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White Paper CFHSSIC

THE INFLUENCE OF CUTTING FLUID COMPOSITION ON THE WEAR OF HIGH SPEED STEEL TOOLS IN INTERMITTENT CUTTING

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ABSTRACT

High speed steel (HSS) tools are being replaced for many continuous cutting operations, but the size and complexity of some tools, e.g. as used in gear hobbing, mean that HSS will continue to be used for the foreseeable future. In these situations, cutting fluids and additives are used extensively in industry to prolong the working life of the tool by reducing the rate of wear during cutting. Shaw (1) has concluded that the selection and application of metal cutting fluids is much more of an art than a science and Trent (2) states that the influence of active lubricants on the rate of tool wear is very complex and that too little attention has been given to the mechanisms by which lubricants affect tool wear. There is little science in the method of choosing, which is the optimum in a particular operation. Most recommendations and choices are still based on general guidelines, as contained in several handbooks, previous experience or very time-consuming, and hence expensive, in-service trials.

Thus the aim of the present work was to develop an appropriate tool wear assessment procedure, and to use this to evaluate the performance of seven mineral oil based cutting fluids. The gear hobbing operation was simulated by using a single point high-speed steel tool (composition {wt%} C-l.l: Co-8.0: Cr-3.7: Mo-9.5: V- 1.2: W-l.5) intermittently cutting a low alloy steel (composition {wt%} (C-0.13: Cr-l.0l: Mn-0.54: Mo- 0.49: N-0.25: P-0.018: S-0.034: Si-0.2: V-0.005).

Single point intermittent was achieved by mounting the tools, which were shaped in-house from standard HSS rods of 9.5 mm diameter, in a fly cutter attached to the head spindle of a vertical milling machine. The cutting speed varied between 0.3 m/s and 1.1 m/s, thickness of cut, ti, between 0.09 and 0.37 mm and the depth of cut was constant at 1.6 mm.

The cutting fluids used covered a range of values of viscosity (5-39 cSt at. 40°C), elemental sulphur (0- 0,8%), sulphurised fat (0-10%), chlorinated paraffin (0- 23:%), and free fatty acid 0-0.2%). The amount of cutting with a particular fluid was limited to ensure little depletion of the additives.

The undeformed chip thickness, ti, was used as the main control parameter regarding the severity of the machining operation. The worn tool from each test, and chips from some of the tests, were examined by optical microscopy and scanning electron microscopy, with attached energy dispersive X-ray analysis.

Conventionally, the rate of tool wear is assessed in terms of one particular measure of tool wear, e.g. length of flank wear scar. A different approach to determining effectively the rate of tool wear was developed in this work. The problem with the conventional approach is that the trials have to be conducted until 'failure' occurs, which may require prolonged machining, and it is not necessarily a priori possible to determine the critical wear mechanism when this may change as a result of the composition of the cutting fluid. The methodology adopted required an assessment of the relative extent and smoothness of the worn regions on the flank and rake faces, the degree of 'built-up edge' on the rake face and the degree and intensity of 'tempering' colours in the vicinity of the cutting zone.

It was found that the variation in viscosity had no discernible effect, and also the limited amount of free fatty acid had no effect. These observations would be as generally expected. The effects of the sulphur and chlorine containing levels on the wear processes can be summarised as follows:

Low ti (0.09 & 0.1 mm)

Increasing the chlorinated paraffin content decreased rake face temperature and decreased the rate of flank wear or built-up edge formation. Increasing the elemental sulphur increased the rate of flank wear.

Medium ti (0.14 & 0.19 mm)

Increasing the chlorinated paraffin decreased the flank face temperature. Increasing the elemental sulphur or sulphurised fat decreased the rate of rake face wear. Increasing the sulphurised fat resulted in an increase in the flank face wear rate.

High ti (0.29 & 0.37 mm)

Increasing the chlorinated paraffin decreased the flank face temperature. Increasing the sulphurised fat tended to increase the rates of both rake and flank face wear.

REFERENCES

(1) M. C. Shaw, Metal Cutting Principles, Clarendon Press, Oxford, 1984.
(2) E. M. Trent, Metal Cutting, Butterworth's, London, 2nd Edition, 1984.