VOL. 11, NO. 4, FEBRUARY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
©2006-2016 Asian Research Publishing Network (ARPN). All rights reserved.
www.arpnjournals.com

DESIGN KIT OF VARIANT PARTS VIA KITTING SYSTEM FOR MASS CUSTOMIZATION IN AUTOMOTIVE INDUSTRY

W. S. W. A Najmuddin[1], M. T. Mustaffa[2], Mohd Azam Musa[1], Azalan Mohamed Ibrahim[1], Nazrul Idzham Kassim[1], M. H Norhidayah[3], and S. A. B. S. N Faridah[4]
[1]Faculty of Engineering, International College of Automotive, Pekan Automotive Complex, Pahang Darul Makmur, Malaysia
[2]School of Manufacturing Engineering, Universiti Malaysia Perlis, Kampus Pauh Putra, Arau, Perlis, Malaysia
[3]Muamalat Department, Kolej Antarabangsa Sultan Ismail Petra, Nilam Puri, Kota Bharu, Kelantan, Malaysia
[4]Development Centre, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, Durian Tunggal, Melaka, Malaysia
E-Mail: najmuddin@icam.edu.my

ABSTRACT

This present paper addresses on designing the kit parts for variant engine model in new kitting area of sub-assembly line, one of the main processes in final assembly line. To date, a variant model of vehicles leading to parts variety that can deliver inefficiency of production in terms of cost and time. One of the major processes in vehicle assembly that is sub-assembly line aims at producing a large number of finish line products encompasses variety of components that supports other main assembly process such as final assembly. The availability of parts needed at each workstation in the assembly line is critical for the production efficiency. Due to this fact, this paper aim to design a kit for two variants engine models in a reliable feeding system. This situation ensure the required parts available at line with high diversity of components and different physical features (i.e. weight, volume) to name a few in single complete different model. As such, the total operating cost and time consume in assembly production is rely on how efficient the system can response to a prompt target plan without neglecting the quality of the product. A design of kit for parts placing enables reliability of variant parts model in single line that will corresponds to mass customization of the production line. Overall, this paper offers a solution in terms of the availability of parts needed in rapid mass customization production of assembly line at one of the key player manufacturer plant in automotive industry. It is expected that the findings of this on-going study will provide production team with kits design to choose from in evaluating the assembly system performance which would lead to the production efficiency as well as minimize the associated costs.

Keywords: kitting, design for assembly, material handling, assembly line.

INTRODUCTION

In recent years, manufacturers of automotive industry facing a competitive market due to highly customer demands. To achieve this, all relevant organizations in this sector need to adapt their system with the changing environment via mass customization. As described by (Chryssolouris et.al, 2008), the transition of the automotive industry from mass production to mass customization is based on the need for more customized vehicles to be produced, providing many variants, with the use of fewer resources and materials, in the shortest time possible. The transformation of the system can produce variety demands from customer while controlling their costs and maintaining their profitability.

Presence of variant parts and components provide a further complicated in assembly process. In details, each vehicle assemble that coming off the line will be different from the one that came before or after it because a specific request by a customer. In order to meet these demands, the need for efficient material handling part delivery is vital because of extensive product customization and the lack of space to keep all the necessary parts at the assembly line. For example, variant part of vehicle engine that leads to a large number of parts moving around in the sub assembly line for delivery to others main assembly processes resulting to a critical material supply process. In industry, perhaps the most commonly applied alternative to kitting is continuous supply, where each part number is presented in a separate container in a component rack (Deechongkit and Srinon, 2009; Wa¨nstro¨m and Medbo, 2009; Hua and Johnson, 2010). As an alternative to material supply systems known as line stocking, implementation of kitting take place in a large number of study between practitioner and researcher. In paper of (Limère *et al.* 2012), build upon the definition of the kitting material supply system given by Bozer and McGinnis, as delivers specific sets of components and subassemblies to the shop floor in predetermined quantities, where each kit is collected, transported and stored in a specific container. Compared with continuous supply, where each part number is generally presented in a separate container, kitting represents as parts are delivered and presented to the assembly operations in pre-sorted kits, with each kit containing parts for one assembly object. In similar, the main difference between these two systems is that the non-value adding activities in line side stocking systems are moved from the assembly lines to the kitting area in kitting systems (Kilic and Durmusoglu, 2012).

