Material Delivery System for Aircraft Composite Component Manufacturing Workshop

Mei Zhongyi, Liu Yongjin, and Muhammad Younus

***Abstract*—This paper presents a material delivery system for the aircraft composite component manufacturing workshop. By analyzing the disadvantages of the passive material supply model, an active material delivery model is proposed. Subsequently, an improved work flow of material delivery is introduced in detail for optimizing the traditional material supply. Barcode technology is used to collect the data of material receiving and issuing in the warehouse. By scanning the barcode, material information and working personnel information can be collected and inputted into the system in real time. The function module of material delivery system is composed of material delivery management, inventory management, and production planning management. The integration relationship between the material delivery system and other systems is also described. Three-layer structure is adopted to design and develop the system. The material delivery system has been implemented in an aircraft composite component manufacturing workshop. The results show that material supply time and cost has been reduced.**

***Index Terms*—material delivery, composite component, MES, barcode**

I. Introduction

Currently, many aircraft manufacturing enterprises have been using Enterprise Resource Planning (ERP) systems. Matching material, predicting production capacity of the enterprise, and arranging main production plans may be done simultaneously after issuing production plan. Most of the enterprises do not have such kind of controlling and information management in the workshops. After the production plans are issued to the workshops, the information transferring and management is still done manually by using traditional paper works. So it's difficult to keep the consistency between the workshop production plan and the enterprises production plans.

In recent years, a lot of enterprises have adopted Manufacturing Execution System (MES) to improve the level of information management. Cheng et al proposed a systematic approach to develop an open, modularized, distributive, configurable, and integrated MES framework by using object-oriented technique [1]. In 2006, Zhilun Cheng et al introduced the framework for developing manufacturing execution system dedicated to iron and steel industry. Unified Modeling Language (UML) is used to specify the system model and components [2]. In 2006, Walkden Michelle presented MES for a paper making enterprise which is composed of reliable delivery time, planning, and production invoicing [3]. In 2009, Jingfeng Shao et al developed a manufacturing execution system oriented to spinning workshop [4]. In 2008, Huang ZH et al implemented the optimization control and management of the auto electronic parts enterprise production process [5]. In 2008, Jiwei Hua et al adopted radio frequency identification (RFID) technology to obtain real-time production information which is applied in the MES [6]. In 2008, Bruno Costa et al described the procedures used during the planning of a material delivery system for the manufacturing lines of an electronic company. A simulation model was created to measure the material delivery system capacity for the manufacturing line [7]. In 2006, Timo Ala-Risku proposed a potential solution for managing the material logistics of construction projects and a pro-active delivery approach for efficient material deliveries [8].

A local aircraft composite component manufacturing enterprise collaborating with Airbus Company and Boeing Company has improved its production capability and product quality by purchasing advanced manufacturing equipments and learning advanced manufacture technology from these two aerospace giants. But due to late material delivery and unavailability of material in production process, production schedule and delivery time is often delayed. The conflict between efficient equipment and inefficient material delivery has become the main problem of restricting the enterprise to improve its production capability. A suitable MES has been developed to improve the traditional working efficiency. This paper mainly presents the material delivery system of the developed MES.

II. Current Status of Material Delivery

Currently, material delivery of the composite component manufacturing workshop is in passive supply mode. Production material is stored in their respective warehouse according to classification, such as material warehouse, fixture warehouse, tool warehouse, finished product and semi finished product warehouse, and so on. According to production order and production procedure, the workers draw production material from the relative warehouse and

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complete the manufacturing task of the composite component. The process of current material delivery is shown in Fig.1.

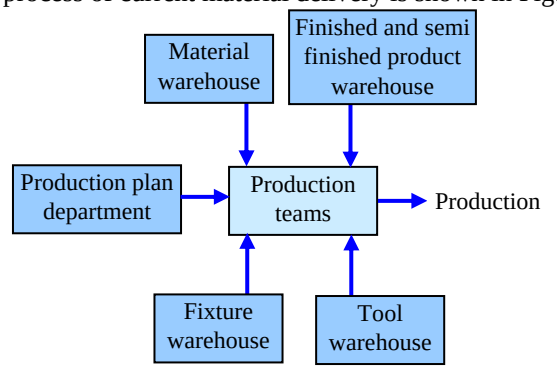

Fig. 1. Process of current material delivery

There are some disadvantages in this passive material supply mode, as follows:

(1) Long Production Preparing Time

The key production procedure such as cloth cutting, lay-up, and other processes must be done in air-condition room due to strict production environment requirement in a composite component manufacturing workshop. If workers go in or out of the air-condition room, they have to change their working uniform. When the workers draw material for production preparation, they have to go in and out many times and have to change their uniform frequently. This may prolong production preparing time and decrease production efficiency.

