DEVELOPMENT OF INTEGRATED PRODUCT MODEL FOR SUPPORTING PRODUCTION MONITORING SYSTEM ON AN AUTOMOBILE ASSEMBLY INDUSTRY

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Abstract

Making a good production planning is a first step to produce products in effective and efficient ways. A good production planning needs information about the real conditions in the shop-floor. Without knowing the actual conditions in the shop-floor, it will be difficult to plan production well. In order to know the conditions of the shop-floor, a production monitoring system is needed. This paper deals with development of integrated product model for supporting production monitoring system on an automobile assembly industry.

The integration of information between the production controls with the shop-floor is needed to build a production monitoring system. One way to integrate the two systems is by using a product model that is a representation of a real product. In general, the research method used in this research is the development of product models and other related models. The modelling concept used in this research is object oriented modelling. After that, this research also has developed a database in accordance with the developed models and interfaces used to manipulate them.

The main proposed models in this research are the product type model and the product model. The product type model is the product model that represents the product designs. On the other hand, the product model is a model that represents the actual products. If the data on the product type model is relatively static, then the data on the product model is dynamic depending on the state of the real product. Each product model will have production sequence processes in accordance with the sequence processes of the represented product. Each time a process of real product is finished, and then the related process model in the product model will be updated. The condition of the processes that has occurred in the shop-floor will be known by manipulating data of the product models.

***Keywords**: integrated product data model, production monitoring system, production information system, automobile assembly industry*

1. Introduction

Everything in the world basically has a life cycle. A product also has a product life cycle. Roughly, Züst and Wagner [1] divide stages of the product life cycle into four stages agree with time function, namely (1) Product development, (2) Production, (3) Product usage, and (4) Product disposal and product recycle.

A product development stage can be divided into more detail phases that are a research and development phase and a product design phase. Furthermore, a production stage also can be divided into more detail phases that are a process planning phase, a production planning phase, and a production phase. On the other hands, in the product life cycle there are two streams, the first one is flow of a physical material, and the second one is flow of information.

Mierzejewska [2] declares that the material flow is affected by the information flow. Bottle neck at information flow will give also a bottle neck at the material flow. In order the information as long as the product life cycle to flow with fluently, the integration all phases in the product life cycle are needed. System integration enables to avoid the duplication of data and the missing of information caused by conversion process [3].

Generally, production processes in the automobile assembly industry include a welding process, a painting process, and a trimming process [4]. Welding process area and painting process area, generally, to process more than one type of vehicle, whereas the trimming area usually only to process one type of vehicle only. Those three process areas have different characteristic each other. In order to bridging the different, usually between two process areas there is a buffer. Buffers can be found in between welding process area with painting process area, and between painting area with trimming area.

In the real condition, not all production conditions are matching with generated production planning. Not appropriate conditions can cause the delay of product delivery to the customer. In order to avoid not appropriate conditions the buffer stocks are needed in production line. Uncertainty or dynamic condition in production can be reduced if there is good communication among phases. Too many stocks in the buffer are not good-situation.

Suzaki said [5], the high stock in the buffer can cover real problems in production. If problems in production are covered, the effort to make a better system will be more difficult to be done. On the other hands, stocks are capital goods. More stocks that have to be handled higher production cost that has to be paid.

In order to know the problem at shop-floor, the real condition of shop-floor has to be monitored. There is a need to connect the real condition of shop-floor with the production control system. A problem statement of this research is, how to integrate shop-floor with the production control system, with the result that production monitoring system can be developed.

2. Problem Solution Approach

There are many approaches to integrate the existing system. One of them is the integration through the product model [6][7]. The reason background is because to produce automobile (product) is the focus of the production process. So overall activities in the production systems starts from the research and development until the process related to the end phase of the life time of product, are focused to the information of the product.

Consequence of the overall process is focused to the product, it is reasonable if the product has most complete information about processes that are occurring on its life cycle. Information needed at each phase of products' life cycle such as, a material requirement (bill of materials) to make a product, which part of a product that able to be recycled or reused, can be extracted from product information. If the required information cannot be extracted directly from product information, at least the information contained at the product information can be used as starting information to get more complex information. As example, production cost of a product can be calculated based on the overall cost of operations which are carried out on the product.

