SIMULATION OF TITANIUM ALLOY CUTTING PROCESS AND DETERMINATION OF CUTTING TOOL CONSUMPTION

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Annotation. In this thesis, the issues of modeling the mechanical machining process of titanium alloys as well as determining the wear of cutting tool are investigated. During the study, the cutting process of the Ti-6Al-4V titanium alloy was simulated in the SimScale program. As a result of modeling, it was determined that high temperatures and deformation are generated in the shear zone. Also with increased cutting speed, tool eating increased. Based on the results obtained, optimal processing modes have been recommended.

Keywords: Titanium alloy, Ti-6Al-4V, cutting process, modeling, SimScale, cutting tool, tool eating, temperature area, cutting force, mechanical machining.

Introduction. Currently, titanium alloys are widely used in aviation and space engineering. The main reason for this is the high strength of titanium alloys, low density, corrosion resistance, and their ability to work at high temperatures. Notably, titanium alloy Ti-6Al-4V is one of the most widely used materials in the aviation industry.

Despite the fact that titanium alloys have higher mechanical properties, their mechanical processing process is considered to be complex. A large amount of heat is generated in the process of cutting, and this heat accumulates mainly in the cutting zone. As a result, the cutting tool eats up quickly and the processing efficiency decreases.

Cutting tool consumption has a significant impact on processing quality, production costs, and tool service life. Therefore, models of the cutting process and the analysis of the tool feed are of important scientific and practical importance.

In this study, the process of cutting a titanium alloy was modeled using the SimScale program and the factors influencing the consumption of cutting tool were studied.

Analysis and modeling. One of the main problems in cutting titanium alloys is the high temperature generation. The heat generated by which titanium alloys have low thermal conductivity accumulates in the shear zone. This leads to a rapid wear down of the cutting tool.

During the study, the mechanical processing 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, temperature field and tension state of the part were analyzed. According to the results obtained in the SimScale program, it was determined that the greatest temperature is generated in the instrument and part contact zone. It was in the cutting area that the bulk of the heat was observed to accumulate.

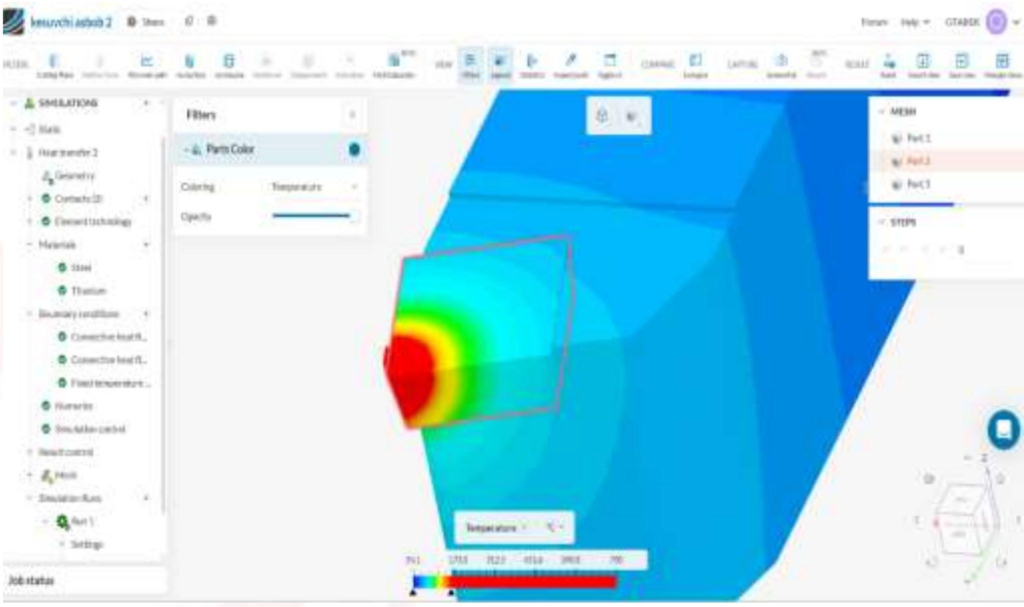


Figure 1. Simulation Result of Titanium Alloy Cutting Process in SimScale Software

According to the picture analysis, the high temperature generated in the cutting zone has a great influence on the cutting tool. This increases the rate of feeding of the instrument. Further, with an increase in shear force, temperature also increased.

Cutting Tool Feed Analysis. The consumption of cutting tools is one of the main indicators of a mechanical machining process. Tool eating varies with varying rates of cutting speed, cutting force and temperature.

During the study, tool eating at different cutting speeds was analyzed. The results showed that as the cutting speed increases, the temperature at the cutting zone also increases, resulting in faster tool eating.