(2) Large Redundancy of Material Inventory

The material warehouse has to store a large safety stock to avoid the unavailability of material at the workstations. Because most material of composite component production must be stored in low temperature and has an expiry life, large safety stock may lead to increase purchasing cost and inventory cost. If the material has exceeded the shelf life period and expired, the cost will increase much more.

(3) Old Manage Method

All warehouses are still adopted account ledger and manually updating the inventory. This kind of work method has made large workload and inconsistency in the material record. It often leads to lack of material supply and affecting production schedule.

(4) Fixtures and Tools Do Not Return in Time

There is no real-time tracking of the process, so, fixtures and tools are not returned in time which can delay their calibration and reuse. It can also affect production schedule.

Passive material supply not only affects production schedule, but also leads to disordered material management and costly production. So changing passive material supply mode to active material delivery mode is essential under this situation.

III. Material Delivery Scheme

Material delivery department completes material selection and matching based on the requirement of production planning. Subsequently, the selected material is sent to respective workstation. After completing the manufacturing of composite component, the remainder composite material, fixtures, and the tools are reclaimed, inspected, and sent back to warehouse.

A. Information Requirement of Material Delivery

Workshop production needs smooth material flow and information flow. The aim of material delivery is to build a smooth material flow route. Material delivery needs the support of real time and exact production information. This information includes material requirement planning, material delivery planning, and warehouse inventory information.

(1) Material Requirement Planning

Material requirement planning is a method of calculating material purchasing according to production quantity. Based on the main production planning and BOM (Bill of Material), it calculates material requirement by using information management system.

Main production planning is one of the main inputting information of the material requirement planning. On the basis of the customer order, main production planning transfers a detail production schedule. Main production planning is a prior production planning. It gives the production quantity for some products for a specific period. Main production planning has been a connecting link between the preceding aggregate planning and the following detail planning.

BOM provides the bill of all needed material for one product. It's also one of the main inputting information of material requirement planning. In order to be identified by computer conveniently, it transforms the product structure which is expressed by using chart to a determinate data format.

(2) Material Delivery Planning

Material delivery planning is the basis of material delivery mode. It is automatically generated on the basis of the daily production planning and the delivery BOM.

Daily production planning is a sub-division of the main production planning. It's the production planning with the shortest planning period which constituted in workshop. Daily production planning is the basis and standard of workshop production task executing. It's also the main inputting information of material delivery planning.

Delivery BOM is the data information basis of material delivery. On the basis of the original BOM, some information which is related with material delivery is added to the delivery BOM. Considering different effect and requirement of the material in composite component production, material is divided into two kinds. One kind is most universal material which is used in a huge quantity. It generally has small volume and is stored in normal temperature, such as vacuum bag, adhesive tape, and so on. Generally, this kind of material does not enter the final product and delivery. Even though needing delivery, it also does not need delivery according to the order, but delivering according to the quantity which is used in one day or several days. This kind of material is called non delivery material. Another kind of material has large volume. The quantity of this material is determined according to the order quantity. It's generally stored in low temperature. Due to the restriction of volume and store condition, this kind of material can not be delivered too much for one time. Material in one order is often delivered in a period of time. This kind of material is called active delivery material. Material delivery management is mainly aimed this kind of material to manage and control its delivery.

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Preparation of delivery BOM is completed by production planning and material delivery departments with consultation. Material delivery department determines whether material in BOM need to be delivered. It also sets delivery identifier and determines the smallest delivery quantity and the largest delivery quantity for the work station. Based on the needed delivery material which is determined by material delivery department, production planning department completes the production preparation work which includes delivery procedure, delivery to the work position, delivery time, and so on.

(3) Inventory Information

Inventory information includes material inventory quantity, useable inventory quantity, warehouse position, warehouse in /out record, and so on. Inventory information mainly explains static information of the warehouse position and dynamic information of the material inventory quantity and usable inventory quantity. Inventory information is the basic information of implementing material delivery model.

B. Material Delivery Model

Traditional passive material supply model can not satisfy the requirement of current heavy production task. It was the main factor of restricting workshop production ability. In order to thoroughly solve the problem of current material supply mode based on the needed information of material delivery, the material delivery model which is used in workshop production is established. It is shown in Fig.2.

