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A Novel Approach to the Design of Self-Piloting Drills With External Chip Removal, Part 2: Bottom Clearance Topology and Experimental Results

In the first part of this paper, geometrical relations were formulated to describe the geometry of a self-piloting drill with external chip removal. A novel approach to the design of the cutting tip was proposed and an experimental comparison between conventional and newly designed drills was made. In deep hole drilling, after the tool and the machine, the most important component is the coolant. It is important that the coolant be distributed uniformly within the machining zone to improve chip removal, lubrication and cooling. Thus, in this paper, the coolant flow in the limited space between the drill flanks and the bottom of the hole being drilled (called "bottom clearance") is emphasized. Experimental investigations were done by using a specially designed workpiece which enables continuous monitoring of coolant flow and pressure distribution in the machining zone. The investigation shows that the newly designed drill is characterized by a significantly better coolant distribution in the bottom clearance resulting in an increase in tool life and better chip removal conditions.

Introduction

Cutting tool life is one of the most important economic considerations in metal cutting. In self-piloted drilling, various tool angles, cutting speed, feed rates, and conditions of coolant supply are usually selected to give an economical tool life (Griffits, 1977). Clearly any tool improvements that increase tool life will be beneficial. Tool life depends to a large degree on the coolant flow in the machining zone (Boothroyd, 1985; Astakhov et al., 1993).

As discussed in Part 1 (Astakhov et al., 1993), while drilling, the geometry of a self-piloted drill results in the formation of the surface 1 (the bottom of the hole being drilled) (Fig. 1). This bottom, from the one side, with the drill flanks 2, 3, 4, from the other side, create the limited space 5 (named as "bottom clearance"). The coolant is carried under pressure to the bottom clearance through the internal channels in the shank 6 and the drill tip 7. The coolant pressure in the bottom clearance has a major influence on cooling and lubricating conditions on the flank contact areas and it is obvious that this pressure should be as high as possible. Increasing the coolant pressure in the bottom clearance provides better penetration of the oil-based coolant to the narrow passages between the tool flanks and the bottom, i.e., better conditions for lubricating and cooling of the flank's contact areas. This aids in reducing the flank wear thereby increasing tool life. Unfortunately, till today, little is known of the effect of the drill geometry and the design parameters on the tool life; thus, judgment may well be based on false impressions.

This paper presents an extensive study of the influence of coolant "quantity" on the performance of deep hole drilling process. The investigation was classified into:

- Analytical study of the bottom clearance
- An experimental investigation of the pressure distributions in the bottom clearance
- An analysis of the influences of the geometric parameters on chip removal and tool life.

1 Analysis of the Bottom Clearance Topology

The important features of a self-piloting drill are described by the shape of its flanks and the bottom of the hole being drilled, i.e., by the topology of the bottom clearance. The bottom clearance is a three-dimensional space; however, its basic geometry can be analyzed in two dimensions by generating a series of cross sections. The bottom and the flank surfaces appear in two-dimensional cross-sections as curves which can be expressed by mathematical functions.

The analysis of the bottom-clearance geometry is based on

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