The efficiency of material transportation between the different stages in production line is one of the main factors for overall product cost minimization. As such, the material feeding system such as kitting is an important strategy in major processes of assembly line. The kitting system can reduce an inventory space needed at the assembly station via collection of specific parts container.

©2006-2016 Asian Research Publishing Network (ARPN). All rights reserved.

The specific parts inside these containers are placed in proper arrangements such that the reductions of assembly time can be attained. (De Cuypere and Fiems, 2011) further added the benefits include reduced learning time of the workers at the assembly stations and increased quality of the product. (Hanson and Medbo, 2012) claimed that, presentation of parts by kitting, compared with by continuous supply, seems to hold a potential for reducing the time spent by the assembler fetching parts. Kitting had also being identified can improve the ergonomic conditions for the line operators. Finnsgard *et al.* (2011) carried out a study to compare the ergonomic conditions for the assembly operator where components are exposed in wooden pallets versus smaller bins. It seems that the result obtained had improved greatly, thereby almost eliminating potentially harmful body movements. Due to a amount of significant benefits gain from the implementation of kitting system, an experimental initial design of engine parts variant model is introduced as to be placed at new kitting area of engine assembly at one of the manufacturer plant in Malaysia.

In the study, parts involved is identified as they perform in the same assembly operations with a number of distinguish engine model where each it named by sequencing module. This kitting system is being considered as a potential option to continuous supply, however the knowledge of how the efficient of this principles can perform yet to be determined through next experiment. As demonstrated in this paper, this initial design proposal would gain insight into how the use of kitting and the approach could deliver essential benefits in terms of costs, efficiency and quality of the products as well.

LITERATURE REVIEW

In measuring manufacturing performance, manufacturers usually compare their own plants with other manufacturing plants in the industry in terms of such parameters as customer satisfaction, product quality, speed in completing manufacturing orders, productivity, diversity of product line, and flexibility in manufacturing new products (Cordero *et al.* 2005). Following these parameters, amid the main factors that contribute to the efficient assembly line is the decision about the material supply system and order picking activities. The decisions of materials feeding are crucial since they enable a manufacturer to increase the control and affect the overall efficiency of its production system. Thus, according to (Hanson, 2009), kitting is gaining increasing attention from the automotive industry and is becoming an alternative to continuous supply. In addition, other literature focuses on operationally organising and scheduling the part supply to mixed-model assembly lines (Boysen and Bock, 2011), (Klampfl *et al.* 2006).

Massive variety of products is propagated to accommodate a diversify customers needs. Variation exists regardless of the structural complexity of products, which might be as simple as a light bulb or as complex as an automobile (AlGeddawy and ElMaraghy, 2012). As product variety increases due to the shift from mass production to mass customization, assembly systems must be designed and operated to handle such high variety (Hu *et al.* 2011). Following this, kitting system have been utilized to solve these situation with several aspects need to be considered in designing the kits for the system. The research literature reveals both kitting and line stocking systems can offer significant operational benefits. According to (Caputo and Pelagagge, 2011), kitting is related with lower inventory levels, which denotes that for high-value parts, kitting has an advantage over continuous supply, and vice versa.

(Hanson, 2012) cited among the potential benefits associated with kitting, compared to continuous supply, are space efficient parts presentation (Bozer and McGinnis, 1992; Medbo, 2003;Hua and Johnson, 2010; Caputo and Pelagagge, 2011), improved assembly quality (Sellers and Nof, 1986; Johansson, 1991; Bozer and McGinnis, 1992; Caputo and Pelagagge, 2011), increased flexibility (Sellers and Nof, 1986; Hua and Johnson, 2010;

Caputo and Pelagagge, 2011), shorter learning times (Johansson, 1991) a more holistic understanding of the assembly work (Medbo, 1999) and less time spent by the assembler fetching parts (Ding and Puvitharan, 1990; Johansson, 1991; Hua and Johnson, 2010; Caputo and Pelagagge, 2011; Hanson and Medbo, 2011).

