

Applications in the Aerospace Industry

V. Zerrouki*, A. Martinez*, C. Turrini*, J.Vigneau**, D. Lourdin***

* : Snecma Moteurs - Research and Development Machining Group – RN7/BP81 – F-91003 EVRY Cdx

** : Snecma Moteurs – Machining Expert – Rond Point Rene Ravaud – F-77550 MOISSY CRAMAYEL

*** : Snecma Moteurs – Rotating Part Manufacture – RN7/BP81 – F-91003 EVRY CEDEX

CONTEXT

In an intense competitive industry, aircraft engines manufacturers have to build up components with high mechanical performance while remaining cost effective. In this context, designers and manufacturers work together in order to maximize the capability of a process regarding a component features for a high level of in flight resistance.

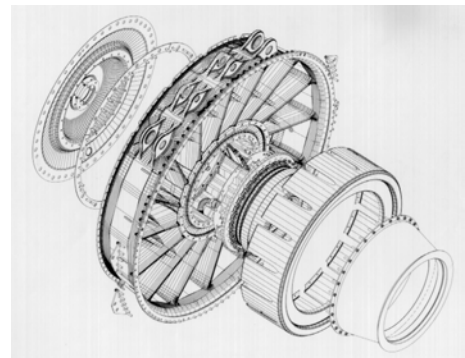
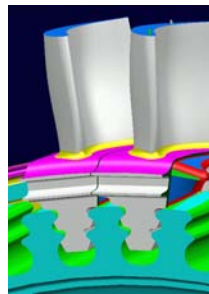
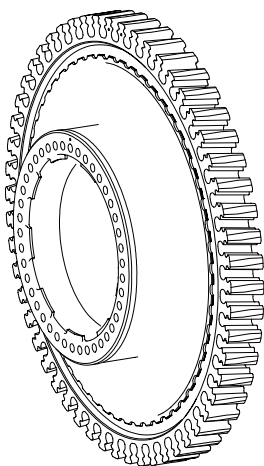
Snecma Moteurs is one of the major aero-engines manufacturers of the world and organizes its research and development for manufacturing processes to reach these objectives. By this way, efforts are concentrated in machining, especially developing new cutting processes and increasing the performance of ones already used in shopfloors.

HSS MAIN APPLICATIONS

High Speed Steel (HSS) Tools are situated in the second category as described before. If new developments seem not to allow a performance gap compared to the current situation, works are made with the aim to increase their own capabilities during a cutting operation.

HSS are mainly used for two applications at Snecma Moteurs, see figure 1 :

- broaching for disks slots manufacture,
- tapping for components assembly.



(a) Turbine disk and zoom on slots

(b) Example of a turbine casing assembly

Fig. 1 – Applications of HSS tools for aircraft engines

Increase in tool life is the best item to estimate the improvement of HSS tools. A few years ago, HSS providers developed powder metallurgy steels to take over from conventional steels. Difficulties were to find the good combination between the two main properties needed for HSS capability :

- the fracture toughness – notch resistance under an impact

- hardness.

Equilibrium has to be found between the grain size, the carbon amount in the steel, etc. Here the heat treatment is also a dominant parameter: austenitizing temperature, aging time and temperature may influence the material features. Figure 2 shows this tendency. Different heat treatments were applied on conventional and powder metallurgy steel. Each sample was characterized by microhardness and fracture toughness (rupture weight on a 3 points bending specimen) highlighting each material behaviour.

While a high aging temperature can bring a high level of fracture toughness, this tends to decrease the hardness. In an another hand, fracture toughness can decrease under elevated austenitizing temperature but effect on microhardness is not relevant.

That shows the difficulties to combine a high hardness and a high toughness. This trend may have a limit because a too high material hardness may provokes a cutting edge damage as chipping or a dramatic tool breakage.

Thus, this work allows us to get from 25 to 60% higher cutting time with a same tool.

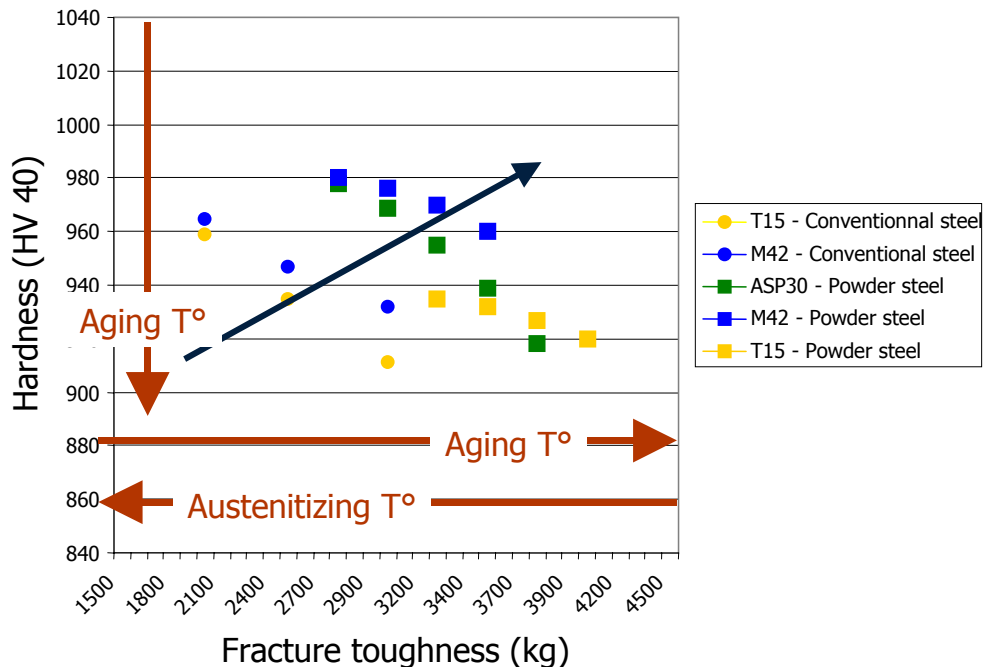


Fig. 2 – HSS relationships between fracture toughness and hardness by changing heat treatment

ZOOM ON HSS FOR BROACHING APPLICATIONS

Process basics

High Speed Steels are dedicated to roughing and finishing operations which are done on a unique machine tool. Same tools are also employed for nickel based alloys components (wrought INCO718 for example) and titanium alloys (wrought Ti6-4 for example).

