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Digitalized Assembly Process Design and Processing Simulation of Modern Aircraft

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Abstract: Problems of the domestic traditional aircraft assembly process design are analyzed in detail firstly; the necessity of digital assembly process design and process simulation technology in modern aircraft design and manufacture is put forward. Secondly, the digital manufacturing process based on the model of the digital product definition about domestic aircraft design is summarized and analyzed. Thirdly, 3D digitalized virtual assembly process workflow of an SAC aircraft based on DELMIA is introduced. Finally, the advantages of 3D digitalized virtual assembly process design and processing simulation are summarized.

Key words: Digitalized, 3D assembly process, processing simulation

INTRODUCTION

Digitalized assembly process design and processing simulation technology play an increasingly important role in modern aircraft design and manufacturing process. Currently, all the large complex production research companies' special aircraft and motor vehicle company have applied digitalized assembly technology and have obtained prominent benefit. No matter in Boeing or Airbus digitalized assembly has become a reality. The 7E7 aircraft of Boeing has achieved 3D virtual assembly simulation and confirmation in complete machine which enormously shortened design change time and process planning time, improved yield and reduced cost. Series of products of Airbus have adopted the same technology and data display that the assembly cycle of typical unit has been reduced 60% and the whole assembly cycle reduced 10%, assembly process design reduced 30-50%, assembly rework rate reduced 50%, assembly cost reduced 20-30%, assembly quality greatly improved and maximally meet customer's requirement (Xia *et al*., 2005).

Domestic aircraft digitalized assembly technology research and application is now in exploratory and advanced research stage, represented as Shanxi Aircraft Company (SAC), the aircraft manufacturing industry still adopt traditional assembly means and method. The traditional assembly design has the following questions:

2D pattern was still adopted: Firstly in traditional process design the designer imagine the 3D assembly space and sequence, express in 2D pattern. Design quality is completely depended on the designer's engineering level and experience. Secondly the assembler according to the files and 2D drawing to understand assembly sequence and assembly requirements and rebuild 3D assembly process.

Ambiguity is easy to produce and which leads to assembly error (Xiao, 2004).

Unable to meet the assembly process requirements of 3D digitalized manufacture: The existing process design systems adopt traditional 2D way, this leads to downplay of design details and degrade of manufacturing resource and assembly technique knowledge, in the mean time unable to take full advantage of 3D CAD data. It's impossible to realize the inheritance, the normalization, the standard ability and the optimization.

It is difficult to guarantee the assembly cycle: Technological design environment is incapable to offer 3D technological certification which leads to series problems, such as whether assembly interferences is existing and whether assembly sequence is reasonable and whether the equipment could meet assembly requirements and whether the working space is open. These problems could only be exposed in trial manufacture. Any link goes out of order would affect the aircraft research schedule and quality.

Lack of 3D dynamic assembly demonstration and not be convenient for assembler to understand: To solve the above questions we select ARJ21's central wing assembly as example to conduct 3D digitalized assembly technological design and simulation and optimization analysis technology to accumulate experience for building aircraft digitalized manufacturing system.

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MODULE BASED DEFINITION OF DIGITALIZED MANUFACTURING PROCESS

Domestic aircraft design would adopt module based definition (MBD) of Digitalized manufacturing process. Adopt no more 2D drawing but rather 3D digitalized module as basis of part manufacturing and unit assembly. The traditional two dimensional design patterns are incapable to fit the requirement of full 3D design. With the development of modern computer technology, network technology, technical design and digitalized simulation software, with the found of collaboration platform, foundation of 3D assembly technique design and Concurrent Engineering was established (Sun and Tao, 2006). Digitalized manufacturing process of module based definition was shown in the Fig. 1.

The research process of aircraft would experiences 5 prime links which are product design and technological design and tooling design and product manufacturing and product inspection. In manufacturing and inspection, the 3D design digitalized module would derive 3D technological and inspecting module.

