of all the workstations is the total work content that determines the total time for the assembly. Assembly line balancing is mainly done for the effective utilization of machine and to achieve less congestion within the production system [10].

The method often used in production line balancing problems is the Ranked Positional Weights (RPW) method. RPW is heuristic methods commonly utilized to arrange and distribute the description element time along the workstations in the system [11]. It was introduced by Helgeson and Birnie in 1961. In this method, a Ranked Positional Weight takes into account both the Tek value and its position in the precedence diagram. Specially, RPWk is calculated by summing Tek and all other times for elements that follow Tek in the arrow chain of the precedence diagram [12]. The RPW method has been recognized as one of the techniques of the line balancing process in the manufacturing industry, which means the process of scheduling assembly activities in a production line aims to maximize velocity and efficiency at each work station and line balancing so that all work stations operate at the same velocity. The RPW method proved relatively easy to apply and has been used for scheduling assembly lines in manufacturing industries [13].

The problems of the line balancing have been solved in previous studies. The research was presented the line balancing problem in a bakery located in Indonesia. One effort efficiency to do is to minimize the number of workstations, especially on the assembly workstation path balancing method of production used the method ranked positional weight (RPW). The observations made in the data collection as much as 20 times each station observed and calculated test the adequacy and uniformity of data that can be obtained by standard time. From the data processing method RPW shows increased production efficiency is 35% at the starting position and following a path balancing the production efficiency of up to 83% due to, among others, the incorporation of several work stations where the initial conditions account for 7 stations and after the merger becomes 3 work stations, while initial jobless 2.97 to 0.33 this means that there is a decrease of 2.64 minutes. Initial wait time balance 64.28% to 16.6%, this means that there is a decrease of 47.68% [14]. Another study conducted in PVT LTD using RPW method by Vrittika, et al. This study is used to minimize assembly time. After applying balancing methods to existing assembly line by reducing cycle time 12 min to 10 min then methods give an more efficient assignment of work element with improvement of line efficiency from 68.58 % to 82.33 % reduced idle time from 23.07 min to 10.6 min, smoothness index reduced from 11.58 to 7.10, increase production rate of 40 units to 48 units [15].
Based on previous research, this research has a Ranked Positional Weight method to balance assembly lines to improve line efficiency, balance delay and smoothing index.

2. Methodology
This study was conducted in one of the industries engaged in the springbed production in the Medan city where the object examined in this study was a springbed size of 180 cm x 200 cm. The study begins with observations to observe and see the state of the company directly. From the results of observations, it is determined the problem formulation in accordance with the conditions occur in the company so that the research objectives can be applied. The research objectives determined were a solution to existing problems. Furthermore, the data collection is the input in conducting this research. The data needed is the number of work stations, number of work elements, standard time, and idle number. The standard time is obtained by time measurement using a stopwatch time study with normal time and allowance consideration given [15]. With these data, data processing is carried out with several stages, namely making precedence diagrams, doing work elements weighting, sorting based on weights and task assignment for each work station. Standard time calculation is carried out for all work centers using the formula.

\[ W_s = W_n \times \frac{100\%}{100\% - \text{Allowance}} \] (1)

Then do the line balancing is carried out by using the Ranked Positional Weight method. Then the optimal work center calculation is done. The optimal number of work centers can be calculated using the following formula.

\[ WC = \frac{\text{Total lead time}}{\text{The longest cycle time}} \] (2)

After determination the optimal number of work centers, the allocation of work elements is done with the condition that it does not violate constraint precedence and zoning constraints. Based on the matrix precedence the weights of each work elements can be obtained from the sum of time worked on other work elements that have a +1 value on each row. Ranking obtained from the weight value of work elements that have been done. The final stage is the determination of the cycle time of each work station to improve the idle number in assembly line. Then the value of line efficiency, balance delay and smoothing index is obtained based on the RPW method. Calculation of Line Efficiency (LE), Balance Delay (D) and Smoothing Index (SI) can be done with the calculation below.

\[ LE = \frac{\sum_{i=1}^{K} S t_i}{(K) (C T)} \times 100\% \] (3)

\[ DL = \frac{n S m - \sum S t_i}{(n) (S m)} \times 100\% \] (4)

\[ SI = \sqrt{\sum_{i=1}^{K} (S T i m a x - S t_i)^2} \] (5)

3. Result and discussion
3.1. Making of precedence diagram
After calculating the work center obtained the optimal number of work center is 8. A precedence diagram for making a 180 cm x 200 cm springbed can be seen in Figure 1.
Based on the figure 1, it can be seen that several work elements are combined into 1 work center and the number of work center is 9.

