http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (16): 3798-3803, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.3798.3803

Space Based Multi-level Process Flow and Logistics Analysis

[1]Zhou Qiu-Zhong, [1]Ning Guo-Liang and [2]Xu Wan-Hong
[1]School of Automotive and Transportation, Shenyang Ligong University, Liaoning, 110159, Shenyang, China
[2]Zhejiang Wanliyang Transmission Co., Ltd., Zhejiang, 321000, Jinhua, China

Abstract: In order to thoroughly promote the enterprise digital construction and meet the demand of production management, the space based multi-level process data organization model has been put forward. Firstly, according to the practical division situation of enterprise production space, the multi-level organization method of production space has been proposed. Then through analyzing the manufacturing process of the products in different space layers, the space based multi-level process flow idea has been presented. At the same time, the mathematical model and formalized expression of multi-level technological process have been established. Finally, the in-output material flow relationship between different levels process flow units has been analyzed and the source of input object as well as the disposition of the output object of various level process flow units has been put into detailed analysis. At the mean time, particular statistical sum and trace arithmetic are provided so as to profoundly illustrate the essence of manufacturing process in theory. As a result, the models proposed in this study are not only express the manufacturing process flow of the product in an intuitive and clear way, but also satisfy all types of demands of production management.

Key words: Production space, multi-level process flow, logistics, statistic algorithm

INTRODUCTION

Process data, especially the assembly process data of complex product, is the key to realize information integration between each department of the enterprise and the important basis of carrying on production management (Li *et al*., 2008; Liu and Cao, 2005; Xu and Wang, 2011). As a result, how to effectively organize process data becomes the research focus. In the organization model of process data, the complete manufacturing process flow of the product should be intuitively and clearly reflected and the successive ordinal relation as well as the in-output component objects of different process units should be confirmed to provide complete information for production planning and production schedule operation.

In the present research work, there are two major methods towards the organization and management of process data: one is integrated by product structure BOM (Li *et al*., 2008; Liu and Cao, 2005; Liu *et al*., 2002; Wu *et al*., 2009; Xu and Wang, 2011); the other is through BOP management mode in unit of JOB (Xu *et al*., 2005; Zhou and Fan, 2008). However, these organization and management methods cannot satisfy the needs of production management which becomes the choke point of developing enterprise digital technology. Thus, this study puts forward the thought of space based multi-level technological process with the reference of research achievements at home and abroad, so as to provide technical base for solving the comprehensive application problem of process data.

MULTI-LEVEL ORGANIZATIONS OF PRODUCTION SPACE

The production of mechanical products organizes in various workshops. According to the component types, the production workshops consist of assembly shop, metal plate shop, machining workshop, milling workshop and casting shop, material preparation shop and so on. According to different size of production lot, component shop can be divided and arranged in terms of technology professional principle which gather equipments of one type to form different working capability centers, or product object principle which come into being the production line. It is organized with assembling line in

Corresponding Author: Zhou Qiu-Zhong, School of Automotive and Transportation, Shenyang Ligong University, Liaoning, 110159, Shenyang, China

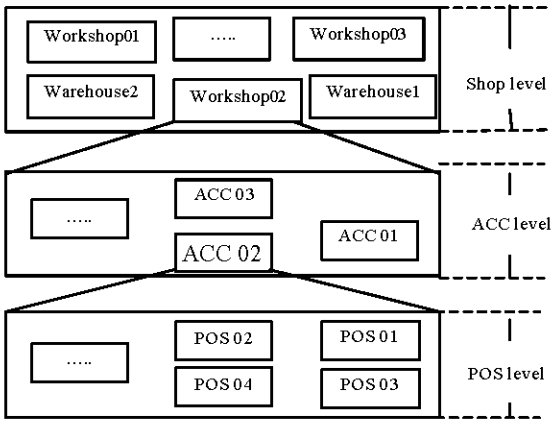

Fig. 1: Multi-level production space organization

assembly shop towards different products. These working capability centers and production lines are all gathered in certain area of the workshop called accommodation (ACC). The specific location occupied by different process or technological equipments within the ACC is called positions (POS). As a result, the production space of any enterprise can precede organization according to the three layers spaces, namely, the workshop, ACC and POS as shown in Fig. 1.

