International Journal of Engineering & Technology, 7 (4.36) (2018) 237-241

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

The Effect of Hidden Time Loss Measures Components from Aspect of Assembly Features Perspective in Automotive Industry

Abdul Rasib A. H.[1], Mohamad Rafaai Z. F.[2]

[1]*Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia*
[2]*Fakulti Kejuruteraan Mekanikal, Universiti Tenaga Nasional, Selangor, Malaysia*
**Corresponding author E-mail: amir.hamzah@utem.edu.my*

Abstract

Hidden Time Loss (HTL) usually effect on productivity during the production processes. Normally, top performance measurement tool is used in the production assembly line such as Overall Equipment Efficiency (OEE). In order to provide HTL, equipment performance as one of the measure components of OEE is used in order to provide HTL. In scope of assembly process especially the manual and the semi-auto in the assembly process, OEE does not suitable in measuring those operation performance. There should be the value of HTL have happened during the manual and semi-auto processes that become serious while related to aspect assembly features such as left and right components, product type/variety, model type/variety, and rear & front component in one production line. In this regards, the objective of this study is to present the Hidden Time Loss Measures (HTLM) components and its' effect to HTL based on the aspect of assembly features. The structure of HTLM components are designed through a detail literature review on production assembly line and its performance measures. The case study at five automotive manufacturing assembly companies in Malaysia is used to validate the HTLM components structure. The outcomes show that there is significant effect of HTLM components on production productive time in the aspects of assembly features.

Keywords: *assembly feature, assembly process, non-value added, productivity, time loss*

1.Introduction

To stay competitive, companies facing today's levels of unprecedented global competition must design and offer better products and services and improve their manufacturing operations [1]. Therefore, in order for manufacturers to improve operational performance, they must have an effective method of measuring and evaluating the performance of their manufacturing processes [2]. In this study, it is essential for the companies which related to manufacturing in identifying the appropriate method for processing time in assembly processes in order to sustain the productivity.

In this study, when the manufacturing lead time accounted for individual type of product to maintain the optimum productivity, it is important for the companies which related to manufacturing in identifying the non-value added or waste activities.

Therefore, this study introduces the parts of HTLM in determination of internal process in the scope of production assembly processes at the manufacturing automotive industry through computing of Hidden Time Loss (HTL). The important of this case is to clarify the HTL due to assembly process activities as the number of product variety in the automotive industry keep increasing. In addition, this paper clarifies the effect of HTLM components on the production assembly productive time in the term of assembly features such as right & left parts, product type/variety, model type/variety, and front & rear parts/components.

This paper consists of five sections. In Section 2, understanding the HTLM components. Section 3 HTLM components measure based on the aspect of assembly features. In Section 4, the results and discussions are
presented. The conclusion of this study are presented in the last section, Section 5.

2.Understanding of Hidden Timeloss Component

The HTLM components is the important part in this study. The HTLM components are clarified through analysis of literature studies in aspects of manufacturing operations. The HTLM components consist of Non-valued Changeover Time (NVCOT), Inefficient Processing Time (IPT), Unnecessary Overtime (UOT), and Non-conformance Time (NCT).

2.1. Non-valued Changeover Time

McIntosh *et al.* [3] claimed that activities such as run-down, setup, and run-up are component of changeover. They claimed when stable state manufacture is being re-established, the duration time consider as a run-up stage with productivity and quality based on requirements.

Besides, Shingo [4] mentioned that the incurred in changeovers is down time. There are two types of Setup in changeover; (i) Internal setup, and External setup. According to Moxham and Greatbanks [5], when the setup that are implemented while machine is stopped, it is defined as internal setup while machine is operating, it is

defined as external setup. Thus, waste or non-value added is considered when the use of resources for any task other than the creation of value for the end user. Finally, the result of their study clearly shows that the HTL exist when doing the internal setup activities as the machine or equipment have to be stopped from operation. Ferradas and Salonitis [6] claimed that the machine is stop when execute the internal activities and external being those that can be conducted during the running of machine.
In this regards, the NVCOT makes additional costs as well. Thus, this study clarifies NCT as a HTLM component.

