

Lug Cutting and Trimming of the Carbon Fibre Wing Panels of the A400m with Portable Hand Positioned Tools

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ABSTRACT

The A400m has carbon fibre wing panels on both the upper and lower surfaces. When manufactured, these panels come supplied with various lugs on the periphery of the panel. Some are used for lifting the panel, some are used for indexing the panel; however, all lugs must be removed at some time during wing build. Lug thickness varies from 4mm to 14mm; in addition, many lugs must be cut to a 2D profile rather than just straight. The main challenge of the project was to deliver a tool that was small, portable and compact, but that could also accurately slot thick carbon fibre panels, without delamination, leaving a good surface finish. The solution was an air powered routing hand tool that was mechanically guided along a 2D path using a cam profile. Special diamond grit cutters were used to cut the initial slot and reduce the machining forces to a bare minimum, with the finishing cut done using a PCD router bit to obtain a good surface finish.

INTRODUCTION

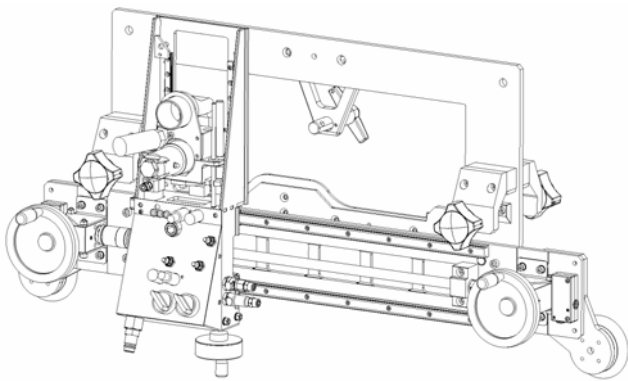


Figure 1 – Hand Tool for Accurate, 2D CFRP Machining

The challenge for this project was to come up with a cutting/slotting solution for 14mm thick CFRP, that did not require a large 'stiff' machine. The solution had to be a basic hand tool that could be used/positioned by production staff. The requirement for a low stiffness machine meant that PCD slotting cutters could not be used, due to the larger cutting forces involved, resulting in deflection of the machine structure, vibration of the cutting head and corresponding CFRP de-lamination.

CUTTER SELECTION AND TRIALS

INITIAL CUT

The initial slot was cut using a diamond grit cutter supplied by Unimerco. Several grades of cutter are available, each with different grit sizes. Cutters tested were 40, 60 and 80 grade grits (40 – coarse). Cutters were tested at 20,000 rpm with and without lube (Hocut 795E).



Figure 2 – Diamond Coated PBS Router Bit from Unimerco (80 Grit shown)

Results:

- i) 40 grit and 60 grit cutters cut very effectively, even without lube. However, 40 grit left a poor surface finish (not de-laminated, just rough), 60 grit gave a better surface finish but started to suffer from carbon build-up on the cutter, surface finish around 5 um RA.
- ii) 80 grit cutters would cut at slow feed rates when used with lubrication and would leave a good surface finish – 3 um. However if used without lube the 80 grit cutters would quickly become clogged with carbon dust/cake which led to a loss in grinding action and rapid heat build up.
- iii) With all cutters, the use of lube increased the maximum permissible feed rate.
- iv) Diamond grit cutters have a very good cutter life. With these results we choose the 60 grit cutters for the initial cut.

FINAL CUT

The customer requirement was to have a better than 3.2 um surface finish. To achieve this it was decided to apply a finishing cut after the initial slot had been made. The finishing cutter chosen was a PCD router bit. In order to keep cutting forces low, the final cut only removed 0.5 mm of material again using a 20,000 rpm spindle, no lube required.



Figure 3 – PCD Slotting Cutter Supplied by Unimerco

Finishing cuts made with this PCD router give a better than 2 um surface finish.

SPINDLE ASSEMBLY

The chosen spindle was an off the shelf 25,000 rpm air die grinder, with engineering features suitable for accurately mounting the grinder in a holder. The spindle exhaust was routed through a gallery into a high noise reduction silencer to reduce the running noise to 78 dB. The spindle assembly included integral dust extraction and compliant OML vacuum shroud to ensure all CFRP dust is collected during cutting operations.

