Theoretical Research on Pull-production of Final Assembly Pulsating Line Based on General Aircraft

Jianxin He, Dongxiao Jiang

CETC Wuhu Diamond Aircraft Manufacture Co., Ltd, Wuhu, Anhui, China, 241000

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Abstract: This paper introduces the theory for the pull-production of assembly pulsating line based on general aircraft and establishes the theoretical model for the aircraft production line. It has been concluded that, through the research and analysis, the pull-relationship set up in the production process of final assembly pulsating line can enhance the production efficiency and make the production line much more stable and efficient.

1. Introduction

The final assembly of aircraft is a technical work characterized by much difficult in technology, wide in disciplines and high in comprehensive integration level. It directly affects and determines the final quality, manufacturing costs and manufacturing cycle of aircraft. The final assembly pulsating production line of aircraft is to adopt the modern high-efficient pipeline operation and combine the technological innovation with the management innovation to change the traditional aircraft assembly mode. It has been successfully applied in the international aviation manufacture industry and gradually introduced into China with the development of the Chinese aviation industry.

2. Current Development of National FINAL Assembly Pulsating Production Line

Due to the fact that the domestic general aviation industry starts late and develops too urgently, most of the production lines were built by copying the foreign modes and lack the local systematic planning, investigation and survey so there exists a certain of blindness. For this purpose, this paper is to analyze the final assembly line for one type of domestic twin-engine, four-seat general aircraft, fully understand & absorb the essence of the national & international aircraft final assembly pulsating line and combine the CAAC airworthiness requirements and its own features to Innovatively create the theory for the pull-production of final assembly pulsating line based on the general aircraft.

3. Module for Pull- production of Final Assembly Pulsating Line (model)

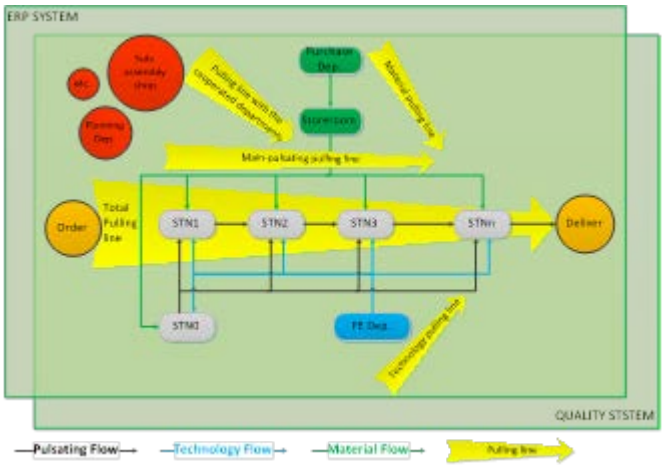

Fig. 1 Model for pull-production of finalassembly pulsating line

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The pull-production of final assembly pulsating line mainly consists of three major value flows such as the pulsating flow, the technology flow & the material flow (designed in one module) and five pulling lines such as the total pulling line, the main-pulsating pulling line, the technology pulling line, the material pulling line and the pulling line with the cooperated departments (designed in one module), which goes throughout the quality system of production process (designed in one module) and cover the ERP system of the entire product life cycle (designed in one module), as a result of four modules in total. The production run model is shown in Fig.1.

3.1 Pulsating flow

The pulsating flow is the pulsating body including the main pulsating line (workstation 1, workstation 2 ... workstation n) and the auxiliary pulsating line (workstation 0). Since the pulsating cycle of the main pulsating line is the off-line (rolling-out) cycle of one aircraft, it is a must for the production line to minimize the pulsation cycle Tm of main pulsating line:

$$T_m = Max.\{T_{Si}\}\ (si = 1,2,3...n) \tag{1}$$

Where, Tsi --- sub-pulsating cycle at each workstation of main pulsating line.

Due to the fact that the off-line cycle of one aircraft mainly depends on the longest sub-pulsating cycle of the main pulsating line, it can be seen that one of the ways for enhancement of production capacity is to shorten the sub-pulsating cycle at each workstation. In order to shorten the sub-pulsating cycle of each workstation, the production line is to build up the auxiliary pulsating line named as workstation 0. The main work at the workstation 0 is to conduct the sub-assembly, that is, the parts required to be assembled in the main pulsating line can be sub-assembled into sub-component at the workstation 0 and then directly installed in the main pulsating line. Thus the assembling can be changed from serialization work to parallelism work so as to shorten the sub-pulsating cycle at each workstation of main pulsating line.

3.2 Technological flow

The technical flow mainly is the engineering and technical support. Its function covers that after confirmation of aircraft purchase order, the engineering department shall determine the aircraft configuration based on the full-channel with the design institute and the customer demands, then issue the valid drawings, the work instructions (WI) and the bill of materials (BOM) to workshops acc. the created configuration lists and finally constantly assess & implement the newly received design changes in workshop.

3.3 Material flow

The material flow is one of the major value flows for the material supply system.

The ultimate goal of the material supply system is timely to distribute the correct and qualified materials to the appropriate workstations acc. the production plan and time node. After the planning department releases a production plan, the ERP system will auto-generate the material request and send the material distribution message to its storeroom. On receiving the said message, the storeroom sets up the links both with automated stereoscopic warehouse and the unmanned logistics vehicle through the ERP system to perform the material automatic off-storeroom and delivery, thus realizing the high-level automation and precision in the production operation.

