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INVESTIGATION OF CUTTING TEMPERATURES' RELATION TO THE TOOL WEAR

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ABSTRACT: On the Department of Manufacturing Engineering of Kecskemét College, we have been researching the monitoring of the cutting processes for several years. We investigate especially the change of the temperature regarding the tool wear. The theme is the part of our scientific research program. This article gives the results of this research.
KEYWORDS: tool wear, cutting temperature, infrared radiation, infrared camera, fibre-optic

❖ INTRODUCTION

Regarding the monitoring systems and the high speed machining the investigation on thermal phenomena of cutting processes is very important nowadays [1], [2].

There are cutting temperature measuring methods that use thermocouples and infrared measuring systems. But measuring the cutting temperature by thermocouples is rather complex. The infrared radiation is coming from the tool-chip interface and it can be relatively easily detected without direct contact. The temperature which is in direct proportion with the infrared radiation can be measured by fibre-optic thermometer [3] [4] or infrared camera [5].

❖ TEMPERATURE MEASUREMENT BY FIBRE-OPTICS

A special fibre-optical temperature measuring system has been developed on our department (Figure 1).

The lapped end of the fibre is positioned near the heat source. As the fibre is not sensible for mechanical and thermal effects and its diameter is small (0.3...1.0 mm) the protection is not difficult, but in certain cases effective dirt protection has to be applied by using compressed air.

From the fibre the radiation is transmitted to a sensible diode, and the analogue voltage signals induced by the heat are transmitted to the computer through a digital voltmeter and analogue-digital converter. The digital signals are evaluated by the computer (the evaluating program is read from the hard disc unit), and the results are plotted on the display or printer.

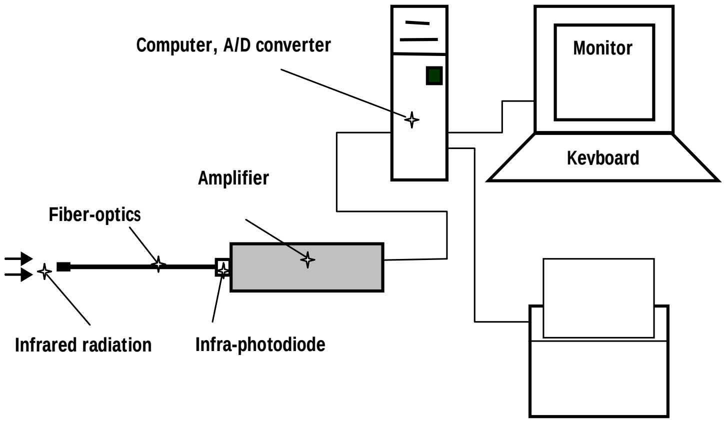

Figure 1. Fibre-optical measuring and evaluating system for measurement the cutting temperature

The changes during the cutting process can be followed by the infrared measuring. The fibre-optic is placed on the tool (acc. to Figure 2a and b) as it could measure the temperature of the leaving chip on the tool-chip interface. The tip of the fibre-optic is 12 mm far from the tool-chip. To avoid the deposition of pollution, compressed air is blown towards the axis of the fibre.