Supposing SP_m is used to represent the production space of the m layer and SPU^i_m is employed to represent number i production space unit of layer m, thus, the relationship between production space and space unit can be expressed in the following way:

$$SP_m = \left\{SPU^1_m, SPU^2_m, ..., SPU^n_m\right\}$$

Among which:

$$m = \begin{cases} 1, workshiplevel; \\ 2, ACClevel; \\ 3, POSlevel; \end{cases}$$

Upper and lower layer space unit exist inclusion relation which can be expressed as following:

$$SPU^i_m = \left\{SPU^1_{m+1}, SPU^2_{m+1}, ..., SPU^N_{m+1}\right\},\ m \in \{1, 2\}$$

MULTI-LEVEL PROCESS FLOW

In present product manufacturing model, component manufacturing and product assembly work of different product objects are carried on in various workshops, such as general assembly shop, subassembly shop, component

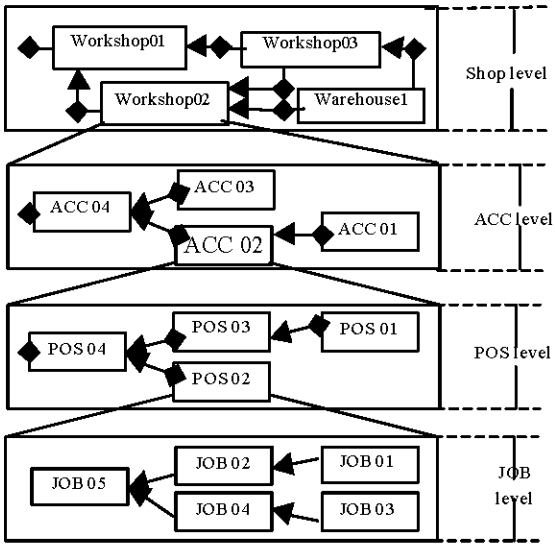

Fig. 2: Multilevel process flow

workshop, warehouse and so on. So workshop layer manufacturing process comes into being according to the flow relation between different workshops. Inside the workshop, the production work of accessory objects is fulfilled through different ACC and POS in a certain order, so as to form the ACC and POS technological process. JOB is the most basic organization unit of the process and composed of steps which are the specific operational order to guide the skilled workers to finish the actual manufacturing work. According to the front and back ordinal relation of each working procedure, the JOB flow takes shape. So the multi-level process flow which is composed by workshop, ACC, POS, JOB comes into being as shown in Fig. 2.

If $PF_m(Prod\text{-}Out^i_m)$ is used to represent the process flow of number m layer of the production object $Prod\text{-}Out^i_m$ while $PFU^{i,j}_m$ represents the number i process flow unit of the layer m which take the afterwards process flow unit number j, so the process flow of workshop, ACC, POS and JOB layer can be expressed as the following:

$$PF_m\left(Prod - Out_m\right) = \left\{PFU^{1,2}_m, PFU^{2,3}_m, ..., PFU^{i,j}_m ..., PFU^{I,*}_m\right\}$$

Among which:

$$m = \begin{cases} 1, workshiplevel \\ 2, ACClevel \\ 3, POSlevel \\ 4, JOBlevel \end{cases}$$

Any process flow unit $PFU^{i,j}_m$ works in the way in which the input object Prod-In^i_m, is transformed into output object Prod-Out^i_m through certain production space SPU^k_m which means:

$$PFU^{i,j}_m = \left(SPU^k_m, Prod-In^i_m, Prod-Out^i_m\right)$$

Among which:

$$Prod-In^i_m = \left\{Prod-In^{i,1}_m, Prod-In^{i,2}_m, ..., Prod-In^{i,n}_m\right\}$$

