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The Manufacturing DMU for Automotive General Assembly

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ABSTRACT – To achieve rapid new car developments and cost saving, new approaches for general automotive assembly in manufacturing are needed. In this paper, CAD and DMU technologies, for design and evaluation of machines and equipment are discussed. Digital Mock-ups based on 3-D CAD models are usually applied in the area of concept design and design review. This paper focuses on manufacturing preparation of machine and equipment, and suggests procedures, examples, and considerations of DMU. By applying DMU to manufacturing preparations of general assembly, time, cost and quality of engineering can be enhanced through engineering collaboration.

1. INTRODUCTION

The market is globalized and customer demands diversify. And then new competitors are entering the market, and global competition is gradually becoming fiercer. In this environment, automobile industry has to reduce product development periods, increase quality, and reduce development, manufacture cost. An automobile company‘s product development, manufacturing preparation business process and manufacturing process represent very complicated and large scale operations. Therefore, press shop, body shop, paint shop, general assembly shop are necessary for optimized manufacturing preparation and manufacturing process as well as verification of product design.[1)] For optimizing process, products and satisfying the demand of customer, extend computer based work environment and achieve engineering collaboration in the product development processes.[2)] Computer base process technology includes CAD(computer-aided design), CAM(computer-aided manufacturing), CAE(computer-aided engineering), simulation and so on. In particular, 3-D CAD is used for the entire car development process.[3)]
DMU that use the 3-D CAD model can achieve design reviews of products, examination of concept design, and examination and correction of various errors, without a prototype. Accordingly, so many research work has been conducted to improve product design quality and reduce the time and cost of the product development process. In particular, for increasing utilization of CAD and PDM systems, K. S. Lee et al. developed DMU systems, and apply to

product development process.[4] Y. H. Jung developed DMU system based on the database for efficient verification of acceptability and interference in the product design process.[5] B. Y. Lee apply DMU to mold production for minimizing the problem through preliminary verification.[6] However, almost researches of DMU are applied to the product design process, especially, on purpose to verify interference between parts and acceptability in the design process. Product design processes performed in the manner of DMU, research of DMU is limited products design phase. However, application of DMU is extended to manufacturing field, especially with products or parts of product design, DMU apply the design of various machines, equipment, jig and fixture, and pallet to preliminary examination, problem analysis and alternative examination in the manufacturing preparation process.

This paper, by using 3-D CAD and manufacturing DMU composed by 3-D CAD, shows methods of various engineering work of machine and equipment in manufacturing preparation processes. In addition, case study of automobile company is introduced. This case is that compare new production with customization of machine and equipment. By applying manufacturing DMU, it is possible that various engineering work, for example, verifying various problems that can occur during the process of production and multi-purpose machine and equipment for producing two types of cars, is performed by digital model on the computer environment. In this paper, the process, consideration and effect are presented by manufacturing DMU.

2. DMU (DIGITAL MOCK-UP)

DMU is replacing prototype as a means to estimate function and feature of new product components for mass production, standing for “Design on the computer, based on the creation and applying a computer model, for final engineering as a real model.[7] That is, by assembly of each part in a virtual space, represented by a computer model, the main purpose is being able to verify and optimize interference between parts and assembling paths.[8] This means that the assembled object is virtually composed on the computer when each part is designed in a solid 3-D model using the CAD system.[5] It also means that cannot only review the features of the product, but also conduct work such as interference and accessibility based on product feature and function as a concept of virtual prototyping.[6] As described above, the DMU mainly applies concept design and design verification, partially applies manufacturing area. However, DMU can be used in product development and manufacturing, particularly in case of an automotive assembly shop, applying necessity is very high in problem previews, in part and product production, countermeasure to mixed production, investigation of part size, workability on weight, material handling problems and so on.

