AIRBUS-ASSEMBLY CONCEPTS TO IMPROVE PRODUCTIVITY AND FLEXIBILITY IN AIRCRAFT CONSTRUCTION

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Abstract

At Messerschmitt-Bölkow-Blohm GmbH, Germany, the first successful beginnings towards rationalizing and humanizing the structural assembly of civil aircraft - in this particular case in the production of riveted joints - have currently been made:
A riveting system for spherically shaped aircraft shells. 5-axis-CNC is the characteristic feature of the riveting equipment, in which an optical sensor system provides the possibility of compensating variations automatically by means of component tolerances. In future it will be possible in aircraft construction to rivet automatically in any desired sequence.
Another riveting system has been developed for the assembly of clip-to-frame connections that is especially characterized by an NC-positioner with an optical sensor system. With this riveting system (weight: 30 kg) it is possible to install connecting elements automatically even on highly spherically curved shells.
By the realization of "ARAS" (Automated Riveting Assembly System), it is possible for the first time to produce longitudinal joint connexions automatically on closed aircraft fuselages. The characterizing design: NC combined drilling and riveting carriage which travels on a pressure and guide strip along the outside of the fuselage and carries out production operations such as drilling, countersinking, sealant application, rivet feeding and rivet setting automatically. MBB has met the future requirements calling for the shortest production time, highest degree of flexibility and humanization of the working environment in civil aircraft construction by the employment of highly automated riveting systems.

1. AUTOMATION OF ASSEMBLY OPERATIONS

In an industrial concern today, assembly is still an area offering a vast potential for rationalization. The german aircraft manufacturs are also compelled by international competition to come to terms with measures of rationalization in this area in order to reduce production costs and achieve greater flexibility and improved quality of their products. In the Transport and Civil Aircraft Division of Messerschmitt-Bölkow-Blohm (MBB) the first successful steps have been taken towards rationalization and humanization of structure assembly especially in the production of riveted connexions.

2. AUTOMATIC RIVETING

Besides bonding, the most widely used means of connexion for structure parts in aircraft production is riveting. Depending on the construction, up to 2 million riveted connexions may be used in the production of wide-body aircraft, which has a considerable effect on the cost structure of the components of economical production, it is essential to replace the riveting process, performed mainly by hand so far, by automatic riveting systems. A comparison of manual and automatic riveting on a stringer/skin panel connexion shows for example that with manual riveting a multitude of worksteps are required which may be reduced considerably by automatic riveting (see Fig. 1).

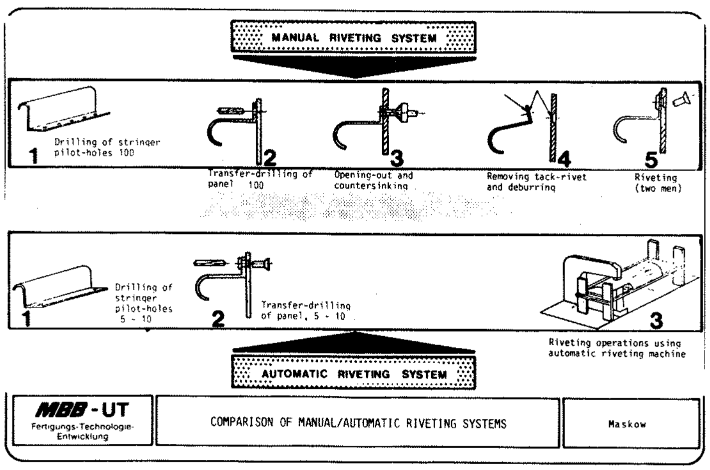

Figure 1:

This is achieved for the most part by a riveting machine performing the following riveting sequence automatically (see Fig. 2):

- positioning,
- drilling and countersinking,
- swarf removal,
- sealant coating,
- rivet feeding and
- rivet forming.

A riveting system capable of producing riveted connexions should fulfil the following requirements:

1) The machine or component references must comply with the prescribed position for the rivet, given mainly by the position of the fixed part and the contour of the component.

