A Case Study: Implementation of Automated Guided Vehicle Replacing Trollies Transportation in Manufacturing Industry to reduce Motion Waste in Lean Manufacturing practicing factory

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Abstract: This research introduces and demonstrates the procedures and method used to eliminate waste of motion to achieve lean manufacturing which is the starting for Industrial Revolution 4.0. This was conducted in a private manufacturing factory that assembles printed circuit board (PCB). The research done provides an advantage by developing an efficient and effective way to carry out the transportation of PCB magazine trolley. The data collected and results obtained proved the benefits of the utilization of automated guided vehicle. In contrast, result attained for time reduction of transportation of PCB magazine trollies was in the range of 3.39% to 8.08%. Moreover, autonomous guided vehicles also verified the capability to eliminate the occurrence of human error and non-added value activities. In conclusion, the research carried showed a successful method towards optimization of the production in the selected PCB assembly manufacturing company.

Keywords: Autonomous Guided Vehicle, Waste of Motion, Time Reduction, Industrial Revolution 4.0, Quality

1. Introduction

Minimization of waste allows increase efficiency, increase business performance, reduce cost of production, increased productivity, increase profit, less time in developed production and minimizing inventory are the strategies of lean manufacturing (Vendan, 2010). Moreover, there are several tools and techniques of lean manufacturing which is also important to be applied such as 5s Housekeeping, Kanban, Kaizen, Just in Time (JIT), single minute exchange of die, seven waste and continuous improvement. Furthermore, in lean manufacturing, it is essential that waste to be identified and eliminate. Elimination of waste was then achieved by the implantation of JIT. Furthermore, Muda is known to be the major source of waste. There are seven types of waste in Muda in which they are waste of motion, waste of waiting, waste due to over processing, waste of over production, waste of transportation, waste of inventory and defects. Therefore, it is very important to eliminate the seven waste of Muda to achieve LM (Womack, 2003).

In this current era, the utilization of automated guided vehicle (AGV) in manufacturing industry plays an essential role as it is the solution towards optimization of materials flow. Besides, comparing human operator and AGV, it was found that the autonomous vehicle carries out task up to the expectation required with good performance and provides high accuracy than the human operators (Ali, 2010). In manufacturing industry, allowing AGV to carry out transportation is the perfect strategy to eliminate the waste of motion. Besides that, AGV are also able to locate themselves and move along the designed path via laser guiding system in order to reach the allocated location. The system consists of very reflective targets and laser scanners (Vis, 2006). The greatest advantage is, the AGV fulfils the requirement of the fourth Industrial Revolution as it utilises the Internet of Things (IoT) effectively. The AGV can be controlled by mobile phones, notepad and phones via Wi-Fi. In addition, the most important thing of the moving vehicle is the safety features. The AGV has three types of safety feature such as front and back bumper switch limit, five-meter range laser sensor, and the emergency button as shown in Figure 1.

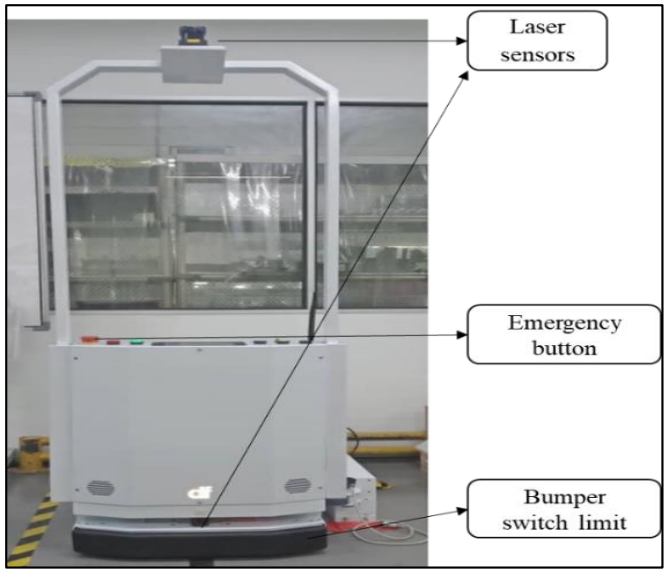

Figure 1. Safety features of AGV

2. Case study

This case study was done in a private manufacturing company which assemblies printed circuit board for electronics appliances.

2.1 Before AGV implementation

Before implementation of AGV, the PCB trollies are transported by the operator from the raw material unit to production. The negative aspects found for the transportation activity were the transportation of trollies by the operator contributes towards the waste motion. Besides this, delay of delivering the PCB trollies to the manual assembly production line cause an impact towards delay in production. This also contributes towards poor human capital management within a manufacturing industry which can cause added expenses due to jobs that are made redundant (Almeida,2016). Furthermore, the time study was carried out to determine the time taken by the operators to carry out the transportation of the PCB magazine trollies. The cycle time in Table 1 was taken by measuring the time taken from the raw material unit to five (5) production lines and vice versa. Each movement were recorded for five time to obtain average time taken respective to the distance from raw materials unit. Therefore, the average cycle time was obtained and was noticed that too much

showed waste of motion that was carried out by the operator for this activity. Besides that, another major problem found was the error caused by operators which causes the PCB magazine to fall during the transportation of the PCB magazine trollies were also identified.

