A publication of sme

2019

AEROSPACE & DEFENSE

MANUFACTURING

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Supplement to Manufacturing Engineering

Taking on Jet Engine Blade Production Challenges

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Maybe you will find this silly or perhaps agree: I never get tired of looking at a jet engine. Those enormous fan blades anticipating the start, like a thoroughbred stallion antsy at the gate. Those huge fans are spurred by the combustion section of the engine where there are also a number of blades, albeit tiny by comparison.

Companies refer to the combination rotor and blade part in the combustion section of the gas turbine engine in different ways. Some companies refer to them as blisks, others call them IBRs (internally bladed rotors).

Whatever they are called, they are a challenge to manufacture, and each engine requires 9 to 13 of them. So tricky are these parts that they have created frustrating bottlenecks in the aircraft supply chain. Just one supplier cites almost 1600 IBRs in the order backlog.

Jet engine blisks are expensive. Each one costs $30,000 to $40,000. Naturally, no one wants to scrap these.

Due to their complicated shapes, and hard-to-cut titanium (Ti) or nickel-based alloys (Ni-alloys), blisk machining requires the use of heavy-duty machining centers with advanced controls and CNC software, special attention to coolant, the optimal cutting tools and holders, and sophisticated metrology. In other words, IBRs require a machining system designed solely for them.

One of the trends to help keep the process consistent for these parts involves data collection at the machine tool to determine the machine's "signature."

That signature includes all the aspects, such as the optimal thrust loads, spindle loads, thermal condition of the motors and positional criteria.

If the real-time data indicates the process is veering from the signature, adjustments can be made on the fly before making a bad part.

Developing more accurate signature profiles via data collection and monitoring is evolving now by many machine tool builders, helping to address the scarcity of skilled machinists and also to align with the overall trend of data-driven manufacturing.

In concert with the signature, data, and lower skills trends, the control system providers are also refining their systems so that the traditional and complicated task of machine tool "tuning" will transfer to advanced digital tuning.

Another important aspect of the optimal IBR or blisk production system is coolant and how it's applied.

Naturally companies want to save money where they can. However, it a shop or factory has invested significantly for the right machine tool for the job, using something like a bargain coolant chiller and cheap nozzles can undermine the whole system.

With this application, to hold the tolerance of the part and achieve the nice finishes required, the coolant temperature must be held to ± 1 degree. If it goes up or down 5 to 6-degrees, hello scrap.

Also if the spray doesn't hit at the proper cutting tool/workpiece interface location, premature tool wear can occur, which if undetected, can ruin a part. If it is detected, the part might be saved but there are still unnecessarily frequent cutting tool changes and lower productivity rates. Goodbye profit margins.

Of course, cutting tools and even tool holders play an important role in blisk machining. So do the metrology aspects, particularly with the intense regulatory requirements in aerospace manufacturing.

Further, proper material structure and stress factors are crucial with these particular parts, and there have been reports of below-standard forgings causing problems in the supply chain.

We suggest analyzing the material as soon as it comes through the door before an issue is discovered well into the machining process.

The main takeaway here is aerospace components are tricky to make, and IBRs/blisks are one of the critical jet engine parts that also happen to be causing some headaches and delivery delays right now.

It behooves the manufacturer's senior engineering executives to meet in person with the machine tool builder's senior applications executives who have decades of experience in the aerospace sector. Vital information can be exchanged to reach a true understanding of what is required to make these parts effectively and profitably.