According to the ordinal relations of each process flow unit, the output of the previous unit becomes the input of the next unit, thus the following relation can be found:

$$Prod-Out^i_m \in Prod-In^j_m$$

At the same time, the inclusion relation exist between upper and lower layer process unit, it can be expressed in the following way:

$$PFU^{i,j}_m = PF_{m+1}\left(Prod-Out^i_m\right),\ m \in \{1,2,3\}$$

In addition, the output product object of any layer process must be the output object of its last process flow unit which is shown as follow:

$$Prod-Out_m = Prod-Out^I_m$$

LOGISTICS ANALYSIS of EACH LAYER PROCESS FLOW UNIT

The manufacturing of the product is a course of material flowing and its morphological alteration. In the multi-level process flow, there is material flowing relation between flow units which possess successive ordinal relation on the same level. At the same time, there is also complex material flowing relation between flow units of different layers.

Logistics analysis of workshop level unit: Every part will form a product through a series of professional operation in workshop which comes into being the material flowing network between workshops as shown in Fig. 3.

As the figure shows, the input object of every workshop comes from the output of the previous workshop or from the warehouse where preserve the suppliers' material procurement.

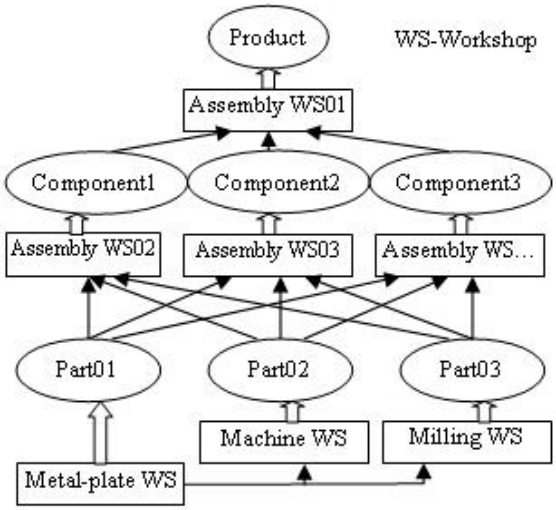

Fig. 3: Logistics supply network of workshop level

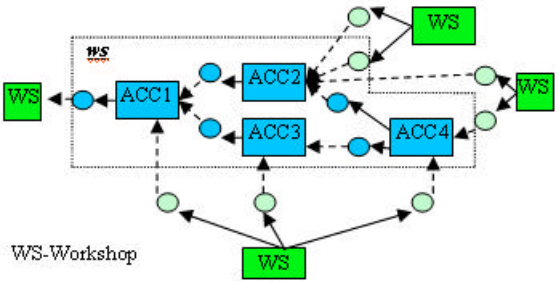

Fig. 4: Logistics supply network of ACC level

Logistics analysis of ACC level unit: In each ACC process flow unit of each workshop, especially the assembly unit, all kinds of input product accessories object should be produced to segment piece, group piece or middle ware as output which forms the logistics supply relation between different ACC inside the workshop as shown in Fig. 4.

As the figure shows, the input object of each ACC inside the workshop may come from the upstream ACC output or directly from the output of other workshop or the warehouse.

Logistics analysis of POS level unit: The manufacturing of product accessories should be accomplished depending on the manufacturing resource like machine equipments and technological equipments located different position in ACC. According to the material flow relation between different POS, the logistics supply network of POS layer is formed as shown in Fig. 5.

