SOME MANUFACTURING ACTIVITIES IN JAPANESE AIRCRAFT INDUSTRIES (JAI)

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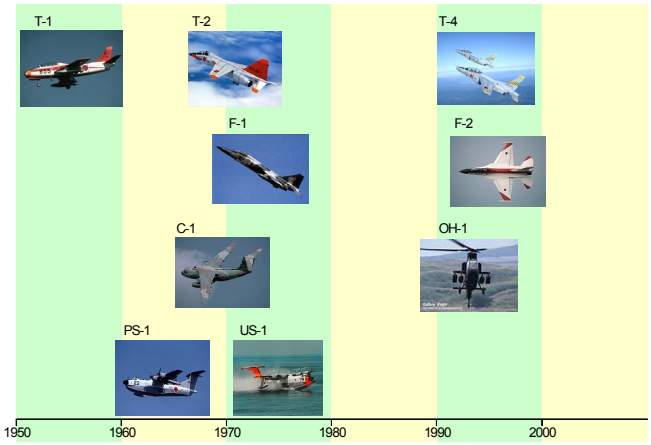
Abstract

Japanese Aircraft Industries were forced to stop manufacturing for 7 years after the World War Ⅱ. 50 years thereafter, JAI returned to the world aircraft industries. JAI restarted operation from repair work of US military aircraft. JAI cumulated their capabilities through a number of aircraft development programs of Japan Self Defense Forces (JSDF) and now they can build their own fighters, carriers, trainers and helicopters. Recently, their capacity of building aircraft is significantly increased mainly in commercial field, building large commercial aircraft components. JAI focused on improving Quality, Cost and Delivery performance. For the purpose, Concurrent Engineering, Lean Manufacturing, Total Quality Management and other improving methods are implemented. For further cost reduction, Manufacturing Research and Development (MR&D) is actively performed.

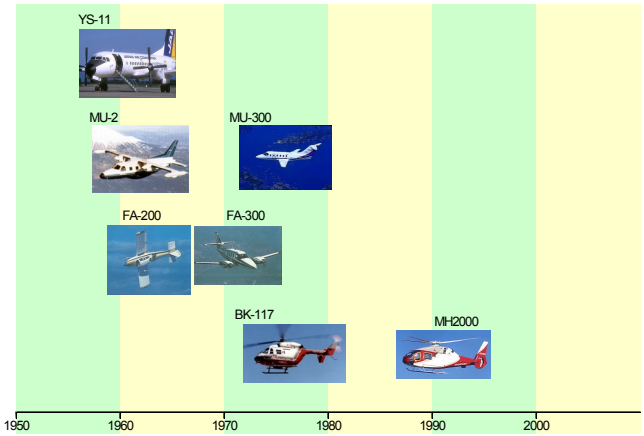
1 JAI Capability and Capacity

1.1 JAI built airplanes

JAI have been developing various types of aircraft after the restart of aircraft manufacturing in 1953.



In military field, they develop and produce trainers, carriers, amphibians and fighters by themselves. The first jet trainer developed in Japan is T-1 which was used in JSDF for over 40 years. T-2 trainer is the first supersonic airplane JAI developed. Latest trainer model is T-4 of which airplanes were made over 200 and are used in JSDF. F-1 fighter was the derivative of T-2. F-2 fighter is the modern fighter made fully of composite, lately deployed in JSDF. C-1 carriers, OH-1 observation helicopters and US-1 amphibians were also developed and deployed in JSDF. Each airplane performance is evaluated as the world class at the time.