To store information into the product is relatively difficult to be done cause by technical reason, instead information of product ID and production time. In order to solve this condition, the approach that was used in this research is by using modelling technique to construct a product model as a system integrator to represent product information. This product model will keep all information of the real product to be modelled as long as its life cycle. Each change that is occurring at the real product, that information will be used as a trigger to update the information of its product model. The approach to use product model as a system integrator is the focus of this research (see Fig. 1).

3. Developed Product Model

In the automobile assembly industries, the main input to carry out production process is an installation drawing. The installation drawing is not direct useable information for production. As shown at Fig. 2, there are several stages that have to be passed through in order to have production information from the installation drawing.

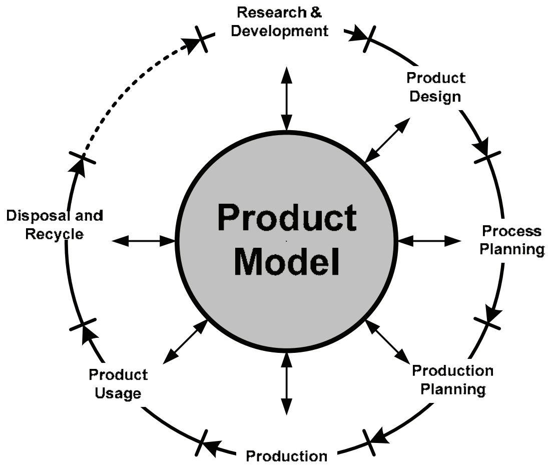

Fig. 1. Product model as a system integrator

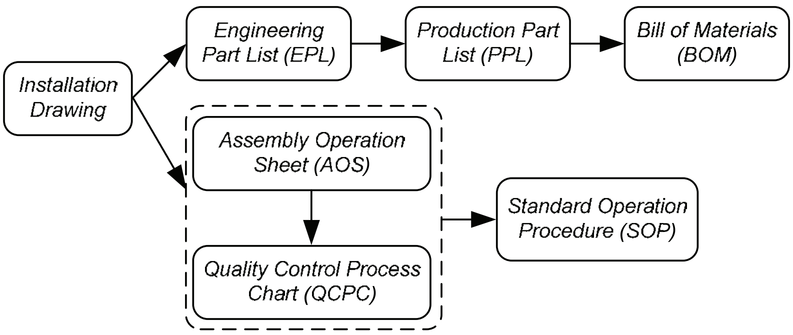

Fig. 2. Engineering processing in utilizing product installation drawing

In general, the process to obtain information for production from the installation drawing is divided into two streams, a first stream is to catch the information about a material requirement, second one is to plan a production process. Information about a requirement of material is needed to prepare the material that will be processed. A production process planning is needed as guidance to do production processes to the material to make a product.

In automobile assembly industries, the production process planning which is generated based on the installation drawing usually called as an Assembly Operation Sheet (AOS). Even the assembly word is used, AOS not only contains trimming and welding processes, but also contains painting process. AOS also only contain one alterative from many other alternatives to produce products. In order to complete the AOS, the Quality Control Process Chart is also published to be a guidance to control the quality of process to be done.

Unfortunately, AOS that had been extracted from the installation drawing is not ready yet to be used in production by operator. The reason is because AOS only contains a process sequence in general and do not detail yet the operation sequence in the form which are ready to be done. The other reason is the realization at a shop, there are assembly operations that need more than one work station to finish the job. At this matter, AOS did not divide that process to be part of process which ready to distribute to the work station. To avoid that matter, AOS do together with QCPC have to translate to be a standard operation procedure (SOP). Furthermore, SOP is brought to the work station to be done.

3.1. Product Structure Model

Structure Model constitutes a model to show a structure of component to construct a complete vehicle product. Structure model is a representation of EPL. As shown at Fig. 3, one variant of vehicle only has one product structure model. As an addition, theoretically there is unlimited depth of structure model, so can be utilized in modelling of a product with uncertain of depth in its structure.