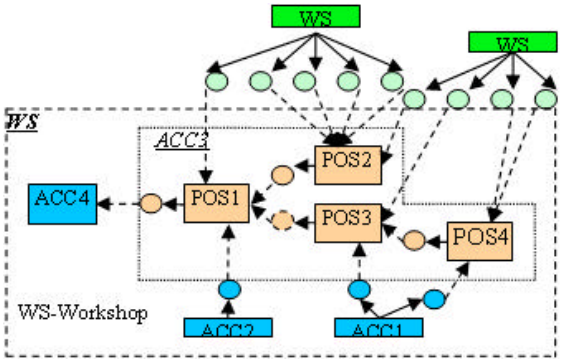

Fig. 5: Logistics supply network of POS level

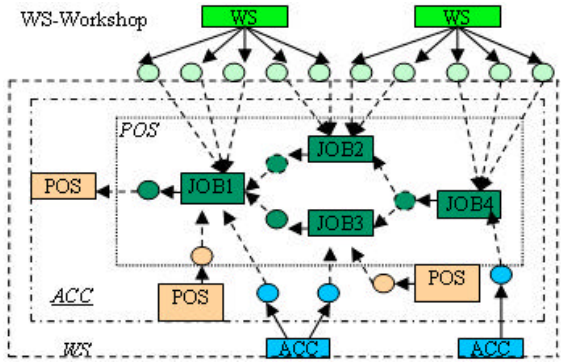

Fig. 6: Logistics supply network of process layer

The figure tells us that the input objects of POS process flow unit come from three aspects: the first one is the output of the previous POS flow unit; the second is the output of ACC previous the ACC which this POS belongs; the third is the output of workshop previous the workshop which this POS belongs.

Logistics analysis of JOB level unit: In the manufacture task of each POS, a series of JOB activities in assigned order should be employed. The accessories state of each JOB should become the working object of the next JOB. As a result, the logistics supply network shown in Fig. 6 can also be formed between the JOBS of each POS.

As the figure shows, the input accessory object of each JOB comes from various directions: the first is the output of upper JOB activity; the second is the output of POS previous the POS which this JOB belongs; the third is the output of ACC previous the ACC which this JOB belongs; the fourth one is from the workshop previous the workshop which this JOB belongs.

PRECISE TRACING STATISTICS of FLOW UNIT MATERIAL

The above section detailed analyzes the logistics relation between each layer flow unit and make sure the material source between different levels of flow unit. Except the flow unit of workshop layer, there are two questions need to be made clear towards other flow units: the first one is to make sure the input object of each flow unit specifically comes from which space unit output of the upper layer space that is to say, the precise tracing statistics of material source; the second one is the output object of each flow unit finally transmits to which space unit to be employed in the next space level which is precise tracing the material flow direction.

Source tracing of flow unit input object

Problem description: When number i flow unit $PFU_m^{i,*}$ output $Prod\text{-}Out^i_m$ in its space unit SPU^k_m on the m layer (when m is ACC/POS/JOB layer which is m>1), each of the object in input object collection $Prod\text{-}In^i_m$, specifically comes from the output object from which space unit and which space layer.

Algorithm thought: Towards any input object $Prod\text{-}In^{I,J}_m$ in the input collection $Prod\text{-}In^i_m$ of flow unit $PFU^{i,*}_m$, the traverse should be carried on to all the flow units on the layer of m-1. Among which, if any flow unit $PFU^{k,*}_{m-1}$'s output $Prod\text{-}Out^k_m$ is equal to this input object $Prod\text{-}Out^{I,J}_m$, it illustrates that this input object $Prod\text{-}In^{I,J}_m$ comes from the $PFU^{k,*}_{m-1}$ flow unit output of the m-1 layer, then this search should come to an end; if this input object $Prod\text{-}In^{I,J}_m$ are not equal to all the output objects from all the space unit on m-1 layer, it illustrates that this input object $Prod\text{-}In^{I,J}_m$ is not comes from the space unit output on the layer m-1. At this time, on layer m-2, the space unit in which it output object is equal to input object $Prod\text{-}In^{I,J}_m$ should be continued to traverse and search among all the flow units, until the space unit in which its output object is equal to input object $Prod\text{-}In^{I,J}_m$, or until each flow units of all the workshop layers are traversed and searched. All those found space units are the source space unit of flow unit $PFU^{i,*}_m$'s input object. The specific process flow is shown in Fig. 7.