HSS tools are especially T15 from Crucible/SouthEast, ASP2030 form Erasteel. Development of carbide tools are in progress.

Machining conditions are adapted to the material such as cutting speed, rise per tooth, lubrication mode. For example, the titanium based alloy conditions are twice higher than those for nickel based alloys.

Also the cutting angles effects are predominant in this process. The rake and the back-off angle are defined by combination of cutting tool behaviour, the machine tool stiffness and the regrinding capability. All are focused to minimize tool costs and to keep the accuracy of the component design geometry.

Economical overview

Broaching time is significant in all the manufacture process¹ of a turbine disk in IN718 as shown in figure 3. It is around the same for high pressure compressor disk made in Ti6-4. The main difference is linked to cutting conditions which are higher for titanium based alloys. Taking into account the cutters costs, broaching tool are not at a high level, reaching 8%. But they take place on few machine tools whereas the other 92% tools concerned several hundred machine tools as milling centres, lathes, ... This qualitative volume tends to show that broaching cutters volume are not a negligible amount.

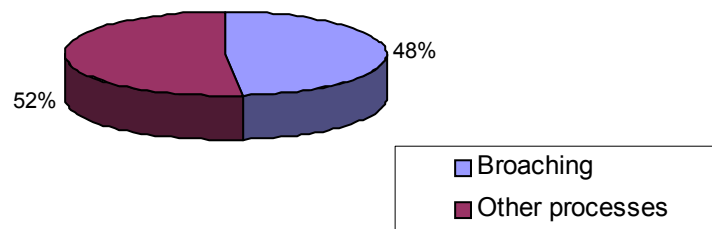


Fig. 3 – Broaching time in the whole machining time for a turbine disk

ZOOM ON HSS FOR TAPPING APPLICATIONS

Process basics

Tapping is a machining operation which generates a high level of torque (around 5N.m for 25CrM4 steel for example). That means tools require a high torsion resistance : high speed steels are the best adapted cutting tool. Starting for this constraint, helical taps are used to manufacture blind hole, GUN geometry for classical hole, see figure 4.

As this operation generates geometrical strain concentration in the thread, the tapping operation is exclusively applied for non-critical parts in the engines as casings in cast IN718 or in Z5CNU17 stainless steel. Tools mainly come from Erasteel under M42 reference or from Armor and Prototyp.

Using straight oil, cutting conditions for steels are from four to five times higher than nickel based alloys.

¹ Manufacture process is considered as machining and finishing operations. Forge and inspection are not integrated in this chart.

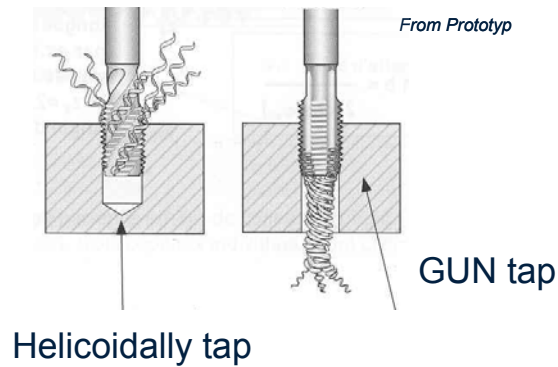


Fig. 4 – Types of taps using for threading operation on casings

Economical overview

Tapping is a specific process with a narrow amount of applications, especially for the in flight component resistance as described before.

It represents less than 1% compared to all the cutters employed at the Corbeil plant where there are the only cases, see figure 5.

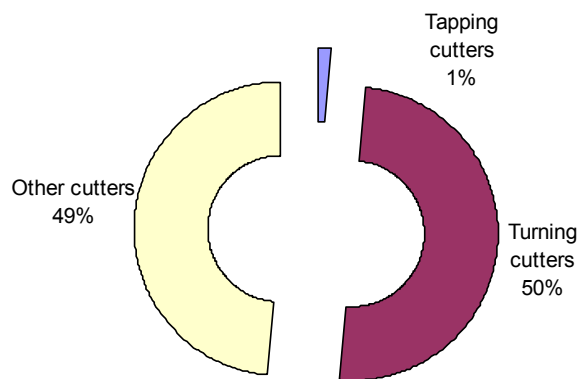


Fig. 5 – Taps cost repartition in the whole consumables used at the Corbeil plant

CONCLUSION

HSS tools are used for very specific processes as broaching and tapping. Few improvements are seen but tools providers have to deeply work on this tool material if they want them to stay competitive against carbide tools for example. Also, other processes can take over as single point milling for threading.

However, broaching with HSS has been applied for many years without manufacture events. This robust application combine with a high level of regrinding capabilities is a real advantage for our industry. A change will go with suitable machine tools (accuracy, stiffness, ...).