- During the process of technological design, the technological department conduct analysis according to 3D digitalized module and give technological review suggestions to design department and establish PBOM according to EBOM and 3D design digitalized module which provided by design department and work out assembly technological coordination scheme and divide technological separation surface and conduct the whole assembly technological simulation and finally establish a MBOM top structure which was verified by assembly simulation and send this MBOM to tooling design department and manufacturing department and testing department
- During the process of tooling design, the tooling design department design tooling according tooling order and 3D technological digital module and product manufacturing technological scheme provided by product manufacturing department. According to 3D design digital module to finish AO (Assembly Order), assembly simulation of the assembly tooling and tooling numerical control
- According to EBOM and 3D design digital module and PBOM, product manufacturing department establish 3D technological module, conduct part material feature simulation and unit geometry simulation, compile AO(Assembly Order) and PO(Production Order) and numerical control programs, accomplish the manufacturing of part and assembly of unit and self-inspecting

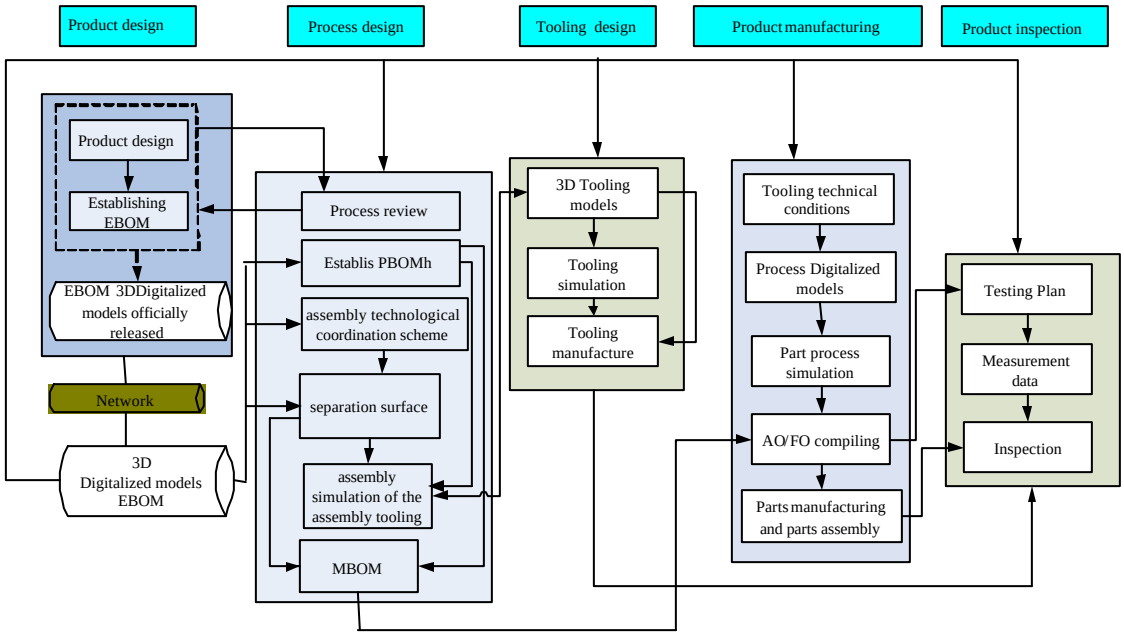

Fig. 1: Digital manufacturing flow chart

- During the inspection process of product, according to EBOM and 3D design digital module and 3D tooling design digital module, the inspection department compile inspection plan and calculate measurement and accomplish testing of units and tooling
- Tooling module and inspection module and 3D technological diagram and simulation video data which were generated during digitalized assembly technological analog simulation, were send to work site by network and provide 3D digitalized basis. programs, accomplish the manufacturing of tooling design and self-inspecting

3D DIGITIZATION ASSEMBLY PROCESS OF AN AIRCRAFT BASED ON DELMIA

DELMIA software for aircraft assembly process design and assembly simulation according to their design requirements provide process engineers, tooling designers and product designers with common visual communication and collaborative work platform. It makes the staff of the manufacturing sector to participate in product development as soon as possible in parallel with the design work. So that the factors of the parts process characteristics, unit assembly ability and product maintainability could be fully taken into account during the design process to help the enterprise realize "Design for Manufacturing" and "Design for maintainability" (Fan, 2001).

Shanxi Aircraft Company (SAC) has utilized fully DELMIA software on a certain type of aircraft since 2010. The function modules include product definition, components division, 3D assembly process, 3D virtual assembly simulation and optimization, man-machine engineering simulation and analysis, issuance of work instructions and export of various reports. This review focuses on concrete application workflow of DELMIA used in a certain type of aircraft of SAC.

First step is to establish PBOM and preparing various data: PBOM is established according to EBOM on the collaborative work platform; CGR model and smgxml model are generated by the product and resources of CATIA V5 models which are needed for 3D digitization assembly process design of DELMIA software and the models of these formats are stored in the specified location for the prepare for reading the importing data.

