

The Advent of Battery Tools in Aerospace Assembly Processes

Christophe Secheret and Thibault Valentin
Desoutter Industrial Tools

ABSTRACT

Until recently most aircrafts, aircraft engines and landing gear as well as other aerospace equipment has been manufactured using essentially traditional mechanical, pneumatic or hydraulic power hand tools maintaining at the same time very strict processes to ensure quality and traceability to a certain level. An increased use of composites, intensified focus on quality and demand for extended traceability, as well as more accuracy, more flexibility, more productivity and more ergonomics in the tooling used during the assembly process has led to many manufacturing shops to invest into wireless battery tools as the best alternative to manufacture aircrafts now and in the future. We will detail in this paper what reasons led some pioneers to choose wireless battery technology to assemble aircrafts. We will describe from our perspective what the next steps are in solutions dedicated to the aerospace industry.

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INTRODUCTION

One of the reasons for the wide variety and offering of fastening systems dedicated to the aerospace industry is the necessity to control the clamping force in the joint in order to safeguard the structure integrity during its lifetime. With many of those fasteners, the clamping/torqueing is managed directly by the fastener design using metallurgical and mechanical properties. To name a few of those systems: Eddie Bolt, HI-LITE® fasteners, Lockbolt and their derivatives as well as multiple types of blind rivets and blind bolts. Originally no torque control was required for all these systems as it is embedded in the fastener itself. However with time, and with the variety of material and applications, most pneumatic torqueing tools used for those applications became equipped with a clutch system. With this approach the principle "one tool for one application" was the general base for error proofing and answering aerospace's ever drastic quality constraint. Today, for various reasons that will be detailed in this paper some Aerospace Manufacturers have decided to move to electrical tooling equipped with transducers with the possibility of using battery wireless tools.

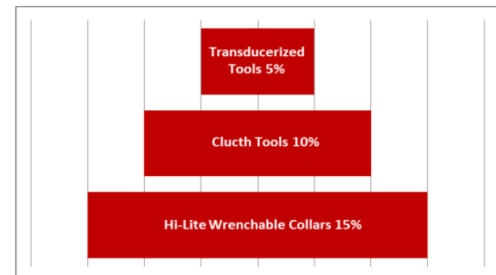


Figure 1. σ of Torqueing control according to ISO 5393

BASE FOR A TECHNOLOGY SHIFT

The development of industrial battery tools is linked to several recent technological developments allowing the development of Wireless Battery tools.

The first significant key progress was made by the battery industry. The development of Lithium-Ion battery in the last 5 years has provided an answer to some of the show stoppers of battery technology: reduced memory effect, higher density, and low self-discharge rate. This technology has been widely used in most consumable battery products today; its availability and prices are now more affordable.

The development in wireless technology allows better results in the difficult aircraft assembly environment. Wi-Fi,

ZigBee and other WirelessHart technology has improved and so has message transmission reliability.

Tightening developments made essentially for the automotive market for electric tools can easily be transferred to new battery tools, therefore proposing an advanced tightening strategy with Battery tools.

The maturity of the RFID technology used for people and object management starts to see many applications in aerospace especially with the new UHF technologies. The recent growth of NFC embedded in smartphones starts to open new horizons in the field of wireless communications. This system built upon RFID technology has the advantage of allowing two-way communication compared to previous one-way and allows therefore smart exchange between devices.

CPU capability keeps growing: Intel observes that over the history of computing hardware, the number of transistors on integrated circuits doubles approximately every two year. This allowed miniaturisation and embedded hardware on the tools.

The use of composite (CFRP, Honeycomb, Kevlar...) has grown significantly over the course of the last decade in Aerospace. This implies many new requirements in terms of fasteners, tightening, traceability and more general assembly processes.

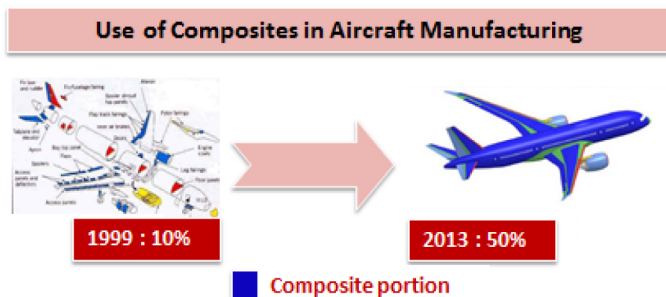


Figure 2. Evolution Of Composite in the aerospace.

INCREASED QUALITY REQUIREMENT

Desoutter 6-Steps Approach

Desoutter Industrial Tools generally split applications into 6 steps of tightening levels depending on the criticality of the application. For the aerospace industry these steps will correspond to the following joint criteria as described in Figure 3:

1. Standard Joints: sub-assemblies, harnesses, interior application.
2. Critical Joints: defined as joints that will damage the integrity of the aircraft but will not put in danger the life of passengers: nacelles, fuselage, landing gear
3. Safety Critical Joints: defined as joints that may potentially lead to a crash, touching a major link in the

primary structure of the aircraft: engine, pylon, wing, wing box, Final Assembly Line

In certain circumstances, standard joints may be seen as critical or use safety critical technology not because of their importance to the structure integrity, but because of recurrent quality related issues or because of customer value perception (airlines or passengers).

