Working with titanium

I have been using titanium for small metal parts for some time. It is only twice as dense as aluminium and very much stronger. You can use thinner metal so the final weight is about the same. On indoor models I use 1mm diameter wire for prop hangers. I beat one end flat on an anvil, file or grind the end into a disk, then drill out a 0.5mm hole for the prop shaft. I have also formed towhook hangers and bellcranks for gliders with it. It doesn't work like other metals, particularly when being drilled. Beating out is much like a hard aluminium alloy and it doesn't get brittle. I haven't yet tried tapping it.

Cost

Small pieces are surprisingly low cost. Sheet and wire is easily obtainable from eBay.

Drilling and cutting out

I found you can use normal drills but must use cutting oil and mustn't press too hard. The work overheats very quickly. Strangely, cutting rough shapes from sheet proves easy. I do it with a fine metal-cutting blade in a Makita jigsaw. Final shaping and smoothing can be done with files, diamond disks, emery or a belt sander. Wear rates are high.

My research

I thought I'd find out more about titanium. Good old duckduckgo (I don't touch google) came up with a lot of stuff and I attach below an edited version of the best of what I found on the web.

Tapping

Titanium is difficult to tap because of its tremendous elastic memory. When tapping, the material closes tightly around the cutting tool, generating friction and heat, resulting in increased wear of the cutting edges. This material also easily work hardens. What is needed is a tap specifically designed with additional clearance to overcome the extreme elastic memory of the material is recommended. Tap clearances would include extra back taper of the threads from the front to the back of the thread section, full radial clearance in the threads across the tap lands, and additional relief in the tap chamfer area.These reduce friction and heat. A compatible tapping fluid should be used that provides plenty of lubrication to reduce friction.The drill should be selected to produce the largest hole size that is allowed by the thread class (2B or 3B).

Hardening and tempering

Work hardening

Non alloyed titanium can only be hardened by deformation. The purer the titanium the softer and more ductile it is and stays. If you use highly alloyed titanium you need special heat treatments and these alloys can also be hardened. The tensile strengths can go up as high as medium hardened tool steel. However the stiffness of titanium is three times lower than steel, so the flexibility stays.

Age hardening

Many titanium alloys are age-hardened similarly to, for example, 6061 aluminum. You heat it above a certain temperature to put alloying elements into solution in the metal. (It's not molten; it's called a solid solution.) This is called solution treating. Then you quench to

freeze the solution in place. Unlike carbon steel, the quenched titanium alloy is now soft. Next, you re-heat at a lower temperature for a controlled time to let some of the dissolved constituents precipitate out. This hardens the metal, and is called age hardening. The strength increases with time and temperature, peaks, then begins to fall off, until you finally reach the annealed state, and the alloy is soft again. The reason it is called age-hardening is that some alloys, like 2024 aluminum, will actually harden with age at room temperature. It just takes a long time. Most of the time, you will want to help the ageing process with heat. Books like *ASM Metals Handbook* tell you times, temperatures, etc., for a given alloy. It won't work with all alloys or commercially pure titanium. Beware that heat treating titanium ought to be done in a controlled-atmosphere or salt pot furnace to avoid problems like embrittlement from contact with air at high temperature.

Tempering

Tempering titanium is easy. Heat it up to just glowing (dull red) 650 °C. Titanium is easier to deform when it is hot above 500 °C if you want to bend a sharp edge. There is no need to quench unless you want maximum strength.

Machining

The fact that titanium is classified as difficult to machine by traditional methods can be explained in part by the physical, chemical, and mechanical properties of the metal. For example titanium is a poor conductor of heat. Heat, generated by cutting, does not dissipate quickly. Therefore heat is concentrated on the cutting edge and the tool face.

Titanium has a strong alloying tendency or chemical reactivity with materials in the cutting tools at tool operating temperatures. This causes galling, welding, and smearing along with rapid destruction of the cutting tool.

Titanium has a relatively low modulus of elasticity, thereby having more "springiness" than steel. Work has a tendency to move away from the cutting tool unless heavy cuts are maintained or proper backup is employed. Slender parts tend to deflect under tool pressures, causing chatter, tool rubbing, and tolerance problems. Rigidity of the entire system is consequently very important, as is the use of sharp, properly shaped cutting tools.

Titanium's work-hardening characteristics are such that titanium alloys demonstrate a complete absence of "built-up edge." Because of the lack of a stationary mass of metal (built-up edge) ahead of the cutting tool, a high shearing angle is formed. This causes a thin chip to contact a relatively small area on the cutting tool face and results in high bearing loads per unit area. The high bearing force, combined with the friction developed by the chip as it rushes over the bearing area, results in a great increase in heat on a very localized portion of the cutting tool. Furthermore, the combination of high bearing forces and heat produces cratering action close to the cutting edge, resulting in rapid tool breakdown

Surface damage is likely to reduce fatigue resistance, so care must be taken to avoid such damage, especially during grinding.

Links to source sites

http://www.eisc.com

http://www.practicalmachinist.com/vb/general-archive/can-titanium-hardened-79055/

http://www.jobshop.com/techinfo/papers/machiningtitanium.shtml

https://orchid.ganoksin.com/t/tempering-titanium/13566

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