Table 1. Cycle time of operator

Production Lines	Cycle time (seconds)					Average (seconds)	Distance from raw materials unit (meter)
	1	2	3	4	5		
A	214	219	210	205	216	212.8	35
B	191	193	198	195	194	194.2	28
C	184	183	185	180	182	182.8	20
D	168	161	164	169	167	165.8	15
E	139	142	146	138	145	142	8

2.2 Implementation of AGV

AGV implementation was carried out from the raw material unit to all the production lines with the details of the path as shown in Figure 2. The main objective of implementation was to eliminate waste of motion (one of the 7 waste in Lean Manufacturing) with increased quality. The AGV transports the raw materials trollies by towing method.

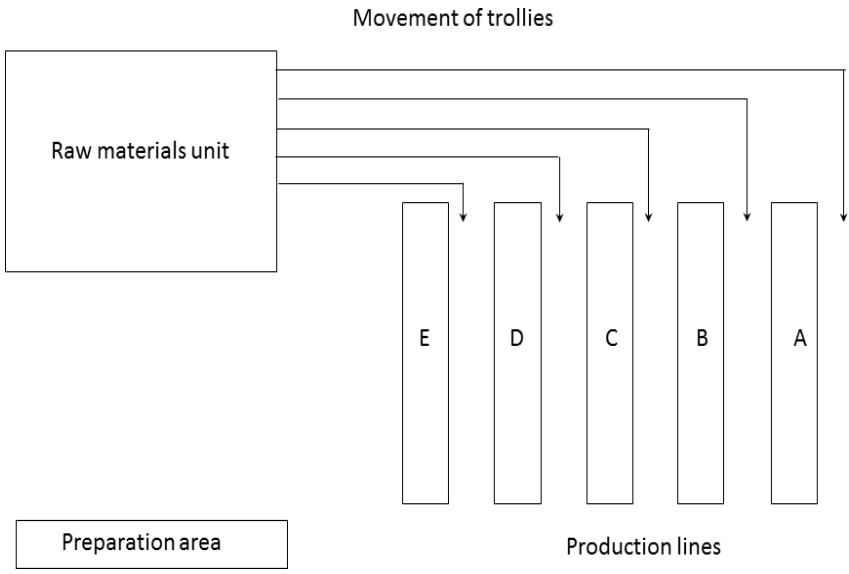

Figure 2. Details for the trollies path for each production line

3. Results and discussion – After implementation of AGV

After the implementation of AGV, the time were taken for the movement from raw materials unit to production line and compared with the manual transportation. Figure 3 shows the time comparison between the both manual and AGV which there is a decrease in the cycle time. The analysis showed, it was identified that the implementation of the AGV allows reduction of time for transportation of PCB magazine trollies (Cheon, 2009). Hence, the percentage time reduction towards all the production line was obtained and it was in the range of 3.39% to 8.08%. This proves that the implementation of AGV was more effective and increases the productivity of the production lines. Normally, the return of investment (ROI) should be recovered with the range of three years (Schulze, 2008). Further calculation on the usage of AGV can be convinced that this can be achieved.

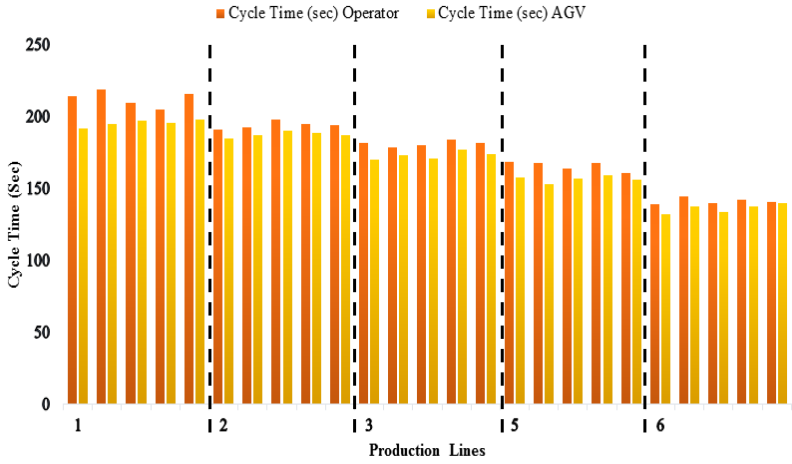

Figure 3. Cycle time comparison between operators and AGV

4. Conclusion

From this case study, the following can be concluded:

a) The percentage time reduction of AGV from the raw materials to all the production lines has been reduced in a range of 3.39% to 8.08%.

b) AGV was able to eliminate one of the human errors for in reducing defective products due to materials fall.

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