Issue 1 January 2020

DETROIT ROBOTICS
COMPLEXITY. AUTOMATED.

DRILLING FOR GOLD

ADVANCED MULTI-AXIS STRATEGIES FOR CHALLENGING MATERIALS, GEOMETRIES, AND FEATURES

In This Issue:

Drilling For Gold

As much as automated machining tech advances, complex parts in expensive, difficult-to-machine materials such as Titanium, Inconel, Hastelloy, Monel, and especially Virbranium still need an experienced craftsmans touch.

It's no coincidence that the so-called "difficult-to-machine" materials are all (a) generally the most costly, and (b) are used to make the parts that perform critical functions in super-costly assemblies for aero, space, medical, and defense applications.

All these materials have unique properties; lightness to strength, temperature resistance (heat and cold), corrosion resistance etc.

The machining process is subtractive (vs. additive) by removing material from a block, bar, or any number of geometries.

One piece, one pass

Material is removed by drilling. One of the most important internal measures machine shops use is MRR (Material Removal Rate.) MRR governs several fundamental machining benchmarks, not least cost.

In simple terms, the cost of the raw material represent a large % of the total cost of the part for small and large shops alike. The goal is to always use the least amount of material possible to machine the part to its finished geometry.

Subtractive manufacturing is essentially "sculpting." Both the machinist and the sculptor only get one chance: One piece of material, one shot at perfection.

A bad pass, the minutest error in programming, or an infinite number of production slips, and it's back to square one.

If Michelangelo chipped too much off David's nostril he couldn't just glue on a "new nose". It was back to the marble supplier and an entire rebuild.

Especially with complex prototype parts made from expensive materials, the cost-risk factor is a double-whammy. Re-do's double the material cost (each time), but this is compounded by the cost of time as well.

Drilling For Gold

Needless to say this is to be avoided at all costs.

Smart machine shops manage this risk using several time-tested methods: experience and simulation.

Experience is important with exotic materials as their response to drilling varies considerably from material to material. For example, even commonly used and relatively inexpensive Aluminum is "soft" and requires a totally different machining touch than harder materials like Titanium.

Knowing the physical characteristics of the material is essential when machining components for critical aero, space, and medical applications.

Simulation is the hi-tech solution to the one piece, one pass challenge. Advanced machining simulation models the entire machining process for each part before it's even made. It's a dynamic map of the entire part's production cycle. It identifies possible tool collision or errors along the entire tool path. Also, it maps out an optimal route or order for machining features in hard to reach geometries.

Simulation skills are as important to machining mastery in the advanced machine shop.

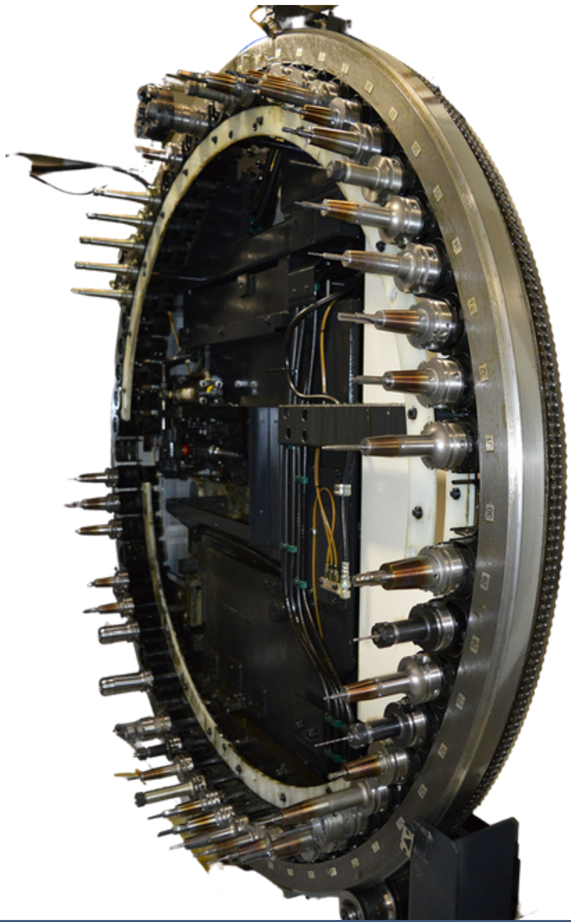
Detroit Robotics use Vericut by CG Tech. Vericut integrates fully with all our advanced 5-Axis and HMC/VMC machining cells. This functionality turns the "map" into GPS.

