Investigating the Influences of Automated Material Handling System (AMHS) and Effect of Layout Changing in Automotive Assembly Process

Seha Saffar, Zamberi Jamaludin and Fairul Azni Jafar

Abstract The material handling equipment adds utilization to the performance level of the manufacturing process. Thus, by investigating the influences of AMHS and at the same time seeing the effect of changing its layout in automotive assembly process help the research in improvising the system easier and guaranteed to be success. A case study focus at the material flow of warehouse to assembly shop is done and the result show the work is done manually and has a lot of time are wasted. From the case study, an approach tool are used to simulate the system by using Delmia Quest simulation software. 4 models are simulated which consist of AGV and tugger train as transportation system, 2 layouts which are the current used layout in case study and new layout, and the supply order system which are picking list and pick-to-light system. The result shows the number of part deliveries highly increase by the changed of layout in the system in model 4. The deliveries able to achieve 3 times value from the current old system in the factory. As the system improves with the change of supply order system and layout in model 3 and 4, the idle time reduce to below 0.5 h and maintain linearly in the system. Lastly, it can be summarized that the improvement shows the influences of automated material handling system and facility layout in increasing the performance of the automotive assembly factory.

Keywords AMHS · Factory layout · Delmia quest

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1 Introduction

The Material Handling Industry of America (MHIA) define Material handling involves the movement, storage, control and protection of material throughout the process of manufacturing which covers the consumption, disposal, and distribution [1]. Material handling can affect 80% of production activity by which 50% of the company operation costs are material handling costs [2, 3]. By having the right quality of material at the right moment and the right place, production effectiveness can be increased [4]. In addition, the direct cost of material handling cannot be measured where it does not directly add to the finished product [5]. The most important part of manufacturing and distribution is the effectiveness of material handling in order to turn the product into profit.

Aim to have income in product make technology and automated system in high demand and the trend to optimize the material handling system is arising. Current topic such as insufficient material handling [5], old technology implementation [6], separation of production system and material handling system can cause various problems in term of cost and time consuming [7]. Thus, the gap of problem is research in between the tolls or the platform that integrates between method of material supplies in production line and the inventory system in warehouse.

Based on case study observation done in automotive factory, the production background is begin from logistic warehouse to body shop, paint shop and lastly is assembly shop where the painted body is assemble in three main stations which are trim line, chassis line and final assembly line. The process during assembly is done by semi-auto processes that involve manual and auto system. The current layout of assembly line is called old layout as show at Fig. 1 state the transportation track from warehouse to assembly line which are called trim line and chassis line. This research work only focus on chassis line which consist of 10 stations with different process and part supplies. In addition, Fig. 2 shows the distance travelled from warehouse to assembly line. In assembly line, each process have their own stations and each station is not fixed with only one process. It involves assembles of 3–4 types of different parts for each stations. Basically, the distance travelled is according movement of transportation from pick-up point at warehouse and return back to its starting point in order to have a total distance travelled in 1 cycle of working hour.

Studies at the assembly shop showed that the process flow of material from warehouse to assembly line is done fully manually. Based on the case study, the current transport equipment that is used to transfer parts is manually driven ‘tugger’ truck called easy-go truck. The truck function is to pull mother trolley and transfer part from warehouse to every station in assembly process. In order to see the improvement that can be made by automated material handling, this research work recommended to change the manual drive truck into automated guided vehicle, AGV. The automated transport equipment is chosen based on the suitable demand to bring the mother trolley to assembly line.

