International Journal of Industrial Management (IJIM)
ISSN (Print): 2289-9286; e-ISSN: 0127-564x; Volume 2, pp. 27-39, June 2016


# COMPOSING OF LEAD TIME REDUCTION APPROACH IN ASSEMBLING AN ELECTRICAL PRODUCT

**Intan Bazliah Mohd**
Faculty of Engineering Technology, Universiti Malaysia Pahang,
Lebuhraya Tun Razak, 26300 Kuantan, Pahang
Email: intanbazliahmohd80@gmail.com

**Abdullah Ibrahim**
Faculty of Engineering Technology, Universiti Malaysia Pahang,
Lebuhraya Tun Razak, 26300 Kuantan, Pahang
Email: abi@ump.edu.my

## ABSTRACT

The paper explores the lead time reduction projects that have been implemented in an electrical product assembly line, called subwoofer speaker. Observation has been conducted on 26 workstations which are involved in an assembly line. Group discussion, real-time study, and action research have been performed to reduce cycle time. The result shows that most ideas are able to reduce cycle time to as minimum as 0.1 seconds from the original cycle time. In other words, the project is able to give an impact of at least 520 seconds on daily normal working hours. Besides, it also enhances the participation of the employee in reducing lead time while improving production capacity.

***Keywords**:* Cycle Time, Lead Time, Assembly Line

## INTRODUCTION

Assembly line system can be defined as the controlling of job movement between every workstation in line (Cohen, 2013). Paced line condition can be referred to as the assembly system that has a different value of cycle time in each station (Calvo et al, 2006). In a standard case, each of the workstations applies standard or same cycle time, so the number of part product transferred would be within the same time, and the number of output product would be fixed, where it is equal to the reciprocal of the cycle time system. This happens in the automated assembly but not in manual assembly system. There is some condition that the cycle times are different and kept in average, and this happens in a mixed model line where single production lines consist of two models or more. Each of the different models consists of different cycle times and target of production due to the fact that each of model faces different types of problem and solution.  This scenario is difficult to see in every production line using the manual system because the bottleneck or problem occurs due to human error, and this different as compared to process cycle time, etc. (Yilmaz & Yilmaz, 2015).

It is different with the un-paced line condition, in this situation workpieces do not need to wait until predetermined time span elapsed. The workpiece can be transferred to another workstation as the process finished. This type of line is often applied if the stochastic variations influence the processing time. Depending on the movement connection on each workstation, two things need to be distinguished, which are the synchronous and asynchronous case. In synchronous case, all the part products are moved as soon as all the stations finish doing the operation. A workstation that finishes early must wait until the station that has highest cycle time has completed doing the operation, and then the part product moved. Meanwhile in asynchronous case, one station can pass it workpiece after all operation finish as long as the station is not blocking another workpiece (Domingo et al, 2007; Gurevsky et al., 2012).

## Lead Time Reduction Strategy

Lead time reduction strategy refers to a solution or a suggestion that is able to minimize cycle time for daily basis working period. There are no specific methods; it will take a look at the production lines from the beginning till the end of the line to observe where the problems are (Agarwal et al, 2006; Coffey and Thornley, 2006). In this project, the strategy will be made based on:

- The process balancing in every station to know the potential problem and to observe which one of the station has the highest cycle time in the process (Agpak, 2010).
- Checking the unnecessary table on the workstation, where the least table used by the operator to do their job would be examined and the potential threat would be taken out from the line with the aim of reducing the line length.
- Checking and observe all the missing element in every workstation which mean the material supply, the operator, the handling of material, the motion of operator.
- Checking the number of work in progress (WIP) in the lines, and identifying the problem regarding the WIP, where the station that causes too many WIP would be addressed. There are several ways to reduce the WIP.

In addition, there are several strategies to reduce lead time (Martínez and Pérez, 2001; Prashar, 2014):

1. **Method improvement**: For the method improvement, first it needs to conduct method study for the bottleneck operations (Usubamatov et al, 2014). Method study is the in-depth monitoring and analysis of the way an operator performs its task. Once the method study is done, strategies to save time and effort by the operator are identified and applied. This could be done by improving work motions or providing work aids like gauges, folders, attachments, trolleys, movers, trucks or machine automation.

