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A Novel Approach to the Design of Self-Piloting Drills With External Chip Removal, Part 1: Geometry of the Cutting Tip and Grinding Process

The performance of a self-piloting drill with external chip removal is affected by the geometry of its cutting tip. A comprehensive analysis of the cutting tip geometry and its influence on the drill performance is made. This subject is treated in two parts. In Part 1, the cutting tip geometry is analyzed. Special attention is given to the flank planes and a novel approach to the design of the drill was developed. By this approach the drill flank planes are located with minimum offset of the supporting pads' faces relative to the plane of the drill corner's rotation. Since several important drill angles are defined, the analysis is extended to cover the grinding process. The experimental comparison between the ordinary and newly designed self-piloting drills with external chip removal is also made to show the advantages of the latter.

Introduction

Basic Description. The techniques of self-piloted drilling began developing in the late 18th century with the growing need for more accurate bores in rifle barrels and cannons. While self-piloting drills are still used for this purpose, their use has been extended to an increasingly wider variety of applications. Today self-piloting drills are the most efficient tools, if not the only tools, for producing extremely deep holes, regardless of the precision required. While most applications involve hole depths varying from 10 to 30 diameters, it is common to encounter drills with depth-to-diameter ratios of 100 to 1. Furthermore, holes with depth-to-diameter ratios of 300 to 1 have been successfully drilled (Bloch et al., 1967). While such features may be accomplished with a twist drill, the extra problems involved in getting the coolant in and the chips out of the hole makes it quite difficult to drill beyond a depth-to-diameter ratio of about 20 to 1, and completely impractical for ratios beyond 50 to 1.

Besides high depth-to-diameter ratios, self-piloting drills are also capable of drilling very straight deep holes. The position of the hole that the tool has machined acts as a continuation to the guide bushing so that the tool will continue to machine a straight hole along the same initial direction. Although the high pressure coolant tools were developed primarily for producing deep holes, their ability to produce holes of good surface finish and close size control is often attractive to engineers requiring close tolerance holes of much shorter lengths. Self-piloting drills can even be economical for holes as short as one diameter, under certain conditions.

Usually in order to produce a finished hole, four to five operations are required: drilling, boring, rough and finish reaming, and finally honing. Not only are these operations costly by themselves, but each carries many other hidden costs that may not be so obvious. These include the cost of multiple handling and transporting of the parts between several machines; making extra setups; carrying more sizes and kind of tool; and, under critical conditions, they can require extra inspections which involve the procuring and maintaining of gages and allied equipment.

Self-piloting drills can eliminate such subsequent operations if one or more of the following conditions exist: (*1*) the precision requirements for the drilled hole (either size, finish, straightness, location, or all four) are such that they are difficult to attain by the more conventional methods; (*2*) the material is one in which a self-piloting drill can readily produce the degree of precision required; (*3*) the configuration of the part is such that it would be difficult to index from one station to another; (*4*) the location of the hole must be held accurately with respect to other holes or surfaces; (*5*) the size of the hole or the configuration of the part and/or machine would require special tooling and/or fixture.

However, self-piloting drills also have their limitations in deep hole applications. A tool as long as 100 diameters or

Contributed by the Manufacturing Engineering Division for publication in the JOURNAL OF ENGINEERING FOR INDUSTRY. Manuscript received Sept. 1993; revised July 1994. Technical Editor: S. Kapoor.

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