The University Of Sheffield.

Advanced Manufacturing Research Centre

BOEING

Titanium machinability in turning

The AMRC with Boeing machinability team compared the relative ease of machining 11 different titanium materials in a turning process.

The in-service properties of these materials are reasonably well understood, but the relative machinability of the materials is not well documented. This project aims to help manufacturers estimate relative machining rates and anticipate quality issues when changing or setting up new machining processes.

Background

Titanium alloys are now widely used in the aerospace industry for structural and engine components, thanks to their extremely high strength to weight ratio, high temperature performance and corrosion resistance.

But the properties that make them suitable for high-temperature high-strength applications also make them difficult to machine.

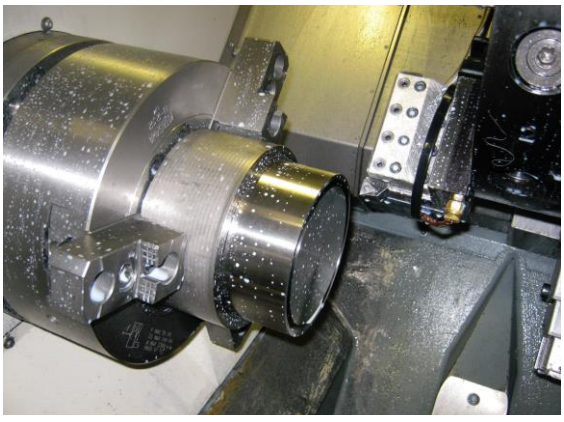
To better understand the machinability of these alloys, we tested 11 variants differing in alloy composition and heat treatment conditions.

Research

The test samples included three variants of the most popular titanium alloy, Ti6-4, as well as Ti54M, Ti6246, Ti1023, Ti17 and Ti834. These alloys have a range of microstructural features, being composed of alpha beta, beta and near-alpha crystal phases.

The samples had undergone various heat treatment conditions, including forged, annealed, solution treated and aged (STA), and beta forged and STA.

The test materials were supplied in bar form by AMRC partner Timet, and machined on our MAG Hawk NC lathe.



Three sets of tests were carried out for each sample:

- **Tool wear** – identifying what surface speed will lead to 15 minutes of tool life. This test is important because wear rates limit the speed of cutting.
- **Cutting forces** – running tests at different feed rates, to calculate cutting force coefficients. Cutting forces also strongly affect productivity, as tools can vibrate or fracture if forces are too high.
- **Chip formation** – documenting chip breaking and curling behaviour. Small, tightly controlled chips are ideal, as these can be most easily removed from the cutting zone. Large, poorly controlled chips can cause tangling and damage.

Results

Based on the test results, the materials were compared in terms of tool wear rates, cutting forces and chip control.

We found that all of the tested titanium variants could be turned at speeds greater than 50m/min, for a carbide tool life of at least 15 minutes. In general, alpha-dominated grades tested such as Ti834 cut more easily than beta-dominated grades such as Ti6246 beta forged.

Further Work

We are now carrying out a follow-up study to examine the microstructure of machined samples from this project, to look into the effect of machining on the near-surface layer, and contrast features between the different alloys. A PhD project will also be launched in the near future, to look at friction and ploughing force effects for the various titanium alloys.

Ti 10-2-3 STA

Ti 10-2-3 annealed

SANDVIK Coromant

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