2.2. Inefficient Processing Time

In this study, IPT as a one of HTLM components. In this study, each workstation has processing time as the actual interval between completions of the consecutive assembly parts. Johnson [7] claimed that reductions in the manufacturing throughput time can generate lower Work-In-Progress (WIP) in the assembly process. On the other hand, Rahani and al-Ashraf [8] explained that WIP or extra processing time potentially happens when the cycle time is more than the takt time. Thus, this study clarifies IPT as a TLM component in the assembly process.
In general, semi-automated assembly and manual assembly had been mentioned by Michalos et al. [9] as approaches could be distinguished in the design of an assembly system. In this study, semi-automated assembly refers to the process operates semi-automatically and partly by hand. According to Rahani and Ashraf [8], they had determined the semi-automated assembly cycle time through a machine time and man time. While, manual refers to the process operates by the worker's hand.
For measuring efficiency, the cycle time efficiency can be measured through a comparison of standard process cycle time which was setting by companies. In this regards, the IPT occurred when the actual process cycle time is longer than a standard process cycle time. Miller et al. [10] defined inefficient as not producing desired results. From this reason cause the production delay and finally effected to the delivery date or time to the customer.
It can be noted that the IPT is a significant issue in term of achievement of on-time delivery dates. According to Li and Rong [11], the low value of cycle time indicates a high probability of punctuality in fulfilling the customer's order in a wide range of time windows.
In this regards, the IPT is the possible reason that affected to delay delivery to the customer. Thus, this study clarifies IPT as a HTLM component.

2.3. Unnecessary Overtime

According to Battaia et al. [12], similar products (variants or models) are assembled on manual mixed-model lines. Boyle [13] identifies the types of flexibility (i.e. volume, product mix, and new product). Thus, the implication of flexibility cause the volume and product mix, number of variants, and cost to be more significant parameter in manufacturing companies. Normally, each variant is managed according to company's operating time for mixed assembly line. In this study, the operating time refers to the total working time in a day or month.
In this regards, the operating time for the tasks is essential to be controlled properly to meet customer demand. However, Klassen and Rohleder [14] claimed that when the flexibility level is increased the potential items (i.e. part-time employees, scheduling, overtime, using cross-trained employees, and calling on potential customers to generate business) should work on developing demand and capacity, increasing the chance that one will cover for the lack of another, and in turn increase profits.
Indeed, the customer will confirm the supplier production capacity through the operating time. The capacity feasibility of the facility for producing an order on time will be clarified through the operating time as a major portion of lead time [15]. Thus, the maximum level of production capacity can be achieved through appropriate constraint of overtime in company's operating time.
Smith [16] claimed that additional overtime could extend operating hours while maintaining the existing workforce size. According to Mathur and Süer [17], the overtime function is to reduce the quantity of delay tasks but overtime can incur costs increase to a company.
However, overtime will makes costs increase. In this study, there has a potential for the unnecessary overtime to achieve the required volume. It can be concluded that the unnecessary overtime is the additional time more than is needed and can be considered as HTL. Therefore, can be concluded that UOT as one of HTLM component.

2.4. Non-conformance Time

According to Jaber and Khan [18], when a product or a service does not follows as specific requirements. Thus, rework is needed and due to that reason with non-conformance will create one additional time. When it does not fit with the quality requirements, can be assumed that some reworked units are scrapped. In this regard, Shetwan and Vitanov [19] stated that some actions should be executed during the inspection activity to rework or scrap a finished good when it does not meet to the specifications. According to Chen and Tsao [20], classified two types of defects such as rework and non-rework able defects. Therefore, the defect will refer to non-conformance product which is not meet to the specifications limit of requirement. Besides, Thomas and Pham [21] also mentioned that decreasing of defect able to enhance manufacturing efficiency. Therefore, the implication of NCT cause the non-value added working time when quality do not meet to the specifications due to scrap or rework a product. Therefore, the company operating time can be expanded to resolve the quality issues. The quality issues might influence the actual production capacity because of the quantity of finished good defects in the production if the planned production capacity had been fulfilled to meet the customer requirements.
Quality of products is one of the important issues in production assembly and improvement is compulsory through an suitable and prompt action. According to Radharamanan et al. [22], claim that appropriate action are being needed in order to improve the quality of output. Uyar [23] agreed that operational performance measures can be seen from the aspects of quality performance such as the reworked units, material inspections, customer complaints, and cost. Murugaiah et al. [24] have stated that the defect criteria consists of rework, scrap, and paperwork mistake.
It can be understood to produce a product saleable in the marketplace through product quality is one of the vital factors. In short, to achieve the maximum productivity and performance need to consider a quality as a fundamental driver [25] [26]. On the other hand, quality has never been measured through how long it takes to make a decision on the status of product quality such as an on-hold/KIV product. The waiting time for an action to be taken when a product-quality problem arises generate a loss of time and can be considered as HTL.
The NCT cause additional costs as well. Thus, there is potential for the NCT to provide the expected volume. But, the NCT is the time taken regarding defects and can be understood as HTL. Therefore, this study clarifies NCT as a HTLM component.
Overall, HTLM components (i.e. NVCOT, IPT, UOT, and NCT) make additional cost through the non-value added time on manual assembly process and semi-auto assembly process.

