16 "Plastic Flow and Rupture of Metals," by C. Zener and J. H. Holloman, Trans. ASM, vol. 33, 1944, pp. 163–235.

Discussion

A. O. Schmidt[8] and J. R. Roubik.[9] Tool wear in general and cratering in particular are associated with tool-tip temperature, the rate of wear increasing with increasing temperature. Although it has been known that an intimate relation exists between tool wear and temperatures in the region surrounding the cutting edge, this is the first attempt to relate analytically the volume of tool wear to tool temperature. Many tests have established that, with speed, feed, and depth of cut remaining constant, tool wear is a linear function of time or length of chip produced. Variation in cutting speed affects the slope of the curve. That increased cutting speeds as well as heavier feeds entail higher tool-tip temperatures has been well substantiated.

The authors' contribution lies in the delineation of wear factors which can be rather unstable. Although the volume of tool top wear can be the same for a deep, narrow crater or a shallow, wide abrasion mark, this difference in character of wear has a great influence on the over-all performance of a tool.

Authors' Closure

The authors appreciate the remarks by Dr. Schmidt and Mr. Roubik. The tool crater wear measured after a cut represents the total due to (1) adhesion and transfer, (2) abrasion, and (3) chemical wear (if any). If abrasive wear for a given tool-work pair can be considered to be influenced by chip asperity hardness, it is evident that both this type of wear and that due to adhesion are dependent upon temperature in the same manner. Removal of material due to a chemical reaction would similarly depend upon temperature as an exponential function.

The degree of crater wear for the several tool-work combinations depends upon such factors as initial hardness, degree of strain hardening, presence of abrasive constituents, tendency toward adhesion (welding), and so on. Whether abrasion or adhesion wear predominates would depend upon the characteristics of a particular pair.

The authors agree that the geometrical shape of the crater has an important bearing on tool performance. For the same volume a deep narrow crater would endanger the cutting edge more than a shallow broad crater. Numerous factors affect the geometrical shape of the crater. Included are the tool-work pair, the cutting conditions, and adhesion temperature.

It is pertinent to point out that the numerical values of $W_i/(s_i N)$ tabulated in Tables 1 and 2 were calculated on the basis of a 1-in. depth of cut whereas the normal forces were determined for a 0.1-in. depth. Accordingly, the values of $W_i/(s_i N)$ are too large by a factor of 10.

Confirmation of the proposed theory of crater wear has been obtained for Type T1 (18-4-1) high-speed-steel tools turning annealed AISI 4142 steel under diversified cutting conditions. Details can be found elsewhere.[10]

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[10] Final Report, Contract DA-11-022-1121, August, 1955, by K. J. Trigger and B. T. Chao, Office of Ordnance Research, U. S. Army, Durham, N. C.