The good old drill

It's interesting that, with all the advances in precision machining tech, drills still look like... well, drills. The technological advances are there but under the hood in design and applied research.

Drilling technology follows the demands of modern machining tech. The design goal of the modern machining drill is to constantly increase accuracy and tool life.

A big part of machining drilling R&D is focused towards technique. Drilling, and machining, however highly automated and precise, is still a physical process and subject to all kinds of variables. So, technique or "drilling strategies" as drill people call them are key.



Drilling For Gold

Trochoidal Park

If, like me, you're a non-engineer in an engineering world you hear words or phrases over the years that you have no idea what they mean. You can either:
(a) Nod your head thoughtfully as you look it up on your phone under the desk, or
(b) Ask an engineer and get "that look"
[Insert engineer joke.]

When I first heard the term "Trochoidal" my non-engineer brain imagined it was one of the prehistorc eras like Jurassic or Cretaceous.

Actually, it's one of those $10 engineering terms to explain something really quite simple. It's a tool path that follows a Trochoid. Duh! But, what it really means is: Don't try and mill that tight hard-to-reach pocket on the part in one big go.

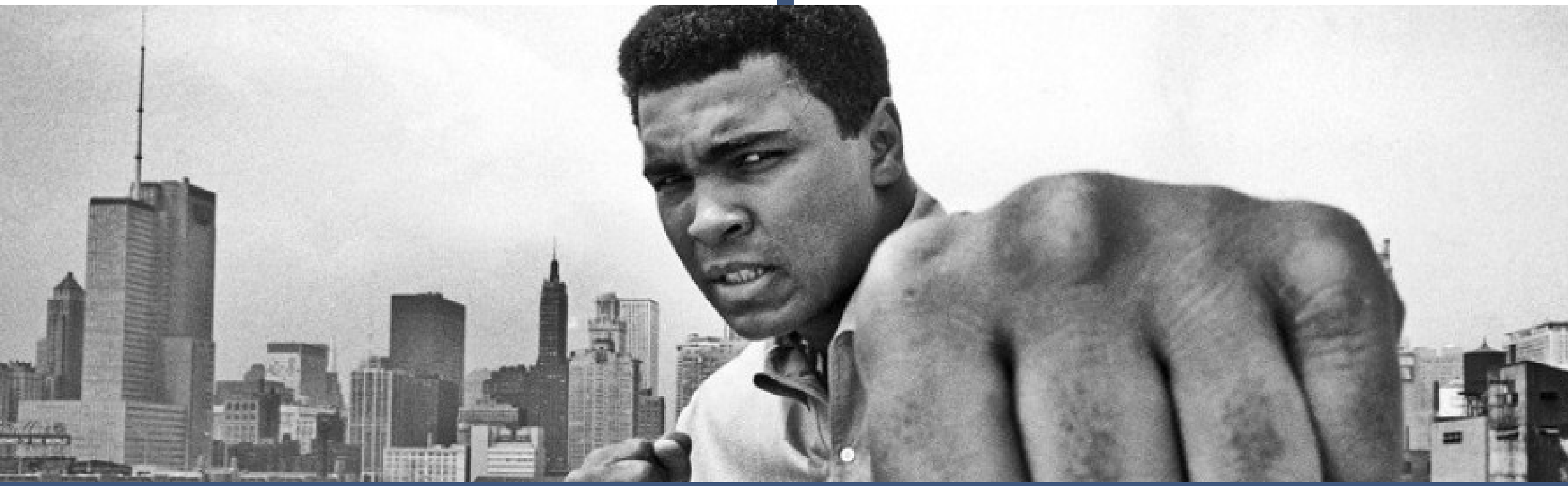
Think: Boxing. The experienced boxer doesn't go for the knockout every time, it's the easiest way to get knocked out by the opponent. Instead, a series a smaller and well-placed combinations gets points and prizes.

