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TEMPERATURE IN ORTHOGONAL METAL CUTTING

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Introduction

Practically all the energy dissipated in metal cutting appears as heat. Basically, two regions of heat generation can be distinguished for a sharp tool: the shear zone and the chip-tool interface (fig. 1).

![Fig.1 Examination of chip formation process for AISI 1045 steel.](Image)

Experimental

In the present study the temperature distribution at the top side of the chip is measured using an infrared camera (fig. 2). Thus, a graph is obtained revealing the temperature at the chip top versus the distance to the cutting edge (fig. 3). Nearest to the cutting edge the chip is merely heated by the energy dissipated in the shear zone. So, the first flat part of the graph can be considered to be the shear plane temperature Ts. Moving along the cutting edge a further increase in temperature can be distinguished, which can be attributed to the diffusion of friction energy from the chip-tool interface to the chip top. After this energy has been homogeneously distributed across the chip the uniform chip temperature Tc is reached.

![Fig.2 Image of measured chip temperature. Cutting speed = 120 m/min, feed rate = 0.4 mm/rev, steel AISI 1045.](Image)

Integration of the volumetric specific heat of the chip material between Ts and Tc yields the heat entering the chip at the chip-tool interface. Then, a finite difference model can be used to compute the interfacial temperature between chip and tool. A typical temperature distribution obtained with the finite difference model is shown in fig. 4. The computed temperature at the chip top (y = h₂) can be compared to the thermographic measured profile. For all cutting conditions, a close resemblance is found between the measured and the computed results. An example of such a comparison has already been given in fig. 3.

![Fig.4 Temperature distribution inside chip computed with FD-model. AD is the chip-tool contact length, cutting conditions as in fig. 2.](Image)

Conclusion

With the presented technique of thermographic measurements the shear plane temperature at the chip top Ts, and also the uniform chip temperature Tc are found. Even though, the uniform chip temperature is not of primary interest for the cutting process, it is shown that it can be used to determine the heat rate entering the chip. Thus, the temperature at the chip-tool interface can be computed using a FD-model.