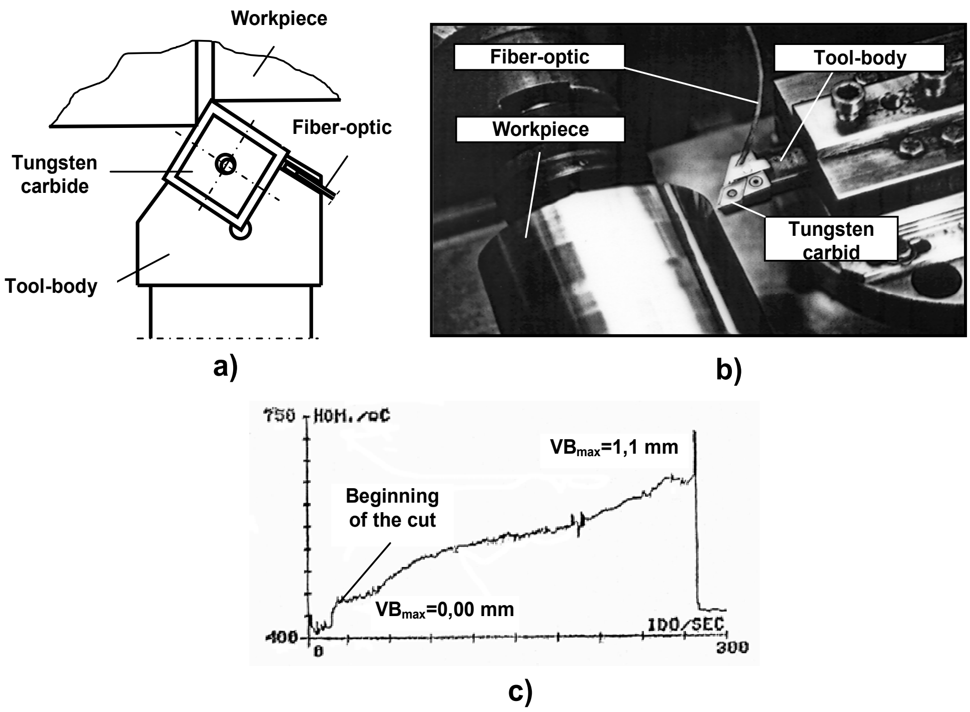

Figure 2. The lay-out of the fibre-optic (a),
(b) and the temperature-time diagram taken by fibre-optic measuring system (c)

The diagram of temperature-cutting time taken by the fibre-optical measuring system (Figure 2 c) shows the thermal changes plotted against the tool wear in progress. Because of the conductivity of the fibre-optic and of the sensitivity of the diode, the system can discern only $\Theta > 400°C$ temperature. At the beginning of the cutting method, the temperature at the original tool edge (VB_{max} = 0.00 mm) stagnates around Θ_c = 460°C temperature for a short time. After the tool and the workpiece warm up the temperature rises in proportion with the tool wear. The initial stagnation is due to the fact that the "cold" tool and the workpiece conduct the larger proportion of the temperature.

❖ TEMPERATURE MEASUREMENT BY INFRARED CAMERA

In Figure 3, the positioning of the FLIR T360 infrared camera, the 2D thermo-map and the 3D thermo-map on the designated part can be seen. The 3D thermo-map is taken by FLIR QuickReport 2.1. software.

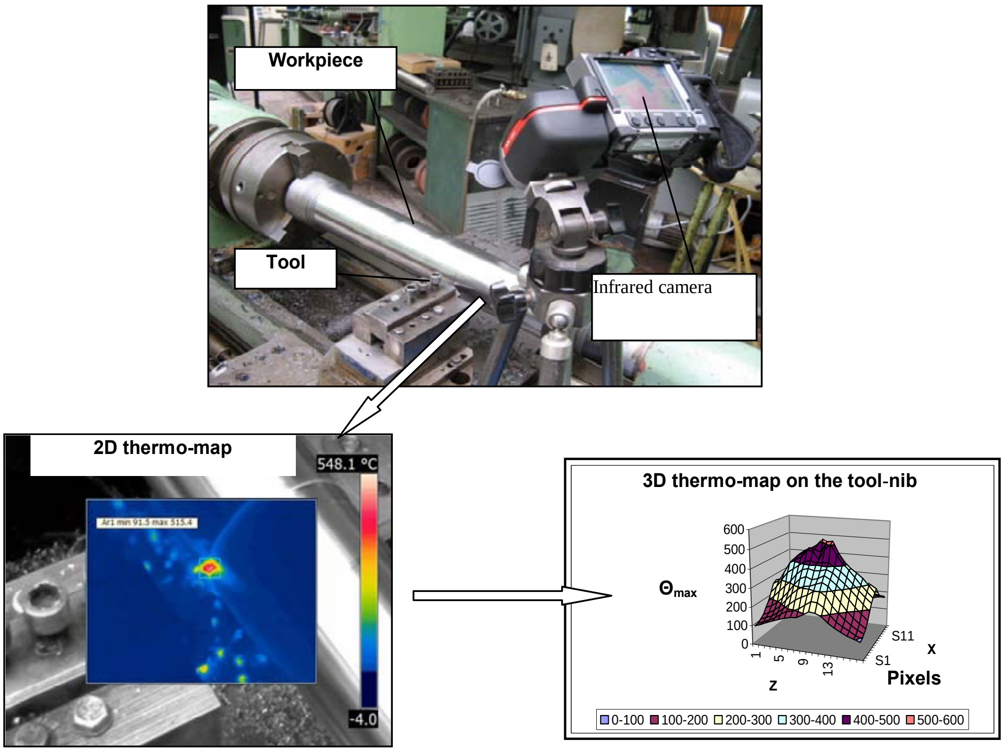

Figure 3. Cutting temperature measuring system with infrared camera

Experiments are carried out on a turret-lathe, on ∅ 76 x 600 big and of KO36Ti (X10CrNiTi1810) substance quality shaft. The workpiece is held in chuck and leaned with the lathe-centre. We applied no lubrication or minimal quantity lubrication (MQL). The body of the roughing-tool is PSBNR 2525 M12, the plate is signed by SNMM 120408 FN. The substance of the plate is P20 tungsten carbide, the tool wear is VB = 0.1 mm. Technological parameters: cutting speed $v_c \approx 147$ m/min; feed f = 0.25 mm/rev; depth of cut a = 1 mm.