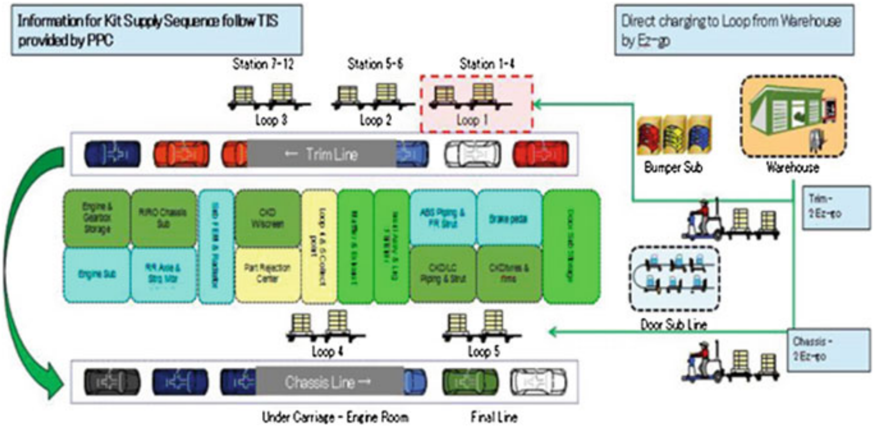

Fig. 1 Old layout of case study factory

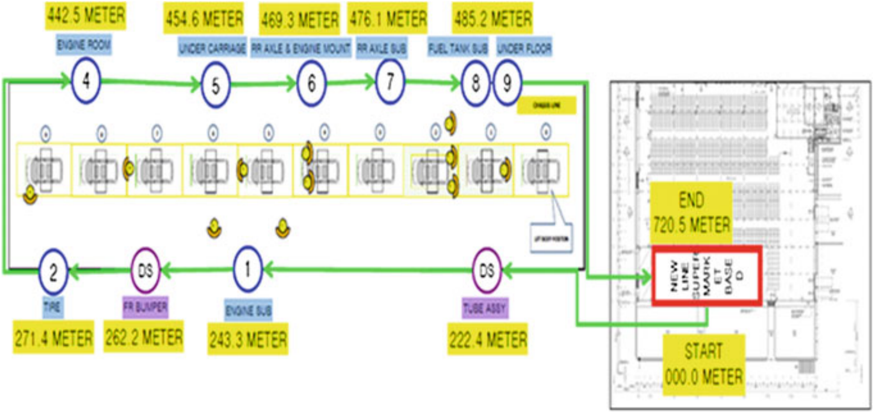

Fig. 2 Measurement of old layout in chassis line

The case study storage equipment that's currently used is storage bin and rack in warehouse. Meanwhile storage for part handling during distribution process is called kit supply and was put inside mother trolley which was pulled by tugger truck. The picking list method is applied, where so called 'Maruka' concept in Japanese is implemented by workers to pick component and place in the kit. It purpose is to simplify the operators work and easy for unskilled operators to do their work. But, this method took a lot of time to order and transfer the material.

All the parts in the kit need to be placed inside the cart and into mother trolley as shown in Fig. 3 and brought directly to the assembly line through easy-go cart which drive by workers. Thus it took time in trafficking the material and high risk of damage (either human or material) when transfer the material. The pick-to-light

Fig. 3 Mother trolley carry carts in plant layout of actual automation factory

system is recommended to replace the old picking list system from the case study. Pick-to-light system guided worker to pick specific parts for different variances. The necessary picking information is show on small display boards. Each variants has individual identification displays, acknowledgement button with digital display for indicating quantity.

The main purpose of this study is to assess the influences of automated material handling system and at the same time seeing the effect of changing its layout in automotive assembly process. A design on the integration system that is comparable with current system of material handling system in the automotive industry will be done through simulation and analysis of the influences of the new system with the conventional system will be done in order to achieve the main objective.

2 Materials and Methodology

This section explained the process flow of this research as shown in Fig. 4, starting from phase 1 which consist of literature review and preliminary data gathering. This phase is meant to understand the research problem and assess data from case study in real automotive manufacturing environment. Phase 2 is to design and propose a new material handling system.