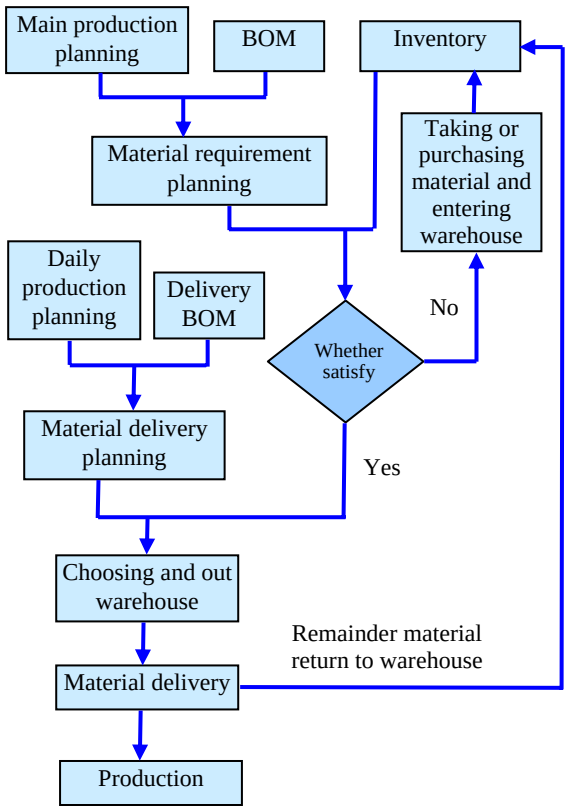

Fig. 2. Material delivery model

C. Work Flow of Material Delivery

Material delivery department is responsible for the materials delivery and materials reclaim work. Main work flow of material delivery includes material requirement planning, taking material or purchasing material, entering warehouse, warehouse work, selecting material, material in/out of warehouse, material delivery, and material reclaiming.

(1) Material Requirement Planning

Material delivery department obtains main production planning from enterprise planning department and obtains BOM from planning department. Based on the obtained main production planning and BOM, material requirement planning is calculated automatically. Then material requirement planning is compared with current inventory. If current inventory can satisfies the requirement of material requirement planning. Material delivery is done according to material requirement planning.

(2) Taking Material or Purchasing Material

If the inventory can not satisfy material requirement planning, it must take material from other warehouses of the enterprise. If other warehouses also can not satisfy material requirement planning, it must issue a procurement demand to the purchasing department and provide related purchasing information.

(3) Entering Warehouse

Before entering warehouse, material must be checked. If the quality or quantity of the material does not accord with material bill, it must be treated specially. Material of entering warehouse is stored according to assigned position. It's also registered and noted in the account.

(4) Warehouse Work

Warehouse work includes account bill management of out warehouse, inventory check in a fixed time, rechecking material, fixture and tool check, material placing planning, and so on. Inventory information must be reported in time and sent to the production planning department of the workshop. It is the basis of production planning.

(5) Choosing Material

Choosing material means that different kind of material and different quantity of material is taken out from the warehouse according to material delivery planning. After choosing material, material is collected and waits for delivery.

(6) Out Warehouse

Material that has been chosen and is waiting for delivery is registered for out warehouse. The inventory information is also updated.

(7) Material Delivery

According to material delivery planning, the chosen material is delivered to assigned work station by assigned person at an appointed time. Material is checked and accepted by the worker who will use this material. This material delivery task is completed now.

(8) Material Reclaiming

Material reclaiming in the warehouse includes reclaiming remainder material, reclaiming fixture and tool which has been used. Remainder material reclaiming mainly reclaims the material which must be stored in low temperature, such as prepregnated cloths, glue mould, and so on. Composite material which must be stored in low temperature can not be kept in normal temperature for a long time. After using, the remainder material must be reclaimed and reenter into the warehouse. Fixture and tool which has been used must be

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reclaimed in time. So it can be reused by the warehouse. Before reclaiming, Remainder material, fixture, and tool must be checked. Unqualified material, fixture, and tools must be repaired or discarded as useless.

The improved work flow of material delivery in composite component manufacturing workshop is shown in Fig.3.