2) On reaching this position, the riveting machine must form the selected rivet, taking into account the parameters set for the appropriate rivet type.

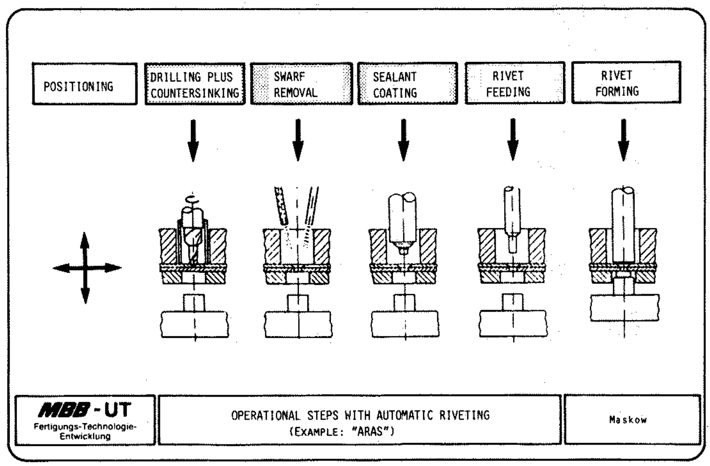

Figure 2:

Riveting systems have been developed by MBB meeting these requirements, in some cases in close cooperation with the relevant manufacturers. The final production concepts are such that experience gained in aircraft construction may be transferred to other branches of industry. The following gives some examples of this type of riveting system of the latest generation.

3. THE LATEST GENERATION OF RIVETING SYSTEMS IN AIRBUS PRODUCTION

5-Axis CNC riveting system for fuselage skin panel assembly

The Airbus fuselage section manufactured by MBB comprises two types of skin panel assembly.

- In the pressurized sections there are bonded skin panels with lesser and medium degrees of spherical contour, fitted with riveted clips and window frames.

- In the non-pressurized rear fuselage there are only riveted skin panels, some which have a high degree of spherical contour.

The task was to develop a riveting system capable of riveting successfully the highly contoured skin panels of the Airbus on the one hand, and on the other hand to contribute to the humanization of the working environment by reducing the noise level in the assembly shop.
In the context of this task and promoted by the BMFT (German Federal Ministry for Research and Technology), MBB and the Gemcor company cooperated in the design and construction of a 5-axis CNC riveting system. Owing to the high degree of automation, this system is now capable of riveting even spherically formed skin panels considerably more economically than the 3-axis systems previously on the market.
The CNC riveting system comprises three main components (see Fig. 3):

- riveting machine,
- component fixture,
- CNC unit.

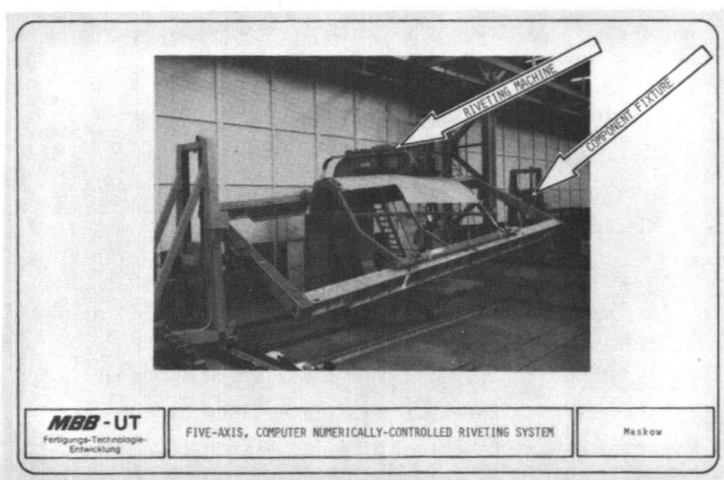

Figure 3: 5-axis CNC riveting system

Riveting systems of this type available until now had a considerable disadvantage insofar as they only operate automatically for one single rivet type, with the set parameters. When changing the type of rivet, other tools had to be inserted by hand and new drilling and rivet parameters set manually.