3.2. Arrangement of work elements in actual condition

The division of tasks at each element for all work stations in the actual conditions can be seen in Table 1.

| Work Center | Work Elements | Standard Time | Number | Idle |
|-------------|---------------|---------------|--------|------|
| I           | 1             | 2418          | 2648   | 772  |
| II          | 2             | 865           | 1601   | 1819 |
|             | 3             | 596           |        |      |
| III         | 4             | 1136          | 2551   | 869  |
|             | 5             | 1193          |        |      |
| IV          | 6             | 1600          | 1753   | 1668 |
|             | 7             | 1831          | 2006   | 1415 |
| VI          | 8             | 748           |        |      |
|             | 9             | 729           |        |      |
| VII         | 10            | 544           |        |      |
|             | 11            | 552           |        |      |
|             | 12            | 550           |        |      |
|             | 13            | 533           |        |      |
|             | 14            | 50            |        |      |
|             | 15            | 893           | 3420   | 0    |
| VIII        | 16            | 1600          |        |      |
|             | 17            | 899           | 2737   | 683  |
| IX          | 18            | 69            |        |      |
|             | 19            | 1764          | 2008   | 1228 |
| Total       |               | 20340         | 20340  | 10441|

The number of actual work stations is 9. The number of idle obtained is high of 10441. This is indicates that it is necessary to do idle minimization to reduce the bottleneck occurs. Line efficiency, balance delay and smoothing index are 66.08%, 33.92% and 3385.165 respectively.
3.3. Arrangement of work elements using RPW method

The division of tasks at each element for all work stations using the RPW method can be seen in Table 2.

| Work Center | Work Elements | Standard Time | Number | Idle |
|-------------|---------------|---------------|--------|------|
| I           | 5             | 1306          |        |      |
|             | 4             | 1244          | 2551   | 403  |
| II          | 1             | 2648          | 2648   | 305  |
| III         | 6             | 1753          | 1753   | 1201 |
| IV          | 2             | 948           |        |      |
|             | 7             | 2006          | 2953   | 0    |
| V           | 8             | 819           |        |      |
|             | 3             | 653           |        |      |
|             | 9             | 798           |        |      |
|             | 10            | 596           | 2866   | 87   |
| VI          | 11            | 605           |        |      |
|             | 12            | 603           |        |      |
|             | 13            | 584           |        |      |
|             | 14            | 55            |        |      |
|             | 15            | 978           | 2824   | 129  |
| VII         | 16            | 1753          |        |      |
|             | 17            | 984           | 2737   | 216  |
| VIII        | 18            | 76            |        |      |
|             | 19            | 1932          | 2008   | 945  |
| Total       |               | 20340         | 20340  | 3286 |

The movement of work elements between the actual method and the RPW method is on work elements 1, 2, 3, 4, 5, 6, 7 and 8. Work elements no 5 and 4 move to work station I, work element 1 becomes the work element of station no II, work elements 2 and 3 become work elements of work stations IV and V, work elements 6 and 7 become work elements of work stations III and IV, work elements 8 become elements of work stations V. Idle reduction from 10441 to 3286. The number of work stations is 8. Line efficiency, balance delay and smoothing index respectively are 86.09%, 13.91% and 1418.45.

4. Conclusion

The problem of line balancing production needs to be done to reduce the amount of bottleneck. The Ranked Positional Weight method is one method that can be used in overcoming production line problems. There was a reduction in the number of work centers from 9 to 8. Line efficiency values, balance delay and smoothing index were 86.09%, 13.91% and 1418.45%. Idle reduction occurred from 10441 to 3286. Performance with the RPW method also proved to be better than the actual method of the company can be seen from the reduction in the number of work centers, the number of idle and the value of line efficiency, balance delay and smoothing index better.

Acknowledgement

Authors thank to Kartika Widya Astuti, Omaar Al Faridzi Siregar, and Alisha Rizki Siregar for the support provided during this research and Andy Suryadi who actualize the research.
References

[1] I Purnamasari, A S Cahyana 2015 Spektrum Industri 13 (2) 157-168
[2] G Rosnani 2007 Sistem Produksi (Yogyakarta: Graha Ilmu)
[3] B Townsend 2012 The Basics of Line Balancing and JIT Kitting (USA: Productivity Press)
[4] V Minzu, J M Henrioud 1997 Proc. of ISATP 103-114
[5] M Z Matondang, M I Jambak 2010 Journal of Computer Science 6 (2) 141-162
[6] R M A Hamza, J Y Al-Manaa 2013 Global Perspectives on Engineering Management 2 (2) 70-81
[7] H Fazlollahtabar, H Hajmohammadi, A Es’haghzedeh 2011 Int. Journal Advance Manufacturing Technology 311-320
[8] P R Patel, S Kulkarni, D Kumar 2015 Int. Research Journal of Engineering and Technology 2 (3) 2141-2145
[9] A Tomar, A Monaria 2016 Int. Journal of Software & Hardware Research in Engineering 4 (1) 23-27
[10] P S Jha, M S Khan 2017 Int. Journal of Mechanical Engineering Technology 8 (3) 22-33
[11] P Umarani, K Valase 2017 Int. Journal of Scientific Research Engineering Technology 6 (4) 323-330
[12] M A Ikon, N C Nkechi 2015 Int. Journal of Business and Management Review 3 (8) 29-43
[13] N M Jaya, A A D P Dewi 2007 Jurnal Ilmiah Teknik Sipil 11 (2) 100-108
[14] M Siska, R Suryanata 2012 Seminar Nasional Teknologi Informasi Komunikasi dan Industri, 481-488
[15] V V Pachgare, R S Dalu 2014 Int. Journal of Science and Research 3 (5) 1901-905