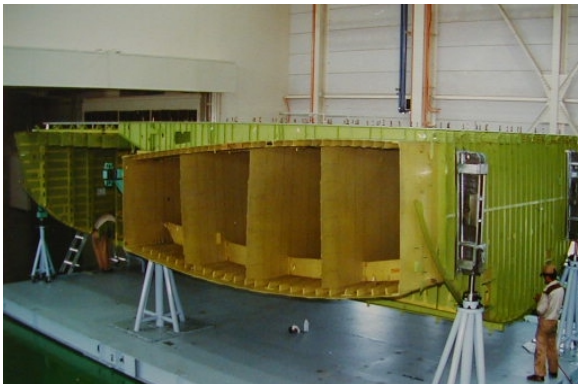


In commercial field, they also develop and produce trainers, transporters, business airplanes and helicopters. YS-11 is the turbo-prop commercial transporter with 60 seats, first and ever made in Japan and sold over 180 in domestic and world market. FA-200 is a sport plane made 300 shipset for domestic and world market. FA-300 and MU-2 are turbo-prop and MU-300 is the jet business planes, made 50, 750 and 100 respectively. BK-117 is the helicopter made by international cooperation and M2000 is

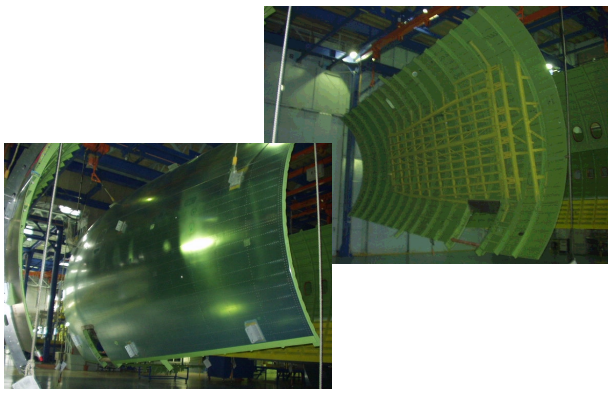
the domestic developed helicopter. JAI continue challenging for entering into the world market although the total deliveries of each program are not so large because of very small domestic market and lack of worldwide sales network and consequently, successful programs are a few.

Regarding manufacturing of aircraft components, JAI have been building large components of B767 and B777 for Boeing. Looking the other commercial business, JAI build wing and fuselage component of regional jets for the world aircraft integrators.

B777 Center Wing Structure



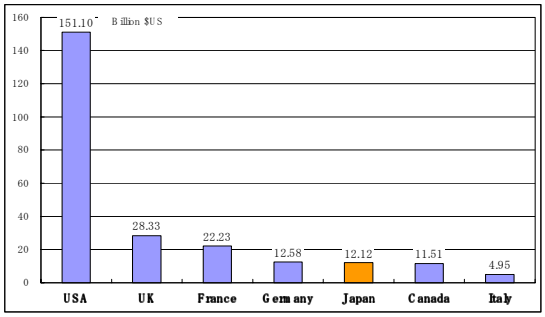
B777 Fuselage Structure



1.2 JAI production status

JAI have been increasing their capacity of aircraft manufacturing. Recently, the amount of aircraft related production was over US$9,000M. Production of aircraft and components is over 80% of total. Regarding fraction of military and commercial, military demands have occupied most of their capacity for long term after the restart of aircraft manufacturing. In this decade, commercial production gradually increases by many subcontract programs. This shows the JAI become competitive in Quality, Cost and Delivery performance in the world. However the size of the JAI aircraft related sales is less than 1/10 of that of the USA.

Sales Size of JAI



2 JAI Focused Activities

Their aircraft manufacturing activity starts from the producibility input in the concurrent engineering and ends up with the lean manufacturing. It is famous for JAI to keep manufacturing schedule. It comes from their continuous quality improvement. Every aspect of production, they make efforts of Kaizen (Japanese word of improvement) in all disciplines under control of Total Quality Management (TQM). Very close cooperation among disciplines contributes well to the effect of the TQM activities. Very low defect ratio in production makes their schedule firm and makes their cost as planned. It must be essentially necessary in the circumstances of the lean manufacturing operation.