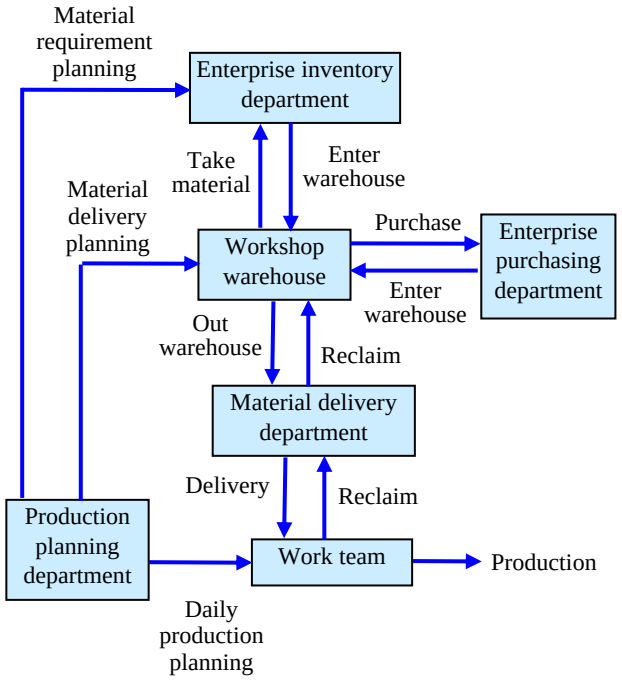

Fig. 3. Improved work flow of material delivery

IV. Application of Barcode Technology in Material Delivery

Barcode technology is the most popular technology in the field of data and information collection. The material delivery system adopts barcode technology to collect in/out warehouse data, reclaiming and accepting material data, and other information.

A. Coding Determination

Every barcode includes blank area in two sides, starting character, datum character, verifying character, ending character, and characters that can be read by person. This is shown in Fig. 4.

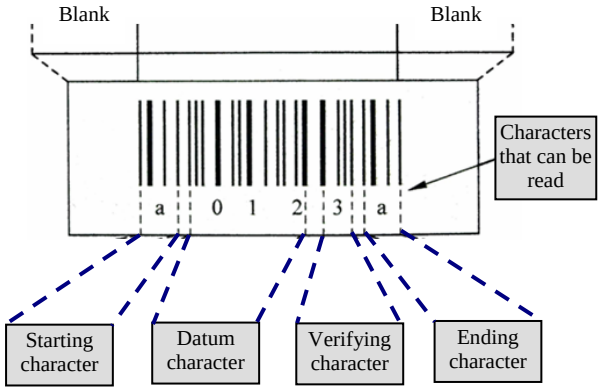

Fig. 4. The whole barcode

There are about 250 kinds of barcodes used in the world. Code 39 and Code 128 are widely used in industry. Code 128 can represent more characters than Code 39 in unit length. Because the barcode content of the developed system includes several kinds of characters, Code 128 is selected as the barcode for the proposed material delivery system.

Most data and information collected in material delivery focuses on in/out of warehouse. Other information collection is based on the existed data record of in/out of warehouse.

The contents of entering warehouse data collection include material code, material name, material trademark, material specification, material unit, aircraft type, time of entering warehouse, quantity of entering warehouse, operation personnel number, and so on. Material name, material trademark, material specification, material unit, and applied aircraft type are the basic attributes of the material. It can be queried from the database according to the material code. Time of entering warehouse can be determined by system time. So the needed data collection only includes material code and quantity of entering warehouse. Material code is inputted by scanning material barcode.

The contents of out warehouse data collection include material information out warehouse, time of out warehouse, quantity of out warehouse, operation personnel number, and so on. Material information of out warehouse can be obtained from the information of entering warehouse. Time of out warehouse can be determined by system time. The needed data collection includes material code, taking material personnel number, and quantity of out warehouse. Material code and taking material personnel number can be inputted by scanning material barcode and working personnel barcode.

Considering the practice of the workshop, applied barcodes of the material delivery system include material code, material entering warehouse number, and working personnel number. The code rule is described as follows:

(1) Material Code

Material code is composed of seven-digit letter and number. The first two digits are letters. It expresses aircraft type code. The third is number. It expresses the identifier of the main material and the assistant material. 1 expresses main material. 0 expresses assistant material. The fourth and the fifth can be letter or number. It expresses the classifying of the material. The sixth and the seventh are numbers. It expresses the serial number of the material. The code rule and content of material code is shown in Fig.5.

