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OPTIMIZATION CUTTING TOOL GEOMETRY FOR TITANIUM ALLOYS

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ОПТИМІЗАЦІЯ ГЕОМЕТРІЇ РІЗАЛЬНОГО ІНСТРУМЕНТУ ДЛЯ ТИТАНОВИХ СПЛАВІВ

Titanium alloys are extensively used in mechanical engineering and metal-working industry, automobile and chemical applications due to their classical properties of high strength to weight ratio, specific strength at high temperatures, corrosion resistance, creep and fatigue strength etc. Manufacture of precision components from titanium alloys is a challenging task as the alloys comes under difficult to cut material due to the inherent qualities of low thermal conductivity, low modulus of rigidity, work hardening, high chemical reactivity with tool, built-up edge formation etc. during machining.

The cutting tools exhibits forces on the work piece and similar forces are experienced by the cutting tool while cutting the work material. Cutting tool geometries such as cutting angles and nose radius play a vital role in machining of any work material (titanium alloys). The rake angles have major effects on cutting forces and chip formation by giving adequate strength to the cutting tool. The tool nose radius has effect on strength of the cutting edge and surface finish. The manufacturing engineers always quest for optimized cutting tool geometry, but it is very difficult to carry out the experiments with various tool geometries as it involves consumption of tools, material and time etc. Hence, to address the above issues, a computer aided engineering (CAE) approach has been adopted in the recent days. Here, the cutting tool geometry can be optimized by design of experiments (DOE) techniques and a machining simulation and analysis (Deform 3D) software by defining required material properties of titanium alloys, tool geometry, cutting parameters etc. The axial directional feed force, radial directional thrust force and tangential cutting force may be calculated for turning experiments through computer aided machining simulations. These cutting forces need to research in statistical (Minitab) software for percentage contribution of cutting tool geometries such as back rake angle, side rake angle and nose radius.

In machining process, most of the mechanical energy used to remove material becomes heat. This heat generates high temperature in the cutting region. The new challenge in machining is to use high cutting speed in order to increase the productivity. This is the main reason for rapid tool wear. For titanium and its alloy, this problem is more severe due to their low thermal conductivity. 80% of the heat generated in the cutting region goes to the cutting tool and cause wear. So it is convenient to use transient cutting speed for machining the highly reactive material like titanium alloy. So, it is better to optimize the variables either cutting parameters or tool geometry parameters for tool life to increase the productivity at good surface finish. The influence of each control factor can be more clearly presented with the Taguchi method as a well-known technique that provides a systematic and efficient methodology for process optimization and this is a powerful tool for the design of high quality systems. Taguchi approach to design of experiments (DOE) is easy to adopt and apply for users with limited knowledge of statistics, hence gained wide popularity in the engineering and scientific community. This is an engineering methodology for obtaining product and process condition, which are minimally sensitive to the various causes of variation, and which produce high-quality products with low development and manufacturing costs.