Acknowledging numerous of potential benefits lies in the kitting system, the first phase is implemented and demonstrated in this paper. In this way, it is possible to focus on major critical parts in sub assembly line to be allocated at specific kitting area so that the significant impact can be obtained for major improvement within the system.

METHOD

The kit preparation area is required to assemble the kits due to diversity of parts resulting in space deduction of assembly line. As time is concerned, the placement of the kitting area next to the assembly line is preferred to mitigate kits transportation. This situation is significant considering prompt deliveries if any materials issues exist, therefore a fast action can be deployed.

This paper is focused on the engine parts which consider as major parts in assembly production. At initial stage, all related engine parts received from supplier need to be unpacked for tagging and labelling, thus allowing assembly and integrating with other parts. The engine comprise of four variants in Module 1 (M1) named as Code 1(IAFM+), Code 2 (IAFM), Code 3 (Campro) and Code 4 (CPS). Then, for Module 2 (M2), four variants named in sequence with similar code parts name.

VOL. 11, NO. 4, FEBRUARY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
©2006-2016 Asian Research Publishing Network (ARPN). All rights reserved.
www.arpnjournals.com

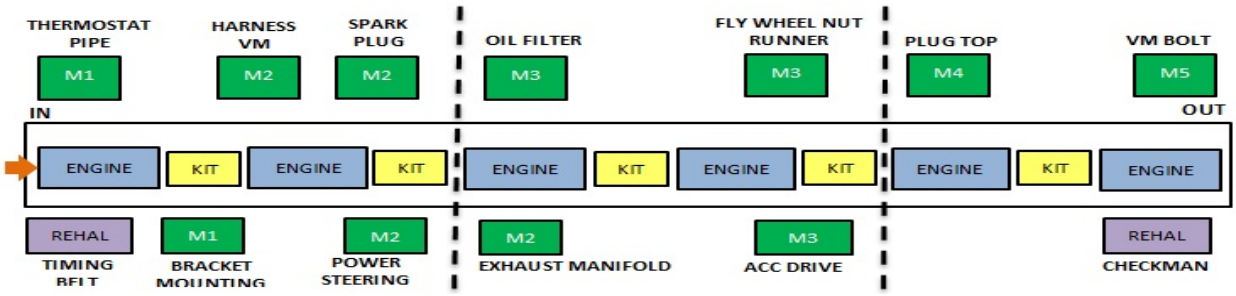

Figure-1. Kitting area layout (Production team, 2014).

Figure-1 shows the kitting area layout for engine variants at assembly line. The kitting area is located near the assembly line to minimize transportation time and easy handling throughout the operation. Parts and components involved are identified and arranged accordingly in each workstation.

Specifically, engine parts and components of M1 and M2 are identified and will be placed into kit container in design phase as seen in Figure-2 and Figure-3 with code parts name respectively. Then, the following product families' parameters need to be identified such as part-id, parts per product, frequency, weight and volume. Before implementing the kitting system, all parts are arranged in polybox according to their models to ensure part identification. A part-id is provided to identify a unique Inventory Keeping Unit's throughout the design procedure.

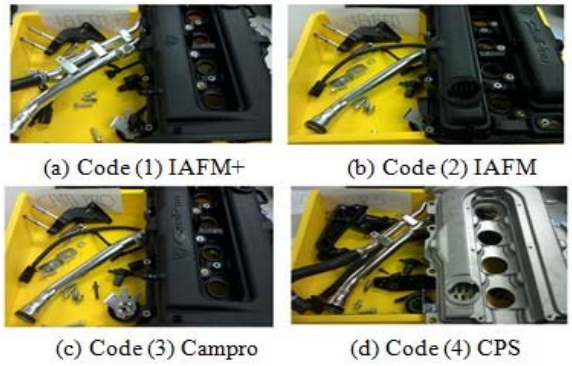

Figure-2. Engine parts variant module 1.

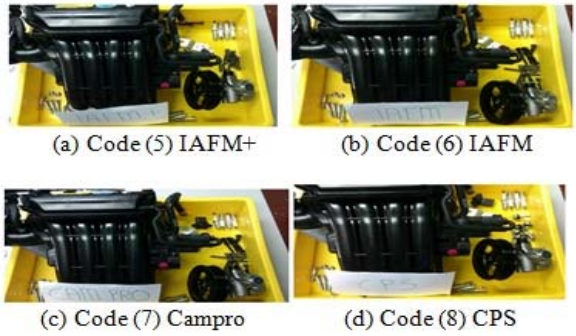

Figure-3. Engine parts variant model; module 2.