This paper demonstrates the idea of applying production DMU to various kinds of equipment and facilities. Through correct and verified facility and equipment confirmation by DMU, remodelling or regulation is minimized on the spot. In addition, finally the basic model can be

constructed, composing a digital factory, which can implement general simulation, such as a real workshop. The general purpose of production DMU in this paper is the following

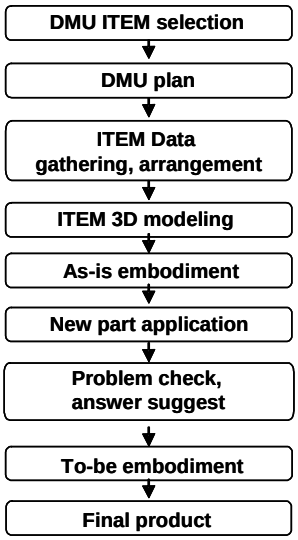
- Reliable preview to concept, design of equipment and facilities
- Reduction of time and frequency for prototype and pilot production
- Easy search and management of the 3-D CAD model
- Procurement and visualization of data for workshop
- Education, training and investigation of the degree of difficulty, risk, and work
- Procurement of basic data for PLM (Product Lifecycle Management)
- Collaboration implementation and communication with partner, customer and so on

3. PRODUCTION DMU TO AUTOMOTIVE ASSEMBLY SHOP

This chapter presents DMU for constructed domestic Automotive Assembly Shop production. In an assembly shop, through a chain of process, various kinds of parts are assembled on the chassis, and the automobile is completed; in addition, the majority of work is done by hand. Generally, in the case of mixed-model production of two kinds of car, there are approximately 300 work stations in a shop, and more than about 300 workers assemble 2,000 parts.[1)] Equipment and facilities used in an assembly shop assists workers, and when a new car model is inputted or new parts cause design change, development of new equipment and facility or adaptation of existing equipment and facility is required. In order to verify various kinds of alternatives and to investigate the result in this process of decision making, DMU tools and 3-D CAD models are used. It is possible to investigate part, equipment and facility, through visualization and verification of work using DMU S/W, and modelling of equipment using 3-D CAD, therefore, a clear plan can be established by procuring the data required for adaptation and new development. In general, the steps of DMU implementation can be regulated in the following way. Following this step, it can be visualized equipment and facility, various engineering can be implemented on the 3-D DMU environment.

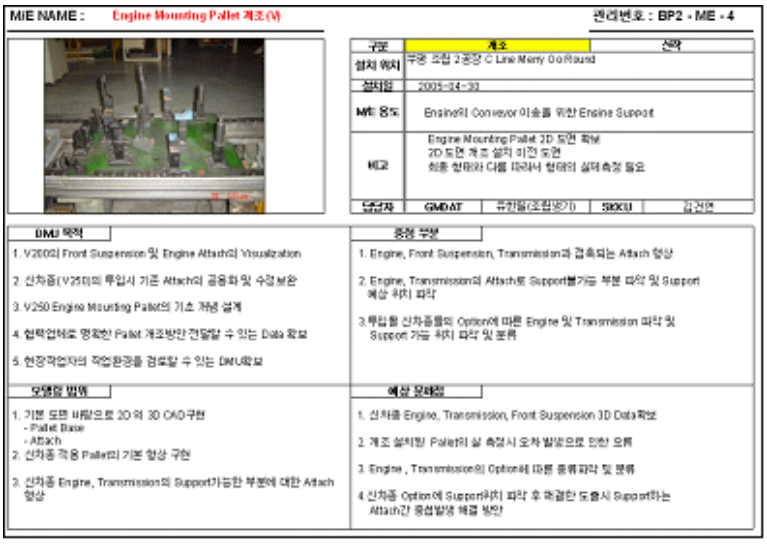
1) Data gathering through analysis of existing 2D drawing, actual survey and so on
2) Modelling equipment and facility using 3-D CAD
3) United construction between product DMU and production DMU using 3-D DMU S/W
4) Visualization and DMU implementation

When the way of DMU implementation is determined, a detail plan should be established for DMU processing. The process steps of production DMU, including implementation, are Fig. 1