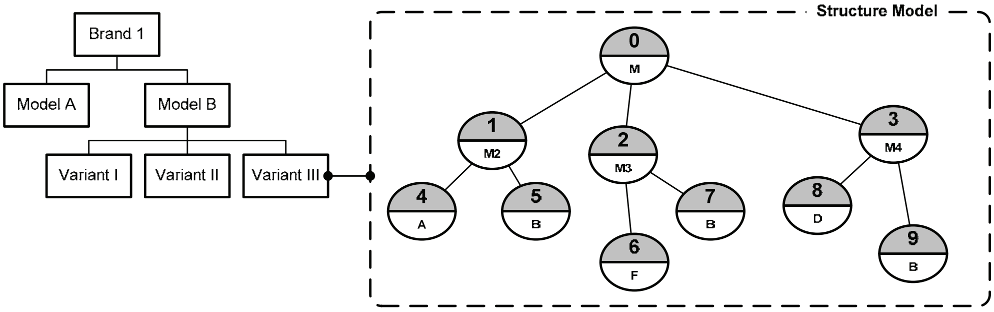

Fig. 3. Model of product structure

3.2. Model of Assembly Operation Sheet (AOS)

At this research, process sequence (AOS) was modelled as a process model. For a certain product structure configuration will ably to give more than one production process sequence model. For the reason of simplicity, product model at this research only has the best one of the process sequence models. On the other hands, process types that can be modelled not only a welding process, painting process, and trimming process but also includes buffering process, repair, transportation, and inspection (see Fig. 4).

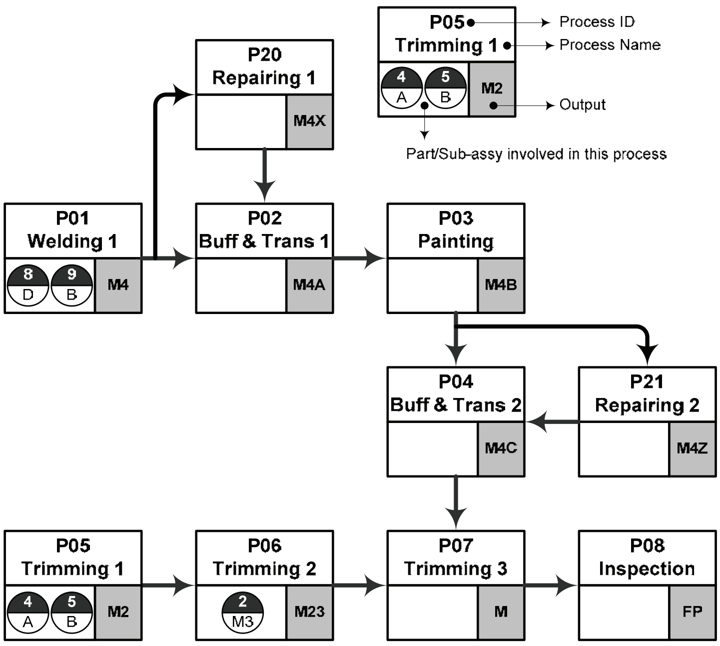

Fig. 4. Model of process which shows sequence of production process

Each node of that process sequence model constitutes a representation of one step of process to be passed through by the product. Each node contains information of a process name and its ID, a process output, and component and sub-assay that is related with that process. The material involved at that process was extracted from product structure model. As example, process P05 has a name Trimming 1. Material involved at this process are A and B which are extracted from node 4 and 5 at product structure model. Furthermore, when process P05 successfully is done, so this process will produce a sub-assay M2.

3.2. SOP Model

SOP model is a model to represent a standard procedure to carry out operations at shop-floor. SOP model includes information about job sequence, standard times to be needed to carry out all defined jobs, and operator qualification and its number. In general, process model able to has more than one SOP model. The number of SOP model is based on the requirement, such as cycle time constraint, or there is impossible to finish a process all at once, etc. The relation among SOP models with production process sequence models is shown completely at Fig. 5.

3.3. Mapping of SOP Model

After SOP model was successfully developed, the next step is to map each existing standard operation procedure to production unit model. The mapping process, is basically activity to design the production unit configuration that will be used in production. By this mapping, each work station at a production unit will receive a task to carry out certain production process which is explained as a process sequence. In addition to a process sequence, the other information that can be catch from mapping activity is the operators' qualification and its number, the standard time to be needed to realize that mandatory process, the required tools, and the supplied material to each work station (see Fig. 6).