3.Measurement Based on Aspect of Assembly Features

3.1. Assembly Features

In this study, the HTLM components are measured based on aspects of assembly features:

- Right and Left

The automotive Right and Left refer to the component position from the viewpoint of sitting in the car looking forward (i.e. Right-Hand Side Head Lamp and Left-Hand Side Head Lamp).

- Product Variety

Automotive product variety refers to different categories of models (i.e. Civic, City, CRV, and Accord).

- Model Variety

Automotive model variety refers to different type of series (i.e. 1.8, 2.0, and 2.4).

- Front and Rear

Automotive Front and Rear refer to component position head (front) and back (rear) of an automobile (i.e. Front Door Latch and Rear Door Latch).

The assembly features derive from the changeover activities of right and left component different, product different, model different, and front and rear different during NVCOT measures. Therefore, the IPT, UOT, and NCT will be measured according to the aspect of assembly features occurred during changeover time.

3.2. Hidden Time Loss Measures based on Aspect of Assembly Features

In this study, the five case studies are carried out and based on Company A, B, C, D, and E as five automotive companies in Malaysia.

This section explains the effects of the four HTLM components from the aspects of assembly features, i.e. right and left, product variety, model variety, and front and rear. Based on companies' changeover activities, the right and left assembly feature is related to Companies A and C. B.

The product variety assembly feature is related to Companies B, C, and D. The model variety assembly feature is related to Companies A, B, C, and E. The front and rear assembly feature is related to Companies C and E. Table-1 shows the summary of assembly features and related companies.

Table-1. Summary of assembly features and related companies

Assembly Feature	Company
1. Right and Left	A and C
2. Product Variety	B, C, and D
3. Model Variety	A, B, C, D, and E
4. Front and Rear	C and E

4.Results and Discussion

As can be seen from Figure-1 for right and left assembly feature, the UOT contributes to the highest HTL for both Companies A and C, but it does not involve IPT at all. Figure-2 shows the product variety assembly feature; the UOT contributes to the highest HTL for Companies C and D, while the NCT contributes to the highest HTL for Company B. Figure-3 shows the model variety assembly feature; the UOT contributes to the highest HTL for Companies A, B, C, and E. Figure-4 shows the front and rear assembly feature; the UOT contributes to the highest HTL for Company E, while the NVCOT contributes to the highest HTL for Company C.

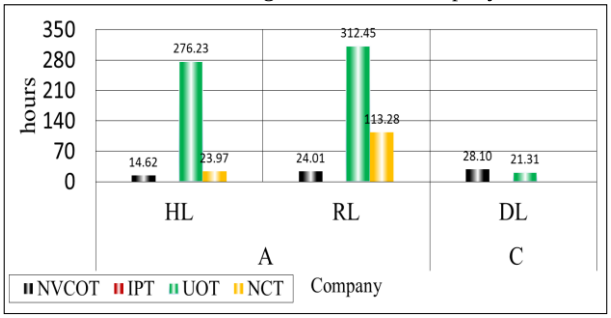

Figure-1. HTL for right and left assembly feature by the HTLM components.

Notes
HL: Head Lamp
RL: Rear Combination Lamp
DL: Door Latch

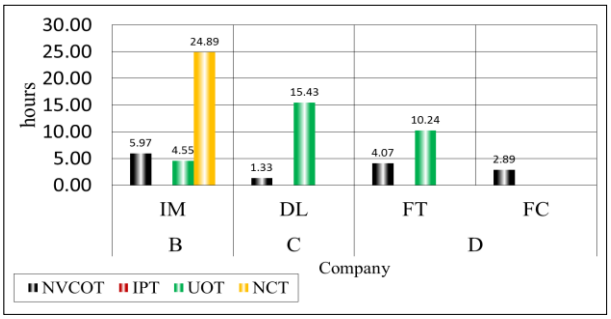

Figure-2. HTL for product variety assembly feature by the HTLM components.