International Journal of Industrial Management (IJIM)
ISSN (Print): 2289-9286; e-ISSN: 0127-564x; Volume 2, pp. 27-39, June 2016


2. **Share capacity**: In the line, it is easier to find some operation with higher capacity than required for line's target production. Take few pieces from the bottleneck operation to nearby operation which has the potentially higher capacity. Maintain this capacity sharing in a certain interval. Operators who had the potential capacity to share his/her capacity for bottleneck operation intentionally reduce his/her speed to balance the bundle completion time with the line speed.

3. **Add additional manpower or machine**: This is the easiest way to increase production at bottleneck operations. Calculate each machine capacity and demand from the bottleneck operation. It must be kept in mind that machine productivity may reduce in some cases.

4. **Improve workstation layout**: The first and last movement (i.e. pick up and dispose of) performed by an operator in an operation cycle depend on the workstation layout. A closer look at workstation layout of the bottleneck operators will help to find out whether the layout is following principles of best workstation design:
    a. Position material, tool and controls within easy reach.
    b. Use jigs and other devices to save time and efforts.

    This could be related to ergonomic issues like light, fan, seat adjustment, etc. Redesign workstation to reduce material handling time and get increased production.

5. **Better operator allocation**: Each operator has a different set of skill level (operations they generally perform) and efficiency at work. Allocate high content jobs to highly skilled (matching to the job) operators. And for low-skilled operators select jobs that required low skill to perform and that has comparatively low work content.

6. **Work for extra hours**: If you find that additional machine setup is not the possible due unavailability of machine or space and above steps do not make much difference in WIP reduction then follow this step. Working overtime (complimentary with policy permits for working extra hours) to make enough pieces and create WIP for the following operations.

7. **Use time-saving tricks**: Lot of time is spent by operators in material handling and associated jobs. Here, few time-saving tricks have been listed.
    a. If the bottleneck operation is having sub-parts of operations, they can be bifurcated and given to helpers or other nearby operators. In this way, the operator can produce extra pieces and keep the smooth flow to the line.
    b. Check the previous operation if there is any quality issue due to which the operator is not receiving proper input to work on. This may reduce production and create bottleneck operation.

## RESEARCH METHOD

International Journal of Industrial Management (IJIM)
ISSN (Print): 2289-9286; e-ISSN: 0127-564x; Volume 2, pp. 27-39, June 2016


The study involves observation, group discussion, real-time study and action research on the selected countermeasure which can be performed in the fastest way. Figure 1 shows the layout of the selected assembly line. The assembly line performs the assembly in two different types of product where both products are assembled at the different assembly line at the inspection station and paired together. Product X is going through three workstations and one inspection station meanwhile product Y is going through nine workstations and five inspection stations. Both products is paired and inspected for final checking before they enter the packaging station.