Second step is importing pbom data: PBOM (as Fig. 2 shows) of XML format which comes from the digital collaborative work platform is imported in DPE module of

```
<?xml version="1.0" encoding="UTF-8" ?>
<!--  XMLSpy v2006 U (http://www.altova.com) 由any
(any)  -->
- <PBOM From="Windchill" Company="SAC"
  ProductID="BXX" CreatedTime="20110421-000000">
  - <Part partId="U10-5224000000-001" Version="A.A"
      Revision="1">
      <RelatedCADDocContent>U10-5224000000-001 -
        A.CATProduct</RelatedCADDocContent>
      <RelatedECNo />
      <DescOfChange />
      <UseBy />
    - <BomUse>
      - <PartInstance PartID="U10-5224200000-001"
          Version="A.A" Revision="1">
          <Quantity>1</Quantity>
          <Route>156F-313B</Route>
        </PartInstance>
      </BomUse>
    - <Attribute>
        <PartName>U10-5224200000-
          001</PartName>
        <Note>Test Top Note</Note>
        <Weight>20</Weight>
        <Quantity_2>1</Quantity_2>
        <Type/>
        <TailNuber>001+</TailNuber>
      </Attribute>
    </Part>
```

Fig. 2: PBOM chart of XML format exported by the digital collaborative work platform

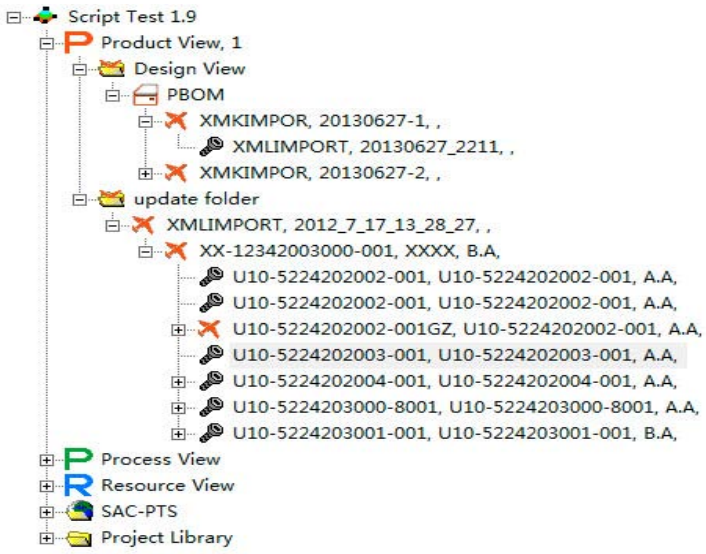

Fig. 3: Product structure tree chart imported in DPE module of DELMIA software

DELMIA software by the secondary development interface program. As Fig. 3 shows, product structure tree is built and the 3D models data including the attribute are imported in the product node at the same time.

Third step is to divide of units and process breakdown interface: After importing of data, process breakdown interface is divided in DPE module of DELMIA software according to production batch size and assembly ability. Process assembly units and assembly item is identified according to EBOM, in the meantime big unit process module is built. Design preliminary assembly process and divide assembly operation station for each big, identify assembly item of each assembly operation station and build process module in 3D digital design. Identify assembly process base and assembly locating method; develop assembly flow chart of whole assembly product.

Fourth step is to compile of mbom: MBOM is compiled according to dividing of process and units breakdown interface. 3D digital module is correlated with product structure tree. On the basis of operation station dividing, according to stage unit assembly process module in 3D digital circumstance, assembly process of each operation station is design, in the meantime, part and unit assembly sequence is identified and corresponding AO number of assembly is defined.

Fifth step is to plan the detail assembly process: On the basis of AO dividing, the detail assembly process is designed according to assembly process module of stage unit; the needed standard parts in assembly are defined; the assembly sequence of parts, units, standard parts and accessory parts is confirmed during the assembly process; the method of assembly process is defined; the assembly steps are confirmed and a series of manufacturing resources including tooling, fixtures, tools, auxiliary materials are selected, so the AO for guiding production is formed, parts are associated with steps and tooling are associated with the work stations.