Notes
IM: Intake Manifold
DL: Door Latch
FT: Fuel Tank
FC: Front Corner

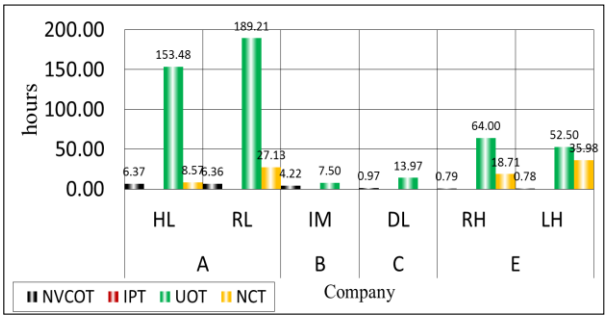

Figure-3. HTL for model variety assembly feature by the HTLM components

Notes
HL: Head Lamp
RL: Rear Combination Lamp
IM: Intake Manifold
DL: Door Latch
RH: Right Hand Door Inside
LH: Left Hand Door Inside

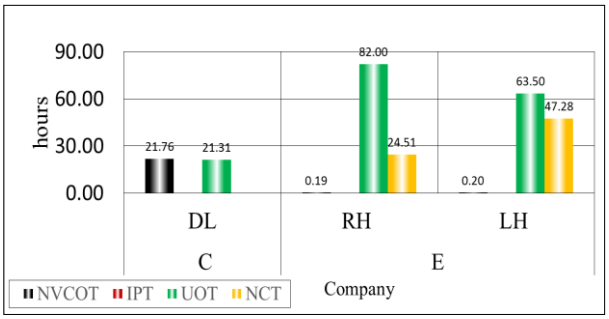

Figure-4. HTL for front and rear assembly feature by the HTLM components

Notes
DL: Door Latch
RH: Right Hand Door Inside
LH: Left Hand Door Inside

Table-2 presents the contribution of UOT to HTL for individual companies, from the viewpoint of assembly features. As can be seen, the UOT is the main contributor of HTL for assembly features. Through observation, UOT is significant to the assembly feature of model variety. There are two situations of UOT. The first situation occurred when the Production Input meets the Regular Production Capacity, overtime is not necessary. Nevertheless, overtime is provided because of certain reasons. A possible reason for this situation is related to setup frequency through implementation of a smaller batch. Logically, as a smaller batch increases, the frequency of setup increases. Therefore, as the frequency of setup increases, the Regular Production Time decreases. The reason is supported by Johnson [7]; he highlights that as the frequency of setup increases and more of the available

capacity is used for setups, workstation utilisation increases, which causes queues to grow.

In other aspects, the high frequency setup often has potential to cause worker mistakes and machine problems. According to Li and Rong [11], high frequency setup which often leads to high potential of operation worker mistake and machine not able to perform according to schedule will be influenced to production system and Just In Time (JIT) could be influenced by a worker's skill..

The second situation occurred when the Production Input is more than Regular Production Capacity. In this case, overtime is necessary. However, the additional working time required is more than the necessary overtime. As a result, UOT occurs. There are reasons for the UOT to occur. One of the reasons is inappropriate overtime planning. This situation occurs because the current Actual Process Cycle Time for each process is not clarified in a timely manner by a production person-in-charge. Therefore, the capability of worker is not accurately estimated in order to determine the appropriate production capacity. This reason is supported by Mathur and Süer [17], he mentions that the capacity planning supports to manage the cells quantity required or shifts number used, and also to assess whether overtime will be required in cellular manufacturing.

Table-2. UOT as the main contributor to HTL

Assembly Feature	Company				
	A	**B**	**C**	**D**	**E**
Right and Left	1st	NA	2nd	NA	NA
Product Variety	NA	3rd	1st	1st	NA
Model Variety	1st	1st	1st	NA	1st
Front and Rear	NA	NA	2nd	NA	1st

Table-3 presents the contribution of NCT as the 2nd contributor to HTL for individual companies from the viewpoint of assembly features. Through observation, NCT is significant to the assembly feature of model variety. In this study, Model Variety is crucial and frequently practised to meet customer demands. Therefore, there is a possibility that HTL is due to the occurrence of NCT when Model Variety is practised.