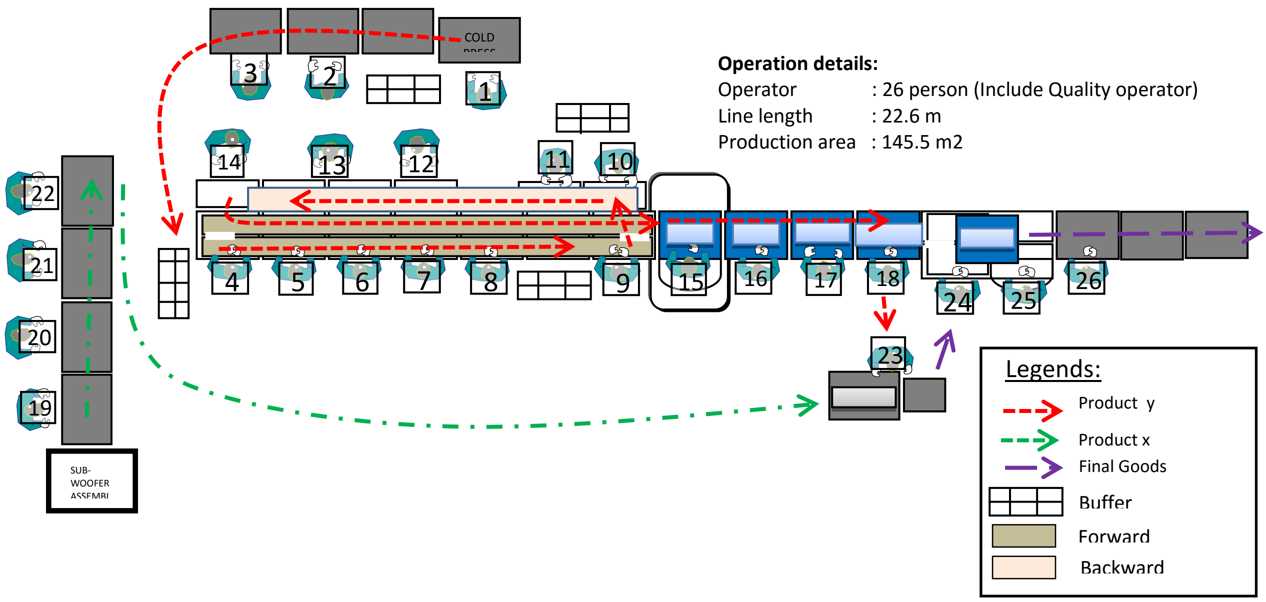


Figure 1: General Layout of an Assembly Line

Product X go through three types of workstations where the first two workstations are assembling of the electronic component on the board, which was located on the rear panel of the product and assembling of other component parts, and the third workstation is a station to assemble the cover parts of the product. The last workstation is used to inspect the vulnerability of the product X so that the product is in good condition and can function well. Product Y go through nine types of assembling workstations from the preparation of front panel and, assembling of speakers on the front panel, dressing the wire on the front panel, screwing the small parts, assembling of all the printed circuit board (PCB) and assembling of the back panel. Then the assembled product will go through the five inspection stations which are BBD Station, EDID station, VIERA station, BT puncture and appearance check station. After the product X and Y are completely assembled, they will be paired in the pairing station to test the functionality of both products before they are sent out to a packaging station for packaging.

International Journal of Industrial Management (IJIM)
ISSN (Print): 2289-9286; e-ISSN: 0127-564x; Volume 2, pp. 27-39, June 2016


Table 1 shows the mean cycle time and the distribution coefficient which had been analysed by Input Analyser. The Input Analyzer is a standard component provided in the ARENA software. The function of the input analyzer is to identify the quality of fits of the distribution function of the input data station. The data will show the result on the histogram chart and from there, the function such as specific distribution function from the data will be comparing the distribution and showing the effect of the changes in a parameter on the same distribution. Based on the trials data of each of the station, the input analyzer can be configured to show the changes of the parameter in each of the station between the distributions, and the statistic test of the chart. Trials of data are important to the input analyzer because the more the trials of data, the better distribution it will be.

Total lead time for single fairing product is 2218.1 seconds and required 443,620 seconds or 7393.67 minutes to complete 200 unit daily demands.

Table 1: Cycle Time Distribution Analysis

| Workstation | Mean (in second) | CT Distribution | Square Errors |
|---|---|---|---|
| **WS1** | 75.8 | 75.1 + 1.45 * BETA(1.43, 1.63) | 0.018456 |
| **WS2** | 85.7 | 84 + 2.96 * BETA(1.17, 0.951) | 0.018570 |
| **WS3** | 176.0 | TRIA(173, 176, 177) | 0.100998 |
| **WS4** | 146.0 | 143 + 5.72 * BETA(1.07, 0.9) | 0.056070 |
| **WS5** | 88.5 | 85 + 6 * BETA(0.991, 0.708) | 0.008087 |
| **WS6** | 83.8 | 82.1 + LOGN(1.75, 1.44) | 0.011701 |
| **WS7** | 112.0 | 110 + LOGN(1.93, 1.3) | 0.019281 |
| **WS8** | 113.0 | 109 + 7 * BETA(0.893, 0.848) | 0.057365 |
| **WS9** | 86.3 | TRIA(83.1, 87.1, 88.8) | 0.013379 |
| **WS10** | 69.1 | 66 + 5 * BETA(0.835, 0.525) | 0.044335 |
| **WS11** | 71.8 | TRIA(70.3, 70.6, 74.5) | 0.004522 |
| **WS12** | 88.6 | 85 + 6 * BETA(1.1, 0.777) | 0.022879 |
| **WS13** | 75.5 | UNIF(73, 78) | 0.020000 |
| **WS14** | 85.1 | NORM(85.1, 1.39) | 0.027741 |
| **WS15** | 73.1 | 71 + GAMM(0.989, 2.11) | 0.047108 |
| **WS16** | 82.2 | UNIF(80, 84) | 0.080000 |
| **WS17** | 86.7 | TRIA(83.2, 88, 89) | 0.050658 |
| **WS18** | 58.6 | 56.3 + LOGN(2.45, 1.83) | 0.061772 |
| **WS19** | 62.4 | 58.1 + 6.84 * BETA(1.86, 1.18) | 0.062194 |
| **WS20** | 88.6 | 85 + ERLA(1.79, 2) | 0.040622 |
| **WS21** | 70.4 | TRIA(68, 70.4, 73) | 0.090324 |
| **WS22** | 84.3 | 83.1 + 2.53 * BETA(1.3, 1.45) | 0.007049 |
| **WS23** | 80.9 | 79.6 + ERLA(0.41, 3) | 0.017899 |
| **WS24** | 62.3 | NORM(62.3, 0.659) | 0.014317 |
| **WS25** | 41.7 | TRIA(40.7, 41.2, 43.3) | 0.029892 |
| **WS26** | 69.7 | 64 + 8 * BETA(0.646, 0.347) | 0.044358 |
| **Lead time (per product)** | 2218.1 | | |