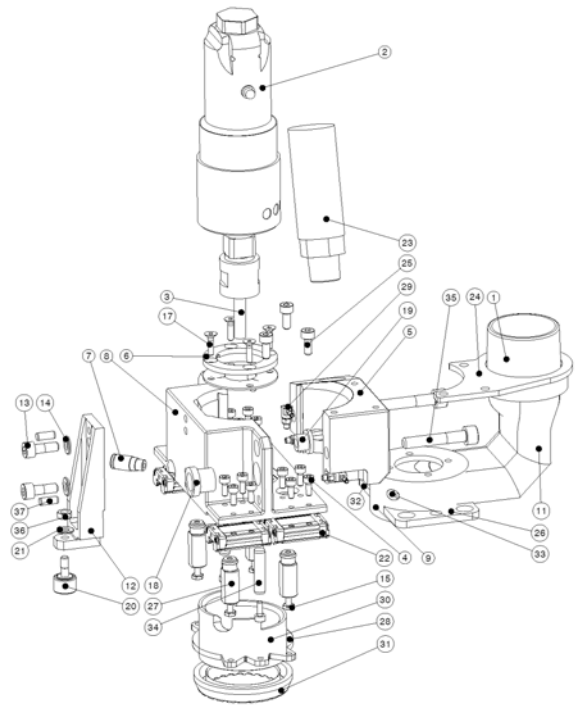


Figure 4 – Spindle Assembly

MACHINE X & Y AXIS

X axis would be described as being along the panel edge with Y axis being orthogonal to this. It was decided to drive the X axis using a hand wheel and screw, rather than just letting the user push the axis manually. There were two reasons for this. The first was that the use of a screw and wheel meant that it would be difficult for the operator to over feed the cut since the operator would have to expend excessive energy in spinning the hand wheel fast to do this. The second reason was that the Y axis was sprung loaded to follow a cam profile and that this would result in a variable X axis force during cutting depending on what part of the cam you were following. The X & Y axes are mounted to the machine base, but the machine base does not include a cam profile.

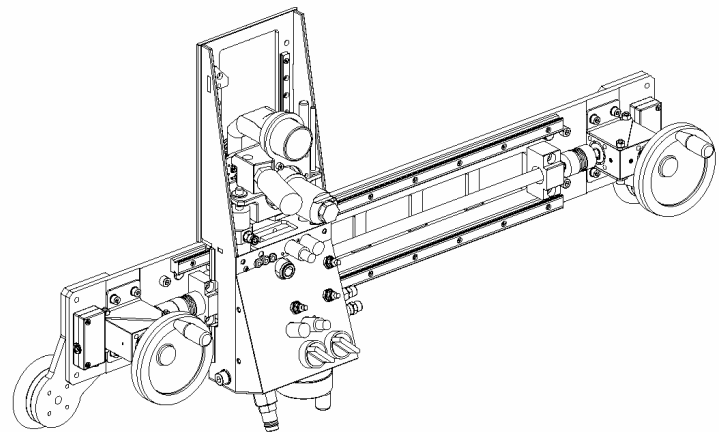


FIGURE 5 – Machine X & Y Axis

INDEX PLATE ASSEMBLIES

The cam profile is mounted to a second removable plate such that the machine can be used with any number of different cam profiles. Each different lug position has a specific cam profile and index plate, which indexes on to the panel EOP and uses the lug hole for X axis positioning. Index plates are reversible to facilitate port or starboard cutting, without the need for additional tooling.

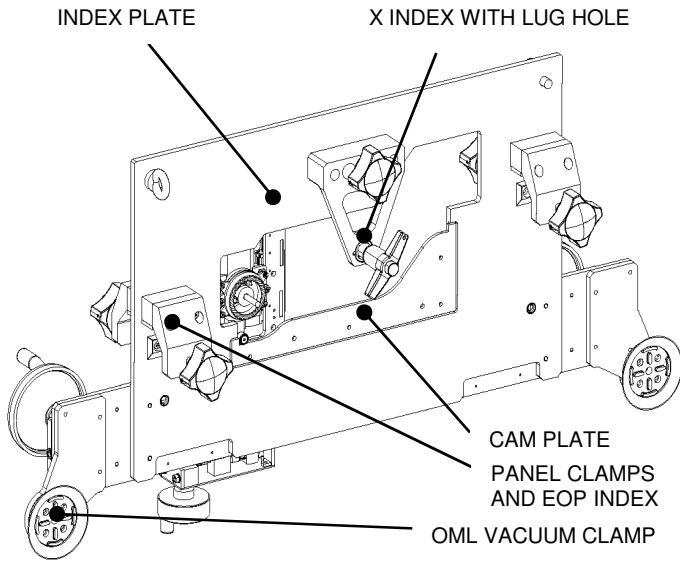


FIGURE 6 – INDEX & CAM PLATE

CAM TO CAM PROFILE AND SHROUD

The spindle assembly is held to the cam profile using an air cylinder, which energises only when the main cutter pilot valve is activated. As the machine is driven in X, the spindle assembly follows the cam profile to enable 2D cutting. The OML vacuum shroud has compliance and is presented to the panel via small air cylinders, when the main cutter pilot is activated.