The 2D thermo-map shows that the maximal temperature of the cutting zone is $\Theta_{max} = 514.4^{\circ}C$, while the thermo distribution can be well seen on the 3D thermo-map.

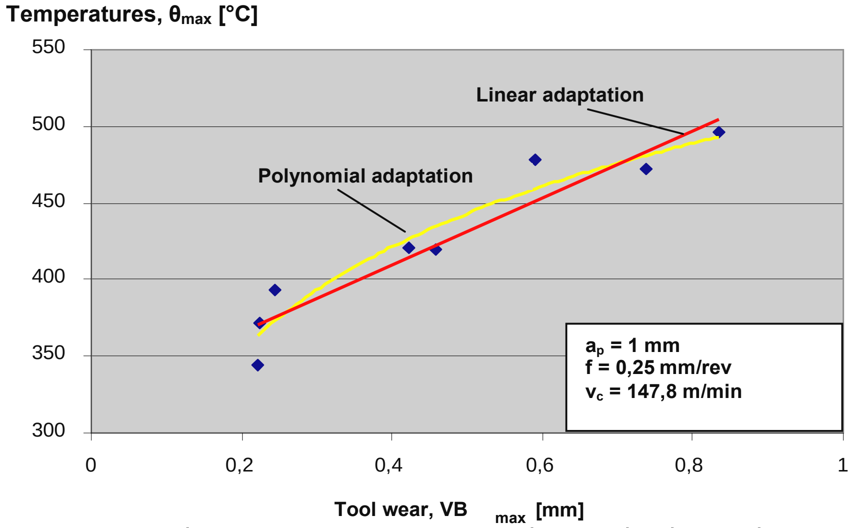

Figure 4. Tool wear-cutting temperature diagram by dry machining

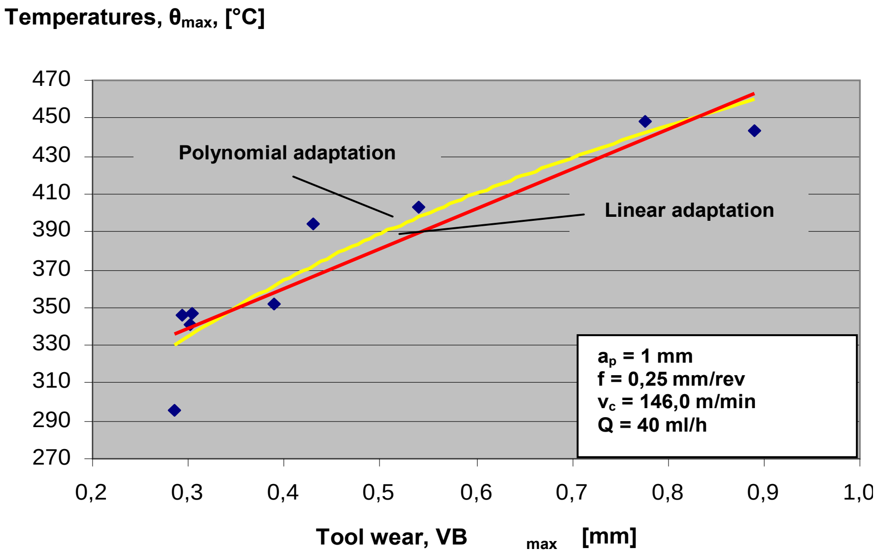

Figure 5. Tool wear-cutting temperature diagram by MQL

In Figure 4 can be seen a tool wear-temperatures diagram with dry machining and in the Figure 5 with MQL taken by infrared camera.

CONCLUDING REMARKS

With the demonstrated infrared measuring systems, the temperature of the tool-chips can be measured. Results received by the infrared camera well correspond with the results of the fibre-optic measuring system: the thermal changes plotted against the tool wear in progress.

The measuring of infrared camera is preferably used for cutting experiments and diagnostical purposes. Application of the infrared camera is especially suitable in the area of High Speed Cutting (HSC), but not suitable for continuous measuring and monitoring.

The fibre-optical measuring and evaluating system used for the tests can be made suitable for monitoring the cutting process. This system could prevent the burning of cutting edges of expensive tools – especially on CNC tool machines.

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