<Fig. 1> DMU Process

DMU implementation starts on the selection of the DMU item and plan establishment, leading to the gathering of basic data. In DMU item selection, it is selected as the order of following: (1) equipment for applying new car model (2) equipment for adapting for next time. In DMU plan establishment, DMU plan implementation is established in detail for each step, including the purpose of implementation, detail level of 3-D CAD modelling and so on. In the step of DMU data gathering and arrangement, after examine drawing of target item , if drawing is existing, after analyze reliability through comparison between real target item and drawing, modelling is performed based on drawing. The other case, 3-D CAD modelling is performed based on acquired data that feature measured. In a step of implementation of the as-is model, the as-is model is implemented by defining a clear purpose and scope. The problem is grasped by applying a new part, based on an as-is model, and alternatives are verified. Finally, the order composing the to-be model is implemented as a new or adapting alternative, DMU. Fig. 2 is an example, written for defining clear purpose and scope for each item.



<Fig. 2> A sample of DMU Sheet

4. PRODUCTION DMU IMPLEMENTATION CASE

In this paper, a case of DMU implementation is shown about the pallet for an engine construction line, which is one of the DMU items. It fixes the engine on the assembly process, and moves the engine; in addition, if needed, it uses equipment as an assembly jig. It uses different engines and transmissions according to displacement volume, fuel and selling area, even for the same type of automobile. In the case of mixed production, a new type of automobile is added in a line, the targets' number of types of engines and transmissions increases. A bracket feature on pallet is applied differently to support each kind. However, actually, it is very difficult make all kinds of bracket of pallet, and it is not acceptable for a present production line. Therefore, to solve this problem, engineers examine the commonness of equipment. In equipment, the commonness of methods is applied to all kinds of product lists. The first is to customized existing pallet, and the second is making a new pallet for various kinds of engines and transmissions. In this paper, compare the customized pallet and a new pallet is made for the mounting operation of the engine is compared and examined, According to this result, this paper shows how to approach the concept of customizing verification, creating new pallet, and forming commonness planning.

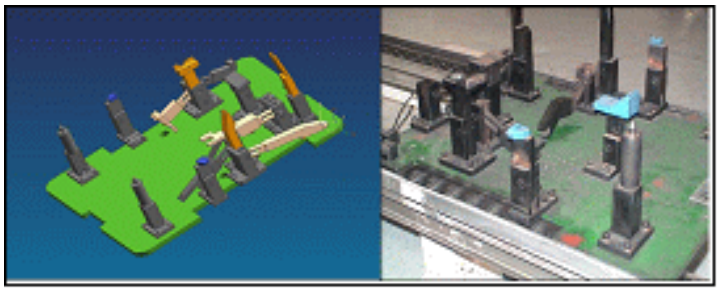
4.1 Case of production DMU implementation, customizing

In DMU implementation, engine mount pallet, are the final process used for equipment to assemble engines and transmissions on a frame. It suffers from the limitation that is attaches a set on the basis of coordinate information of each automobile component and angle assembled on a frame. First, according to the business process in Fig. 1, characteristics of these include the items and details of the pallet, and the design step. Then, the base data of pallet is collected.

The following is collected base data.

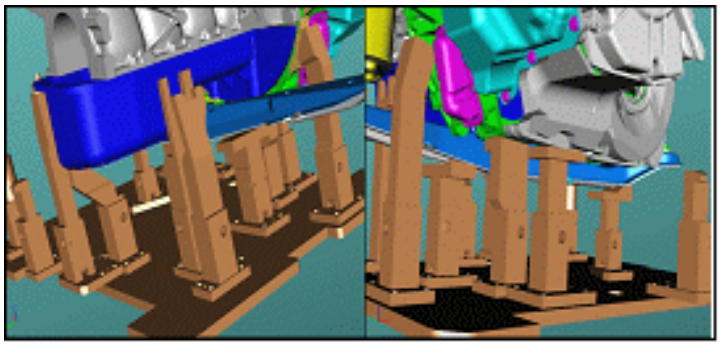
1. Design
   - Present design by 2-dimensions
2. Compare real items with drawing of item
   - Check the part feature which modified on-site with initial design
   - Measure dimension of modified parts
3. Data of item features
4. 3-D CAD model of engine
5. Data of components about pallet by 3-dimensions

Like Fig. 3, according to designed important parts in advance and detail designs, based on data collected in the process of collecting base data of pallet, the present pallet are modelled.