Flow direction tracing of flow unit output object: Problem description: When number i flow unit $PFU^{i,j}_m$ exports $Prod\text{-}Out^i_m$ in corresponding space unit SPU^k_m on the layer m(when m is the workshop, ACC and POS layer that is to say, when m<4), this output object $Prod\text{-}Out^i_m$ finally become the input object of which space unit on which space layer.

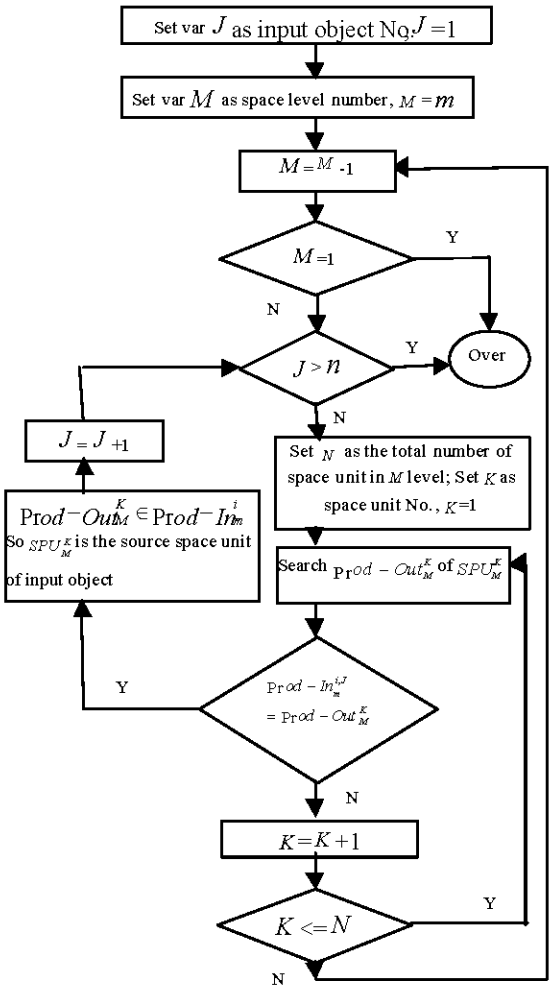

Fig.7: Source tracing arithmetic of input object

Algorithm thought: At first, the successor flow unit $PFU^{j,*}_m$ should undergo when the process unit $PFU^{i,j}_m$ exports Prod-Out^i_m in $SPU_{m,k}$ space unit and the next level flow PF_{m+1}(Prod-Out^i_m) of the flow unit $PFU^{j,*}_m$ should be searched. Prod-Out^i_m, should be respectively compared with each input object Prod-In^{kn}_{m+1}, of each space flow unit forming PF_{m+1}(Prod-Out^j_m); if Prod-Out^i_m = Prod-$In^{k,n}_{m+1}$ can be discovered, then the flow unit $PFU^{k,*}_{m+1}$ to which this Prod-In^{k+n}_{m+1} belongs and space unit SPU^k_{m+1} is the next level flow unit or space unit of Prod-Out^i_m object; PF_{m+2}(Prod-Out^i_{m+1}), the next level flow of $PFU^{k,*}_{m+1}$, should be searched continuously until the search of the JOB layer comes to an end. All found flow unit from different level flow unit is the sublevel disposition flow unit of Prod-Out^i_m, and the corresponding space unit is the disposition space unit. The specific algorithm flow is shown in Fig. 8.