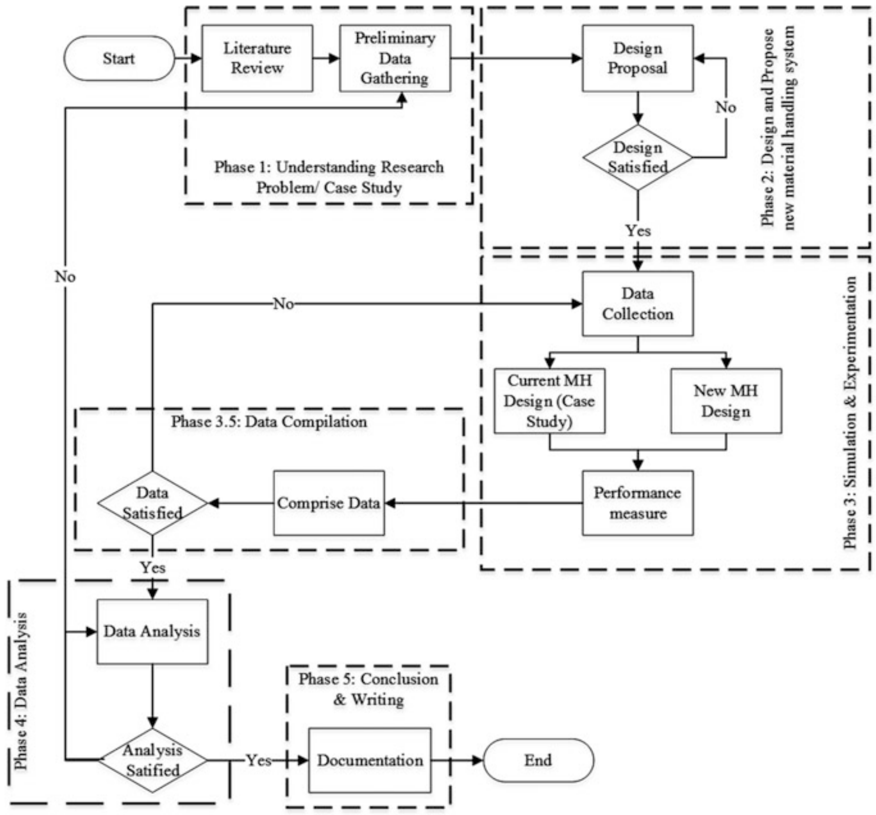

Fig. 4 Overall research process flow [9, 10]

The design process flow is using a stand product design and development where it involves the process of creating a concept too concept selection and concept proposal. In this phase, a decision block is put in order to have satisfaction design so that the process can only be proceed to the next phase. After that, phase 3 is where the experiments is conducted and phase 3.5 and 4 is where the result is compiled and analyse. Lastly, the documentation phase where the process of writing is done.

In order to see the result of the system, the material handling system and the layout need to be replaced from the current system. Thus, by doing so a simulation is a suitable method to avoid wasting the resource and consume a lot of time. Simulation modelling is an effective tools used in addressing and challenging issues to become more flexible, feasible and provide infinite integration of various simulation method [8].

Delmia Quest software is the selected software to use in this research. Its aim to prepare, setup and perform the simulation for this research. Delmia Quest simulation software able to conduct the design system without destroying in a factory of disturbing the system and enable the users to experience the process of the target equipment.

2.1 Variation of Factors and List of Models

The preliminary data gathering shows the collection of data from case study of real industry situation. The data involves plant layout from warehouse too assembly line, travel distance, distance between each station, parts involved in the process and their material handling equipment used during the transfer process. The current layout used in the factory shows the transportation track from warehouse to assembly line which consist of few workstations. Certain models contains same and different material handling system and layout.

The factors focused in this research experiments are type of layout, transport equipment, and storage equipment. Table 1 describe the variation of factors used for the experiments. Noted, that model 1 is similar process used in the case study factory. Model 2 aims to study the influence of automated guided vehicle replacing the tugger train transportation.

Meanwhile, model 3 purpose is to observe the influences of new supply order system which is pick-to-light replacing the old current picking list system. Lastly, model 4 hold the purpose of studying the new layout effect together with the improved material handling system to the whole system performance. The comparison between all models is to show the significant effect of the improved AMHS and layout too the system. The validation of all models is when all the system are capable to function similarly to the real case study factory.