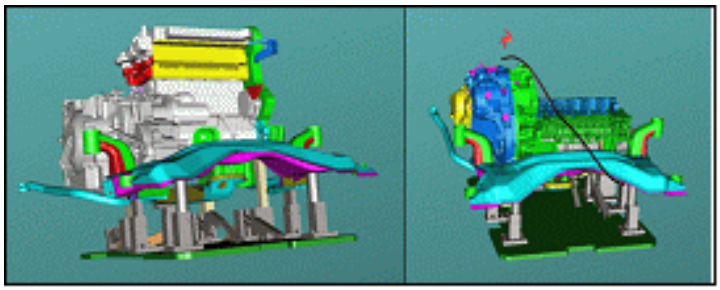
<Fig. 3> The Item and its'3-D DMU Model

Like Fig. 4, the present as-is model applied to DMU is embodied based on collected data and embodied 3-D CAD models.

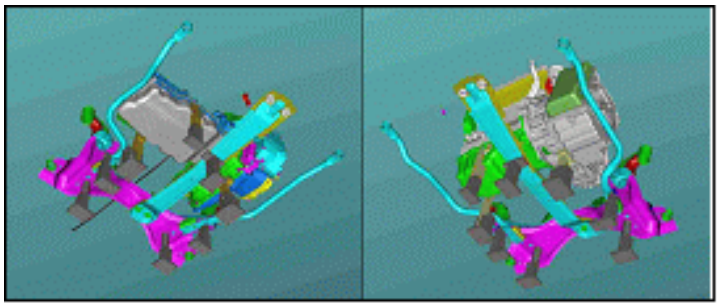


<Fig. 4> Supporting Areas of the DMU Item

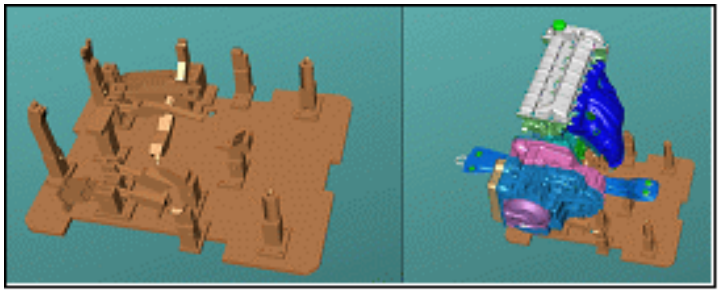
Fig. 5 has embodied the present as-is model. Next step, a combination of power train about next new automobile models is applied to the present as-is model. Fig. 6 shows the potential problems such as parts resulting in interference through checking various alternatives and defined limitations. The model can be used various alternatives of modification plan of pallet , such as available parts, expected customized parts, and new attachments. Fig. 7 presents customized pallet feature and to-be models based on verified results given from the DMU.



<Fig. 5> As-is model of the DMU item



<Fig. 6> Applying new part



<Fig. 7> To-be model of the DMU item(final design)

4.2 Applying Manufacturing DMU, In Case of new production

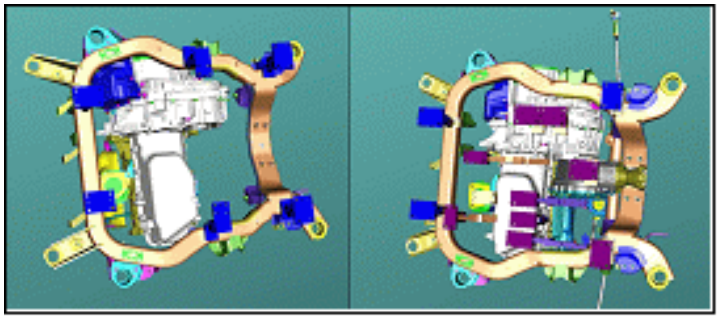
In case of the scope of remodelling is very large, or using remodelling machine and equipment use makes it difficult in work, making new machine and equipment is more efficient than remodelling machine and equipment. Therefore, basic data are collected as follows.

