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THERMOVISION ANALYSIS OF A CNC MILLING MACHINE

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Abstract: This article concerns a thermovision analysis of a DMU40 5-axis CNC milling machine [1] using a thermal camera. First I specify the measuring instrument and I present the layout of the measurement. Before this measurement I created a thermal model of machine tool and I analysed it by finite element method. After evaluating simulation results I make the thermovision analysis. Finally I compare measured and simulated results with each other and I draw up some conclusions about thermal analysis.

Keywords: *thermovision analysis, thermal camera, milling machine, compare results, conclusions*

1. Preparation of Measurement

For preparation I removed possible heat sources from the environment of machine to reduce possible measurement errors. I set an optimal $750\ mm$ distance between object and camera. During the machining process, it is necessary to use coolant, but in my case, this liquid would have greatly distorted the thermal conditions, so the measurement had to be done without it. It was also necessary to open the door closing the machine's work space, as infrared radiation cannot pass through such surfaces (glass, plexiglass). For safety reasons I examined a primitive milling process. The ambient temperature was also checked before the measurement, it was $T_{amb} = 23,3\ °C$. *Figure 1* shows the preparation of measurement the thermal conditions before milling process.

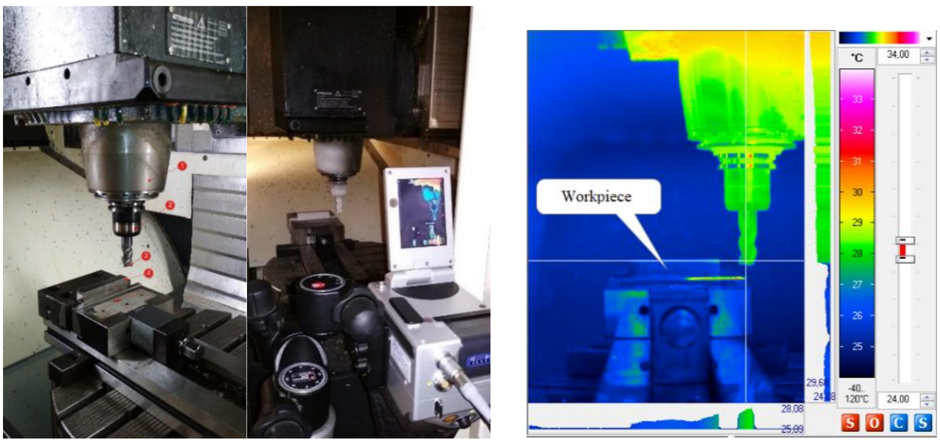

Figure 1. Preparation of measurement, thermal conditions before milling process

2. EVALUATION OF MEASURED RESULT

After the thermovision measurement, I present the results in this chapter and I evaluate them using IRBIS 3 software. During the evaluation first I examined the initial heat conditions. We can see that in Figure 1 at which the spindle operating temperature can be observed. It can be seen that the heat distribution on the spindle and the tool surface can be considered quasi-homogeneous.

Figure 2 shows a quasi-stationary heat state during process and also shows the end of the milling process, where we can see remaining heat loads of tool. They are eventually reduced by using coolant, in order to they will have a quasi-ambient temperature. By using coolant, the heat distribution zone can be limited, the cooling process can be accelerated, thereby reducing the heat load of the tool and increasing its lifecycle.

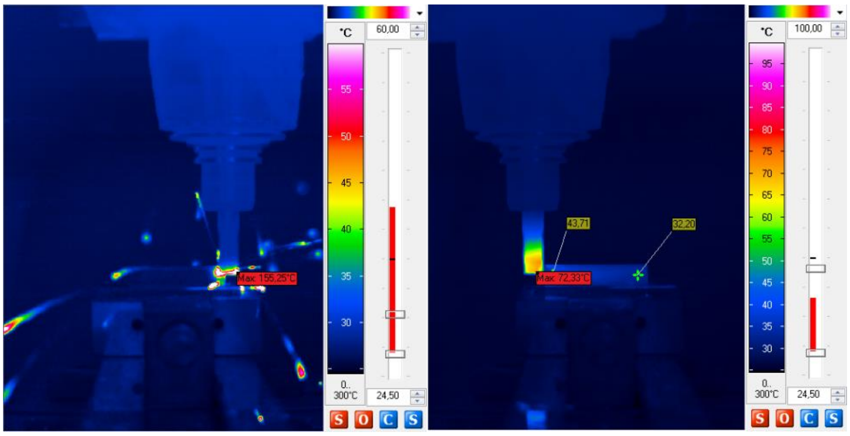

Figure 2. Thermal conditions during and after milling process

2.1. Transient thermal conditions and comparing result

In this section I examine transient thermal conditions of milling process. I also use the IRBIS 3 software to evaluate these results. First I examined the temperature change of the workpiece surface in time. Figure 3 shows the changing of workpiece temperature in process time.