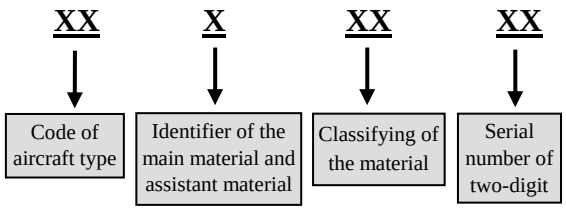

Fig. 5. Code rule and content of the material code

(2) Material Entering Warehouse Number

Material entering warehouse number is composed of number and "-". It's divided into three code segment. The first segment expresses time. The format is "YYYY-MM-DD". The second segment is the dividing symbol "-". The third segment is two-digit or three-digit number. It expresses the serial number of material entering warehouse in that day.

(3) Working Personnel Number

Working personnel number is composed of five-digit letter

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and number. The first two digits are letters. It expresses working personnel on duty. The third and the fourth are number. It expresses the serial number. The fifth is letter or number. It expresses the department of the working personnel. The code rule and content of working personnel number is shown in Fig.6.

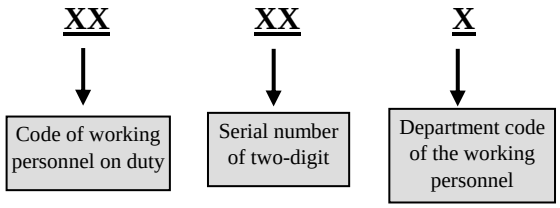

Fig. 6. Code rule and content of working personnel number

B. Data Collection

Data collection of material delivery system includes data collection of material entering warehouse, data collection of out warehouse, and data collection of material arriving work position, as follows:

(1) Data Collection of Entering Warehouse

Entering warehouse can be divided into three steps. The first step is checking and accepting material. The second step is noting and registering for completing data collection of entering warehouse. In this step, material code is inputted by scanning material barcode, material entering warehouse number is automatically generated by the system, and the quantity of entering warehouse is inputted manually. The third step is sending material to assigned warehouse.

(2) Data Collection of Out Warehouse

In out warehouse process, by scanning material barcode, material code is inputted into the system. Material delivery personnel number is also inputted by scanning working personnel code. The quantity of out warehouse is inputted manually.

(3) Data Collection of Material Arriving Work Position

When material arrives at the work position, material code is scanned again for determining delivery success. The working personnel number of accepting material is also inputted by scanning the working personnel code.

V. Developing Material Delivery System

MES is an important part of the enterprise information management system. Material delivery system is the main function module of MES. Referring to material delivery model and work flow of material delivery, it can be seen that material delivery process includes large information, such as production planning information, specification information, inventory information, taking material and purchasing material information, delivery information, and so on. A material delivery system is developed to collect accurate information and to improve the efficiency of material delivery system according to the requirement of the composite component manufacturing workshop.

A. Function Module of the Material Delivery System

Material delivery system is composed of three modules, namely production planning management, inventory management, and material delivery management. The function module of material delivery system is shown in Fig.7.