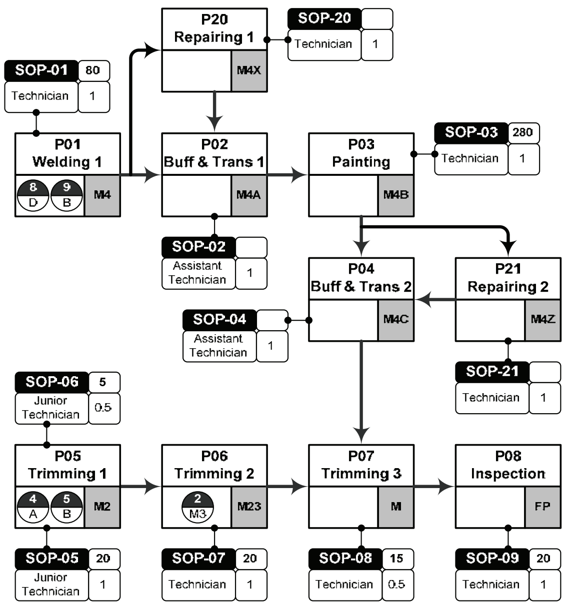

Fig. 5. Relation among SOP model with production process sequences

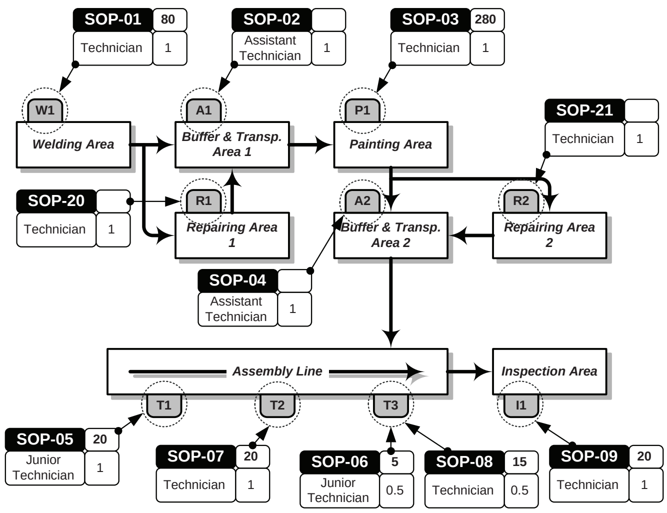

Fig. 6. Mapping of standard operation procedure to a production unit

When each standard operation procedure has finished to be mapped to work stations, so for each vehicle model automatically will be achieved the relation among standard operation procedures with work stations. Each changing on that mapping will give a new relational model as a result (see Fig. 7).

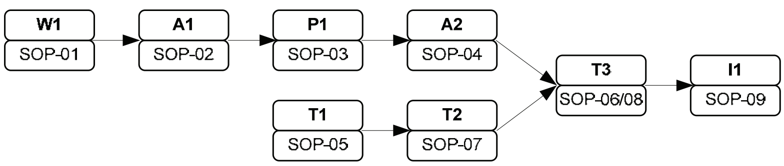

Fig. 7. Model of standard operation procedure – work station relation

4. Production Monitoring System Development

The first step in the development of production monitoring system is to plan location and number of monitoring points. In general the location and the number of monitoring points are based on the requirement. The requirements are maybe to know the condition of a starting point of assembly process, to know the number of sub-assay located at a certain storage area and to know the number of products has been manufactured. The example of monitoring point location planning is shown at Fig. 8.