3.4 Five major pulling lines

This production system covers five major pulling lines incl. the total pulling line, the main pulsating pulling line, the technology pulling line, the material pulling line and the pulling line with the cooperated departments. These five major pulling lines are jointly composed of the pull-production mode for the aircraft final assembling line.

For each production unit, the pull-force of pull-production is just required by the next production unit, that of the total pulling line is just required by the customers, that of the main pulling line is just required by the next workstation faced to each workstation of main pulsating line, that of the technology pulling line is just required by the technical support of on-site production, that of the

material pulling line is just required for the materials of on-site production and that of the pilling line with the cooperated departments is just required by the planning department, the engineering department, the sub-assembly plant, the special processing workshops and the human resources department, etc. to provide the other support for the final assembly line.

In order to better realize the pull-production, the planning department shall enter all the pulling demands for the final assembly line into the ERP system. The ERP system serves as a carrier in the whole pulling system and integrates a visualization display board in the system so as to facilitate each production unit for access to their production needs, thus achieving the refined production and avoiding the anomalies such as the production rhythm disorder, overcapacity of individual production unit, etc.

In the material supply, the materials, if supplied not in time, easily cause the production unplanned downtime and if purchased overmuch, easily cause the materials hoarded, expired, etc., resulting in waste. Thus, to take the ERP system as a carrier for setup of pull-relationship between the production line and the material supply system and to adopt the run mode in which the production pulls the material supply are the inevitable way to solve such a conflicting issue.

3.5 Quality system

The quality is the life of an airplane. In this production run mode, the quality control (QC) shall penetrate into every production link, mainly incl. the quality control of incoming materials, monitoring of production process and aircraft final inspection and release.

The quality system must be established and implemented strictly acc. the relevant regulations of CAAC. Its ultimate goal is to ensure the initial airworthiness of the aircraft. A scientific and comprehensive quality system is an import significance to guarantee the initial airworthiness of the aircraft and also makes the production run mode strong support.

3.6 ERP system

The ERP system covers the operation of the entire company. As to the operation scope shown in Fig. 1, the ERP system has played a vitally important role in the pull-production line and the material supply. It has effectively assisted the production line to solve the problems such as disengagement between actual production schedule and plan, imbalance of operation missions, unsatisfactory production capacity, etc., thus making the entire production line run efficiently and orderly.

4. Analysis on Efficiency of production line

Through the analysis on the model of main pulsating line, it can be seen that there exist the mutual counterbalance and interplay among the different workstations so the concept of production line efficiency η is put forward below:

$$\eta = 1 - \frac{\sum_{si=1}^{n} (T_m - T_{Si})}{nT_m} \tag{2}$$

The efficiency η of production line reflects the operating time for one aircraft as a percentage of the total time involving the production means such as equipment, staffs, etc. in the process from the workstation 1 to workstation n of main pulsating line. The lower the η is, the more idle time is available in the main pulsating line, i.e., the more idle man hours. However, for the actual production, besides of the attributive factors pertaining in the pulsating line, its total pulsating line efficiency is also affected by the issues as faults, material supply, coordinated factors from various cooperated departments, which occur in the production, and the other external factors (the factors except those specially set up in the production line called the external factors, and the same below).

Where, all the external factors are set as A1, A2, A3 ... An. The influencing factors of each external factor affected on each workstation of pulsating line are set as ξA1•Si，ξA2•Si，ξA3•Si…，.(The ξX•Si≥1 shall indicate the extension of sub-pulsating cycle Tsi at each workstation

caused by each external factor). Therefore, for each, the actual pulsating cycle Tm′ under the superposition influence by various external factors is: (Tsi' is the actual sub-pulsating cycle)

$$T_m' = Max.\{T_{Si}'\} = Max.\{T_{Si} \bullet \prod_{i=1}^{n} \xi_{Ai \bullet Si}\} \tag{3}$$

And then, the actual production efficiency η ' of production line can be deduced:

$$\eta' = 1 - \frac{\sum_{si=1}^{n} (T_m' - T_{Si}')}{nT_m'} = \frac{\sum_{si=1}^{n} T_{Si} \bullet \prod_{i=1}^{n} \xi_{Ai \bullet Si})}{n \bullet Max.\{T_{Si} \bullet \prod_{i=1}^{n} \xi_{Ai \bullet Si}\}} \tag{4}$$

Hence, the production line needs to be serially improved so as to make the η′ tend to 1. So, it is a must to equilibrate the sub-pulsating cycle at each workstation and reduce the generated possibility of each external influencing factor.

In this case, the pull-relationship established in the production flow of the aircraft final-assembly pulsating line is possibly to well-solve such a conflict issue. As mentioned above, for each production unit, the pull-force of pull-production is just required by the next production unit so the last production unit takes the demand of next production unit as a direct input to fully ensure the supply to the next production unit, which make the target and responsibility of last production unit clear and explicit so as to well-accomplish its own mission. In this pull-production mode, if every production unit does it so, the entire production line will be smooth and efficient in operation. Moreover, the positive and negative feedback generated by the pull-relationship can also enable the entire production line gradually self-perfected, that is, the "balance of sub-pulsating cycle at each work station" could be self-perfected to make the production line gradually move towards the optimal state.

5. Conclusions

Therefore, with the rapid development of domestic general aircraft, the final assembly production line shall inevitably step from the "blindness" back to "reason" and "science". Viewing from the current development for both national and international final assembly lines of general aircraft and in combination with the aircraft assembly features, the pull-production for final assembly pulsating line is the future inexorable development trend for aircraft final assembly in order to enhance the aircraft production efficiency in premise of aircraft quality assurance.

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