Table 1 The list of models and variation of factors used in experiments

Models	MHS configuration		
	Layout	Transport equipment	Storage equipment
Model 1	Old layout	Tugger train	Picking list system
Model 2	Old layout	AGV	Picking list system
Model 3	Old layout	AGV	Pick-to-light
Model 4	New layout	AGV	Pick-to-light

2.2 Simulation Decision Point for Each Models

In Quest, transport and labor elements loading and unloading parts at decision point where the parts from other elements may enter and exit the path system only through the decision points. In addition, traffic management of AGVs' and trains' stopping point is also at decision point. Process logic defined the behavior of the decision point and the decision point able to make their own decision making logics acting as local controller. Basically, if there is no local decision making involved, the decision making is passed to the AGV and labor controller.

AGV and tugger train

In this research work, the decision point for AGV and train will divided into 2 sections covers 4 models used in the experiment. Section 1 consist of model 1 and 2, where their path system and decision point is created similar with case study's transportation path system. For model 4, the path system is a bit different due to the different layout and application of pick-to-light system in their warehouse. In Table 2, show the list of decision point for model 1 and 2. It consist of 10 decision points at assembly line and function as the parts drop-off point and 1 decision point at warehouse and function as the parts pick up point.

All the decision point were located on the path system at every assembly and warehouse part entry point. As illustrates in Fig. 5, the red-cross mark is the decision point location in model 1 and 2.

The list of decision point for model 3 is shown in Table 3 and model 4 in Table 4. It consist of decision point at assembly line as much as 8 drop off points and 7 pickup points at warehouse. Also as illustrates at Figs. 6 and 7, the location of decision point for model 3 and 4 is much differ from model 1 and 2. Due to the different layout and storage system applied in both sections make the path and behavior of the AGV and train a bit different.

Table 2 List of AGV and train decision points for model 1 and 2

Position	Decision points	Name of stations
Assembly line	AGV_Dec_Pt2	Station 1: Engine Sub 1
	AGV_Dec_Pt3	Station 2: Engine Sub 2
	AGV_Dec_Pt4	Station 3: FR Bumber and Axle Sub
	AGV_Dec_Pt5	Station 4: RR Bumper
	AGV_Dec_Pt6	Station 5: Engine Room
	AGV_Dec_Pt7	Station 6: Under Carriage
	AGV_Dec_Pt8	Station 7: RR Axle and Engine Mount
	AGV_Dec_Pt9	Station 8: RR Axle Sub
	AGV_Dec_Pt10	Station 9: Fuel Tank Sub
	AGV_Dec_Pt11	Station 10: Under Floor
Warehouse	AGV_Dec_Pt1	Warehouse pick up point