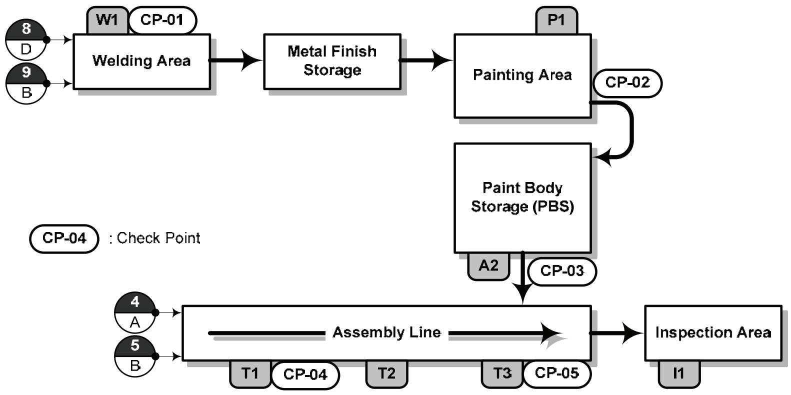

Fig. 8. An example of the monitoring point location design

The configuration of monitoring point location planning as shown at Fig.8 will give some benefits as follow:

1) Point CP-01 and CP-02 are used to determine all sub-assays between the welding area and painting area that is all sub-assay located at finished metal storage.
2) Point CP-02 and CP-03 are used to determine sub-assay is temporary stored at painted body storage (PBS).
3) Point CP-04 and CP-05 are used to determine sub-assay at the assembly line.
4) Point CP-05 is used to determine finish products which leave the assembly line.

Point CP-01 is used to update the product model operation data related to the W1 station. Point CP-02 is used to update the product model operation data related to the P1 station. Furthermore, CP-03, CP-04, and CP-05 are used to update the product model operation data related to A2 station, T1 station, and T3 station respectively.

Basically the construction of product model by stages method is always being done at a start point of monitoring. Constructed model is sub-product model that is the model represents the sequence of processes that will be done on the real product object. The complete combination of that sub-model will construct the product model. By using the configuration as be shown at Fig. 8, the starting point of product model construction will happen at point CP-01 and CP-04. The next monitoring points will produce the related sub-product model. An initialization mechanism of product model construction at a starting point of monitoring, as an example is monitoring point CP-01, is noticed at Fig. 9. Based on Fig. 9, the initializations mechanism in product model development are as follows:

1) An operator at the monitoring point CP-01 identifies model and variant of the sub-assay that has been done. After that, this data which includes operator ID, work station ID, and finishing time of operation at W1, sent to the server.
2) By using the work station ID and model and variant sent by CP-01, the server will search a relational model of standard operation procedure with the appropriate work station.
3) After a correct model was found, furthermore a standard operation procedure model for that station is searched.

4) If the appropriate standard operation procedure model was found, the next step is sending that model to the server.
5) After a server receives that standard operation procedure model, the next step is to develop sub-product model which includes information notice at Fig. 9. At the developed system, product model ID and sub-assay ID was developed unique for all products that ever made.
6) To send a generated sub-assay ID to an ID printing machine.
7) To adhere that sub-assay ID to the real sub-assay object at the shop floor as its identity.

Whereas the development mechanism of sub-product model for the other monitoring points, except the monitoring start point, is noticed at Fig. 10. Based on the Fig. 10, the mechanisms are as follows:

1) A monitoring system at CP-02 reads the ID of the sub-assay and then to send the sub-assay ID, an operator ID, a work station ID, and the finishing time of operation to the server.
2) By using sub-assay ID, the server searches the sub-product model has that sub-assay ID.
3) Searching is done by using the sent sub-assay ID.
4) When the sub-model was found, furthermore based on that sub-model, product model and its variants are searched and sent to the server.
5) Based on the model information, the variant, and the work station ID, the appropriate standard operation procedure of the work station was searched.
6) When the model was found, the model included with the model for the prior operation, will be sent back to the server. As an example, if the searched model was (SOP-03)(P1), in addition to (SOP-03)(P1), (SOP-02)(A1) and (SOP-03)(P1) will be sent to the server.
7) Found work station's standard operation procedure model is used to develop sub-product model between X3 and X1.

