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Simply Supported Retractable Top Beam for Wing Major Assembly Jig

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ABSTRACT

A large free-standing structure is constructed to positively position the rear spar and related components in the major assembly jig of the wing for a military transport aircraft. The beam of this structure is mounted on mechanisms enabling the lateral retraction of the beam and tooling to provide full part loading access and extraction of a completed wing. The free-standing nature of this design also allows full integration of an automated drilling machine into the jig.

INTRODUCTION

Figure 1 - Retractable Top Beam Wing Jig

The structure is designed primarily to provide a rigid, repeatable set of index points by which to secure the aircraft components of the A400m wing. As the wing jig orientation is vertical with the front spar down, these components comprise the hinge points of the rear spar subassembly. Additionally, support points for the wing skin tooling straps are integrated into the tooling modules mounted to the beam. To facilitate loading of the composite spars, metallic ribs, and composite skins, the entire beam and attached tooling laterally retract 1.2m. The beam movement is automated and interlocked with the in-jig drilling machine (CAWDE).

MAIN SECTION

This section is divided into three sub-sections:

- Wing Assembly Process
- Major Components
- Future Applications

WING ASSEMBLY PROCESS

The wing assembly process can be summarized as follows:

1. Front spar loaded
2. Ribs loaded into jig, loosely positioned
3. Rear spar loaded
4. Ribs fastened to spars
5. Lower skin loaded, drilled and slaved
6. Lower skin removed and de-burred
7. Upper skin loaded, drilled and slaved
8. Upper skin removed and de-burred
9. Lower skin re-loaded and fastened
10. Upper skin re-loaded and fastened
11. Wing extraction

The simply supported retractable top beam provides the following functionality:

- Unfettered overhead access for all component loading
- Ideal vertical access for removing a completed wing from jig
- Clear pathways adjacent to jig for transporting skins to and from the de-bur area.

- Open unlimited height (except by building roof) zones for CAWDE drilling machine along both wing surfaces
- Greatly simplified retraction of tooling
- Ideal hardpoint locations for skin tooling straps
- Enhanced rigidity of tooling index points due to reduced reach of tooling

Previously built and more traditional offset fixed beam wing major jigs generally employ a large steel lattice structure, much like a modern office building, that provides multi-level access staging and support to mount the fixed top beam. Offsetting the beam from above the wing is generally required to facilitate wing extraction. The offset fixed top beam, in and of itself, is very rigid but cannot provide all the aforementioned access on one surface of the wing, generally the lower one, as the tooling must reach across the access zone to the wing. Overall rigidity is generally compromised by this reach distance.

MAJOR COMPONENTS

The apparatus is discussed in five sections:

- Beam & Overall Assembly
- Slider mechanisms
- Towers
- Tooling
- Drives & Controls

Each tower is permanently attached to a highly reinforced concrete & steel foundation. Mounted atop each tower is a slider mechanism that controls the position of the beam and its tooling. The horizontal forward spar down wing jig orientation means the beam is positioned at an angle with respect to the floor.

