FORMATION AND DISTRIBUTION OF HEAT FIELD IN CUTTING TITANIUM ALLOYS

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Annotation: *In this thesis, the formation and distribution of the thermal field generated during the machining process of titanium alloys were studied. During the research, the cutting process of the Ti-6Al-4V titanium alloy was modeled using the SimScale software. The simulation results showed that the maximum temperature in the cutting zone occurs in the contact area between the tool and the workpiece. In addition, it was observed that an increase in cutting speed and cutting force leads to a rise in the amount of generated heat. Based on the obtained results, recommendations for selecting optimal machining parameters were developed.*

Keywords: *Titanium alloy, Ti-6Al-4V, cutting process, heat field, SimScale, temperature distribution, cutting instrument, modeling, mechanical machining, tool eating.*

INTRODUCTION

At present, titanium alloys are widely used in the aerospace industry. The reason for this is the higher strength, low density, corrosion resistance as well as the ability to withstand high temperatures. Notably, titanium alloy Ti-6Al-4V is one of the most widely used materials in the aviation industry.

However, the mechanical processing process of titanium alloys is challenging. As the main reason for this, one can point to the low thermal conductivity and high strength of titanium alloys. The heat generated by the cutting process mainly accumulates in the cutting zone and this leads to rapid wear by the cutting tool.

The high temperatures generated in the cutting zone have a significant influence on processing quality, cutting force as well as tool service life. Therefore, the analysis of the formation of the heat field during shear processes and its modeling are of great scientific and practical value.

In this study, the process of cutting a titanium alloy was modeled using the SimScale software, and the formation and distribution of a heat field was studied.

Analysis and modeling. The generation of heat in the mechanical processing of titanium alloys is mainly associated with plastic deformation and etching processes. A large amount of heat is generated in the contact region between the cutting tool and the part.

During the study, the cutting process of the Ti-6Al-4V titanium alloy was modeled in the SimScale program. The model took into account detail, cutting tool and fastening element. Shear forces, clamping condition, and thermal effects were given as boundary conditions.

During the modeling, the deformation and heat distribution of the part were analyzed. The image below shows the modeling result obtained by the SimScale program.

According to the image analysis, the highest temperature and deformation was generated in the shear zone, that is, in the area of contact of the tool and the part. It was in this area that the bulk of the heat was observed. In other parts of the detail, the temperature remained relatively low.

Because of the low thermal conductivity of titanium alloys, the heat generated does not dissipate rapidly. As a result, the high temperature has a large effect on the cutting tool and the tool burn is accelerated.

Analysis has shown that with increasing shear speed, the temperature inside the shear zone also increases. This leads to a reduction in the service life of the tool. In addition, an increase in shear force also increases the amount of heat.

Uneven distribution of heat field during cutting can adversely affect the processing quality. That is why it is important to choose the optimal cutting parameters.

During the modeling, the deformation and heat distribution of the part were analyzed. The image below shows the modeling result obtained by the SimScale program.

