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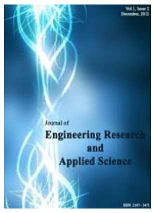

3D end milling of AISI 1040 finite element thermal analysis

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Abstract

In the manufacturing industry, cutting simulations are performed by finite element analysis methods to optimize cost and operational performance. This article aims to model and simulate the temperature of the AISI 1040 steel at the cutting zone in the surface milling process by the finite element method (FEM). The formation of thermal events in the surface milling process was studied with the Third Wave AdvatEdge, which simulation program. The influence of cutting speed on the temperature in the cutting zone was modeled and analyzed.

Keywords: FEM simulation, milling, temperature, Third Wave AdvatEdge

1. Introduction

Milling operation is one of the most traditional machining processes used in the manufacturing industry. It is believed that the significant improvement of machining processes that are common in the manufacturing sector today can be achieved by systematically modeling these processes [1]. Besides, the metal cutting process is one of the most complex processes in forming metals. These operations are affected by many output parameters. The most crucial output parameter is temperature. Because it directly affects the tool wear and tool life. Therefore, estimating temperature and tool wear occurring during the machining process is of great importance for understanding and optimization of the process parameters.
Metal cutting process researchers have developed many modeling techniques, including analytical techniques, finite element techniques, , empirical approaches, and slip line solutions. In recent years, the finite element method (FEM) has become the primary tool, especially for simulating metal cutting operations [2-4]. FEM analysis is a useful and effective method of saving cost and both time for achieving fast results [2]. According to Arrazola et al.[5], FEM analysis can seem to reduce operating costs more than physically conducting the processing test. Also, FEM analysis provides information that is complicated to measure, such as temperature and pressure. However, a precise numerical model capable of accurate estimates of chip morphology, temperature, stress contributes and strain, to cost reduction by optimizing the processing process without conducting numerous experimental tests.

In the literature researches, it was observed that no study of finite element modeling related to thermal events occurring in the surface milling process of AISI 1040 stainless steel was conducted. In this study, the effects on thermal at different cutting speeds of AISI 1040 stainless steel were investigated by numerical methods.

2. Material and method

In the investigation of the cutting process, FEA is seen as a very useful tool to study the cutting process of materials[6]. A 3D finite element model for the milling process of AISI 1040 has been established using the finite element software Third Wave AdvantEdge. The mechanical properties of AISI 1040 stainless steel material is given in Table 1[7].

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Table 1. Mechanical properties of AISI 1040.

	Hardness (Rockwell C)	Density (g/cm^3)	Poisson rate	Young modülü (GPa)	Thermal conductivity (W/mxK 100°C)
AISI 1040	30	7.845	0.29	205	24,7

It is considered that the plastic deformation behavior of AISI 1040 stainless steel is defined by Johnson-Cook (JC) model. The Johnson-Cook material model used is given in equation 1.[8-10].

$$\sigma^0 = (A + B(\varepsilon^\rho)^n\left(1 + C\ \log\left(\frac{\dot{\varepsilon}^\rho}{\dot{\varepsilon_0}}\right)\right)\left(1 - \left(\frac{T-T_r}{T_m-T_r}\right)^m\right) \quad (1)$$

In this study, The parameters for the Johnson-Cook model used are specified in Table 2 [11].

Table 2. Johnson – Cook (J-C) constitutive model parameters [11]

Material	A (MPa)	B (MPa)	C	N	m
AISI 1040 Steel	553.1	600.8	0.013	0.234	1

In the first step of the analysis, the dimensions of the workpiece material were determined by 20 x 10 x 10 mm. Standard cutting tools with a diameter of ø10 were used in the analyses. In the final step, simulations were performed by selecting the cutting parameters in accordance with the manufacturer's catalog as given in Table 3.