A special feature of the system presented here is that all 12 rivet types used in this component spectrum can be formed automatically by automatic tool selection.

This is made possible by 5 rivet feed tubes, 9 different drilling and countersinking units and 9 different rivet forming units each of which may be called up by programm. The system is also equipped with an automatic rivet selection system with 42 rivet magazines and a device for measuring component thickness, by which the various rivet types of different lenghts are programed and automatically conveyed to the riveting position. All the necessary drilling and rivet parameters may be set manually or automatically by program at the control panel.

Another new technological feature of this system is the automatic rivet position correction facility. The rivet position corrections which may be necessary, giben the considerable component tolerances, can be performed automatically on this system at the tack rivet position by means of an optical sensor system. This consists of a camera positioned above the riveting position, centered at the drill and connected to a computer, which determines coordinate deviations from the centroid of the black tack rivet representing the theoretical position.
In order to minimize setup times on the system a component support frame was designed. The base frame contains adjustable template frames connected to the skin panel assembly by various elements. By means of the locking and shifting system on the riveting machine frame, it is possible to shift the base frame in such a way that the component may still be riveted even if the rivets are hidden by the frame. The component support frame with the component may also be adjusted at the work stations before or after the riveting machine. In connexion with a lifting

apparatus it can also be used to transport the skin panel assemblies between the work stations.

"Mini" riveting machine - TFH 21PL - for clip-frame riveting

At this work station clip*-to-frame riveting is performed using a robot-driven "mini" riveting machine developed by MBB-Hamburg.

Figure 4 shows the lightest "mini" riveting machine (30 kg) currently on the market. The riveting system is connected to a rivet feed separator by a flexible feed supply tube. Using this tube it is possible to bridge distances up to 18 m between the riveting system and the rivet feed seperator. The "mini" riveting machine is guided by a newly developed positioner with 6 NC axes controled by a Siemens 8MC.

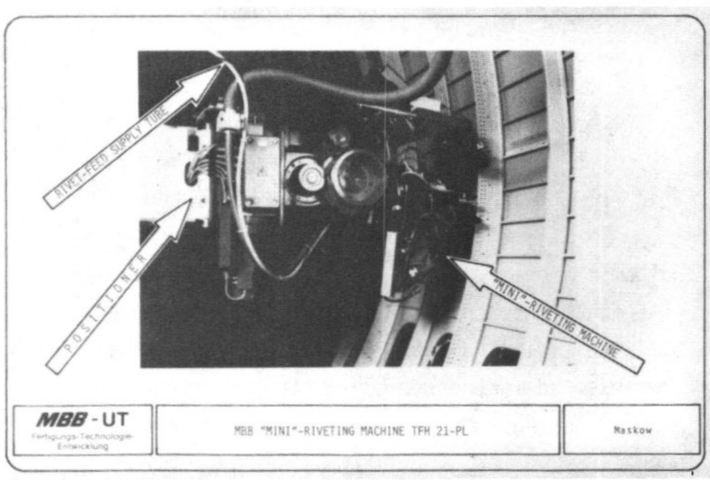

Figure 4:

The riveting system itself is a unit comprising a collection of individual components, fitted with a radial guide which operates in sequence

- drilling unit,
- rivet and
- rivet forming tool.

The riveting machine is also provided with a tooling unit cone which, together with the appropriate mounting console on the positioner, enables the riveting machine to be taken up and replaced automatically.

In order to compensate for deviations in the frame system lines or in the position of the fram-clip riveting, the positioner is fitted with a proximity sensor operating in the x direction and scanning the frame position, as well as an optical sensor to control the frame radius position. In connexion with a DNC computer, they apply the theoretical coordinates for the rivet locations to the actual coordinates.

