CFRP AND ALUMINUM STACKS DRILLED IN ONE DRILLING STEP IN 25 MICRONS OF TOLERANCE

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Keywords: OSD, CFRP, AIRBUS, KLENK.

Abstract

The new materials and materials combination such as composites and aluminum combinations used on today's new airplanes are proving to be very challenging when drilling holes during manufacturing and assembly operations. One shot drilling (OSD) is based on different new drilling technologies in order to reduce drilling operations and reduction of recurrent costs for holes manufacturing. This paper will show the development work for defining a drilling strategy between Airbus and Klenk in a combination stack of Aluminum and Composites, and with holes diameter requirement of 25 µm.

1. Introduction

One shot drilling is a technique based on different new technologies that offers a number of advantages over conventional drilling in the assembly of aircraft structures. With the competitive scenario, cost reduction is one of the main driver, these advantages become even more beneficial. One shot drilling is possible, because of the implementation of new technologies into the Advance Drilling Units (ADU) and new cutter geometry developments.

Airbus Puerto Real has been working with Klenk to develop a drill bit and a drilling strategy that can be used in a production environment to realize these benefits.

1.1. One Shot Drilling General Benefits:

One shot drilling is based on machining the material in one drilling operations. The drilling steps reduction improves drilling costs, reduces process time and reduces the amount of cutting tools to be on stock. The main driver for achieving this drilling steps reduction is to reduce temperature on the drill bit and to be able to cut the chips. To achieve the hole tolerance of 25 µm, it is very important to have small chips, especially when drilling CFRP-Al stacks. Otherwise the chips will increase the hole size of the CFRP and decreases the hole surface quality.

In order to be capable of this drilling steps reduction, this study was based on the usage of Advance Drilling Units (ADU) equipped with micro-lubrication and micro-vibrating system.

1.1.1. Advanced Drilling Unit (ADU):

Advanced Drilling Units (ADU) are drilling machines designed to perform drilling operations (Drilling, reaming, countersinking) with pre-set feed rate (mm/min) and tool rotation (RPM) parameters.

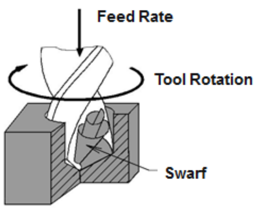

Figure 1. Feed rate and cutting tool rotation squeme.

These machines are locked in drilling Jigs/Template which ensures the correct drilling position as well as holes perpendicularity by using a concentric collet system.

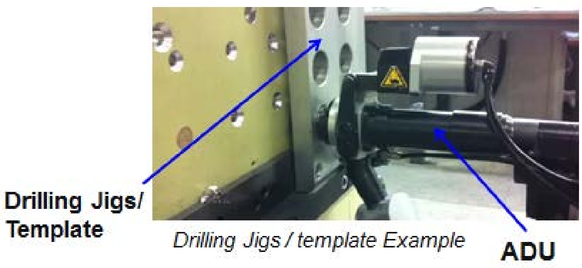

Figure 2. ADU locked in a drilling template.

1.1.2. Micro-lubrication:

The lubrication can be part of the ADU or can be a separated unit feeding several ADUs.

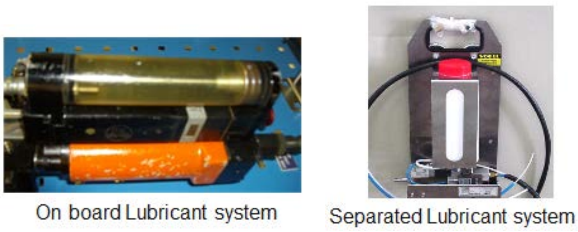

Figure 3. Examples of lubricant systems

The lubrication system brings lubricant to the cutting faces of the tool, this improves cutting efficiency, tool life, surface finish and reduces the temperature.