Table 3. Analysis of cutting parameters

Cutting Parameters	**Experiment 1,**	**Experiment 2**	**Experiment 3**
cutting speed (m/min) (V)	200	225	250
Feed, f (mm/tooth)	0.045	0.045	0.045
Depth of cut a, mm	1	1	1

AdvantEdge users have the option to change workpiece network parameters; however, these changes may affect performance and accuracy. The mesh parameters selected in the Workpiece Mesh tab of the 3D Simulation Options window are important for successful 3D simulations. In milling, these values are calculated with the maximum chip load depending on feed per tooth and radial cutting depth.For all these operations, mesh values are recalculated each time they change[12]. Technological parameters which axis configuration in the FEM system. (Fig.1)

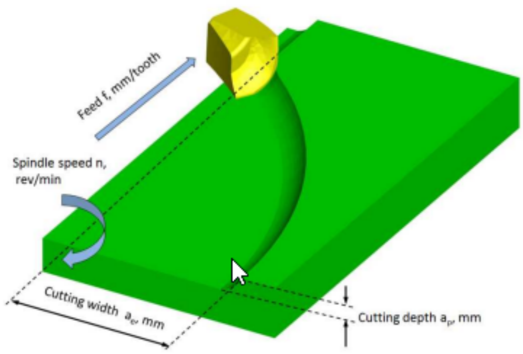

Figure 1. Technological parameters (a) and axis configuration with defined vectors of cutting force components in the FEM system [4].

3. Simulation results

Compressor is consist of rotor and stator components. Rotor is rotating at about 3000 rpm and dimention of the blades that are used on the rotor and stator are different from each other. Each stage stator is guiding air for laminar flow. This section is compress air for more power output. The blades dimensions are different from each other. They star from the big dimentions and drops related to the stages. Number of stages can differ form each other related to the power of the unit. Most of them have 13-14 or 17 stages. Figure 3 show the compressor section.

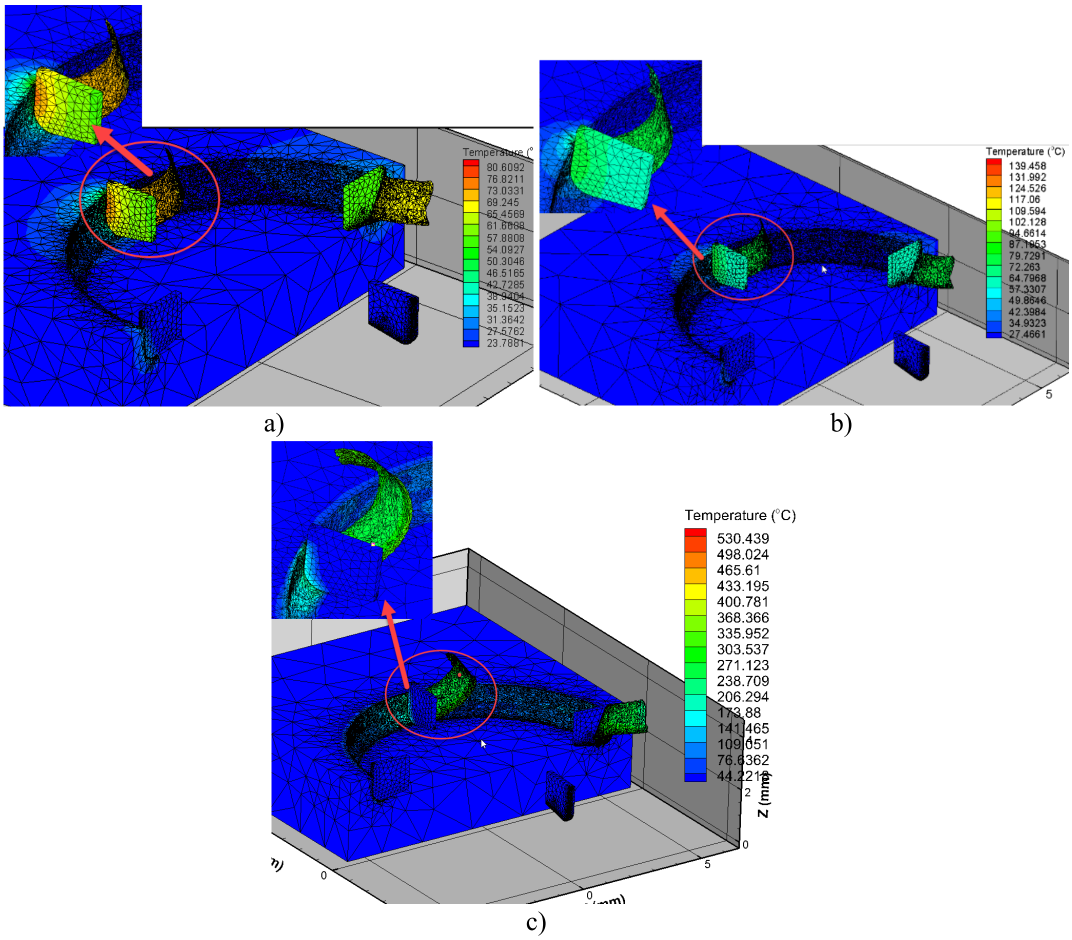

Figure 2. The temperature distribution at different cutting speed a) V=200 m/min b) V=225 m/min c) V=250 m/min.