- Engine 3-D CAD Model Data
- Engine, Transmission Combine Data
- Relate Part Data Without Engine, Transmission Part
- Engine, Transmission, Relate Part Assembly Sequence
- Machine Appling Part

<Fig. 8> Initial attach design of the DMU item

Based on collecting basic data, generate basic attach and base plate. Fig.8 shows preparing components before mounted engine and transmission, and conceptual design of attach and mounting location based on component. And then, by applying engine and transmission data,

examining and analyze as in Fig.9. Through examination and analysis, generate new attach that considers interference part, engine, transmission and assembly conditions.



<Fig. 9> Adding attaches to initial DMU model

Through this process makes conceptual design of new attach, Fig. 10 shows the case of a completed new pallet through this process and application.

4.3 Compare Remodelling Case and New Manufacture Case

Through actual applying example of DMU, remodelling and new manufacture have suitability verification differences for actual manufacture application. This occurs in the case of remodelling existing machines and equipment. However, in case of new manufacture, suitability must be verified through collaborate and expert engineers for manufacturing environment situation, assembly sequence, machine operation condition, and so on. The new model can be applied to actual manufacturing situations.
Table.1 shows a comparison of remodelling and new manufacture in terms of the importance of main consideration factors and each manufacturing DMU factor.

Table. 1 Major considerations for Manufacturing DMU

	Modify	New
Purpose and Main Part Choice	1 2 3 4 (5)	1 2 3 4 (5)
Modeling Scope	1 2 (3) 4 5	1 (2) 3 4 5
Modeling Detail Drawing	1 2 3 (4) 5	1 2 (3) 4 5
Drawing Information	1 2 3 4 (5)	N/A
Actual Measurement Data	1 2 3 4 (5)	N/A
Machine, Equipment Feature Picture	1 2 (3) 4 5	N/A
Part Data Accuracy	1 2 3 4 (5)	1 2 3 4 (5)
Limit Item Information	1 2 (3) 4 5	1 2 3 4 (5)

* 1:very low, 2:low, 3:normal, 4:high, 5:very high

In Table. 1, the importance gap about each factor is found in the early plan part and basic data collecting from the DMU process of remodelling and new manufacture. ‘Purpose and Main Part Choice’ eliminated unnecessary work in the DMU process from examining the main part grasp from object item before the DMU process. ‘Modelling scope’ is influenced by ‘Purpose and Main Part Choice’, so that is decides examination of object scope. (For instance, object scopes define only machine and equipment or structure operating environment for related machines and equipment, and examines a part or whole model of machine and equipment). In particular, the case remodelling considers other related machines and equipment. Depending on product scope, much time can be lost and a cost gap occurs. ‘Modelling Detail Drawing’ is the definition model detail level in the modelling stage. The main part contains detailed expressions and other parts express the simple features and main dimensions of the defined modelling scope. Generally, in the case of new manufacture, it is important to apply the design of actual manufacturing machines and equipment. Detail modelling requires less than remodelling. ‘Drawing Information’, ‘Actual Measurement Information’ and ‘Feature Picture’ are 3-D CAD modelling of basic machine and equipment data. New manufacture can refer to drawing and feature pictures of similar machines and equipment, but this importance is very small. ‘Part Data’ refers to related parts of CAD data, such as car, engine, and so on. In the case of imprecise part data, it is difficult to enforce precise DMU application. Assembly work operating in a car assembly factory is conducted through the same features and must consider assembly angle and position through process, and work methods. If not through DMU, precise remodelling examining new manufacture is difficult. In case of remodelling of machine and equipment, ‘Restricts’ is reflected conditions of existing machine and equipment. However, another case of making new machine and equipment, it is reflected in all processes, so degree of importance and reflection differs from remodelling case.