The frequency is the percentage of finished products that contain this specific part whereas parts per product mean the amount of a specific part that is needed for the assembly of one particular product. Next, the weight and volume is classified by introducing three levels ranging from light to heavy and small to large parts (nuts, bolts etc.) respectively whereas the identification for common, variant and rare is used to determine the frequency of the parts. The plan order interval is determined by designer based on customer request. Several characteristics are defined such as target plan, number of concurrent picks and space for kit arrangement. Order Picking System (OPS) should be established as well due to existing of two major groups as mentioned by some authors. These groups are complex and rely on many factors; however these two methods as stated above will not be discussed in this study.

RESULTS AND DISCUSSIONS

The following parameter based on weight is determined as shown in Table-1.

Table-1. Parts weight classification based module.

	IAFM [kg]	IAFM+ [kg]	CPS/STD [kg]
Module 1	5.7	7.0	7.7
Module 2	8.3	8.3	8.3

Based on industrial practice, several ranges of parts size from distinguish product parameters is placed in the kit in order to combine into homogeneous product families. For saving cost, foam is used to reserve each parts included in individual place in the kit. This foam is carved based on the parts shape accordingly. This will ensure the parts identify firmly located in the container. The foam fixture secures the parts in order to prevent defect of material to occur. Due to economic reason, weight and strength, the polybox made from plastic is selected as a kit container.

Sequence of the picking parts is established as a procedure to ensure the quality of the parts and time involved during the kitting and feeding process. Potential of damaging the parts is quite high if the handler defies the procedure therefore it is a requirement for assembler to

©2006-2016 Asian Research Publishing Network (ARPN). All rights reserved.

understand and conform to the procedure provided at assembly line. Completed arrangement of parts is finalise and displayed in the kits as a sample as shown in Figure-4 and Figure-5 respectively.

Figure-4. Module 1, completed engine parts variant kit.

Figure-5. Module 2, completed engine parts variant kit.

Nevertheless, further study need to undertake which focus on other variables, for example floor space requirement and costs associated with the design in order to achieve the overall optimum efficiency of the kitting system.

CONCLUSIONS

The design of the kit and method introduced in this paper is the initial step into designing the kitting system. The model is applied to case study data from the automotive industry in mass customization operation. On purpose, the system can eliminated searching time and material handling and improving the production control. At this point, two models named Module 1 and Module 2 have been designed via kitting system based on the advantages of the system in lean production environment. This model offers the opportunity for each engine part variant to adapt with the material supply and handling method that is most cost effective for the overall material delivery system. At the end of the iterations, the solution having the cost-efficient, better parts placement and without damage to the components was chosen.

By using the proposed model, a good design of kitting system can be obtained. In the future work, further validation of the kit design can be carried out to achieved target by performing a trial on the module model and collecting essential data based on analysis and establish the validity of the results in an extensive multiplicity of applications in the industry. On top of that, by obtaining these initial outcomes for certain will provide a beneficial impact for optimizing the production output, cost associated as well as the quality of the products.

REFERENCES

[1] AlGeddawy, T. and ElMaraghy, H. (2012). Product variety management in design and manufacturing: challenges and strategies. In Enabling Manufacturing Competitiveness and Economic Sustainability (pp. 518-523). Springer Berlin Heidelberg.

[2] Boysen, N. and Bock, S. (2011). Scheduling just-in-time part supply for mixed-model assembly lines. European Journal of Operational Research, 211(1), pp. 15-25.

[3] Bozer, Y.A. and McGinnis, L.F. (1992). Kitting versus line stocking: A conceptual framework. International Journal of Production Economics, 28, pp. 1-19.

[4] Caputo, A. C. and Pelagagge, P. M. (2011). A methodology for selecting assembly systems feeding policy. Industrial Management & Data Systems, 111(1), pp. 84-112.