1.1.3. Micro-vibration

The micro-vibrating is as system that breaks the chips through a small alternative axial motion in addition to the standard drilling motion (rotation + feed). That system increases chip evacuation, reduces chip congestion, decrease risk of tool breakage.

Figure 4. Chips without vibrating system.

Figure 5. Chips with vibrating system.

2. Description of the Analysis

2.1. Brief description of the application case

On Airbus aircrafts, the elevators are attached to the Horizontal Tail Plane (HTP) through actuator fittings. These actuators fittings are assembled to the ribs by 7.9 mm bolts with a hole diameter requirement of 25 microns at Long Range Aircrafts. The stack to be drilled is composite with aluminum.

This operation takes place in the HTP Box assembly jigs at Airbus Puerto Real Plant. Manual drilling for these bolts has traditionally required several drilling steps in order to achieve the final hole quality. For improving ergonomics and decreasing costs, Airbus Puerto Real wanted to explore a more efficient method of drilling these holes.

2.2. Previous drilling process (multistep process)

In the HTP Box assembly station, actuators fittings are assembled to the ribs in drill jigs, that are placed on the workbenches.

Figure 6. Previous process

To achieve proper hole quality using manual processes, drill jig like the one shown in Figure 6 are used. Each manual drill template consists of a machined aluminum plate with various drill and fixture bushing. The jigs are located on the workbenches. Due to the location of the drilling template, drilling is not performed in a good ergonomic position.

Figure 7. Ergnonomic position and power tools needed

Manual drilling technology is not suited for accurately and efficiently cutting tight holes. One hole require as many as five drilling steps (see Figure 8). The hole is started with a pilot hole and the stepped up to the final size. The hole is finished with a final reaming operation.

Drill 4,81mm → Core Drill 6,33 mm → Core Drill 7,7 mm → Reamer 7,92 mm

Figure 8. Power tools needed

2.3 One Shot Drilling Process

For allowing the use of the new ADUs, a new jig was designed following ergonomics requirements. Jig was designed to provide a stiff structure for supporting concentric collet ADUs.

Figure 9. Ergnonomic position and power tools needed

Multiple coupons were drilled to define the characteristics and wear mechanism of this drilling process. Klenk supported Airbus Puerto Real by developing a drill bit for this CFRP-Al application. This was done in several project steps. The first step was to carry out some trials at Klenk to define a proper cutting tool geometry, which is able to achieve the hole quality requirements. First trials at Klenk can be seen at figure 10.