4.4 Production DMU application result and effect

In this paper, DMU to 24 reengineering is applied to 4 new products, shown on table 2. The following are the obtained results and effects.

Table. 2 List of DMU items

Category	Modify	New
Hanger part	4	-
Pallet part	8	3
Manipulator part	5	-
Loader part	5	1
Other equipments	2	-

(1) Visualization. Digital modelling

Visualization based on parts data, equipment and 3-D CAD data of facilities is obtained by applying DMU in the progress of production preparation. Hence, engineering operation is changed by visualization based on computer environment, previously performed by a 2D map and real equipment.

(2) Implementing digital engineering

By using a digital model of equipment and facility on the computer environment, the various decision making and planning process can be implemented. With computer environment, requested in reengineering and new production, and examine many different alternatives are implemented in the manner of collaboration engineering. The method of high reliable reengineering and the idea designing of new manufacture, is developed as engineers set many-sided alternatives up and verify preliminarily problems that could occur on the step of real applied production of equipment and facility. And without limitation of time, space, size and weight, engineering work reduce man-hours. In other words, without additional limitations, it is possible to more easily deal with a model of equipment, facilities and new parts, implement engineering in a computer environment.
For instance, by applying manufacturing DMU to Loader which drawing data does not exist, through using part data and applying the 3-D CAD model, the discordance problem of bracket shape and the Grip of a new part can be found. Design period of a bracket remodelling feature take months before applying manufacturing DMU, but after applying DMU, it takes only 20 days. By using manufacturing DMU, the range of remodelling can develop an optimized design and plan, minimized operation and reduce costs and time

(3) Designing-production, achieving cooperative work with cooperate company

By using digital model of machine and equipment, it can share and delivery design information. In additional it can cooperate with partner companies based on digital model. For example, before applying DMU, only basic concepts data of pallet deliver company which is related production of pallet. However, after applying DMU, it has been able to transmit the detailed ordered data for partner companies. In making the proposal of concept design by DMU, position, number and size data of attach are obtained. In particular, based on idea proposal by DMU, given in the example, help transmit precise new proposals to partner companies, and make a base model with detailed shape pallet.

(4) Database construction and model practical use of another thing class

If integration database for equipment is constructed for presenting the effect in front, when establishing item and new manufacture inside similarity equipment, continuous application is

made possible. In addition, a base that can inflect data such as equipment data, product and parts data, process data, can be used to construct data for line simulation, traffic line analysis and so on. This makes it possible to formulate process design and product line.
Through in various production DMU applications, reliable layout of new manufacture and reconstruction, plan establishment and examination of equipment are made available. It is confirmed that this can reduce greatly time and expense greater than the cost of design, examination, order, manufacture and so on.

5. CONCLUSION

This research focuses in the automobile assembly plant. This research applies managed production preparation businesses, before new car is applied, as an example of a digital manufacturing technique. DMU is applied in the design phase of products and is applied in the sacred ground of adaptation or interference between parts. This implies DMU is for equipment used in production preparation phases. This paper introduced the application method and an instance of production DMU. In addition, it divides the difference of reconstruction and new manufacture for progress process and production DMU. This establishes a fundamental concept and plan against reorganization and new production when this process is applied in new parts. The object computer, securing the base technology and the data which can distribute clear reorganization and a new production plan, can formulate the final engineering achievement process.
In this paper, the productive DMU model for constructed equipment has become the necessary fundamental data for constructing a digital assembly plant as a base for digital manufacturing technique application. Ultimately, this becomes the base for constructing the reliable digital assembly plant. In addition, this can communicate with the cooperative enterprises and customers designing production using DMU. Through this, clear data can be found for manufacturing equipment. The construct production DMU database can be found and becomes the foundation for achieving knowledge share and administration of applied new regulation and reconstruction methods.

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