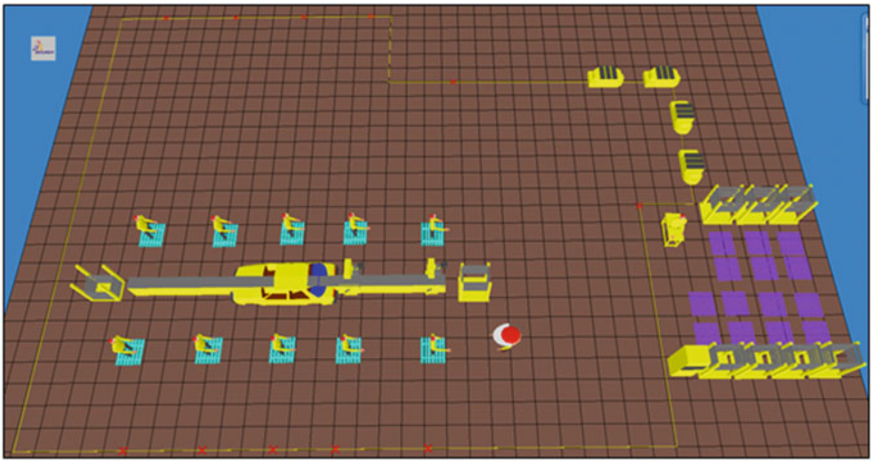

Fig. 5 The location of AGV and train decision point for model 1 and 2

Table 3 List of decision points for model 3

Position	Decision points	Name of stations
Assembly line	AGV_Dec_Pt1	Station 1: Engine Sub 1
	AGV_Dec_Pt2	Station 2: Engine Sub 2
	AGV_Dec_Pt3	Station 3: FR Bumber & Axle Sub
	AGV_Dec_Pt4	Station 4: RR Bumper
	AGV_Dec_Pt5	Station 5: Engine Room
	AGV_Dec_Pt6	Station 6: Under Carriage
	AGV_Dec_Pt7	Station 7: RR Axle and Engine Mount
	AGV_Dec_Pt8	Station 8: RR Axle Sub
	AGV_Dec_Pt9	Station 9: Fuel Tank Sub
	AGV_Dec_Pt10	Station 10: Under Floor
Warehouse	AGV_Warehouse_1	OPT1
	AGV_Warehouse_2	OPT2
	AGV_Warehouse_3	OPT3
	AGV_Warehouse_4	OPT4
	AGV_Warehouse_5	RC Bin
	AGV_Warehouse_6	Dash Insul
	AGV_Warehouse_7	RR Centre Bracket

Table 4 List of decision point for model 4

Position	Decision points	Name of stations
Assembly line	AGV_Line_1	Station 1: Engine Sub 1
	AGV_Line_2	Station 2: FR and RR Bumper and Axle Sub
	AGV_Line_3	Station 3: Engine Room
	AGV_Line_4	Station 4: Under Carriage
	AGV_Line_5	Station 5: RR Axle and Engine Mount
	AGV_Line_6	Station 6: RR Axle Sub
	AGV_Line_7	Station 7: Fuel Tank Sub
	AGV_Line_8	Station 8: Under Floor
Warehouse	AGV_Warehouse_1	OPT1
	AGV_Warehouse_2	OPT2
	AGV_Warehouse_3	OPT3
	AGV_Warehouse_4	OPT4
	AGV_Warehouse_5	RC Bin
	AGV_Warehouse_6	Dash Insul
	AGV_Warehouse_7	RR Centre Bracket