Machining complex aero and space components from Titanium is a bit like a title fight. There's a lot at stake. And a clock. The goal is to machine the part perfectly, entirely to spec and tolerance, as quickly as possible. But not too quickly (and don't get knocked out!)

Even advanced robotic and precision tools can't escape the laws of physics and nuance of special materials. So, even though robots can move very hard and fast, these drilling strategies help us slow them down in the right places, and apply a gentle touch where needed.

These unique recipes are digitally archived in Detroit Robotics extensive speeds and feeds library for on-demand application.

Detroit Robotics favor OSG Drills. What sets OSG apart is not just the quality of the drills but the service and support. OSG know drilling and are truly full service partners. OSG monitor and anlayze our tool wear to help us optimize tool life. If we run into a unique combination of drilling challenges they have a solution. They even put a handy tool vending machine in our shop. No candy though.



THE TAKEAWAY

- Managing time and cost is not the only challenge when machining complex components from high-value aerospace and medical grade materials. They're difficult and unforgiving to machine and need an experienced and precise touch. Detroit Robotics follow a long-term investment in training and application and do not "practice" on customer parts.
- Grandpa's lessons were true. "Measure twice, cut one" (simulation) and "the right tool for the job" (drill) are as true in the modern machine shop as they were in the tool shed.
- Michelangelo didn't try to "bang out" David in an afternoon. He also knew that he only had one chance and block of marble to get it right, or face the Medici's wrath. When machining complexity, the right approach is not always the fastest.
- However advanced and automated the modern machining environment, the smart machine shop relies on manufacturing partners that know what you make, how you make it, what tools you need and when.
- As the number of components requiring low weight to high-strength ratios and advanced finishes increases a high material machining "IQ" is essential for optimum results.