Beam & Overall Assembly

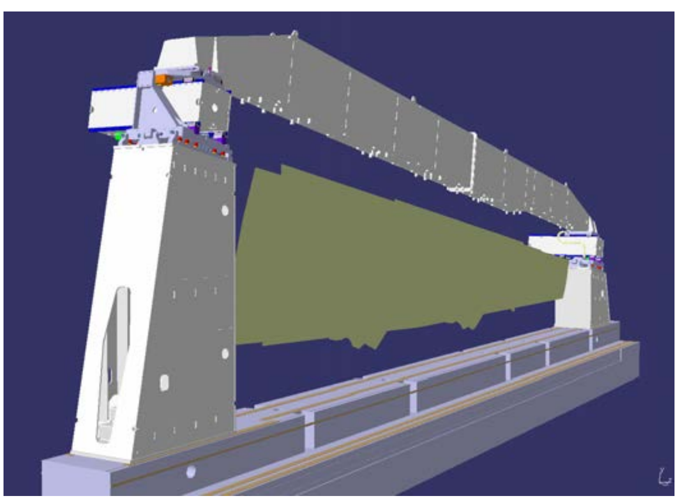

Figure 2 - Top Beam Indexed, Shuttles to Lower

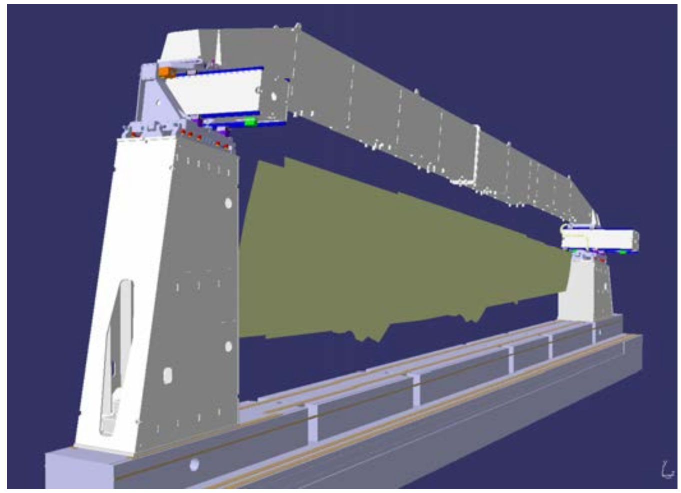

Figure 3 - Top Beam Indexed, Shuttles to Upper

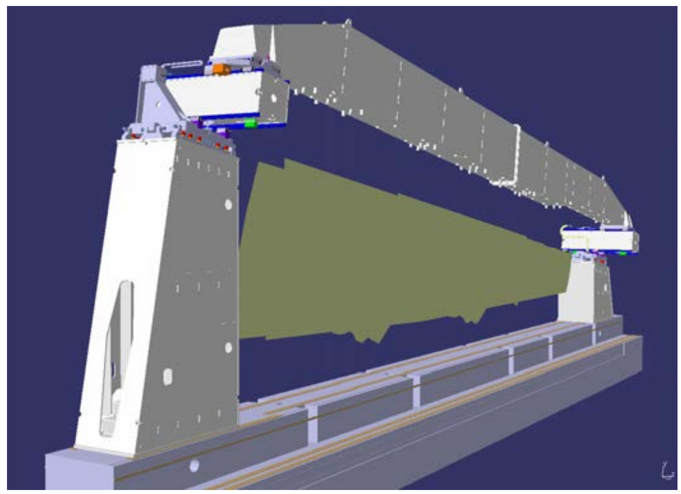

Figure 4 - Top Beam Retracted

The top beam is approximately 24m long, 20 tonnes in mass, and is divided into two roughly equal length sections joined by a keyed and bolted connection. The beam section is 1500mm x 650mm (h x w), formed by welded steel plate. The major design considerations are stiffness and natural frequency. Deflections due to wing weight are minimized as are those due to component distortion and machine clamp-up loads. The natural frequency of the beam is high enough to exhibit short settling times and the shear mass of the entire apparatus also helps resist excitation.

The three different states of the structure are illustrated in Figures 2 – 4. Figure 2 shows the beam at its indexed position with the shuttles on the lower surface (far side). This would allow the CAWDE machine to work on the upper surface (near side). Figure 3 shows the opposite state whereby the machine would be working on the lower surface. Figure 4 shows the beam retracted for component loading and wing removal.