Figure 3 shows the temperature changes in the cutter as a result of the analyses. When the cutting speed is low, the temperature appears to be on the whole face of the cutting tool, while if the cutting speed is high, the temperature appears to be at the tip of the cutting tool.

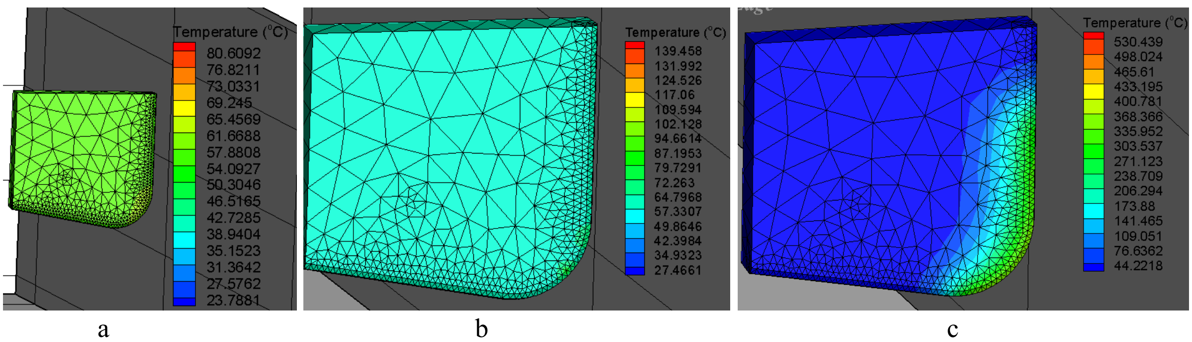

Figure 3. The temperature distribution at different cutting speed in cutting tool a) V=200 m/min b) V=225 m/min c) V=250 m/min.

Figure 4 shows the contours of temperature changes occurring in the workpiece and chips. As the cutting speed increases, it is seen that the temperature occurring in the material and sawdust increases.