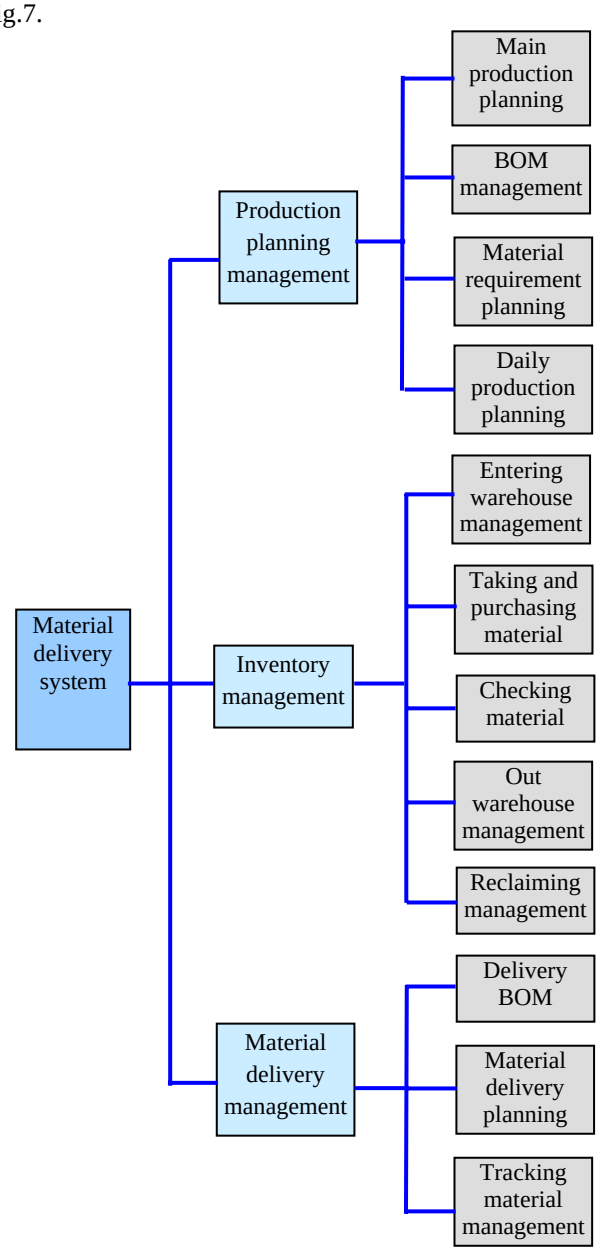

Fig. 7. Function module of material delivery system

B. Integrating with Other Systems

Before developing material delivery system, other modules of the MES have been developed and applied in the composite component manufacture workshop. Besides MES, CAPP system and ERP system have also been implemented in the enterprise. In order to implement information communication between these systems, material delivery system and MES have been integrated with CAPP system and ERP system. Material delivery system obtains main production planning from ERP and obtains BOM from CAPP. This is shown in Fig.8. Integration between these systems ensures the accuracy of data transfer and avoids repeatedly developing the same system function.

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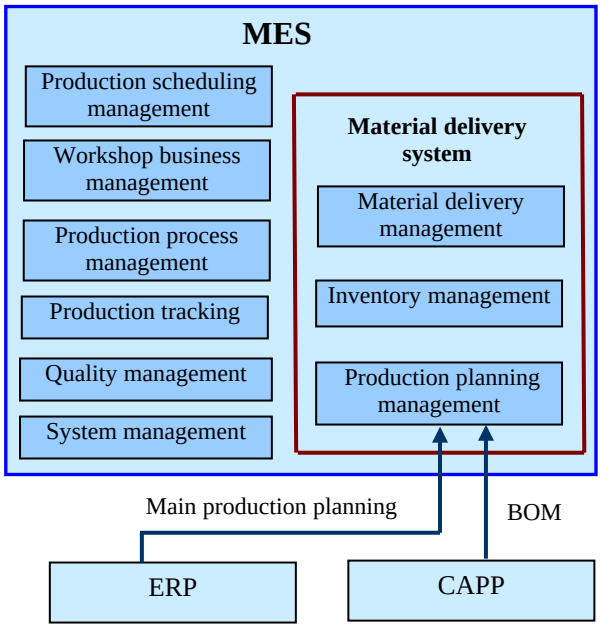

Fig. 8. Integration relationship between systems

C. *Software Technology of Material Delivery System*

Designing the material delivery system adopts three-layer structure which based on Web technology and browser/server (B/S) architecture. The developing languages are ASP.NET and C#. The application architecture of the system is divided into three layers that include user presentation layer, transaction logical layer, and data access layer. The architecture of the system is shown in Fig.9.

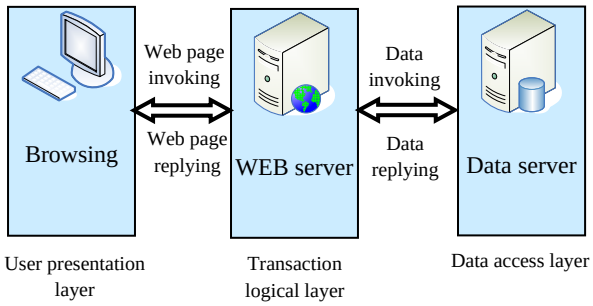

Fig. 9. Architecture of the system

User presentation layer is the user interface of the system. This layer is used to implement human-computer interaction between the users and the developed system. Transaction logical layer is the core of the entire system. All the transaction rules and logics implemented are packaged in the logical groupware. Data access layer is used to access, store, and optimize data in database. The client-side is the WEB browser of every computer. By using Internet or Intranet, the client-side can access the server in real time. All the transaction logical codes and data are saved in the server.

VI. Conclusions

This paper takes an aircraft composite component manufacturing workshop as a researching object. Based on the actual requirement of the workshop, a material delivery system has been developed. The developed system has transformed traditional passive material supply mode to active material delivery mode. Material delivery system has changed former disorder status of the workshop material delivery. With the application of this system production preparation time has been reduced and the production efficiency has been improved. It also decreases material inventory and saves the cost of material delivery. The material delivery system is an important part of the information system in the workshop. It provides real time information support to the production and planning managers.

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