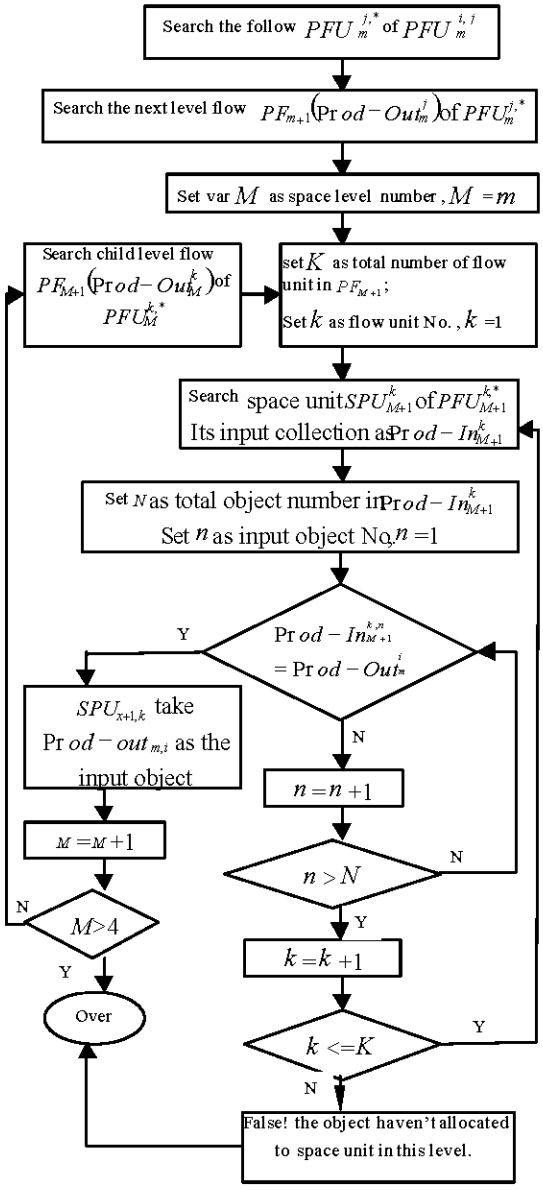

Fig. 8: Flow tracing arithmetic of output object

CONCLUSION

Space based multi-level process data organization model intuitively yet clearly expresses the complete productive process of the product and faithfully reflects the complex material flow relation between space flow units of different levels which realize the source statistics of each level flow unit input object and the disposition inquiry of the output object. As a result, this model profoundly elaborates the essence of manufacturing process from theoretical level which will provide

comprehensive and precise data information from the production management and satisfy the demands towards process data of different departments which can make sure the process data can actually work as bridge and link in the informational process of modern enterprise and which can promote the enterprise digitalization construction to a deeper level of application and development.

REFERENCES

Li, Z.Y., X.T. Tian and X.L. Jia, 2008. Single enterprise BOM-based process management system for aircraft manufacturing. J. Northwestern Polytech. Univ., 26: 771-776.

Liu, M.Z. and F. Cao, 2005. Process planning modeling to support product life cycle data management. J. Comput. Aided Des. Comput. Graph., 17: 137-142.

Liu, X.B., X.W. Huang and Y. Ma, 2002. Research on xBOM for product whole life cycle. Comput. Integr. Manuf. Syst., 8: 983-987.

Wu, J.W., W.G. Jiang and S.X. Pan, 2009. Integration model and its evolution for product lifecycle. Comput. Integr. Manuf. Syst., 15: 1493-1513.

Xu, T.B. and J.Y. Wang, 2011. Bill of material mapping technology based on process management. Comput. Integr. Manuf. Syst., 17: 1913-1920.

Xu, H.C., X.F. Xu and D.C. Zhan, 2005. A method of generating manufacturing BOM based on engineering BOM and BOP. Chin. J. Mech. Eng., 16: 701-705.

Zhou, Q.Z. and Y.Q. Fan, 2008. EBOP based research on complicated product process data model. Manuf. Autom., 8: 15-18.