Table-4 presents the contribution of NVCOT as the 3rd contributor to HTL for individual companies from the viewpoint of assembly features. Through observation, NVCOT is significant to the assembly feature of model variety because of the frequency of model change. Model variety occurs more frequently in a day compare to other assembly features. Therefore, the NVCOT for model variety is higher than that of others.

Table-3. NCT as the 2nd contributor to HTL

Assembly Feature	Company				
	A	**B**	**C**	**D**	**E**
Right and Left	2nd	NA	Not Occurred	NA	NA
Product Variety	NA	1st	Not Occurred	Not Occurred	NA
Model Variety	2nd	Not Occurred	Not Occurred	NA	2nd
Front and Rear	NA	NA	Not Occurred	NA	2nd

Table- 4. NVCOT as the 3rd contributor to HTL

Assembly Feature	Company				
	A	**B**	**C**	**D**	**E**
Right and Left	3rd	NA	1st	NA	NA
Product Variety	NA	3rd	2nd	2nd	NA
Model Variety	3rd	2nd	2nd	NA	3rd
Front and Rear	NA	NA	1st	NA	3rd

Table-5 presents the contribution of IPT as the 4th and lowest contributor to HTL for individual companies from the viewpoint of assembly features and appears as Merit Time. As can be seen there is Merit Time for assembly features. Through observation, the Merit Time is significant to the assembly feature of Model Variety because of workers' capability. In this case, the Model Variety has similar assembly process. Therefore, workers are more familiar with the process. According to Ramezanian and Ezzatpanah [27], special package of product can be defined as different models of products could be parts of a base product or, so fundamentally that the assembly processes are somehow affinity; and the only difference between these assembly models is the performance time. The period of 24 hours is used as a guideline for value added activities.

5.Conclusion

The results of this study show that the Hidden Time Loss Measures (HTLM) components, i.e. Non-valued Changeover Time (NVCOT), Inefficient Processing Time (IPT), Unnecessary Overtime (UOT), and Non-conformance Time (NCT) are the contributors to Hidden Time Loss (HTL). The validation of HTLM components has been done in the context of assembly features, i.e. right and Left, Model Variety, Product Variety, and Front and Rear. Thus, UOT is the main contributor to HTL, NCT is the 2nd, NVCOT is the 3rd, and IPT is the 4th. In short, the TLM Components have contributed to HTL in the assembly process of the automotive manufacturing companies.

Table-5. IPT as the 4th contributor to HTL but appears as merit time

Assembly Feature	**Company**				
	A	**B**	**C**	**D**	**E**
Right and Left	Above 24 hours	NA	Above 24 hours	NA	NA
Product Variety	NA	Above 24 hours	Above 24 hours	Above 24 hours	NA
Model Variety	Above 24 hours	Below 24 hours	Above 24 hours	NA	Above 24 hours
Front and Rear	NA	NA	Above 24 hours	NA	Above 24 hours

Acknowledgement

The author special thanks to Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan of Universiti Teknikal Malaysia Melaka and five automotive companies in Malaysia for the use of the facilities and useful data in order to complete this study.

References

[1] Taj, S. and Morosan, C. 2011. The impact of lean operations on the Chinese manufacturing performance. Journal of Manufacturing Technology Management. 22(1): 223-240.

[2] Jain, S., Triantis, K. P. and Liu, S. 2011. Manufacturing performance measurement and target setting: A data envelopment analysis approach. European Journal of Operational Research. 214(3): 616-626.

[3] R. I. McIntosh, S. J. Culley, G. Gest, A. R. Mileham, and G. W. Owen, "An assessment of the role of design in the improvement of changeover performance," International Journal of Operations and Production Management, vol. 16, no. 9, pp. 5–22, 1996.

[4] Shingo, S. 1985. A Revolution in manufacturing: the SMED System Productivity Press. Cambridge. 1985.

[5] Moxham, C. and Greatbanks, R. 2001. Prerequisites for the Implementation of the SMED methodology: A study in a textile processing environment. The International Journal of Quality and Reliability Management. 18(4): 404-414.