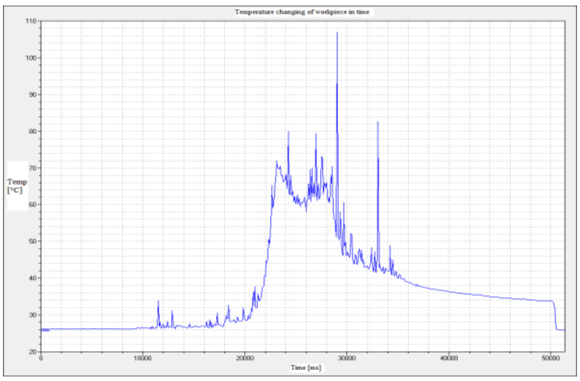

Figure 3. Temperature change of workpiece in time

To do this, I have selected a point on the given surface, and I have created the function for the entire time range while the thermal imager made the recordings. In this time range peaks appear, because of the chips generated by milling process, but they can be eliminated. Thus, a control curve can be fitted to the function, neglecting the influencing factors.

After analyzing the surface of the workpiece, I also examined the maximum values of the temperatures during process. The moment the tool enters, the maximum temperature is suddenly increased. In this case, there are also peaks that can be eliminated like the previous function, because they represent the separated chips, which do not signify directly heat load on the tool or on the workpiece. These temperature values appear at the edges of the tool in the vicinity of the cutting temperatures. So the values previously obtained in the simulation by finite element method are supported by this time diagram, because the heat load I have defined and set in the simulation is close to the average of this measured temperature range. *Figure 4* shows comparing of measured and simulated results.

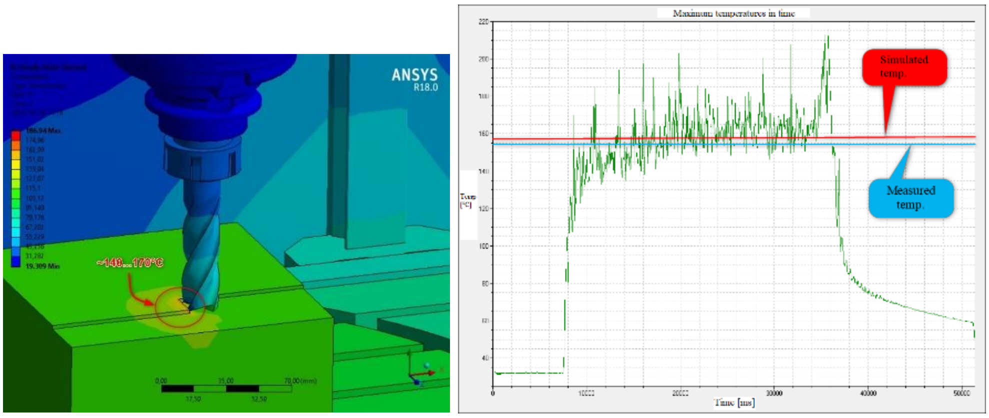

Figure 4. Comparing of the simulated and measured results

By comparing the simulation and measurement results, there was a $\delta \cong 2\%$ error between the results obtained by the two methods. Because of the compicated machine model and complex transient thermal conditions it is a good result of thermal analysis.

The output of the tool is also clearly visible on the chart, whereby the maximum temperature is greatly reduced. In this time range the cooling process curve corresponding to the theoretical cooling curve (exponential character), reaching the equilibrium heat state near the ambient temperature.

3. SUMMARY

In this article was performed a thermovision analysis of a 5-axis CNC milling machine during process. First I presented preparation of measurement and I deatiled the measuring conditions. After that I created the measured results and I used IRBIS 3 software to evaluate them. With the thermal imaging measurements, I was able to compare and support the results of the simulation tools previously used. Among the results obtained with the different methods, only a little $\delta \cong 2\%$ error value appeared, which is a good approximation for the simulation. It has become clear that when examining the case without using coolant, the measured and the simulated results are almost the same, so there is reason to assume that the thermal imaging measurements would produce similar results, even in the case of using coolant. In addition, it has become evident that even during the design phase or in the manufacturing process, the investigation and treatment of thermal conditions and loads is really important, as they can affect the tool life and may also have a negative impact on the quality of the produced component.

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