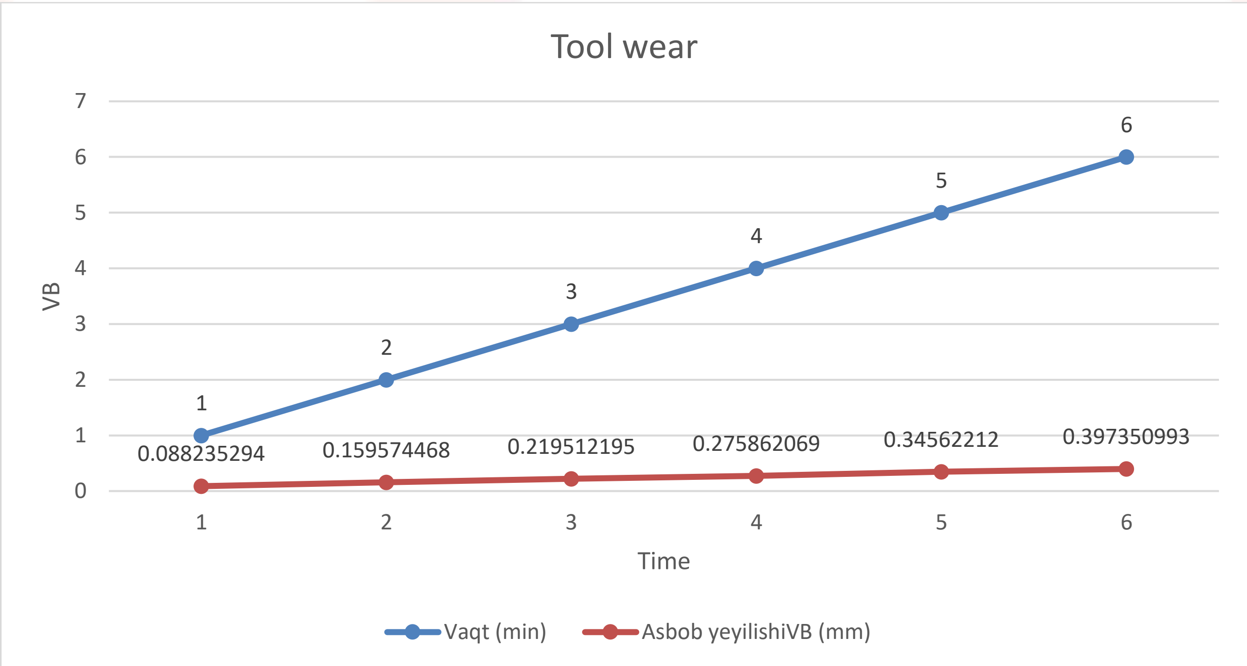
The table below shows the correlation between cutting speed and tool consumption.

No	Shear Speed	Working time of cutting tool T(min)	Time (min)	Tool FeedingVB(mm)
1	37,79304	3,4	1	0,088235294
2	35,55662118	3,76	2	0,159574468
3	33,991128	4,1	3	0,219512195
4	32,83402435	4,35	4	0,275862069
5	32,91009846	4,34	5	0,34562212
6	32,10422621	4,53	6	0,397350993

Table 1. The correlation between cutting speed and tool eating

When machining aircraft parts reaches a bending point of 0.3 mm, the tool must be replaced.

As you can see from the table, this is 4 - for the titanium alloy above, which takes more time in minutes. Using this table, we can form a graph of the consumption of the instrument.



Graph 1. Cutting tool wear

The Taylor equation was used to estimate the eating of the cutting tool:

$$V * T^n = C$$

Here:

V - is the rate of shear;

T - is the period of operation of the instrument;

n - is the coefficient of instrument material;

C - is the constant coefficient.

As a result of the analysis, optimal cutting speed is found to be in the range of 50–75 m/min. In this range, tool consumption was relatively small, and high processing efficiency was observed.

Results. Based on the modeling and analysis, the following results were obtained:

- established maximum temperature formation in the cutting zone;
- The bulk of the heat was observed to accumulate in the instrument and detail contact area;
- It has been determined that with an increase in cutting speed, tool eating increased;
- It was observed that high temperatures caused a reduction in the service life of the instrument;
- It has been recommended that the optimal cutting speed be in the range of 50–75 m/min.

Conclusion. In this study, the issues of modeling the cutting process of titanium alloys and determining the consumption of cutting tools were investigated. As a result of modeling carried out using the SimScale software, it was determined that the largest temperature is generated in the shear zone.

Analysis has shown that increasing shear speed and cutting force will accelerate tool wearing. It has been found that high temperatures and uneven distribution of heat adversely affect the service life of the instrument.

The obtained results are important for the selection of optimal process modes in the mechanical processing of titanium alloys and to increase the service life of cutting tool.

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