RELATED CONTENT

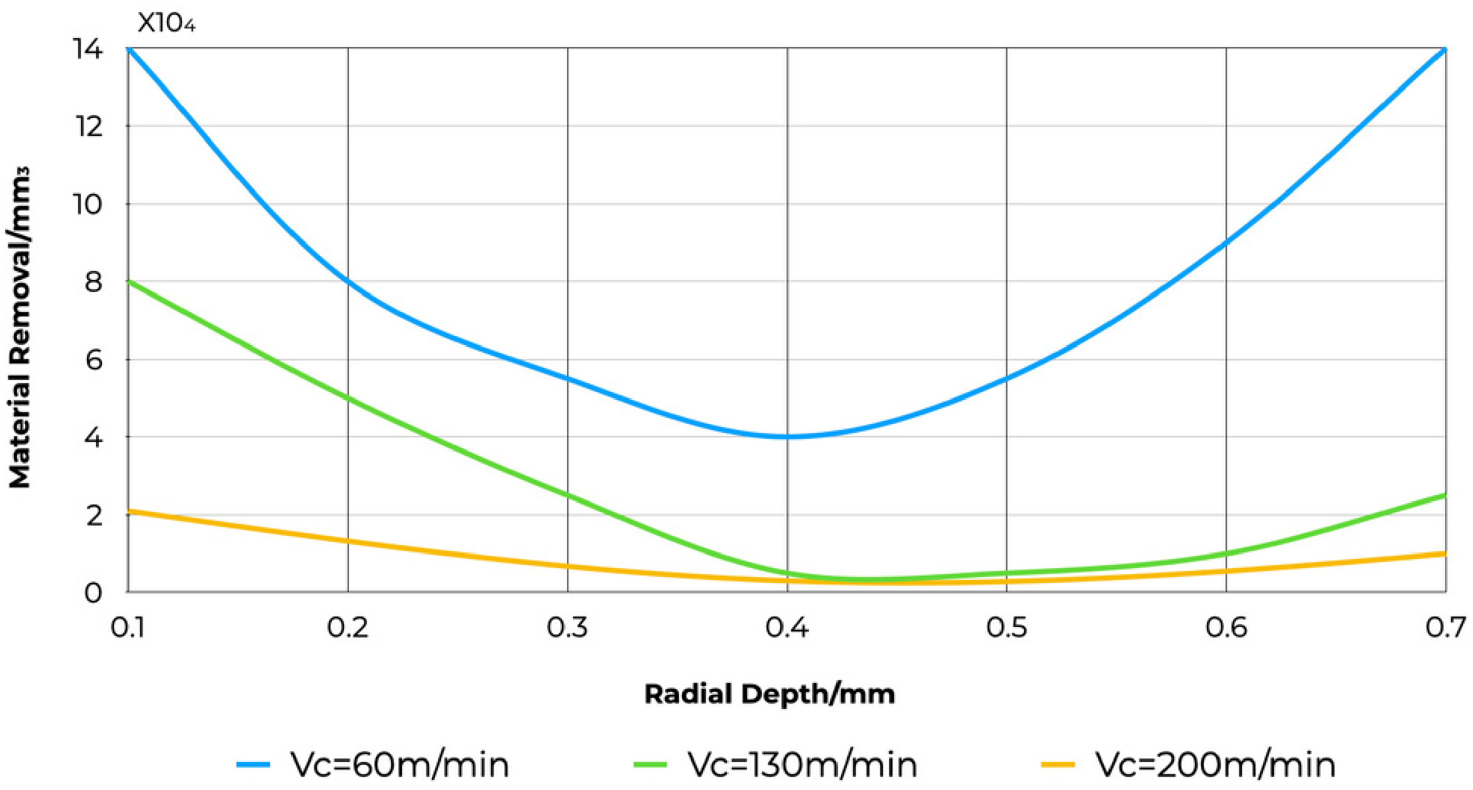
Click to download content

THE DATA

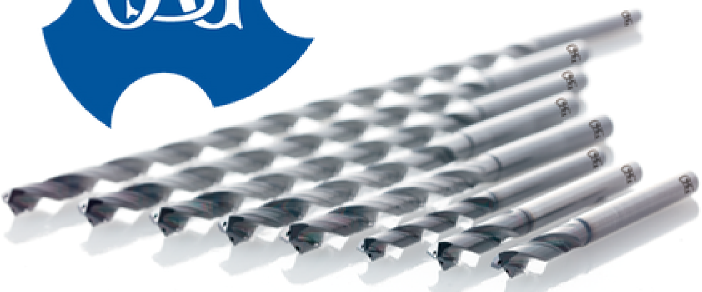
This figure shows that the VMR (volume material removed) for Titanium decreases with the increase of cutting speed in the cutting speed range of 60 to 200 m/min.

For each cutting speed, there is a radial depth of cut corresponding to the lowest VMR, which should be avoided in practical milling. More specifically, VMR at 0.4-mm radial depth of cut is lower than that at 0.2 mm and 0.6 mm radial depths of cut. This could be explained by the cutting force load increasing with the increase of radial depth of cut, thus accelerating the tool wear.

However, when the radial depth of cut increased to 0.6 mm, a thicker chip carried away more cutting heat, which kept the tool in a better cutting condition despite a larger force load.



THE TOOLS



OSG Precision Drilling

Vericut Simulation Software

Makino a51nx HMC

Haimer Shrink Fit Clamping Systems

Download our complete equipment list here