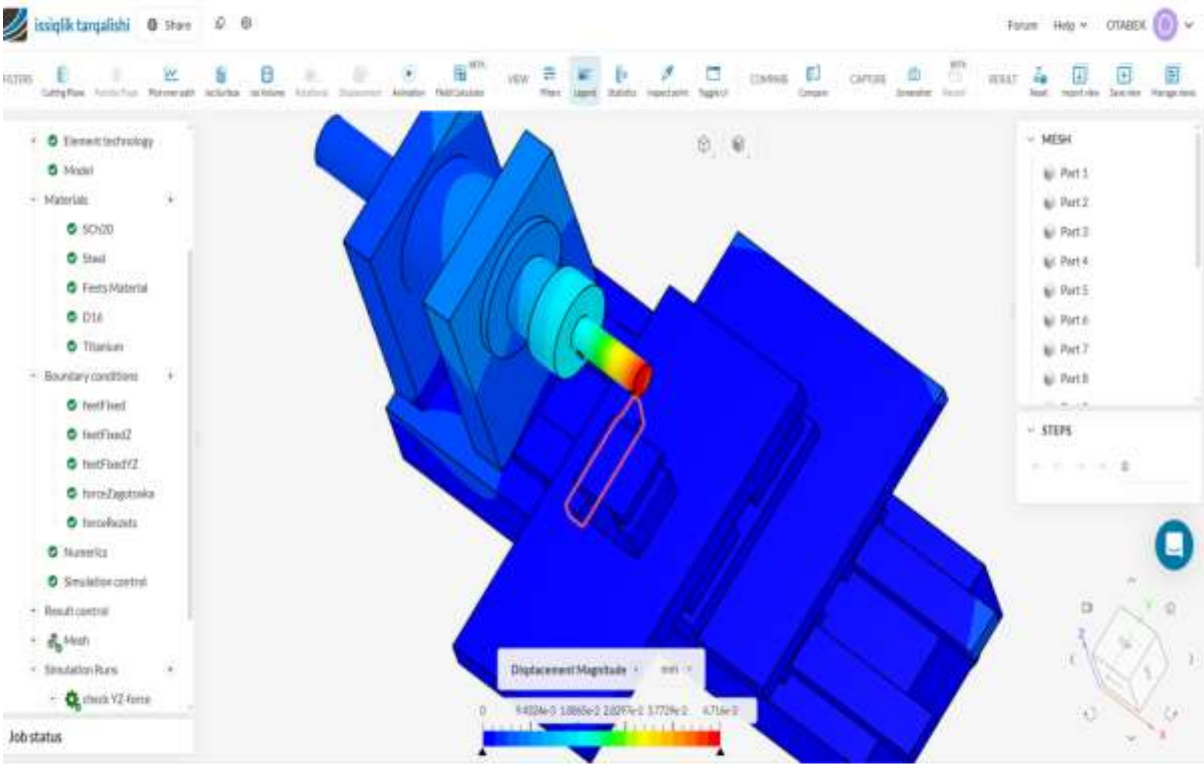


Figure 1. Distribution of heat field in the cutting zone

Results. According to the results of modelling, the following results were obtained:

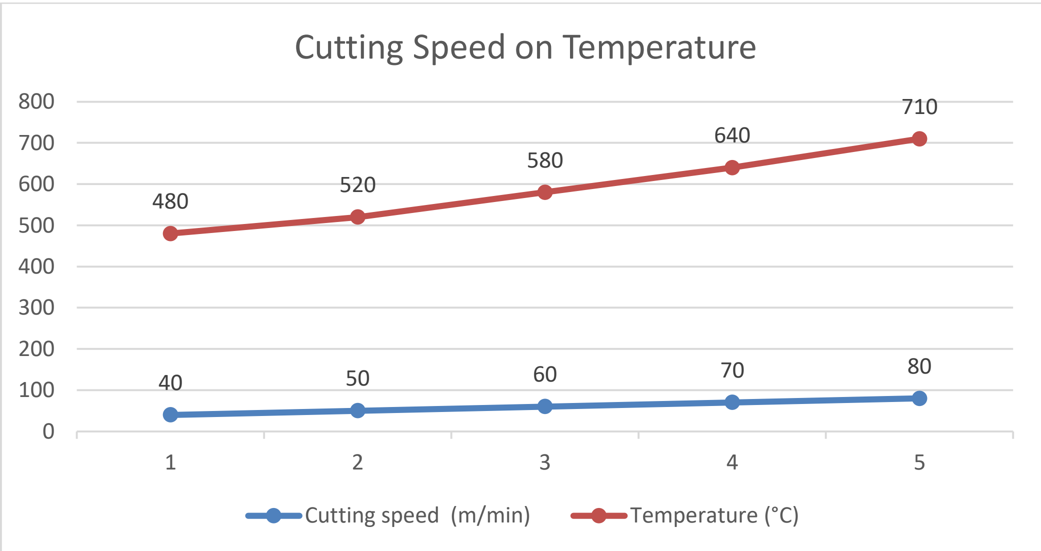
- It was determined that the maximum temperature would be generated in the contact zone of the instrument and the part;
- the accumulation of titanium alloy in the heat shear zone due to its low thermal conductivity was observed;
- it was found that with increasing shear speed, the temperature increases in quantity;
- high temperature was observed to lead to an acceleration of cutting instrument consumption;
- It was found that uneven heat dissipation can affect the surface quality of the detail.

In the table below, we can see that as the cutting speed increases, so does the temperature

Table 1

Cutting speed (m/min)	Temperature (°C)
40	480
50	520
60	580
70	640
80	710

From this table we can see that as the cutting rate increases, the temperature also increases, and by depicting this process graphically, we can learn how the temperature increases



Graph 1. The temperature dependence of the cutting process

Based on the analyses, it was recommended that the optimal cutting speed be in the range of 50–75 m/min. Within this range, the temperature at the cutting process and tool eating were relatively stable.

Conclusion. In this study, the formation and dissipation of the heat field generated during the cutting process of titanium alloys was investigated. As a result of modeling carried out using the SimScale software, it was determined that the greatest temperature is generated in the instrument and detail contact zone.

Analysis has shown that increasing shear speed and shear force would result in an increase in temperature. And high temperatures have been found to cause accelerated cutting tool consumption.

The obtained results are important for the selection of optimal process modes in the mechanical processing of titanium alloys as well as for increasing the service life of the tool.

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