International Journal of Industrial Management (IJIM)
ISSN (Print): 2289-9286; e-ISSN: 0127-564x; Volume 2, pp. 27-39, June 2016


## FINDINGS

The scope of this project is focused on the analysis of actual production system in the manufacturing industry. A case study had been carried out on an electrical product manufacturer, which is located in the southern of Malaysia. In the factory, one of the production is facing a problem which is related to the fact that the amount of output produced in a day is less than expected goal. Therefore, it has become a subject for analysis. The information such as the layout, the target setting, cycle time has been gathered. The result is presented by the project. There are 13 projects which have been completed, yet, having different types of problem statements as the followings:

**Project 1:**

Problem statement:
Lead time is almost fluctuating due to moving operator from WS3 to WS4. See Figure 1.

Countermeasure:
Make a roller conveyor with box between WS3 to WS4 to reduce lead time and increase the efficiency of carrying front panel. See Figure 2.

Impact: Reduce by 0.1 sec

Figure 1: WS3 and WS4

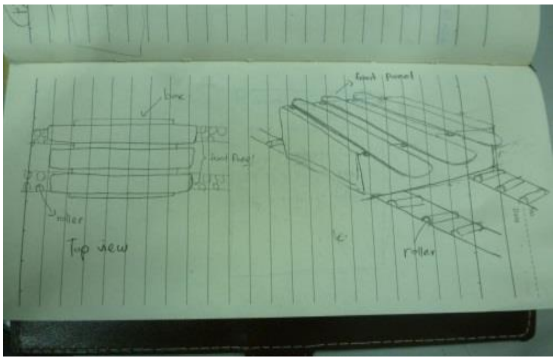

Figure 2: Example of Roller Conveyor

**Project 2:**

Problem statement:
WS2 to WS8 facing problem regarding missing component on front panel. See Figure 3.

International Journal of Industrial Management (IJIM)
ISSN (Print): 2289-9286; e-ISSN: 0127-564x; Volume 2, pp. 27-39, June 2016


Countermeasure:
Provide checking template to every station to make sure the next operator will do quick checking to the component assembled by previous operator before starting their next process.

Impact: Reduce by 2.0 sec


Figure 3: WS8


Figure 4: WS1

**Project 3:**

Problem statement:
Problem carrying panel from one station to another (passing set). Defect of front panel that come from box. Usually operator WS1 (see Figure 4) need to do checking first to make sure the panel is OK or NG. Waste on movement. Walk 4 foots step.

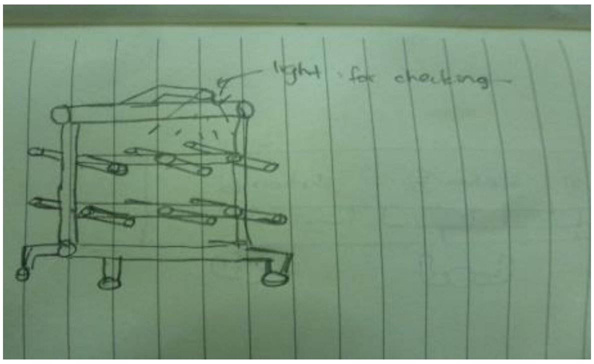

Figure 5: Example of Light Positioning

Countermeasure:
Make a roller conveyor with fixture on each of table station to reduce movement of operator sending set to another station and reduce number of cabinet used.

(i) Add process for RP-Prep operator for checking front appearance before arranged at cabinet.
(ii) Provide light on front and rear cabinet so that is easier for the operator to check on defect (see Figure 5). Reduce movement time.


Figure 6: Inactive Workstation

Impact: Reduce by 0.2 sec

International Journal of Industrial Management (IJIM)
ISSN (Print): 2289-9286; e-ISSN: 0127-564x; Volume 2, pp. 27-39, June 2016


**Project 4:**

Problem statement:
The box carry item such as PCB are usually place on bottom of floor.