[5] Chryssolouris, G., Papakostas, N. and Mavrikios, D. (2008). A perspective on manufacturing strategy: Produce more with less. CIRP Journal of Manufacturing Science and Technology, 1(1), pp. 45-52.

[6] Cordero, R., Walsh, S. T. and Kirchhoff, B. A. (2005). Motivating performance in innovative manufacturing plants. The Journal of High Technology Management Research, 16(1), pp. 89-99.

[7] Deechongkit, S. and Srinon, R. (2009). Three alternatives of material supply in assembly line: a comparative study. Proceedings of the 10th Asia Pacific Industrial Engineering and Management Systems Conference, Kitakyushu, Japan, pp. 2062-9.

[8] Ding, F. Y. and Puvitharan, B. (1990). Kitting in just-in-time production. Production and Inventory Management Journal, 31(4), 25-28.

[9] De Cuypere, E. and Fiems, D. (2011). Performance evaluation of a kitting process, Proceedings of the 18th International Conference on Analytical and Stochastic Modelling Techniques and Applications, pp. 175–188,

[10] Finnsgård, C., Wänström, C., Medbo, L. and Neumann, W. P. (2011). Impact of materials exposure on assembly workstation performance. International Journal of Production Research, 49(24), 7253-7274.

©2006-2016 Asian Research Publishing Network (ARPN). All rights reserved.

[11] Hanson, R. (2009). On the options available in the design of in-plant materials supply systems, Lic. Chalmers University of Technology, Göteborg. Chalmers Reproservice, Göteborg.

[12] Hanson, R. and Medbo, L. (2012). Kitting and time efficiency in manual assembly. International Journal of Production Research, 50(4), 1115-1125.

[13] Hanson, R., Medbo, L. and Medbo, P. (2012). Assembly station design: a quantitative comparison of the effects of kitting and continuous supply. Journal of Manufacturing Technology Management, 23(3), 315-327.

[14] Hu, S. J., Ko, J., Weyand, L., ElMaraghy, H. A., Lien, T. K., Koren, Y. and Shpitalni, M. (2011). Assembly system design and operations for product variety. CIRP Annals-Manufacturing Technology, 60(2), 715-733.

[15] Hua, S. Y. and Johnson, D. J. (2010). Research issues on factors influencing the choice of kitting versus line stocking. International Journal of Production Research, 48(3), pp. 779-800.

[16] Johansson, B., Johansson, M. (1990). High automated Kitting system for small parts: a case study from the Volvo uddevalla plant. In: Proceedings of the 23rd International Symposium on Automotive Technology and Automation, Vienna, Austria, pp.75-82.

[17] Johansson, M.I. (1991). Kitting Systems for Small Parts in Manual Assembly Systems. In Production Research: Approaching the 21st Century, edited by M. Pridham and C. O'Brien, London: Taylor & Francis, pp. 225–230.

[18] Klampfl, E., Gusikhin, O. and Rossi, G. (2006). Optimization of workcell layouts in a mixed-model assembly line environment. International Journal of Flexible Manufacturing Systems, 17(4), pp. 277-299.

[19] Limère, V., Landeghem, H. V., Goetschalckx, M., Aghezzaf, E. H. and McGinnis, L. F. (2012). Optimising part feeding in the automotive assembly industry: deciding between kitting and line stocking. International Journal of Production Research, 50(15), pp. 4046-4060.

[20] Medbo, L. (2003). Assembly work execution and materials kit functionality in parallel flow assembly systems. International Journal of Industrial Ergonomics, 31(4), 263-281.

[21] Medbo, L. (1999). Materials supply and product descriptions for assembly systems – design and operation, Dissertation, Chalmers University of Technology, Go¨teborg.

[22] Selcuk Kilic, H. and Bulent Durmusoglu, M. (2012). Design of kitting system in lean-based assembly lines. Assembly Automation, 32(3), pp. 226-234.

[23] Sellers, C. J. and S. Y. Nof. (1986). Part kitting in robotic facilities, Material Flow, 3(1-3), pp. 163-174.

[24] Wa¨nstro¨m, C. and Medbo, L. (2009). The impact of materials feeding design on assembly process performance. Journal of Manufacturing Technology Management, Vol. 20 No. 1, pp. 30-51.