In addition, for a defined application, you may find level 3 of the criticality of joints. For example, an engine pylon would see its primary structure as Safety Critical, but the assembly of the skin will be only critical and temporary fastening of the pylon may be seen as standard joints.

It is therefore key to properly define each application and its requirement in order to be cost effective and avoid over-quality.

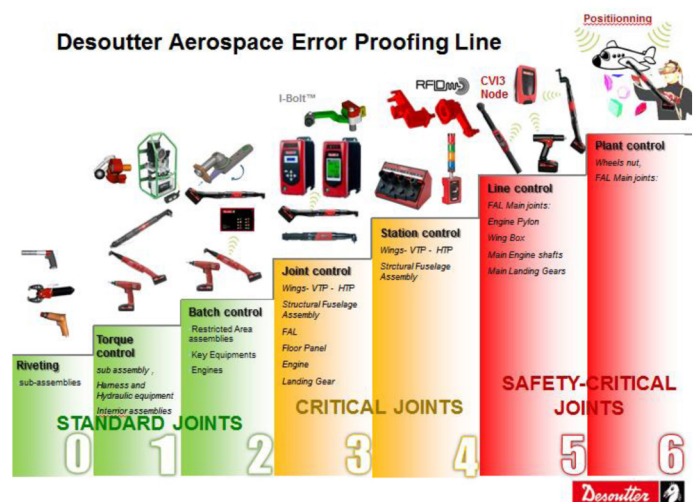


Figure 3. Desoutter 6 Step Error Proofing

Each sub-assembly and equipment of an aircraft can fall into one of the categories, and will then require a level of error proofing corresponding to the given category. We will refer to this category regularly throughout this paper to define the quality level expected.

Error Proofing

Although Aerospace fastener quality control is very stringent, it is very often based on sampling principles and process control. Considering the quantity produced (manufacturing batches contain up to 50,000 pieces), the risk of having a few bad parts in a batch is limited through the laws of probabilities but a risk exists and remains as it is not a 100% controlled.

With clutch technology (torque control only), you have a few limitations in term of error proofing:

1. Tightening quality is ensured only when the next calibration check is validated. In the case of tools that are not calibrated anymore, all work done since the last calibration needs to be evaluated. To reduce the risk and the impact, a

calibration check can be performed on the work station but that would be more time consuming

2. Torque control only checks that a level of torque has been reached but it is not enough to prove that the fastener has been properly assembled: high level of self-locking feature, bad thread not allowing proper clamping of the joint.

With Battery tools equipped with a transducer such as our EABCom product range, the Error Proof is 100% and, as described below many aspects other than Torque can be controlled to ensure 100% good joint assembly.



Figure 4. EABCom System

Tightening Strategy

Simple torque control

Battery clutch tools such as our E-LIT range have as a minimum the same level of technology as an existing pneumatic tool in terms of torque control, using advanced clutch systems

For Pneumatic Tools, fastening strategies are essentially limited to torque control. The torque range of pneumatic tools is much more limited. By the use of gear ratio, speed and torque remains a compromise in the gear ratios. In addition, tool speed and power remains linked to the quality and stability of air pressure.

Some pneumatic tools may be equipped with a torque transducer and an angle encoder but then they become as expensive as DC tools without the flexibility to adjust different torque values and speeds. In addition, angle monitoring can be used but even so angle resolution is only 1° compared to 0.1° with DC tools.

For torques higher than 60Nm a pneumatic tool has a generally slower speed than an electric tool.

In the specific area of temporary fasteners, main suppliers such as LISI Aerospace, Centrix LLC or Monogram have very often neglected to have torque control on the speed runners used to tighten this type of fasteners. More and more with the increasing use of composites, battery tools can be used with a special nose adaptation to control the effective clamping of assembly before starting the drilling process and avoiding any delamination issues. In those instances, torque control is sufficient for most applications but the speed modularity of a battery tool can be a definite advantage in terms of accuracy over standard pneumatic tools with a clutch.



Figure 5. Examples of Temporary fasteners using Desoutter E-LIT and SDP range

Batch count

Counting the number of bolts well tightened is crucial in most aerospace applications. Joints between panels often consist of a wide series of bolts. The human factor can generate errors in the tightening of each bolt if not controlled 100%.

With a battery tool, we don't just count the number of bolts, but we can set a batch and inform the operator when it is finished. This step is the third one in our error proofing scale (Figure 3). A Batch count can be set in our E-LIT ELC range with wireless reporting to the E-LIT BOX, and also to our high-end transducerised battery tool B-FLEX and EABCom.

To complete the error proofing a re-hit detection is enabled, this means the tool detects if the operator tightens the same bolt twice.

With an electric tool we can guarantee that all bolts or screws have been well tightened.



Figure 6. Batch control tools

Prevailing torque compensation

Prevailing torque is due to some friction in the rundown phase, it is typically the case with self-locking nuts using Vespel or geometrical self-locking features. In this case, you have a residual torque during rundown and this torque is