ARAS applied to fuselage section assembly

Half-shell assemblies are produced for the Airbus by joining skin panel shells along the longitudinal seams. Two half-shell assemblies are then joined to form a fuselage section, continuing until the entire aircraft fuselage is obtained. Application of the riveting system described above is not suitable for longitudinal joint assembly for section construction. The rivet forming principle applied there cannot be employed for reasons of component geometry. The riveting procedure adopted here, unlike the two previously described forming methods, is known as percussion riveting. In connexion with a recoilless rivet forming system, developed by Atlas Copco and consisting of rivet former and dolly bar, the impulse-type riveting forces are mostly compensated by recoil absorption, in comparison with the considerable force to approx. 40000 N required for forming a dia. 4,8 aluminum rivet.

What does the design of the automatic riveting system for section assembly look like, that meets the MBB requirements?

ARAS (Automated Riveting Assembly System) developed by Atlas Copco and put into effect in cooperation with MBB, comprises four main components (see Fig. 5):

- component 1: tooling vehicle

- component 2: support and rail beam attached to the exterior of the workpiece

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* clip = connecting element for skin to frame

- component 3: dolly bars on the inside of the workpiece, connected to the support and rail beam

- component 4: central control unit for the tooling vehicle.

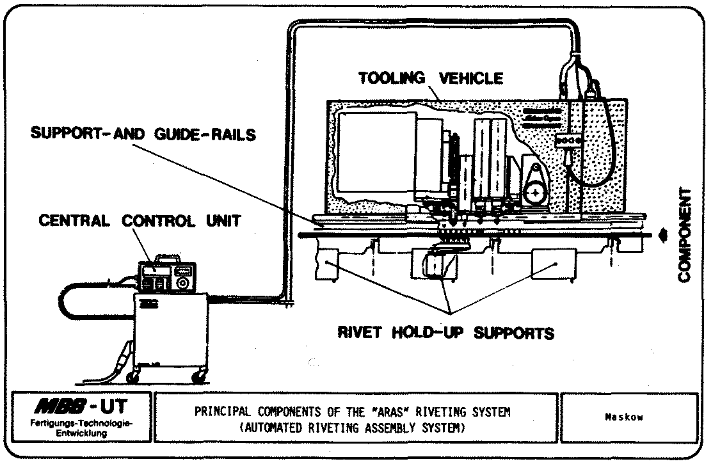

Figure 5:

The NC tooling vehicle consists of a base frame with ball strips which fit into the steel rails of the support and rail beam. A mobile carriage is fitted to the base frame to bring the tools attached to the carriage to any position required for assembly of the longitudinal joints. The tools mounted in sequence on the tooling vehicle are:

- drilling units, one for the aluminum only area, with a speed of 4,000 RPM and a second unit for aluminum/titanium material combinations in the crack stopper area, with 1,200 RPM;

- recoilless riveting former with a timer to set the duration of riveting;

- sealant injector;

- rivet feeding unit with rivet stock control;

- rivet magazin, easily replaceable, fitted to the base frame and attached to the rivet feed unit, it consists of five coiled hoses storing rivets of various lenghts. The magazine is calculated to rivet one complete longitudinal joint.

The second major component of the ARAS, the support beam and guide rail, consists of an aluminum base plate and guide for the NC tooling vehicle. This component, attached on the outside and extending over the entire lenght of the workpiece fulfils the task for:

- guiding the tooling vehicle and

- applying contact pressure for the even distribution of sealant in the joint.

The third major components of the ARAS are the dolly bar supports mounted on the inside of the longitudinal joint. The dolly bars must fulfil the following funcitons:

- The contact pressure required is applied by bolting the outer support beam and guide rail.

- The dolly bar includes a moving dolly plate activated by a cylinder in synchronization with the recoilless riveting hammer to form the rivet head.

On completion of a test programm to check all ARAS functions, the tack program is performed on the longitudinal joint. First of all three rivets are inserted in the stringer** area of each frame panel, then the entire riveting program is commenced.

** stringer = stiffener in the longitudinal direction of the aircraft fuselage