Countermeasure:
Make a small table to hold the box carrying the item such as PCB from supplier to make it easier for the operator to take the item in the box without many movements. Otherwise the operator can suddenly kick the box.

Impact: Reduce by 0.1 sec

**Project 5:**

Problem statement:
One unused table place between WS8 and 9 (see Figure 6).

Countermeasure:
Remove one table station between WS9 and 8 so it can reduce length on assembly line.

Impact: Reduce length by 1.3 m. Reduce by 0.5 sec

**Project 6:**

Problem statement:
Operator take a time to make alignment net on cold press jig (see Figure 7).

Countermeasure:
Make more stoppers on jig in cold press machine to reduce time taken for aligning the net by operator on WS1.

Impact: Reduce by 0.1 sec

**Project 7:**

Problem statement:
Checking appearance and screw on rear panel taking long time, thus, slowing down checking.

Countermeasure:

International Journal of Industrial Management (IJIM)
ISSN (Print): 2289-9286; e-ISSN: 0127-564x; Volume 2, pp. 27-39, June 2016


Provide camera with high resolution on the appearance check station to provide better vision, tracing the defect on set and checking the number of screw on set (see Figure 9).

Impact: Reduce by 0.1 sec

**Project 8:**

Problem statement:
Subwoofer assembly's places are rather too far from the pairing station. It takes about 7 seconds to go to pairing station, WS23. See Figure 10.

Countermeasure:
Place the subwoofer assembly station beside the pairing station to make the delivery of set easier.

Impact: Reduce by 0.1 sec

Figure 7: Cold Press Machine

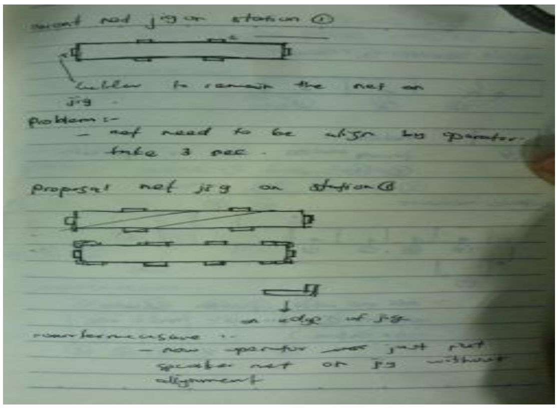

Figure 8: Example of Jig and Fixture For Cold Press Machine

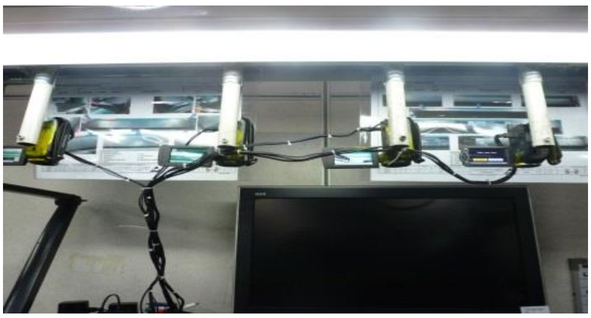

Figure 9: Example of Camera Positioning

Figure 10: WS23

International Journal of Industrial Management (IJIM)
ISSN (Print): 2289-9286; e-ISSN: 0127-564x; Volume 2, pp. 27-39, June 2016


**Project 9:**

Problem statement:
Problem on less efficient sending set to another station especially sending set from appearance check to packaging.

Countermeasure:
Make a double way roller pallet for appearance check station and packaging to reduce time delivering set. See Figure 11.

Impact: Reduce by 0.1 sec

Figure 11: Double Way Roller


Figure 12: Example of Roller Jig

**Project 10:**

Problem statement:
Operator use too much time on pasting hemilon on front panel.

Countermeasure:
Make a roller jig to reduce time for operator to paste hemilon. See Figure 12.

Impact: Reduce by 0.1 sec

**Project 11:**

Problem statement:
Bin (Figure 13) is too far from the operator to throw away unused things.

Countermeasure:

International Journal of Industrial Management (IJIM)
ISSN (Print): 2289-9286; e-ISSN: 0127-564x; Volume 2, pp. 27-39, June 2016


Placed small bin on suitable table station to reduce the length for the operator to throw away the unused things.

Impact: Reduce by 0.1 sec

**Project 12:**

Problem statement:
Checking the appearance and screw on rear panel taking long time because the lighting on the station have poor illumination.

