Analysis on Need of FO/AO on Military Production Lines

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Abstract. Based on the differences on managing contents, targets, model, roles and other aspects between Planning Sheet and FO/AO, analysis is conducted on the advantages of use of FO/AO in aircraft technical management and production management and comes to the conclusion that it is important and feasible to push the use of FO/AO on military production lines all around.

1. FORWARD
Within aircraft manufacturing enterprises of our county, current manufacturing orders are mainly Planning Sheet for detail part manufacturing, Planning Sheet for assembly, detail part fabrication order (FO) and detail part assembly order (FO). Of those orders, Planning Sheet for detail part manufacturing and Planning Sheet for assembly are reference to the standard system of the former Soviet Union, which have been adopted in the early stage in military manufacturing enterprises. Although improvements and innovations have been made to such Planning Sheets, their basic format did not change much. Those Planning Sheets are widely used as process documents for production in most aircraft manufacturing enterprises. However, with the advance of aircraft manufacturing technology and improvement of management, technical standards and management systems based on Planning Sheet cannot meet the demand of the development and manufacturing of the new generation aircraft.

FO/AO are introduced in the 1980’s with foreign commercial subcontracting programs\cite{1}. They are the process standards that are widely adopted by main foreign aircraft manufacturing enterprises such as Boeing and Airbus. FO is the abbreviation of Fabrication Order, which is the production process document that instructs product manufacturing on production site; AO is the abbreviation of Assembly Order, which is the production process document that instructs product assembly on assembly site. As is required by customers, domestic aircraft manufacturing subcontractors have built separate commercial production lines, established process technology systems that are based on FO/AO. Some enterprises even gradually extended the used of FO/AO to military production lines. However, due to various reasons, use of FO/AO has not spread on military production lines. Such extension of use in some domestic aircraft manufacturing enterprises have proven that, use of FO/AO can improve both the process technology level of military production and the product quality control ability and is beneficial to production organization and management\cite{2}. To elevate process technology, production management and quality control level in our military production and market competitiveness, it is imperative to borrow this advanced foreign management experience.

2. MAIN DIFFERENCES BETWEEN PLANNING SHEET AND FO/AO

2.1 Contents
Planning Sheets are operation instructions developed by planners, with the contents of processing
sequence, processing technical requirements, operation instructions for operators, process parameters and special equipment and tooling used in production. In FO/AO, besides the same contents as in Planning Sheet, there are also basic information such as type of work, man-hour quota, material quota; product condition information such as effectivity, processing quantity, date; quality information such as quality code, inspection method, actual measured value, product acceptance rate, names of operators and inspectors, resource information such as equipment, tooling, cutters and measuring gauges used in inspection. FO/AO collectively present and record the complete process for product manufacturing.

2.2 Targets
The targets of Planning Sheets are processing operations classified by specialties. They are developed by individual units by process routing. Planning Sheets for different processes and specialties are separate. There can be several Planning Sheets for one product item and they shall be used by section. Therefore, process flow is not complete in one Planning Sheet. The target of FO/AO is one product item. It is developed by the delivering unit, which includes the work content of each processing unit who coordinate the operations. There is only one FO/AO for one product item, which travels with the product. Process flow in an FO/AO is complete.

2.3 Roles
Planning Sheets are the operation reference for operators for detail part manufacturing, product assembly and inspection and an importance basis for determining working hour quota and product material quota. Planning Sheets and Fabrication Records are used and filed by page, and are applicable to research-and-development batch, trial-production batch and batch production. However, FO/AO, besides as operation instruction, focus on permanent recording of the complete process of product manufacturing and quality status. They are not divided by production stage and therefore are applicable to batch production. Their expression and format is more suitable for MBOM construction and resource capability balance analysis for production lines.

2.4 Managing Model
For technical management system based on Planning Sheet, as the Planning Sheets are effectively controlled by the latest revision, process documents for some shipsets are not complete (such as addition of Process CoC and other documents is adopted for fabricating temporary shipsets and). The Planning Sheets for different units on the process route are separately stored and filed. The Planning Sheet and Fabrication Record of each individual unit is also separately stored and filed. Under FO/AO technical management system, FO/AO are managed by shipset effectivity and each shipset (including temporary shipset) corresponds to a complete FO/AO. Before production of detail parts or product assembly, FO/AO will be distributed to production site and will stay with the product all along. Production and quality information are recorded on FO/AO. In the end, Inspection will file and store the FO/AO.

2.5 Technical Condition Control
As Planning Sheets are developed by specialties and sections, product technical condition is also controlled by section. Each specialty is responsible for the correct product dimension and product condition within its own working procedure and the product technical condition is responsible by multiple departments. FO/AO is collectively developed by the product delivery unit involving the complete procedure. The delivery unit is the main responsible department to secure correct product technical condition.

3. MEANING OF PUSHING FO/AO ON MILITARY PRODUCTION LINES
Nowadays, traditional 2D drawing is already superseded by 3D models at aircraft product design stage. MBD technology has been ripely applied, which improves aircraft product design efficiency and
quality\textsuperscript{[3]}. At facility manufacturing stage, NC equipment has been used commonly and in depth on production lines, thus drives the rapid promotion of manufacturing capability. However, as the process expression technology as a bridge between design and manufacturing, traditional Planning Sheets are still the mainstream for process technology on production lines. Their way of expression cannot meet the technical and production management demand for the new generation aircraft already. FO/AO is one of the scientific and rigorous management models in the world \textsuperscript{[4]}. It is of import to vigorously push the FO/AO management model on military production lines to improve the technical and management level of military manufacturing enterprises and to reduce the gap with advanced foreign countries.