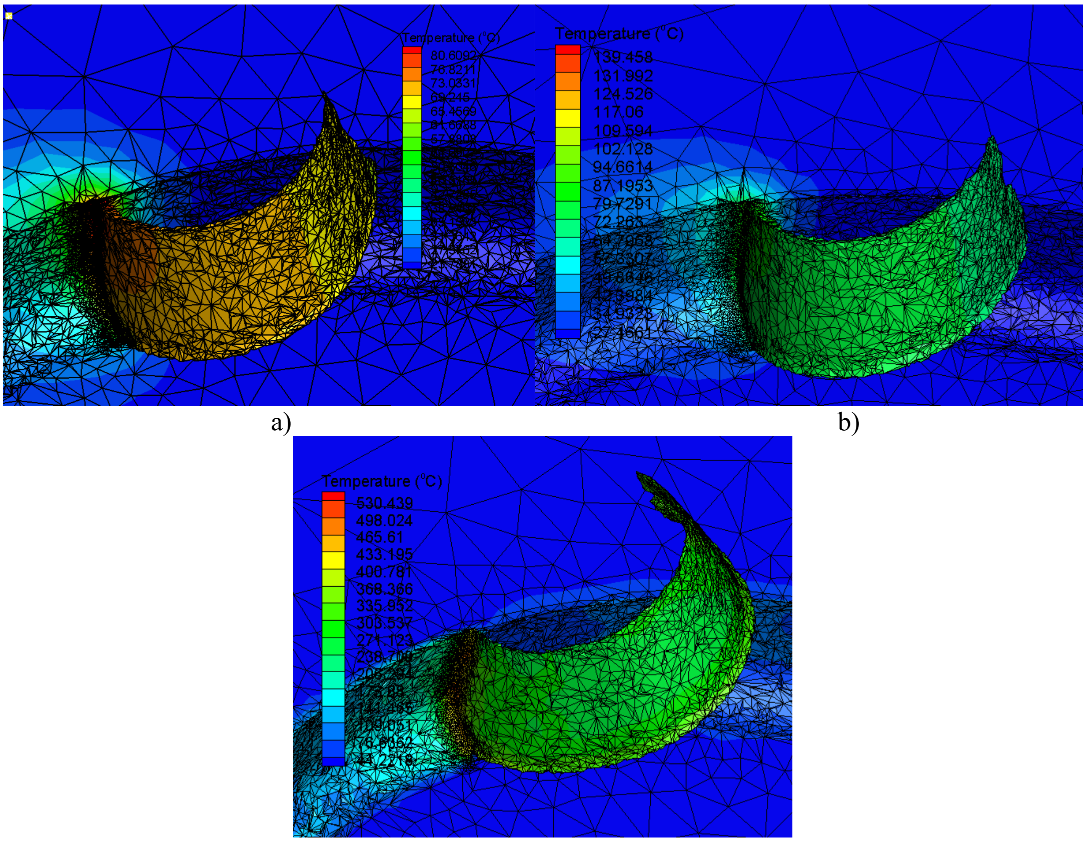

Figure 4. The temperature distribution at different cutting speed on chips and workpiece a) V=200 m/min b) V=225 m/min c) V=250 m/min.

3. Conclusion

In this study, it is seen that FEA simulations can be used to analyze thermal events occurring in the cutting area with great reliability due to the cost of experimental studies. As a result, AISI 1040 can be used to optimize the milling operation parameters of the steel. It was observed that the surface temperature decreased at low cutting speeds, but the temperature change was high on the cutting tool surface. This has been shown to affect the tool life directly. It was noted that the temperature increased in the cutting zone at high cutting speeds, but that the temperature at the cutting tool was at the tip of the cutting tool.

References

[1] C.v. Luttervelt, T. Childs, I. Jawahir, F. Klocke, P. Venuvinod, Present situation and future trends in modelling of machining operations, Annals of the CIRP 47(2) (1998) 587-626.

[2] M. Dali, J.A. Ghani, C.C. Haron, Comparison between dynamic and non-dynamic cutting tool option in FEM simulation for producing dimple structure, Procedia CIRP 58 (2017) 613-616.

[3] I. Cascón, J.A. Sarasua, Mechanistic model for prediction of cutting forces in turning of non-axisymmetric parts, Procedia CIRP 31 (2015) 435-440.

[4] P. Niesłony, W. Grzesik, W. Habrat, Experimental and simulation investigations of face milling process of Ti-6Al-4V titanium alloy, Advances in manufacturing science and technology 39(1) (2015).

[5] P. Arrazola, D. Ugarte, J. Montoya, A. Villar, S. Marya, Finite element modeling of chip formation process with Abaqus/Explicit 6.3, VII International Conference on Computational Plasticity, Barcelona, 2005.

[6] H. Wu, S. Zhang, 3D FEM simulation of milling process for titanium alloy Ti6Al4V, The International Journal of Advanced Manufacturing Technology 71(5-8) (2014) 1319-1326.

[7] M. Akkök, Acar, B., & Açmaz, E. (2013). Experimental analysis and wear modeling for mechanical components of a typical rail launcher. Wear, 306(1-2), 1-9.

[8] H. Yan, Hua, J., & Shivpuri, R. (2007). Flow stress of AISI H13 die steel in hard machining. Materials & design, 28(1), 272-277.

[9] G.R.A.c.m.a.d.f.m.s.t.l.s. Johnson, high strain rates, and high temperatures. Proc. 7th Inf. Sympo. Ballistics, 541-547.

[10] A. Dorogoy, & Rittel, D. (2009). Determination of the Johnson–Cook material parameters using the SCS specimen. Experimental mechanics, 49(6), 881.

[11] A. Shrot, M. Bäker, Determination of Johnson–Cook parameters from machining simulations, Computational Materials Science 52(1) (2012) 298-304.

[12] A. Mitrovic, P. Kovač, N. Kulundžić, B. Savković, 3D finite element simulation of milling, Journal of Production Engineering 19(1) (2016) 31-34.