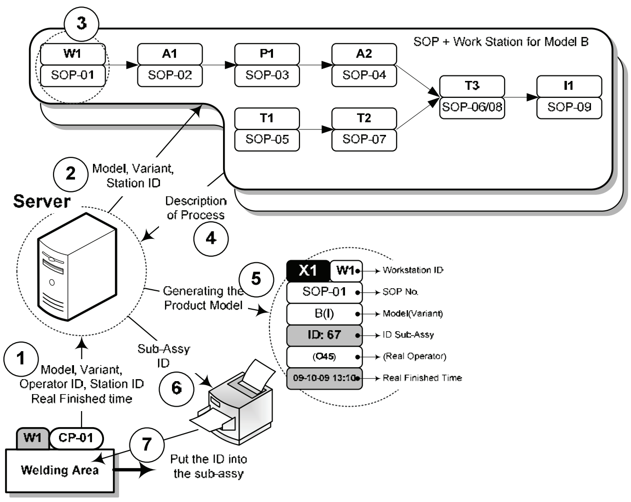

Fig. 9. An initialization mechanism at the product model construction

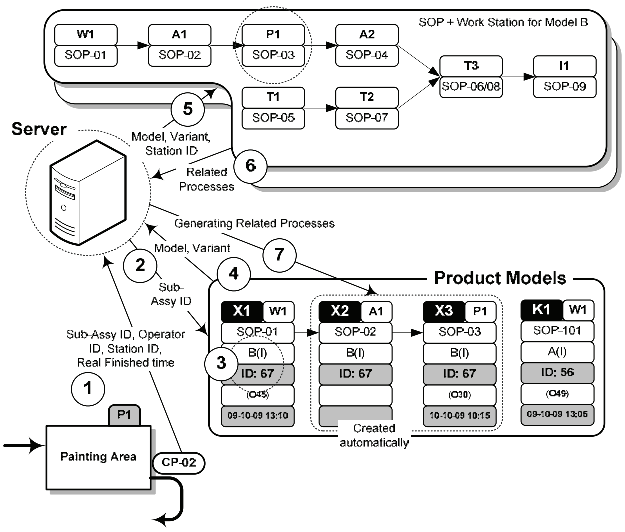

Fig. 10. Development of sub-model of a product at monitoring point CP-02

After product model had been constructed, the next step is to translate the collected information. As example, after monitoring processes was done, the information such as noticed at Fig. 11 was found. While at Fig. 12, the position of sub-assay or product at shop-floor was shown.

5. Conclusion

In order to production monitoring system development, product model that had been designed enable to produce information that can be used as a basis to trace which operation from which product and to fulfil to which order. In another side, the scheduling system implemented at the industry that has been chose as an object of this research was not giving enough functions in supporting a product tracing and it's a related order. A product model just only includes the information about which operation of which product.

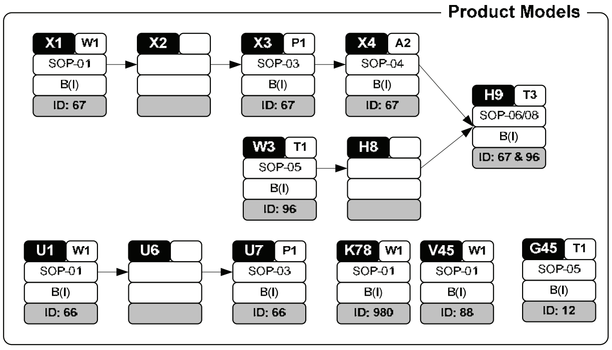

Fig. 11. Example of product model after monitoring

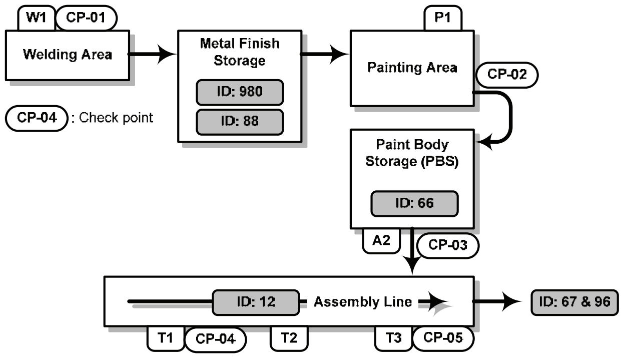

Fig. 12. A Monitoring result based on existing product model data

The developed product model can be used also to calculate the number of materials that has been used at a certain work station. Basically each operation executed at a certain work station involves material needed be side operators and tools. After finish with a certain operation at a certain work station, the number of materials will decrease in appropriate with the number of material required by that operation. So the calculation of the total material that had been used at the production unit at a certain span of time can be done by identification all operations that had been finished at that span of time and the material used by those operations.

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