[6] Ferradas, P. G. and Salonitis, K. 2013. Improving changeover time: A tailored SMED approach for welding cell. Procedia CIRP, 7: 598–603.

[7] Johnson, D. J. 2003. A Framework for reducing manufacturing throughput time. Journal of Manufacturing Systems. 22(4): 283-298.

[8] Rahani, A. R. and Al-Ashraf, M. 2012. Production flow analysis through value stream mapping: A lean manufacturing process case study. Procedia Engineering. 41: 1727-1734.

[9] Michalos, G., Markis, S., Papakostas, N., Mourtzis, D. and Chryssolouris, G. 2010. Automotive assembly technologies review: Challenges and outlook for a flexible and adaptive approach. CIRP Journal of Manufacturing Science and Technology, vol. 2(2): 81-91.
[10] Miller, G. A., Felbaum, C., Tengi, R., Wakefield, P. and Langone, H. 2009. WordNet, NJ. Princeton University.
[11] Li, S. G. and Rong, Y. L. 2009. The reliable design of one-piece flow production system using fuzzy ant colony optimization. Computers & Operations Research. 36(5): 1656-1663.
[12] Battaia, O., Delorme, X., Dolgui, A., Hagemann, A., Kovalev, S. and Malyutin, S. 2015. Workforce minimization for a mixed-model assembly line in the automotive industry. International Journal of Production Economics, 170: Part B.
[13] Boyle, T. A. 2006. Towards best management practices for implementing manufacturing flexibility. Journal of Manufacturing Technology Management. 17(1): 6-21.
[14] Klassen, K. J. and Rohleder, T. R. 2002. Demand capacity management decisions in services: How they impact on one another. International Journal of Operations and Production Management. 22(5): 527-548.
[15] Hung, Y. F., Huang, C. C. and Yeh, Y. 2013. Real-time capacity requirement planning for make-to-order manufacturing with variable time-window orders. Computers and Industrial Engineering. 64(2): 641-652.
[16] Smith, M. and Zagelmeyer, S. 2010. Working time management and SME performance in Europe. International Journal of Manpower. 31(4): 392-409.
[17] Mathur, K. and Suer, G. A. 2013. Math modeling and GA approach to simultaneously make overtime decisions, load cells and sequence products. Computers & Industrial Engineering. 66(3): 614-624.
[18] Jaber, M. Y. and Khan, M. 2010. Managing yield by lot splitting in a serial production line with learning, rework and scrap. International Journal of Production Economics. 124(1): 32-39.
[19] Shetwan, A. G., Vitanov, V. I. and Tjahjono, B. 2011. Allocation of quality control stations in multistage manufacturing systems," Computers and Industrial Engineering. 60(4): 473-484.
[20] Chen, T. H. and Tsao, Y. C. 2014. Optimal lot-sizing integration policy under learning and rework effects in a manufacturer-retailer chain. International Journal of Production Economics. 155: 239-248.
[21] Thomas, A. J. and Pham, D. T. 2004. Making industry Fit: The conceptualization of a generic 'Fit' manufacturing strategy for industry. Proc. 2nd IEEE Conf. on Industrial Informatic (INDIN), Berlin, Germany. 523-528.
[22] Radharamanan, R., Godoy, L. P. and Watanabe. 1996. Quality and productivity improvement in a custom-made furniture industry using kaizen. Computers and Industrial Engineering, 31: 471-474.
[23] Uyar, A. 2009. Quality performance measurement practices in manufacturing companies. The TQM Journal. 21(1): 72-86.
[24] Murugaiah, U., Benjamin, S. J., Marathamuthu, M. S. and Muthaiyah, S. 2010. Scrap loss reduction using the 5-Whys analysis. International Journal of Quality and Reliability Management. 27(5): 527-540.
[25] Deming, W. E. 1982. Quality, productivity and competitive position. Cambridge: Massachusetts Institute of Technology Centre.
[26] Juran, J. M. 1988. Juran on planning for quality, London: Collier Macmilan.
[27] Ramezanian, R. and Ezzatpanah, A. 2015. Modeling and solving multi-objective mixed-model assembly line balancing and worker assignment problem. Computers and Industrial Engineering. 87: 74-80.