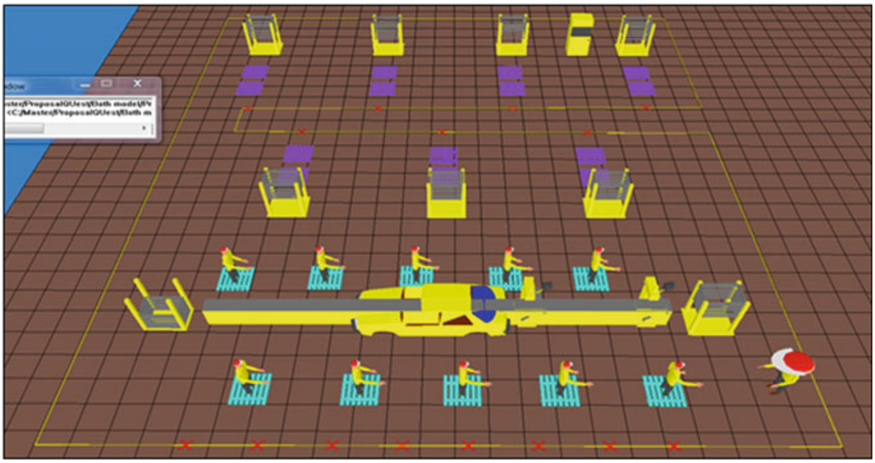

Fig. 6 The location of decision point for model 3

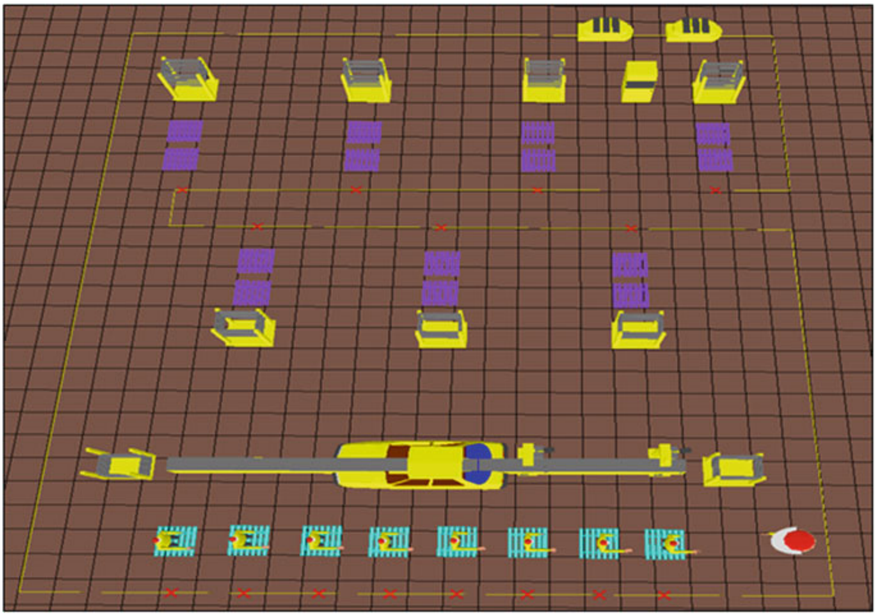

Fig. 7 The location of decision point for model 4

3 Result and Discussion

The result is compiled and presented in the statistical charts that focus on a few elements such as the element class statistics where the result show the number of total part created are showed, the idle time of drop off stations and the utilization of transportation.

As illustrates at Fig. 8, the pie chart show the total number of parts delivered between every models. The chart area increase through every models especially at model 3 where the number of parts delivered increase tremendously from 14 parts to 36 parts per simulation. Its show the changed of AGV and pick-to-light system to the system are effective. Nonetheless, the number highly increase by the changed of layout in the system in model 4. The deliveries able to achieve 3 times value from the current old system in the factory.

Figure 9 shows a line graph for comparison of idle time in assembly line supply buffer. It is observe at stations Assem_Line_Buffer_1, the supply time reduce sharply through Assem_Line_Bufer_2 for model 1. That is due to the layout configuration where the distance between both stations is not too far from each other. Therefore, transportation able to transfer parts faster, thus avoiding time wasted. But, it does not seem a problem for model 2 where the changes of transportation too AGV covers the large difference of idle time between stations. The result at model 2 reduce the idle time and the trend is more linear compared to

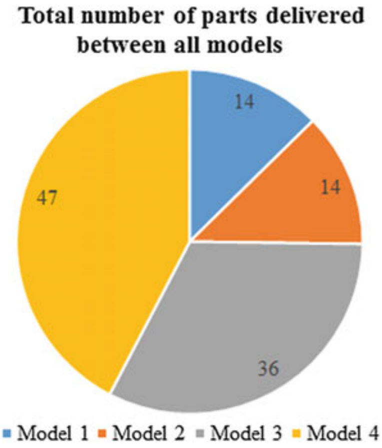

Fig. 8 The pie chart of total number of parts delivered between all models

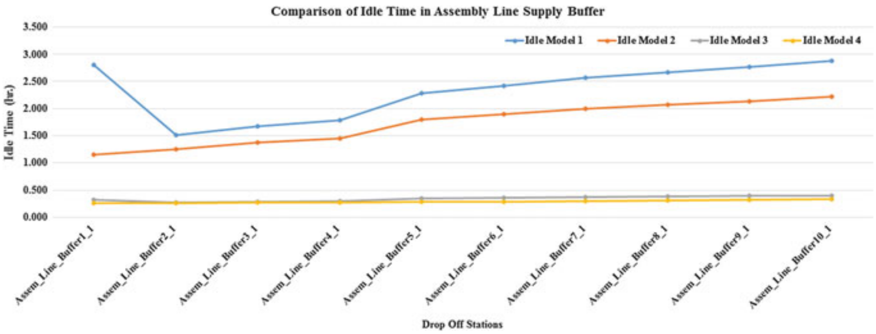

Fig. 9 The line graph of comparison of idle time in assembly line supply buffer

model 1. As the system improves with the change of supply order system and layout in model 3 and 4, the idle time reduce to below 0.5 h and maintain linearly in the system.