Sixth step is 3d virtual assembly simulation and optimization: In the 3D digital virtual assembly environment, 3D manufacturing resource models such as plant, ground and lifting equipments are built (Xu, 2009). 3D manufacturing resource models which have been built such as assembly process modules, assembly frames, work platforms, fixtures are put into the plant, the overall process layout design is determined in the light of the assembly process and the production logistics is simulated, as Fig. 4 shows. In the DPE module of DELMIA software, every part and unit is moved, located, clamped and assembled according to the design assembly process. In the process of assembly, interference checking between parts and components, interference checking between parts and tooling are examined. When the system finds interference, the alarm would be given, the interference region and the amount of interference would be displayed to help process designer check and analyze.

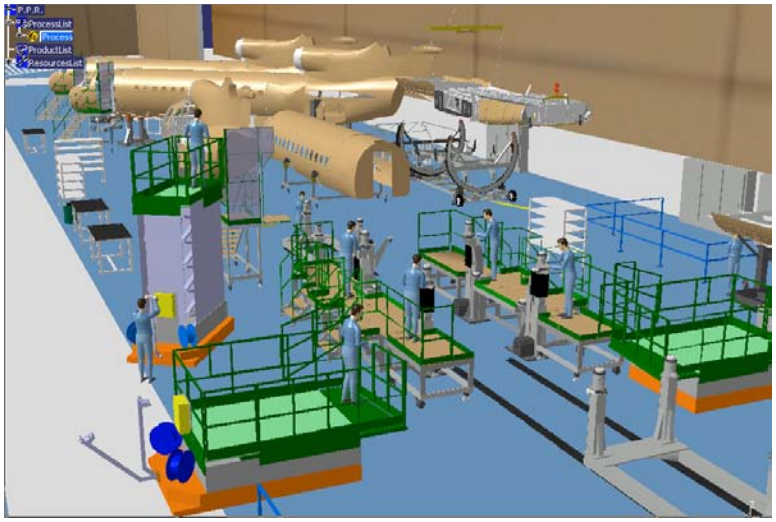

Fig. 4: 3D virtual plant layout and assembly simulation

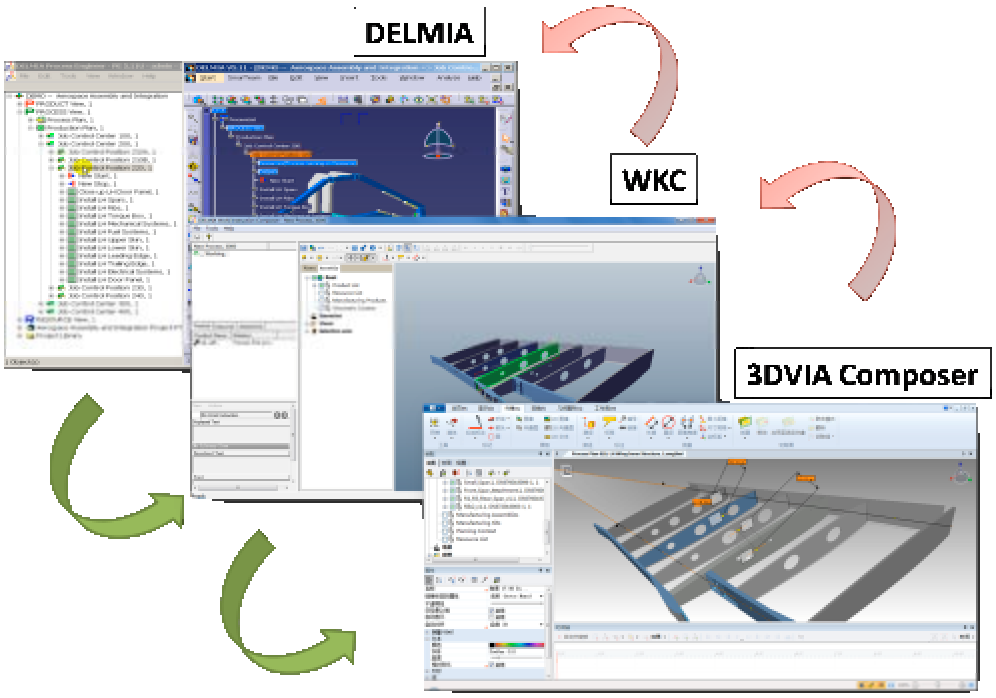

Fig. 5: View designs of steps using COMPOSER of the DPE module of DELMIA

Seventh step is compiling of wkc visual file: According to optimized process planning and design, view designs of steps are carried out using COMPOSER software of the DPE module of DELMIA system. The view designs comprise assembly information remarks such as marks of assembly dimensions, hole-making information, location information and tooling use information and then the visual file of step-level assembly is completed, as Fig. 5 shows.