Countermeasure:
Add few more lighting to provide brightness during checking the appearances. See Figure 14

Impact: Reduce by 0.1 sec

Figure 13: Bin

Figure 14: Example of Lamp

**Project 13:**

Problem statement:
Assembly line is too long. There are big gap existing between workstations.

Countermeasure:
Remove the appearances check table station out from assembly line and place beside wall to reduce the line length.

Impact: Reduce length by 1.5 m. Reduce by 0.5 sec.

Figure 15: Example of Gap

## DISCUSSION AND IMPLICATION

The findings show that at least 13 projects had been performed to improve the lead time reduction program. The action research project also had encouraged the operator to participate in the research. The authors believe that the operators are process owners, have longer experience in the assembly line and able to provide basic information on the process. Besides, the process owner is the expert because he or she spend most of the working time and the input from them are very crucial to support decision making (Coffey and Thornley, 2006).

From the observation, it is found that the range or workstation gap had influenced unnecessary time or non-value added time for lead time. Project 1, 3, 5, 8, and 13 are the examples of this issue. The line manager should be aware of this because the neglect of these settings will affect poor lead time result (Domingo et al., 2007). The layout had utilized more space (not purely optimized) and the scenario is able to add cost on the energy and moving.

Next, the use of special jig and fixture are required to improve lead time in the assembly line. Project 1, 2, 3, 4, 6, 7, 8, 10 and 11 shows that by having new or additional jig and fixtures, it will be able to reduce cycle time. Besides, poor ergonomic workstation influences bad result on time study as per project 12.

Last but not least, as suggested by Prashar (2014), the assembly line should be able to redesign and every single member of the assembly line group must be accountable to the process improvement in the workstations. Analysis of performance must be regularly performed to identify the yield that meets the daily demand which in line with customer Takt time. An assembly line must be extent to achieve the ultimate goal such as perfection and ideal state of the production operation.

## CONCLUSION

In the nutshell, this paper proved that lead time reduction program can be implemented by a small project. Process owner or the particular operators are the most preferable person to do the improvement in the assembly line. This is because he or she is the expert and had gone through the actual problem compare to the observer. Each project must have proper documentation to avoid repetition and guideline for the future assembly line. For future study, the authors will include the result of the study into a simulation model to identify the significance of the lead time reduction as a total.

## REFERENCES

Agarwal, A., Shankar, R. and Tiwari, M.K. (2006). Modeling the metrics of lean, agile and leagile supply chain: an ANP-based approach. *European Journal of Operational Research*, 173(1), 211-25.

Agpak, K. (2010). An approach to find task sequence for re-balancing of assembly lines. *Assembly Automation*, 30(4), 378-387.

Calvo, R., Domingo, R. and Rubio, E.M. (2006). A heuristic approach for decision-making on assembly systems for mass customisation. *Materials Science Forum*, 526, 1-6.

Coffey, D. and Thornley, C. (2006). Automation, motivation and lean production reconsidered. *Assembly Automation*, 26(2), 98-103.

Cohen, Y. (2013). Assembly line segmentation: determining the number of stations per section. *Journal of Manufacturing Technology Management*, 24(3), 397 – 412.

Domingo, R., Alvarez, R., Peña, M.M. & Calvo, R. (2007). Materials flow improvement in a lean assembly line: a case study. *Assembly Automation*, 27(2), 141 – 147.

Gurevsky, E., Battaïa, O. and Dolgui, A. (2012). Balancing of simple assembly lines under variations of task processing times. *Annals of Operations Research*, 201(1), 265-286.

Martínez, A. and Pérez, M. (2001). Lean indicators and manufacturing strategies. *International Journal of Operations & Production Management*, 21(11), 1433-52.

Morrison, D.R., Sewell, E.C. and Jacobson, S.H. (2014). An application of the branch, bound, and remember algorithm to a new simple assembly line balancing dataset. *European Journal of Operational Research*, 236(2), 403-409.

Prashar, A. (2014). Redesigning an assembly line through Lean-Kaizen: an Indian case. *The TQM Journal*, 26(5), 475 – 498.

Usubamatov, R., Alsalameh, A.A., Ahmad, R. & Riza, A.R. (2014). Analysis of buffered assembly line productivity. *Assembly Automation*, 34(1), 34 – 40.

Yilmaz, H. & Yilmaz, M. (2015). Multi-manned assembly line balancing problem with balanced load density. *Assembly Automation*, 35(1), 137 – 142.