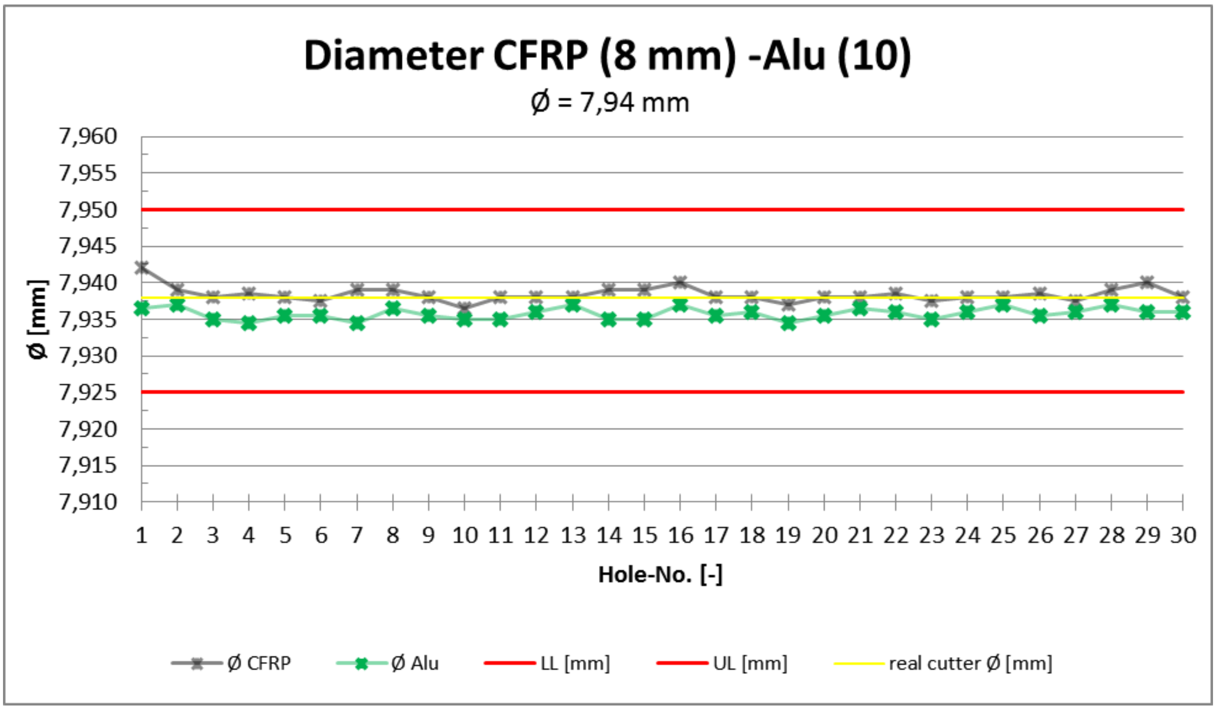

Figure 10. Hole diameter results of the first trials at Klenk

After the first trials at Klenk the cutting tool diameter for the final cutting tool was defined between Airbus Puerto Real and Klenk, to achieve the maximum life time for the uncoated cutting tool.

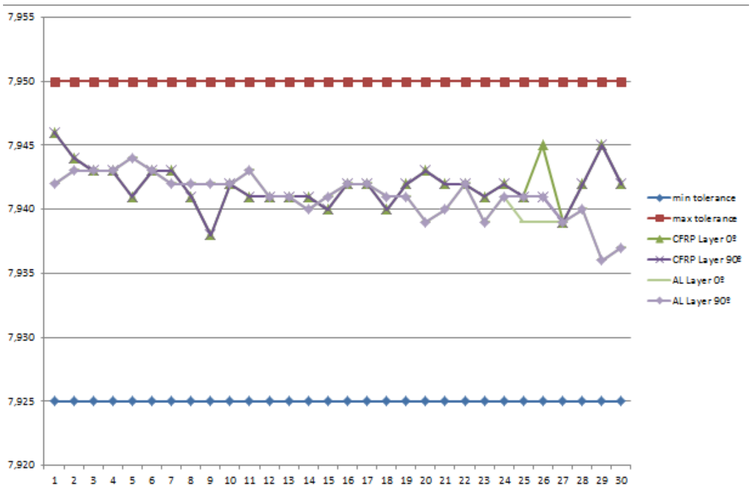

Figure 11. Hole diameter results on the validation phase at Airbus

Thanks to the improvement project, drilling process had a cost reduction of 60%, in addition cost of non-quality will be reduced due to the new process is more stable and has more repeatability.

Also the performance and life of the cutters showed to be much more predictable than that of manual drills. This meant that after the first hole was drilled within tolerance, drilling holes oversize was never a concern.

3. Conclusion

Many drilling tests were performed to define the best drilling parameters, cutter geometry and wearing. Each improvement highlighted the next weakest link in the quest for finding a cutter with a stable behavior.

The results show so far that this drilling strategy will prove itself to be a good choice for drilling stacks of this type of materials and holes requirement in an aeronautical assembly environment. Drilling holes that will not require several drilling steps, with a high level of repeatability and quality.

For further improvements the cooperation between Airbus Puerto Real and Klenk goes on to improve the cutter life time by using a coating. In a next step dry drilling will be implemented. Dry Drilling means drilling without using any kind of lubrication. This will bring the production costs further down, due to the fact that, for example the costs for lubrication and cleaning the aircraft parts before the assembly can be saved.