Special Taps for Space Flight Components

The Design and Production of special tools for manufacturers of aerospace equipment is among the most sophisticated and challenging segments in the metal-working industries. Workpieces are usually made of the toughest, heat-resistant materials to allow for maximum performance in zero-gravity conditions under high thermal stress. SCHUMACHER has developed a tap series with customized geometries and special surface treatments to meet the expectations of this industry segment.

The Challenge of Space Flight Components

Manufacturers of precision tools are used to very demanding applications with limited options to modify or revise the result once the workpiece has been completed and entered into service. Our team has worked in numerous Automotive, Medical Tech or Offshore applications which all come with zero-defect quality standards and very sophisticated production requirements. But Space Flight applications bring with them a number of unique challenges. Working with producers of such components has proven to be a very demanding but also rewarding process since it continuosly challenges the technical status-quo, requiring ever-increasing standards from our R&D, Design and Production teams.

The Particularities

While many of the quality control procedures and development processes are similar to terrestrial applications, these are some of the unique characteristics of this segment:

» Workpieces require narrowest tolerance levels, often close to the technically feasible limit of production
» Once shot into space, maintenance is impossible
» Simple inaccuracies in the threading process (burr remaining in the thread) can threaten the functionality of the entire technical system, in zero gravity. First, space flight components have to complete the launch and lift-off phases which includes a G force (load factor) of 10 g, working on fastening components and internal threading. Once the equipment - such as a satellite system - is orderly positioned in its orbit around the Earth, thermal stress is working on the components continuously. Especially those systems located in geostationary orbits are exposed to intense thermal forces: the side facing the sun heats up to around 120°C, the side in the shade cools down to -90° C due to the vacuum environment.

Satellite components undergo threading operation.

Producers of such components therefore choose high-alloyed nickel steel and aluminum to ensure performance of their systems.

The Development

To meet the requirements of narrowest tolerance levels, it was essential for our R&D team to also consider the machine tools used by manufacturers of aerospace equipment. Depending on the type of machine, clamping situation and lubrication used, several geometry series were developed. The first step - when supplying a manufacturer of space flight components with special tools - is thus always an analysis of the actual machining situation. Two characteristic applications serve to demonstrate this challenge:

a) Aluminum with >35% silicon

In order to machine near-perfect threads in these components and avoid burr in the thread, our R&D team has modified a standard high-performance geometry in the following way: The cutting angle was reduced and equipped with a new combination of relief angles, improving the chip creation in the difficult Aluminum. Moreover, there are two PVD coating variants depending on the machining situation. If our customers work with very stable CNC machinery, we apply a high-end multi-layer coating. When the threading process is executed by hand-driven machines, we recommend a coating with lower surface hardness which produces a similar result in surface quality but reduces the risk of axial pitch errors.

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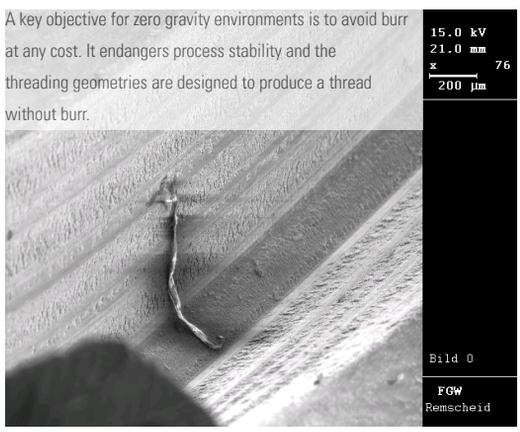
b) Nickel alloys

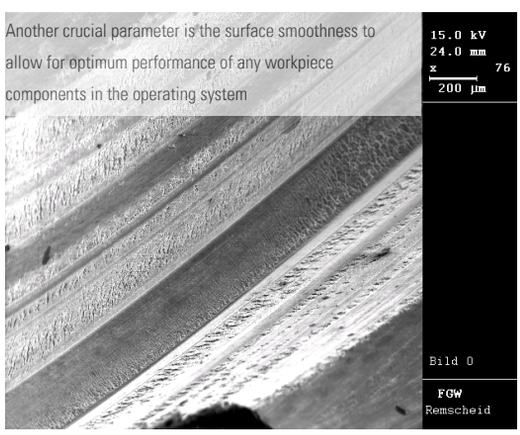
A particular challenge of special steels with high nickel content goes along with the abrasive nature of the workpiece. It only takes few threads to deteriorate the tool's cutting edge. This immediately impacts the surface quality of the internal thread - which has to meet very high standards monitored by the manufacturer of the space flight components. Our R&D team has developed two solutions for this constellation as well: in CNC machining, the cutting angle is modified to better stand the wear of the tough workpiece and additionally protected by a special PVD layer. When hand-driven machines are used, the tap is stabilized (its relief angles reduced) and the key focus of the geometry development is chip control.

Process Stability through Careful Analysis

While each geometry of the new tap series might work in isolation, the result is only sufficient if accompanied by a thorough analysis of all parameters working on the respective application. Since nearly all space flight equipment undergoes a process of electroplating, tolerance levels of the special tools need to be adapted carefully to the target pitch diameter after the plating process. Moreover, clamping, lubrication, pre-drilling and cutting parameters are critical to achieving optimum results.

Selection of SCHUMACHER tool geometries designed for space flight applications





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R&D Team discusses measurement results with Dr. Dültgen of research institute FGW, Germany