2.1 Concurrent Engineering

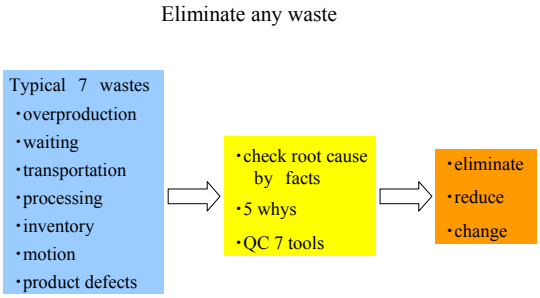
On developing aircraft, product definition phase is the best timing to incorporate producibility, because once the design has established and released, producibility input incurs much time and effort for changing drawings or specifications. Japanese engineers and manufacturing engineers had historically an attitude for working together to incorporate producibility when having translated licensed engineering drawings. In these days, concurrent engineering method is emphasized and JAI implemented the process very effectively into

their business based on the attitude. Recently, introduction of Information Technology (IT) into the concurrent engineering is promoted as a common tool for the process. Finally, they reduced engineering errors to nearly zero and reduced total flow time remarkably.

2.2 Lean Manufacturing

Lean manufacturing has been the basic concept in Japanese automobile manufacturers. JAI take this concept naturally in aircraft manufacturing. The objective is to eliminate any wastes from the manufacturing operation and achieve the minimum inventory. There are various kinds of methods to achieve this objective depending on the manufacturing configurations. Manufacturers making a lot of quantity take methods more likely to the automobile manufacturers using tools such as Kanban (just in time parts supply system) and Andon (job visibility system). JAI do not make many aircraft per year and then take several effective methods into their operations. Some examples are introduced here.

One is to eliminate wastes. It is said that there are 7 typical wastes in manufacturing operations. They scrutinize every operation for wastes existing in the operation and find root causes why such wastes exist there. Traditional 5 why methods and QC 7 tools are used for it. Elimination, Reduction and Change of operation to minimize these wastes are executed to achieve the wasteless operation. These activities are performed as daily work not only in shop floor but also all floors even in indirect worker's offices.



To reduce inventory, JAI challenge to shorten flow time of design, procurement, fabrication, assembly and any other activities from input to return of resources.

In manufacturing field, typical operation is small lot fabrication. Basic concept is "Just make necessary things in necessary timing in necessary quantity". If you pursue and make this concept reality, lot size naturally becomes smaller and smaller and finally you should make piece by piece fabrication. Simplification and reduction of setup time is definitely important. In relation to the small lot production, materials for fabrication are in hand in small quantity. These parts and materials are kitted and delivered to assembly line in necessary timing. In assembly shop, reduction of assembly position and shortening of assembly flow time are the major activities. To achieve these two, improvement of process and compression of assembly time are necessary and at the same time, promoting multi-skill worker and zero defect are inevitably necessary. Energetic daily activities leads JAI achieve shorter flow time securing the designate cycle time.

2.3 Total Quality Management

Defect should be zero and if happens it should be found as fast as possible to minimize recovery cost. Defect happens not only in a shop floor but also its root cause sometimes planted in other related areas.

Extending this thought companywise, all departments, sections and groups, and to the end, each individual must participate in an operation for improving quality.

Total Quality Management (TQM) system is implemented in most of JAI in various different shapes, however the essentials are the same. The objective of TQM is to improve total performance of the company improving the quality of each discipline's operation. Company's management targets are established and announced and are immediately broken down to the lower organizations. Finally each working group has its own targets. To achieve the group target, PDCA cycles are turned again and again. To improve the group performance, Kaizen activities are very active in all area. To remove conflicts between disciplines, cross-

functional activities are frequently observed. The solution for improvement should be good for customer. In this context, customer means the one from the next operation to the final user. Status of achievement is checked and if necessary additional Kaizen activities would be activated. Cumulating the results of groups, the final company target is achieved.

3 Manufacturing Research and Development (MR&D)

Various kinds of MR&D activities are performed in JAI. They have been studying new technologies in Composite Manufacturing, Consolidated Casting, Super Plastic Forming / Diffusion Bonding (SPF/DB), Hole Index Technology and Automated Assembly. These MR&D will be utilized to future production as a tool of further cost reduction.

3.1 Advanced Composite

Advanced composite production boosts in aircraft manufacturers. JAI seek for cost reduction methods and recently, large size one piece panel and non-autoclave curing panel is pursued. For non-autoclave curing method, Resin Transfer Molding (RTM) and Co-bond process are researched. After having finished material development and element fabrication, actual size experimental parts are being produced (Ref. #3.4.3).

