

Experimental study on the performance of coated carbide tools in the ultra-precision machining of stainless steel

Abstract

Ultra-precision machines are widely used to turn aspherical or spherical profiles on mold inserts for the injection molding of optical lenses. During turning of a profile on a stainless steel mold insert, the cutting speed reduces significantly to 0 as the cutting tool is fed towards the center of the machined profile. This article reports on experiments carried out to study the wear of uncoated, physical vapor deposition (PVD) coated and chemical vapor deposition (CVD) coated carbide tools in the ultra-precision machining of STAVAX (modified AISI 420 stainless steel) at low speeds with and without a lubricant. A sprayed mixture of compressed air, liquid paraffin oil, and cyclomethicone was used as a lubricant. During machining at 44 m/min under dry condition, the rake face of the tool edge was predominantly subjected to abrasive wear. Reducing the speed to 10 m/min increased the flank wear and the severity of abrasive wear and caused the tool edge to fracture, leading to a deterioration of the surface finish. The lubricant was effective in preventing surface fracture, reducing flank wear, and improving the surface finish. Among the PVD-coated and the CVD-coated tools, the former tool type is more suitable to be used in ultra-precision machining. The CVD-coated tool vibrated rapidly, causing extensive fracture to take place on the flank face and the surface finish to be undulating. The experimental results obtained in the turning tests gave useful insight on the appropriate parameters and conditions to be used in the machining of a profile on a mold insert. The profile machined on the stainless steel mold insert with the PVD-coated carbide tool in the presence of natural oil had a superior form of accuracy and surface finish.