An Ultrasonic Investigation of Lubrication on the Tool/Chip Interface

A.M.Abodena[1*], M.B. Marshall[1], R.S. Dwyer-Joyce[1]

[1)] The University of Sheffield, Department of Mechanical Engineering, Mappin St., Sheffield S1 3JD, UK

1. Abstract

Friction at the contact in the tool-chip interface generates high heat and influences the tool wear rate. One of the ways of controlling its magnitude is by applying lubricants. Even when considering the current trend towards research minimum quantity lubrication processes, in many cases a flood of liquid is still directed over the tool with the aim of acting as a coolant and lubricant. Cutting fluids play a significant role with respect to a number of objectives which are; preventing the tool and workpiece from overheating, increasing tool life, and improving surface finish. Selecting a suitable fluid for a particular application among the large number of commercially available fluids is an issue, and a significant challenge due to the fact it is often an empirical process.

The nature of the interface between two solid materials is at the very centre of tribology. In this work a novel ultrasonic based tool is used to investigate the contact at the tool-chip interface during turning. The aim of this work is investigate how much this interface is influenced by the lubrication medium at different cutting speeds, and different depths of cut.

Ultrasonic waves can be used to investigate contact conditions at an interface by recording the reflection coefficient. Based on this concept, a transducer is bonded to the bottom of a cutting insert to investigate the contact between the cutting tool and chip. The bonded transducer is wired and connected to an ultrasonic pulser receiver (UPR), which is connected to an oscilloscope and computer (Figure 1). An excitation voltage is then applied causing a short duration ultrasonic pulse of a wide frequency band. This pulse reflects back from the interface and is received by the same transducer. Reflection measurements are then made during cutting tests and analysed post-test using a Labview program. The program has been built based on the concept of reflection coefficient, and this value is calculated using data downloaded from the oscilloscope.

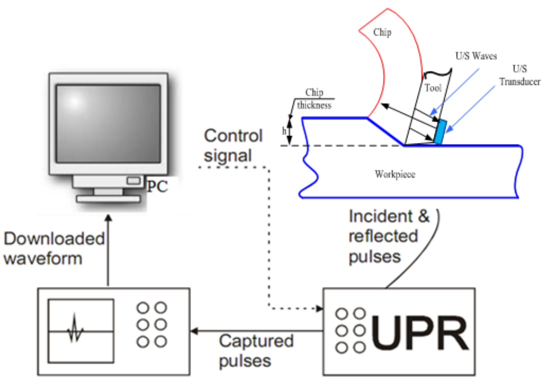

Fig 1 "Schematic diagram of the apparatus"

Results are shown in (Figures 2&3) for both dry and lubricated cutting conditions respectively. Work was initially performed in dry conditions to validate the test equipment, and also investigate chip formation and attachment. The results show how much reflection coefficient is affected by change in cutting speed. The R.C. ranges from 0.64 at low speed and low feed to 0.93 at high speed. This higher R.C. recorded is likely due to the chip detaching early at high speeds [1]. (Figure 3) shows the results when coolant is applied to the cutting process. It shows that the R.C. ranges from 0.9 at low speed and medium oil content to only 0.92 at high speed and medium oil content. The lower R.C. recorded is likely due to oil penetration at the interface.

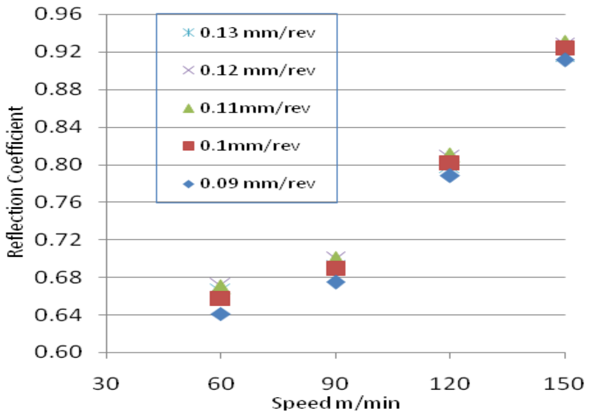

Fig 2 "Reflection Coefficient under dry cutting"

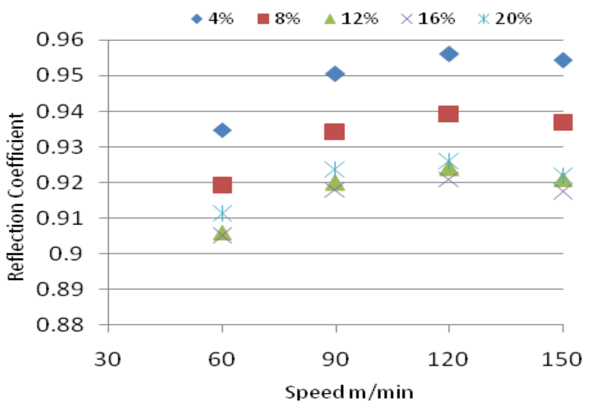

Fig 3 "Reflection Coefficient under lubricated cutting"

References

1. Marinov, V.R., *Hybrid analytical-numerical solution for the shear angle in orthogonal metal cutting -- Part II: experimental verification.* International Journal of Mechanical Sciences, 2001. **43**(2): p. 415-426.