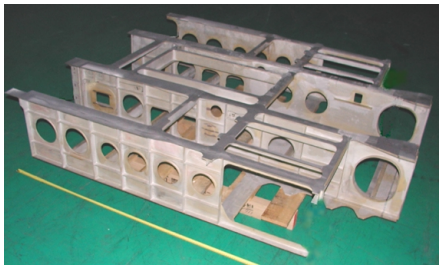
CFRP Sandwich Panel applied to
Pressurized Nose Structure (Cockpit)

Co-bonding of Skin, Stringers and Rear Spar

3.2 Consolidated Casting

170 pieces of parts, which were integrated into a conventional assembly, are consolidated into a single piece casting. JAI overcame hot spots or flow problems of the sophisticated castings and realize the aircraft quality production castings. This will reduce weight and cost significantly in future.

Consolidated Casting



Large and Thin Complicated Casting applied to
Pressure Support Structure
（1850mmL×1520mmW×350mmH, Wall thickness 2.0mm）

3.3 SPF/DB

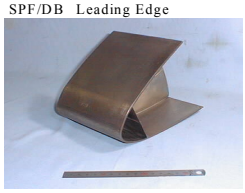
SPF/DB technology for high temperature structures is researched and developed to minimize parts count for cost and weight reduction.

SPF/DB

Four Sheets SPF/DB Wing Panel

size : 200× 300× 25mm
material : SP-700 (Ti-Alloy)
: Face/Core Sheet;1.2/0.8mm
: Core Pitch;30mm

SPF/DB Leading Edge

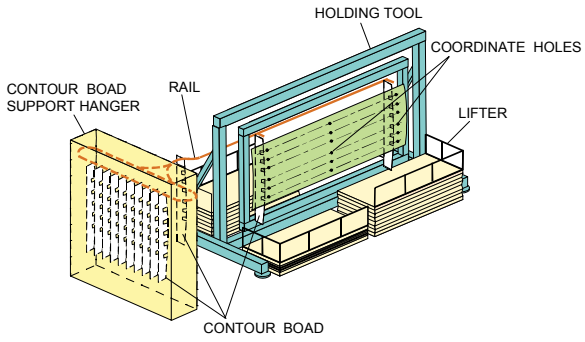


size : 150(chord)× 170(span)mm
material : SP-700 (Ti-Alloy)
: Face/Rib Sheet;2.6/0.7mm
: Bird Strike, anti-icing system

3.4 Hole Index Technology

Conventional low cost techniques such as automated riveting, high speed drilling, laser measurement and etc. were utilized for reducing assembly man-hours. JAI develop Hole Index Technology for reducing tooling and assembly cost at a time. Flat or relatively mild curve parts are drilled part by part by NC machines, set up on a holding tool using the coordinately drilled holes without securing the parts by tool locators and followed by auto-rivet operation.

Hole Index Technology - flexible tool



3.5 Automated Assembly

Another solution for low cost assembly technique is the automated assembly. The machine is consisted with automatic riveter, smart sensors and more capable end effectors. Fuselage panel used to be riveted on skin and stringers. This technique significantly increased the numbers of rivets installed automatically for skin to shear ties and for frames to shear ties. Assembly flow time is also significantly reduced, of course.

Auto-assembly machine

4 Summery and Conclusion

JAI's aircraft production increases up to US$ 9,000 million. Commercial products increase significantly in these days. Their capability goes up to building their own developed fighters, trainers, carriers, transporters and helicopters. Through building commercial products, cost reduction activities are performed in all aspects. They input producibility by concurrent engineering process and manufacture very effectively in lean manufacturing operation reducing inventory. Total quality management is the base concept of JAI for improving company performance. For further cost reduction, MR&D challenges are active.

In these days, JSDF ordered JAI to develop two new generation models of a carrier and a patrol airplane. This will be a big chance for JAI to grow up larger.

JAI have been planning a new commercial jet airplane and devote themselves to develop the technologies which will be applied to it.

JAI will continue improving their QCD performance and will make efforts to increase capability and capacity as world class aircraft manufacturers.