Eighth step is the management and exporting of ao content and visual files: The AO content which has been designed in DELMIA is extracted to the appropriate template in the CAPP by the secondary development

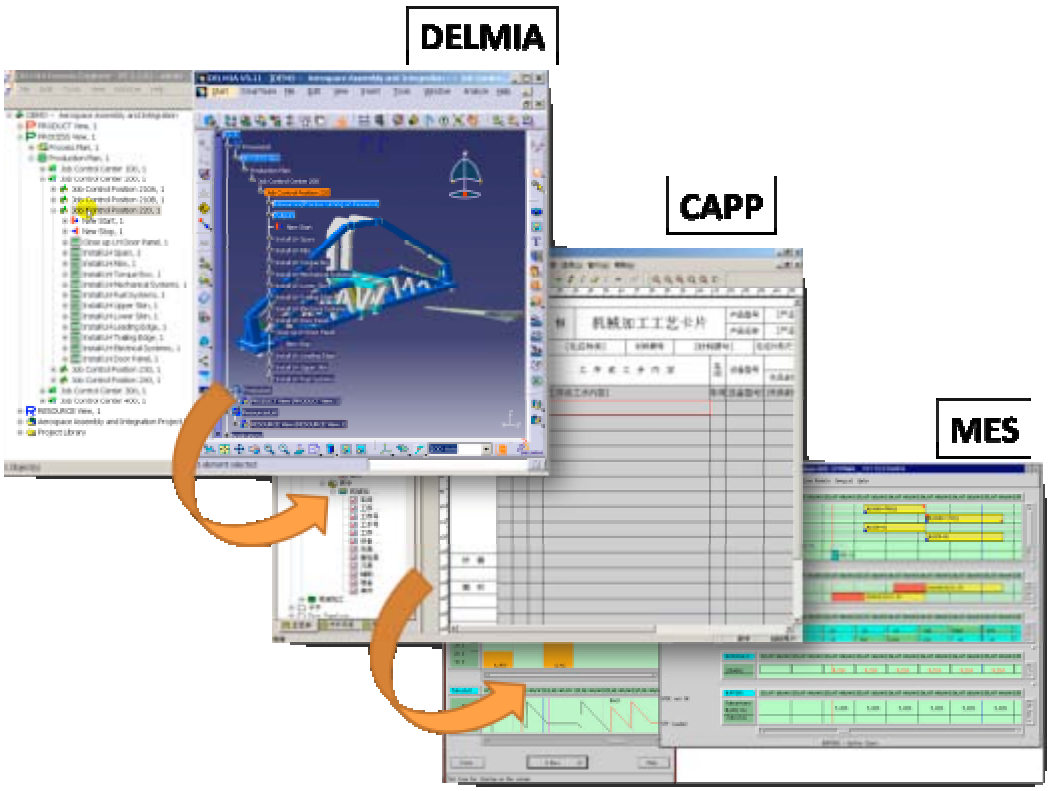

Fig. 6: Management and exporting of AO content and visual files

interface program, meanwhile, the simulation video and the view designs of steps are also exported. The AO content comprises some document Information such as AO content page, the auxiliary supporting table, the standard parts supporting table, the parts supporting table. All kinds of supporting tables and content pages are cheeked and approved by the collaborative work platform and the visual field assembly could be realized by MES system, as Fig. 6 shows.

CONCLUSION

The technology of 3D digitalized virtual assembly process design and processing simulation has the following advantages.

By assembly simulation, questions on product design and process design and tooling design could be found out in time before actual assembly, to effectively reduce assembly defects and failure rate, to reduce the redesign and change which was caused by assembly interference, hence to guarantee assembly quality.

The simulation pictures and videos could directly demonstrate assembly process which could make the worker understand the assembly technique better and reduce human error and be used to train maintenance personnel.

Not only working hour's analysis, 3D workshop process layout but also resource plan and evaluation using the technology of 3D digitalized assembly process design and processing simulation could help to improve production planning accuracy.

The technology transfers digital data during the assembly process could simplify and reduce the entity tooling and digital measurement technology could ensure the quality of assembly.

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