3.1 To Improve Technical Management Capability
To supersede Planning Sheet, Fabrication Records and Route Card with FO/AO, four-in-one (process, production, quality and quota) integrated management can be achieved. In case of any product quality issue, the complete production process of this batch of products can be rapidly and accurately traced by drawing number, realizing rapid and precise statistics and real-time follow-up of the control of key operations on the whole aircraft and thus achieving the whole process management of the product from design through manufacturing.

3.2 To Improve Operability of Fabrication Order
FO/AO emphasizes the integrity of process procedure and the standardization of mature process. Specific operations and requirements are few in the content. Universal and typical operations are detailed in the referenced “DPS – Process Standard”. The aim of simplifying the Planning Sheet and improving the on-site operability is achieved by quoting many process standards and Work Instruction. Therefore, the spread of FO/AO could greatly reduce the workload of process development, and promote the standardization of production, process and quality management.

3.3 To Improve Technical Condition Control Ability
Shipset management is applied to AO, while batch management is applied to FO. Products from different batch/shipset correspond to FO/AO under different condition. One FO/AO includes all the operations on the process route. The production fabrication process is complete, and assembly/fabrication sequence is clear, which could facilitate the overall planning and management on product process. Delivery department shall be responsible for the final condition of the product. Responsibility for technical condition and quality status is clear, so the quality issue, such as missing the change implementation, is not easy to occur. Meanwhile, products from different batch/shipset correspond to the FO/AO with different validity, it also play an important role on promotion of the realization of technical condition management on military products per shipset.

3.4 To Facilitate the Balance of Production Resource and Capacity
FO/AO corresponding to each product has all the continuous operations, and each operation has detailed associated resource demand information such as equipment, personnel, and material. There is also process data such as start time, finish time and operation duration. It could be used to quickly count the demand on the whole aircraft resource (equipment and personnel), quickly count the demand on supplies and capacity (man-hour), realize the balance of demanded resource and available resource before production layout, and rationally establish the resource demand plan. It also plays an important role on supporting the improvement of accuracy and operability of production plan, as well as the improvement of production management ability.

3.5 To Facilitate MBOM Construction
MBOM construction is product-oriented which requires the attribute information such as all the fabrication/assembly operation procedure, man-hour quota, material quota, equipment resource, human resource, etc. And FO/AO is just the core source of these data, and plays an important role to
support the generation of MBOM. Not applying FO/AO on production line is the main cause for not fully realizing MBOM management in some of the military aircraft fabrication enterprises.

4. OPERABILITY OF APPLYING FO/AO TECHNIQUE ON MILITARY PRODUCTION LINE

Based on the analysis mentioned above, on the aspect of aircraft technology management and production management, comparing with the traditional Planning Sheet, FO/AO has a great advantage. And after the mature application on commercial aircraft production line, it already has the operability on overall promotion of military aircraft production line.

4.1 Supported by Powerful Information System

With the advance of technology and development of information technology, information system such as PDM, ERP, MES are already popularized within domestic aircraft enterprises. And CAPP is also the standard system. Through the integration of information-based system, information, such as equipment, personnel, supplies, man-hour, material, required for FO/AO development could be quickly input, and the operations could be fast connected in series.

4.2 With Process Standardization Technology Accumulation

With the deep development of subcontract program, each aircraft fabrication enterprise has introduced large amount of advanced process standard from foreign aircraft fabrication enterprise, and accumulated a lot of experience in process standardization. Meanwhile, with the technology advance, a complete process standard system has been established for domestic military aircraft production line. A lot of process standard have been developed, and application of Work Instruction has gradually spread. All of these provide a good technical basis for FO/AO popularization.

4.3 Experience Accumulation on Commercial Aircraft Subcontract Business

As per customer’s requirement, when domestic aircraft fabrication enterprise undertaking commercial aircraft fabrication business from foreign enterprise, it has established independent FO/AO based technology management system, accumulated large amount of management experience in FO/AO application, and become aware of the benefits of FO/AO management mode. It is the valuable wealth for promoting FO/AO management mode on military production line.

4.4 Demands on Establishing Ecological Environment for Core Data

During aircraft fabrication, core data management becomes more and more important. Establishing the MBOM-based ecological environment is an important tool to reflect the core capability of the enterprise. MBOM could not just reflect the assembly structure relationship, but more important is the attribute information in MBOM such as fabrication duration, resource demand, and supplies demand reflect the importance in technology management. But for FO/AO-based process technology system, the aircraft assembly process planning is actually the MBOM generation process. It is an urgent need to endeavor to promote FO/AO process planning mode on military production line with the help of the promotion of core data management.

5. CONCLUSION

The biggest difference between Planning Sheet and FO/AO is the concept[5]. Planning Sheet is just a technical document, but FO/AO is an order integrating design, method, quality, production, plan & schedule, and cost, and the original record. The management style with Planning Sheet as a carrier is backward way for production management, and is not applicable to product life-cycle management of the new generation of aircraft, also not applicable to requirements of aircraft product technology progress. FO/AO is an advanced technology management mode which is widely applied in domestic and foreign aircraft fabrication enterprise. The promotion of FO/AO within military aircraft system could improve process planning capability and technology management capability for military product. Today, aircraft technology management level is highly developed, and it still has important practical
significance.

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