Manufacturing plan for wing of pav

Business, Industries

Manufacturing processes are differed according to the fabrication techniques such as sheet metal forming and machining processes. For the wings of a new personal air vehicle (PAV); skins ands ribs are produced by sheet metal forming process and spars are produced by machining process. Finally all produced parts are assembled together to produce final wing structure.

In addition, since the components that build up ailerons and flaps are very similar to wing structure, manufacturing techniques applied for skins, ribs and spars are also valid for them. Since there should be actuator and hinge fittings to connect ailerons and flaps to wing structure, they are considered in machined parts manufacturing process section.

SKIN MANUFACTURING

Manufacturing process of skins is shown in Figure -1;

Figure-1 [1]

Tools for sheet metal forming Operations;

Stretching Dies, Drill fixtures, drill plates, holding tools

First Cut

Aluminums Raw Materials are cut by shearing machine or hand router to get available sizes for manufacturing with much enough excess portions.

Heat Treatment

Blanks are then solution heat treated to provide necessary mechanical properties to the parts. Heat treatment operations are done according to the

design requirements which are defined by engineering drawings. Heat treatment processes are applied to make parts generally T4, T5 or T6 tempers.

Stretch Forming - Skins

On the stretch press, skins are stretch formed and their tooling holes are marked. After removing the skins from stretch presses, the marked tooling holes are drilled for succeeding assembly operations. An example of stretch forming process is shown in Figure - 2.

Figure - 2 [2]

Skin Routing

Routing operation could be done with two techniques;

The first one is using a routing shell tool which has two parts which have exactly same form of the skin. The skin is then located in between them which is fixed with the tooling holes previously opened after stretching and a hand router is traveled around the tool to shape the skin to its final contour. Aphotoof a router shell is shown in Figure - 3.

The second technique is using a five axis gantry routing centre with flexible vacuum assisted table. The skin is positioned with the aids of vacuum assisted columns as shown in Figure -4 and tooling holes are used to set the machining coordinate axes.

Figure - 3 [3]

Figure - 4 [4]

During routing operation, tack holes are also drilled. Also during routing operation, excess portions like access openings or some pockets are removed from the skin.

Surface Treatment

Surface treatment operations are also defined by the engineering drawings. Some of the surface treatment operations applied are rinsing for cleaning, chromic acid anodizing, primer and coating for corrosion prevention. Primer coating and painting are also called as Chemical Conversion Coating (CCC) which is beneficial for fatigue prevention.

In our case, chromic acid anodizing is applied to 2024 skins for preventing corrosion and paving the way for painting. Before chromic acid anodizing, fine holes should be masked to keep dimensions accurate.

A typical anodise process would consist of a solvent wash and/ or an alkaline clean to remove any oils or greases from the surface. followed by a de-oxidiser stage to remove the natural oxide film from the surface, followed by chromic acid. This gives you a clean oxide free surface which once anodised will give better adhesion of the anodised layer. There is a water rinse stage between each tank to prevent contamination of the bath solutions. From there you have two choices, spray directly onto te anodise 'honeycomb' structure which will give good paint adhesion, or seal the anodised layer for enhanced corrosion protection but poorer paint adhesion.

Painting

Finally, primer, top coat and final paint are applied on the skin.

RIB (SHEET METAL) MANUFACTURING

Manufacturing process of ribs is shown in Figure - 5;

Figure - 5 [1]

Tools for sheet metal forming Operations;

Hydro press forming dies, Drill fixtures, drill plates, holding tools

The main difference of manufacturing of ribs from skins is hydro press forming process instead of stretch forming.

Hydro press Forming

After heat treatment, blanks become ready to be formed. In aerospace industry fluid cell forming (hydro press forming) is frequently used for forming operation. That is mostly because of the reality that aircraft parts are manufactured in small quantities and parts are mostly different in geometry. Therefore it is necessary to manufacture a different tool for every part and that is very costly. Although the machine is quite expensive, to decrease the tooling costs, hydro press forming is preferred since only male dies are necessary to form parts instead of male-female die combination. That is illustrated in the figure. Also another advantage of hydro press forming is that, on the table of the press machine, several tools, with the blanks on them, could be located randomly at once. In one cycle all the parts

are formed simultaneously. Also in general press machines are equipped with two tables which make it possible to decrease set up time to half. Some photos related with hydro press forming are shown in Figure - 6.

