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An investigation of the static stability in self-piloting drilling

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A comprehensive analysis of the static stability in self-piloting drilling is made in order to define the optimal location (based upon the criteria of the equal pad normal reactions and equal stability coefficients) of the drill's supporting pads (relative to the drill's cutters). The optimal location is achieved under unsymmetrical location of the supporting pad relative to direction of the resultant cutting force in a plain perpendicular to the drill axis. Significant attention is paid to the drill entrance stability and three methods to reduce the bell mouth (the increase of the bore diameter and worse surface finish at the entrance) are introduced. By the detailed consideration of the drill static force system in the plain which contains the drill axis and vectors of the radial and tangential forces, a new design concept is proposed. The essence of this concept is to design the self-piloting drills with minimum offsets of the pad faces relative to the bottom of the hole being drilled. The experimental study of the newly designed drill shows that the use of the proposed design concept provides better hole quality, reduction of the bell mouth (diameter error and length), and reduction of the drill sensitivity to the value of the clearance between tool and pilot bush.

Nomenclature

a_1, a_2	uncut depth of cut at the outer and inner cutting edges, respectively
a_i, b_i	uncut depth and width of cut at unit part i of the cutting edge, respectively
b_1, b_2	width of cut at the outer and inner cutting edge, respectively
b_{ps}, b_{pc}	pad widths which are chosen based upon the criterium of tool entrance stability and maintain a sufficient lubrication conditions between the pads and the bore surface, respectively
C_p, C_R	constants depend upon tool material, workpiece material, and environment
d	diameter of drill
F_Σ	resultant cutting force in a plane which is perpendicular to the drill axis
F_{opt}	optimal pad reaction $F_{opt} = F_{n1} - F_{n2}$
F^0_{n1}, F^0_{n2}	normal pad reactions under $\mu = 0$
F_{n1}, F_{n2}	normal pad reactions under $\mu \neq 0$
k	important stability coefficient
k_1, k_2	stability coefficients relative to supporting pads 1 and 2, respectively
l_1, l_2	arms of the radial and tangential forces (Fig. 13)

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