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On the Experimental Optimization of Tool Geometry for Uniform Pressure Distribution in Single Edge Gundrilling

An investigation into the effect of gundrill geometry on the coolant flow, in gundrilling, is carried out. This investigation deals mainly with the loss of coolant pressure occurring in a limited space between the flank of the gundrill and the bottom of the predrilled hole. This space is named as "bottom clearance." The pressure loss in the bottom clearance is classified into, (a) pressure loss due to flow interaction with the bottom of the drilled hole (impact pressure loss), and (b) pressure loss due to hydraulic resistance of the annular groove connecting the bottom clearance and the chip removal passage. The study indicates that a significant part of the pressure loss occurs due to flow deflection at the bottom of the hole. The reduction of pressure loss can be achieved either by reducing the coolant velocity at the orifice exit, or, by increasing the coolant pressure in the bottom clearance. In this study, the shoulder dub-off angle of the gundrill is experimentally optimized to increase the coolant pressure in the bottom clearance, thereby achieving uniform coolant pressure distribution. This uniform pressure distribution resulted in increased gundrill life without compromising the quality of the machined hole.

Introduction

Gundrills were developed by early gunsmiths for making straight and true holes in gun barrels. The technique of gundrilling came to prominence in the late eighteenth century. Today, their use has been extended to a wider variety of applications in automobile, aircraft, papermill and turbine industries, etc.

When the length-to-diameter ratio of the hole to be drilled exceeds a value of 5, gundrilling becomes more economical than the conventional methods. Gundrills can often be used, advantageously, in short to medium depth applications. In most materials, short holes can be machined at extremely high speeds. The combination of high speed and low feed, in gundrilling, can result in penetration rates, equal to or greater than, that of high speed steel (HSS) drills. These characteristics, of gundrills, are well suited for automated mass production. Gundrills have the following unique advantages [1-6]:

- produces true round and straight holes in a single pass,
- produces holes of length-to-diameter ratio up to 250,
- provides minimal run-out of holes. The holes can often be gundrilled as a last operation on a part, thus reducing cumulative tolerance errors,
- does not require highly skilled operators.

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Geometry of Gundrills

The commonly used gundrill is illustrated in Fig. 1. Geometry of a gundrill is shown in Fig. 2. The gundrill body consists of a steel shank 1, a metallic carbide tip 2 and an enlarged driver 3. Flat surface 4, on the driver, provides the positive engagement of the tool. Exact design of the driver depends on the gundrilling machine.

The shank is a tubular structure having an elongated internal passage 5 along the entire length and joins with the coolant supply passage 6 in the driver. The shank is made of a tubular body with a V-flute 7. The flute extends over the full length of the shank and terminates as an inclined crease 8 adjacent to the driver.

The tip of a gundrill is, generally, cylindrical. The diameter of the tip is larger than that of the shank. This diameter difference results in a clearance between the shank and the side wall 9 of the hole being drilled in workpiece 10 during gundrilling. Tip flute 11 is the extension of flute 7 of the shank. The alignment of flutes 7 and 11 may either be linear or helical but the former is preferred in general design practices.

The tip flute has a pair of side walls 12 and 13. The side wall 13 extends past the axis 14 of the tip, which is also, the axis of the gundrill. The cutting end of the tip is formed with the cutting angles φ_1 and φ_2 on the outer cutting edge 15 and the inner cutting edge 16, respectively. The outer and inner cutting edges meet at drill point P. Location of P can be varied for optimum performance depending on workpiece material and the finished hole specification. The geometry of the cutting end is largely determined by the shape of the chip and effectiveness of the coolant in cooling, lubricating the tool and