Figure - 6 [4]

SPAR, HINGE, RIB AND FITTING MANUFACTURING

Manufacturing process for machined parts, spars, hinges, ribs and fittings is shown in

Figure-7;

Figure - 7 [1]

Tools specific to machining operations;

Milling fixtures

Machining

If necessary those parts which will be machined on milling centers, are firstly cut from blocks of raw material to their required stock sizes. They are mostly skin milled. Skin mill is done to obtain a smooth flat plane to locate the stock on the milling machine table. After skin mill, some holes are drilled on the stock for the sake of transportation and fastening on the machine tables or fixtures. For complex milling operations in which there are more than one stages of operations, it is common to use a milling fixture, see Figure -8. Another reason for use of milling fixtures is that in aerospace industry manufacturing tolerances are so tight and geometries are mostly very

complex that is why it is necessary to provide same machining conditions and set up for every single part. Milling fixtures are tools, on which stock material is located and clamped. Their main functionality is that they hold the machined part tightly throughout the machining process which prevents machining defects and dimensional inaccuracies.

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Figure - 8 [4]

To obtain required dimensional tolerances, some holes require boring. Boring operation removes only a small quantity of material therefore before boring operation the hole must be drilled very close to the final dimension of the hole diameter.

Dimensional accuracy of the machined parts are generally checked with the utilization of Coordinate Measuring Machines (CMM). These machines are very precise such as they are capable of measuring ten thousands of a millimeter in three dimensional spaces. Although they are quite expensive and they need an air conditioned, humidity controlled and vibration isolated chamber, they are the most accurate and flexible measurement equipments.

Shot Peening

Machined parts are exposured to shot peening operation. That process is done to remove and minimize the existing surface cracks on the machined parts. Machined parts are generally bear high amount of repetitive tensial and compressive loads and these repetitive loading is mostly the main cause

of fatiguefailure. Surface cracks are the mostly affected defects from repeated loading and they tend to grow under these conditions. That is why they must be removed or minimized to prevent them to grow and increase the fatigue durability of the part.

Surface treatment

As explained before both chromic acid anodizing, primer coating and painting are the surface treatment operations applied on the parts to make them resistant to corrosion. Another advantage of these chemical conversion coating processes is that they make the part more durable to the fatigue, since they penetrate to surface cracks, scratches and holes. For instance, pitting is a corrosion type which is more susceptible to such surface defects. Therefore surface treatment processes both provide a protective coating in corrosive environments and they generate a smoother aerodynamic surface, which is a requirement to decrease air drag, especially for the outer surfaces which are in contact with the air during flight.

ASSEMBLY OPERATIONS

Assembly Operations are shown in Figure - 9;

Figure - 9 [1]

Tools for assembly operations;

Assembly and sub assembly jigs and fixtures

Assembly Jig

In aerospace fabrication processes, since the parts have very complex geometries and position tolerances are so tight, it necessary to use a fixture to locate parts in their required positions and apply assembly joining operation in these positions without letting them to move. For an air plane wing a single assembly jig could be used for this purpose, see Figure - 10.

Figure - 10 [5]

Spars are located on the jig. They must have a planar smooth contact surface and they must have previously opened tooling holes. Those holes are used to pin the spar on the jig and some clamps are used to fix the spar in its position.

Ribs are located. They are installed on the jig with the utilization contacting surface of spar and some other location surfaces and they are pinned from their tooling holes. Clamps are used to fix ribs in their location.

Some of the holes are transferred from ribs to spars or the contrary.

Bottom skin is loaded on the jig by the aid of tooling holes on the lugs at each lateral short edge. To wrap the rib spar assembly the skin could be pressed by some belts or some header plates could be used to bring the skin to its required form and clamp it to hold it in its required position.

Some of the tack holes on the skin are fastened with clecos, which is a temporary fastener. Pilot holes are drilled to their final sizes and countersinking is applied to locations where countersunk rivets and bolts will be used.

After drilling and countersinking is applied parts are separated to remove chips.

Before putting parts together again, sealant is applied. Sealant is a viscous chemical isolation material which is a polymer in general (polyurethane, polysulfide, etc). It is applied when it is still in fluid form and it solidifies as a result of chemical reaction which takes place as soon as the sealant is exposed to air. They are used to prevent fluid leakage into internal structural components. This leakage could result catastrophic failure since corrosion which erodes material would work against the mechanical strength and stiffness of the structure. For different purposes and for different locations specific types of sealants are applied. For instance polysulfide based sealant is applied to the surfaces where there is fuel content. For fuel tanks these polysulfide based sealants are used since they withstand the attack of sulfur compounds that are present in fuel.

After sealant application, outer skin is brought to close the wing and it is fastened with blind rivets and bolts since it will only be possible to reach rivet from one side.

When riveting and bolting completed the wing is removed from the assembly jig and it is sent to paint shop for the application of top coating and painting. After that manufacturing and assembly operations will be completed.