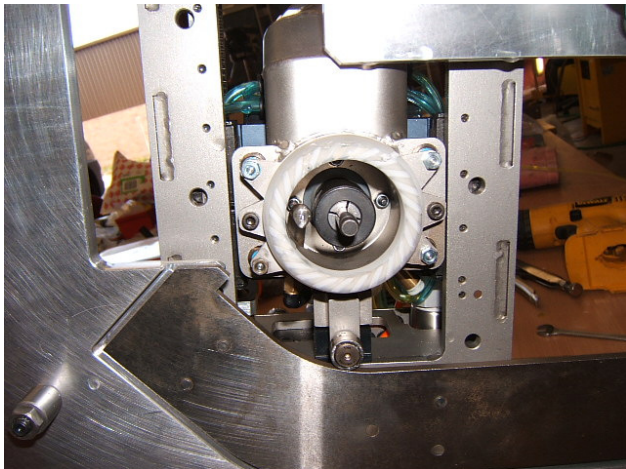


FIGURE 7 – Photo of Cam, Cam Plate and Shroud

CUTTING PROCESS

For carrying out a cut the machine is first parked on the far right by the user. The cut then takes place from right to left, with the spindle rotating in a clockwise direction relative to the user. This is done to ensure that the cutting forces pull the spindle assembly towards the panel EOP and hence push the cam on to the cam profile rather than away from it. The first cut is done using the diamond grit cutter. The cutter is then changed for a PCD router bit and the process repeated. Final cut depth is predetermined by sizing of the diamond grit cutter and PCD cutter.

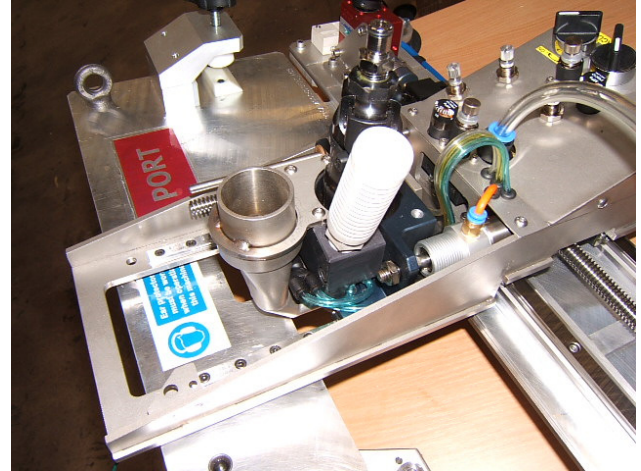
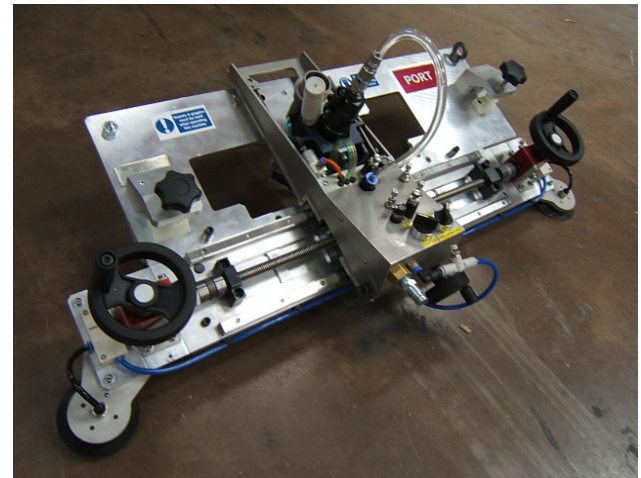


FIGURE 8 – Photo of Machine



FUTURE APPLICATIONS

This technology could be modified to cover the cutting of circular profiles using circular/oval templates or to cut more complex profiles as part of a small 3 axis CNC portable milling machine. Such machines should be able to achieve a cut tolerance of ± 0.004 " using a two stage cut.

CONCLUSION

The ability to accurately machine thick CFRP panels using a small portable hand tool has been proven. Indeed, a ¼" slotting diamond grit cutter can cut through 14mm CFRP. This is mainly due to the fact that the process is a grinding one rather than a cutting one and results in lower cutting forces and less probability of cutting chatter. Diamond coated PBS router bits do not generally wear during this process, even when used without lubrication.

ACKNOWLEDGMENTS

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REFERENCES

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CONTACT

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ADDITIONAL SOURCES

High-quality components used on this apparatus include:

Unimerco Cutting Tools	www.unimerco.com
Cleco	www.coopertools.com
SMC Pneumatics	www.smcusa.com
Parker Pneumatics	www.parker.com
RS Components	www.rswww.com
THK	www.thk.com