Titanium Machining Challenges

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Over 800 787’s sold

Over 2,000 F-35 planes to be built

500 firm A350 orders

There is more titanium for the aerospace industry to machine than ever before, the plan needs to be for more than machining a good part….

but delivering the right number of parts, when needed, to support increasing rates of 10 or more airplanes a month…. 
The urgency of developing this support is due to the long lead times often required to ramp up production for machining hard metals products.

The target for machining titanium is a different set of parameters that have a narrow range for optimal performance.

**Aluminum products for 777**
- Horse power over 100 hp / 74 Kw
- Torque less than 100 ft/lbs /80 Nm
- Base speed 1,000 rpm speed ranges of 5,000-30,000
- Flood coolant, through spindle optional
- Cutting tools with sharp edges, often uncoated
- Removal rates 4 to 6 cubic "/hp/65 to 100 cubic centimeters/Kw
- Machine system stiffness – moderate
- Tool balancing and symmetrical designs essential

**Titanium products for 787**
- Horse power 30-50 hp/22-38Kw
- Torque over 900 up to 3,000 ft lb /2,230 Nm
- Base speed 50-100 rpm, max 3-5,000
- Coolant through spindle 1,000 psi essential
- Machine tool stiffness – essential
- Cutting tool design, edge prep and coatings
- Metal removal rates 1 -2 cubic"/hp/16-32

Primary challenge is to fully utilize horsepower optimizing efficiency

Primary challenge is fully utilizing available torque

Primary challenge for both – match the process- to the cutting tools-to the machine
So where do we start?

We create a baseline process using the equipment and manufacturing plans in place.

Below is a possible simulation....

Map of Baseline Process

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14 Days Flow Time

So we have confirmed that we can make the part, and have a baseline for estimating costs and delivery capability....

The question is are we done?
At Boeing this is just the first step in the process. Next is to create an alternate baseline to identify possible “gaps in technology” that may exist between our current capability and technology available in the industry.

Helping us in this exercise are the “suppliers” that support the manufacturing process such as machine tool builders, cutting tool companies, equipment manufacturers, and their representatives...

Partnerships with other manufacturers to supply parts to Boeing or Vendors

Subcontractor’s supplying The Vendors are called 2nd, 3rd, etc tier suppliers

The challenge is to use these resources to help identify opportunities to improve manufacturing performance.
Improvements are more than just running the current cutting tools faster.

Significant advancements are made by looking at the overall process.

The emphasis is on identifying non-value added operations such as manual drilling fixtures or considering one piece flow compared to batch machining.

Map of Baseline Process

14 Days Flow Time
Alternate Base Line

a more flexible machining process allows for more work completed on fewer machines....

Part flow goes from 14 days down to 5...

the challenge becomes how can we compare one process to another without having to undertake a long complicated study....
The emphasis is on “overall process output”

total amount of material removed less finish milling

total amount of time required to remove the material

950 lb forging,
- 350 lb part ready for finish milling,
600 lbs of material removed preparing to finish

Map of Baseline Process

Map of Alternate Baseline

Current baseline process
8 operations identified
73.41 hours/600 lbs =
8.17 lbs removed per hour

Alternate baseline process
3 operations identified
41.5 hours/600 lbs =
14.45 lbs removed per hour
So we have set a reference target of removing a minimum of 10 lbs per hour - per part - for all non-finishing operations.

The intention is to have a common term to use when comparing different method’s of manufacturing parts...

...that can be exchanged between end users, Vendor’s and suppliers

...that protects each others proprietary information but allows for discussions on performance.

It is only through this exchange of information that we are all going to learn and improve to meet these significant challenges.
Boeing has sold over 800 – 787’s and Airbus has 500 firm orders for their A350, when you combined this work with Lockheed Martin’s F-35 program, there is a significant titanium work statement to be machined in the supply base. The challenge is to develop the supply base’s ability to machine hard metals structures. The requirement goes beyond just being able to machine parts, but being able to support increasing delivery rates of 10 or more. This means delivering the right quantity, of quality parts, on time, with zero defects.

The urgency of developing this support is due to the fact that Boeing does not have the internal capability to meet the backlog of deliveries currently on the books. The solution is in working together to identify the challenges and use the resources available to develop innovative solutions. Boeing has found that this resource utilization is vital to understanding the challenge, and developing solutions that meets all of the program’s requirements.

One aspect of this discussion that is often miss-understood is the word supplier. This has several descriptions when talking about the sourcing of products and the resources available to support the facilities responsible for deliveries. There is the manufacturing facility, outside of the Boeing Company, responsible for delivering the part’s, identified as a the Vendor. Then they quite often have suppliers machining the parts for them which are called Tier two suppliers. These are the facilities that should be looking for ways to improve their ability to machine titanium parts. This is where the identification of resources comes into play, and is where these conferences can work as a communication vehicle to identify partnerships that improve performance.

Again we are talking about suppliers, but this time it is the multitude of supplier resources available to support manufacturing in the machine tool, cutting tool, and distributor supply base. Too often the baseline is established from current capability based on existing equipment and current technology in use out in the shop today. But with the shift in work statement going to machining hard metal complex products, this model creates a gap between what can be done and what is needed. An additional target baseline needs to be created, based on the latest technology in the industry. This does not always mandate large investments, but identifies the size of the gap in capability and develops a plan for narrowing or eliminating the gap entirely.

We have a long history of dealing with these challenges at the Boeing company, and one of the biggest early challenges is where do we need to be on the performance scale? So we want to establish a target for the roughing portion of the task. If you take the total amount of time to rough the part divided by the total amount of material removed during the roughing operations you come up with an average pounds of material removed per hour. The intent is to look at the overall process instead of only looking at individual operations.

The task is to work with the suppliers supporting your facility to help you understand where your shop is today and what is required to raise the performance above this level. Of course with improved performance comes better efficiency, improving profits and most importantly provide the Boeing Company with a supply base capable of meeting our rate requirements.