The radar chart illustrates at Fig. 10 shows the comparison of transport utilization. Number of transport claimed with no wait shows the utilization of the transport in the system during simulation. No wait means the AGV are claimed by station continuously. The increase the AGV shows the higher its productivity. A small increment can be seen from model 1 to model 2. The changes of transport to automated material handling give a slight increment to the utilization of the transportation. But as supply order system are changed into semi-automated pick-to-light system, the utilization of transport largely increase. From current system in model 1, the transport claimed with no wait only maximum of 13 unit transports during working hour. Thus, the transport are claimed for at least 1 h per

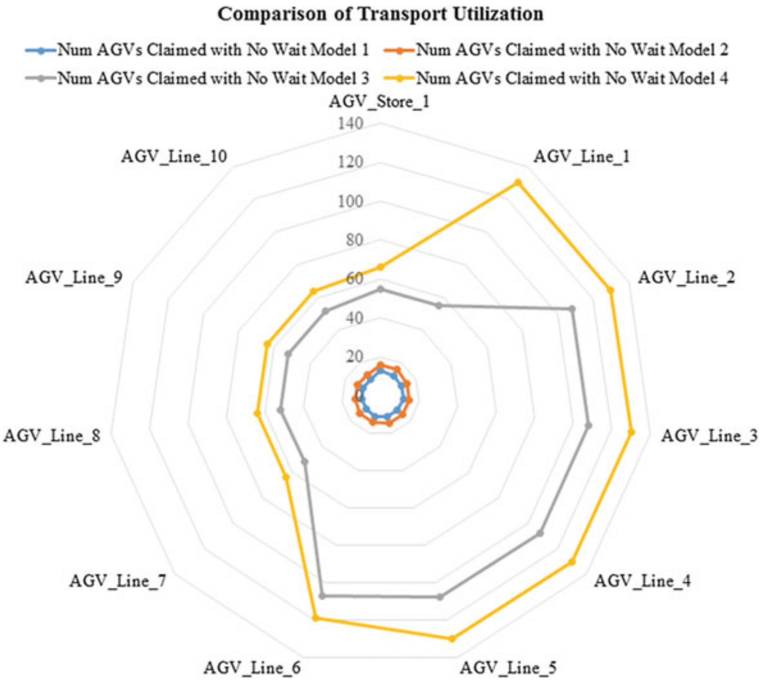

Fig. 10 The radar chart of comparison of transport utilization

cycle. Meanwhile, in model 4 the least claimed transport with no wait is 64 unit of transport during working hour. Therefore, it shows the system able to cover the demands of the stations more than the current old system.

4 Conclusion and Recommendation

This research aim to shows the influences of automated material handling system at the same time observe the effect of layout changing in the system of automotive assembly process. Based on manufacturing strategy and constraint, this research work field covers the improvement of integration between material handling and facility layout from the current case study factory.

Delmia Quest software gave ability for researcher to simulated the manufacturing line and optimize the system without disturbing the real life element. Furthermore, the result can be used to study the influences of the changes made to the system. From the result, 3 elements are discuss to show every influences and effect happen to the system.

Based on the result, the application of AGV and pick-to-light system gave high significant effect into the system. Not to mention, the changes of layout give a large effect to the system where the productivity, time management and transportation become more effective and efficient. Hence, it can be summarized that the improvement shows the influences of automated material handling system and facility layout in increasing the performance of the automotive assembly factory.

A few features in this research study are not covered such as the flexibility of the system and the industrial engineering aspects. Hence, the constraints is likely the manufacturing towards flexibilities and leans.

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