Slider Mechanisms

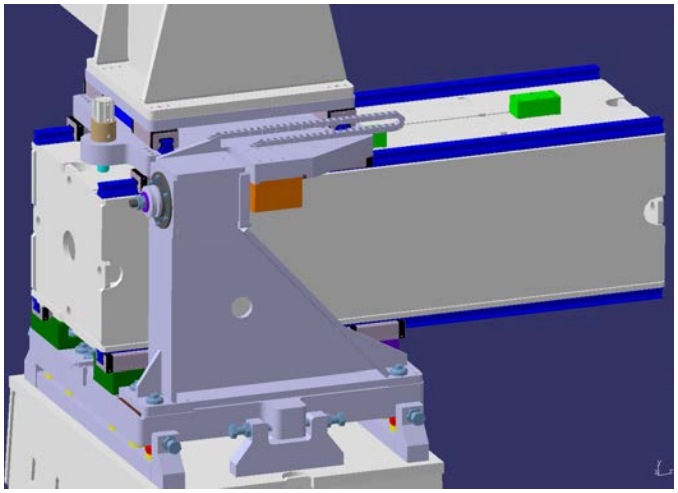

Figure 3 - Root End Slider Indexed, Shuttle to Upper

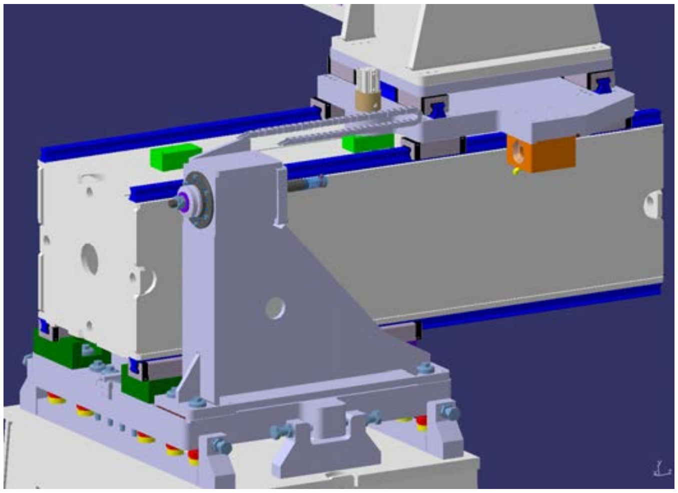

Figure 4 - Root End Slider Retracted

The two slider mechanisms are identical aside from a passive axis on the root-end unit that accommodates thermal expansion of the top beam (see Figures 5 – 6). The sliders are comprised of a fixed baseplate mounted on concentric threaded adjuster feet, a welded steel shuttle box running on linear roller rail cars on the baseplate, and a moving table atop the shuttle box running on bearings of the same type. The table supports the beam. The shuttle box is driven by a rack and pinion AC gearmotor drive. The table is controlled by a shotpin that pins it to the shuttle box, for beam retraction, and a pneumatic ball clamp that indexes the table to the baseplate. When the shotpin is retracted the shuttle boxes can be moved independently without affecting the beam position. This allows the CAWDE machine to enter and exit the jig as it is taller than the towers.

Towers

There are two towers – a taller root-end unit and a shorter tip-end unit, approximately 5m and 2m in height and 12 and 6 tonnes in mass, respectively (see Figure 2). Each tower is a very rigid welded steel plate structure that is welded directly to foundation embedment bars. The root-end tower provides worker access to the root end of the wing via an integrated internal stairway.

Tooling

The tooling details are all mounted to modules which in turn are mounted to the top beam on rails to allow for thermal expansion differentials between the wing and jig. Each module corresponds with a key control surface such as a spoiler or flap or aileron. As the beam is positioned parallel to and as near as is practical to the rear spar, the tooling is compact and bridges a relatively small gap. The short moment arm increases lateral stiffness. Retraction requirements of each individual tooling index are limited to a short (approx 100mm) move normal to the spar plane. Once all the individual tooling is retracted, the beam is then retracted, fully retracting all tooling. Positioning the tooling modules centrally provides ideal anchor points for the skin tooling straps. These straps press the composite skins against the wing spar/rib matrix.

Drives & Controls

Two operators, one at each tower, are required to retract the beam. A single operator can move a shuttle. Automatic control of the beam movement is accomplished by a single Siemens PLC controlling sensorless frequency drives and pneumatic solenoid valves. The drives each power a 1.5kW gearmotor on each slider. The solenoid valves control the operation of the shotpin and index clamp. Each shuttle position is monitored by an MTS Tempesonics magnetic scale. The length of the beam provides significant structural compliance and negates the need to synchronize the two gearmotors. Relative position is monitored, however, to avoid damage in the event of a malfunction. Final positioning of the beam in its deployed position is provided by the index clamps which pull the beam the last few millimeters to a hard cup and cone index. Travel limit switches provide redundancy.

FUTURE APPLICATIONS

Electroimpact is proposing the use of a similar sliding top beam in the wing assembly jigs for the Airbus A350 aircraft due to begin production in the near future. This wing is approximately 30m long (50% longer than A400m) and is very similar in construction to the A400m wing, using single panel composite skins, composite spars and metallic ribs. All the same benefits exist, and as cycle time is the top priority in Stage01, it is currently the preferred jig configuration.

CONCLUSION

Superior part loading access, automated drilling machine integration, and skin strap integration are made possible by the use of a single sliding top beam in the design of a wing major assembly jig for today's composite aircraft wings.

ACKNOWLEDGMENTS

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CONTACT

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ADDITIONAL SOURCES

High-quality components used on this apparatus include:

Bosch-Rexroth Linear Products	www.boschrexroth.com
Bonfiglioli Power & Control	www.bonfigliolili.com
Siemens Control Systems	www.siemens.com
Igus Cable Track	www.igus.com
MTS Sensors	www.mtssensors.com
SMC Pneumatics	www.smcusa.com
Parker Pneumatics	www.parker.com