Investigation of Power Consumption in the Machining of S960QL Steel by Finite Elements Method

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ARTICLE INFO

ABSTRACT

Armor steels have good strength and corrosion resistance; however, due to their difficult machinability, high power consumption occurs. High power consumption increases the cost in machinability studies. Therefore, minimizing power consumption is important for sustainable and cleaner production. For the purpose of minimize power consumption in the course of machining, factors such as workpiece material, cutting tool material and geometry, machining conditions and cutting parameters must be compatible with each other. For this reason, power consumption modeling was carried out in the milling of S960QL structural steel material according to the finite elements method, depending on the cutting parameters. In this context, simulation processes were carried out at three levels for each factor: cutting speed, lateral depth, axial depth and feed rate. The most effective parameter in power consumption was the axial deep of cut. There was a 476% change between the highest and lowest power consumption. It is concluded that finite element modeling is feasible for the purpose of determine the effect of processing parameters on power consumption.

1. INTRODUCTION

The industry accounts for almost half of the energy consumption worldwide, and energy consumption is increasing day by day [1]. In addition, rapid growth in the manufacturing sector, global warming and local wastes pose many economic and social problems [2]. Therefore, besides product quality, energy efficiency has become important criteria in the manufacturing industry. Because machine tools in the manufacturing industry have less than 30% efficiency [3]. The environmental impacts that affect the efficiency of these machines are more than 99% [1]. Machine tools need power during stock removal, from production to machining, to sustain cutting tool and slide systems after machining. In the manufacturing industry, it usually includes machining operations such as milling, turning, drilling and grinding [4].

Milling is widely used to bring materials into desired shapes and sizes. It is necessary to reduce power consumption in metal removal processes in order for the processes to be sustainable [5]. Thus, environmental impacts due to energy consumption are reduced and product efficiency can be increased. Armor and structural steels are materials that are difficult to process due to their high ductility and strength. It is significant to determine the machinability parameters and to minimum the power consumption in machining operations. By improving the

machining parameters such as an axial depth, lateral depth feed rate per tooth and cutting speed reducing the power consumption by reducing the cutting force can be directly regulated [4,6]. Most of the previous studies on milling seem to be on process outputs such as machining parameters such as surface roughness, tool wear and cutting force [7-10].

Recently, researchers have been carrying out studies on the power consumption of cutting parameters during machining [4,11,5,1]. The studies have been carried out with both physical and finite element methods and it has been stated that they are compatible with each other [12-15]. In his study, Bhushan used Response Surface Methodology analysis to define optimal machinability parameters when machining AA7075 SIC using tungsten carbide cutting tool to acquire max. tool life and min. power consumption. In his study, he stated that cutting speed is the most important parameter for tool life and consumption for power, followed by feed rate, nose radius and cutting depth [16]. Camposeco-Negrete (2013) tried to achieve optimization of machining parameters for energy consumption and surface roughness in the course of machining of AISI 6061T6 under roughing conditions using the Taguchi method. As a result of the research, he stated that the most important factor is the feed rate with an impact rate of 87.79% in order to minimum energy consumption [5]. Yan and Li (2013) submitted an optimization method based on RSM to optimize machinability parameters in

the milling process in the course of carbide tool dry machining of medium carbon steel to acquire min cutting energy and surface roughness. As a result of their studies, they reported that the most effective parameter is the lateral cutting depth [17]. Campatelli et al (2014) used the response surface methodology to analyze the effect of machining parameters on energy consumption in the course of milling of carbon steel. They reported that the ideal radial cutting depth and feed rate should be 1 mm and 0.12 mm/tooth, respectively, for the purpose of minimize the energy consumed for cutting efficiency [18]. El-Tamimi and El-Hossainy (2008), investigated the efficiency of machining parameters by turning AISI 420 steels. Mutual effect graphs were created to determine the most effective parameters. They stated that the most significant parameter on the major cutting force is the feed rate, and the more significant parameter on the consumption of power is the cutting speed [19]. Valiorgue et al. (2012) evaluated the estimation of residual stress variation in hard machining of AISI 304-L stainless steel. They created a mixed technique combining numerical and experiments work. They stated that the numerical model appeared to provide trustworthy results in proportion to the empirical results for a wide range of feed rates and cutting speeds [20]. Galanis et al. (2014) studied finite element (FE) modeling to predict cutting forces when machining AISI 316-L stainless steel. The empirical cutting force worths were compared with the numeral results and they concluded that they can be estimated with good correctness when machining with FE modeling [21]. Li et al. investigated the processing-induced surface plastic deformation and microstructural texture development of Ti-6Al-4V alloy by FEM simulation [22]. Budak and Ozlu stated that the developed FEM model can be used in industrial applications by applying the Johnson-Cook material model together with the slip and adhesion models in order to use the thermomechanical dual zone model in cutting processes [23].

As a result of the literature research, it has been determined that there is no study on the energy consumption of the S960QL material. In this study, the effects of machinability parameters on power consumption in the course of machining of S960QL structural steel material were analyzed using finite element modeling.

2. MATERIAL AND METHOD

In this research study carried out with the FE method, the effects of cutting parameters on power consumption were examined in finite element up milling of S960QL structural and armor steel material with TiAlN coated carbide cutting tools. The study was carried out with three-dimensional milling process. Three different cutting speeds, three different lateral depths, three different axial depths and three different feed per tooth were selected as machining parameters. These parameters have been established by considering the studies made for structural steels and the values recommended by KENNAMETAL. Cutting parameters are given in Table 1.

TABLE 1
CUTTING PARAMETERS.

Radial Deep of Cut	Axial Deep of Cut	Cutting Speed	Feed Rate
0.8-1.2-1.6 mm	4-6-8 mm	180-200-220 m/min	0.08-0.12-0.16 mm/tooth

2.1. Workpiece Material

The mechanical properties and percent chemical compositions of the S960QL material used in the study are given in Table 2.

TABLE 2
MECHANICAL PROPERTIES AND CHEMICAL COMPOSITION [24].

Chemical Composition (%)				
C	Mn	Si	S	P
0.20	1.60	0.50	0.010	0.020
Cr	Cu	Ni	Mo	B
0.80	0.3	2.0	0.70	0.005
Mechanical Properties				
Minimum yield strength $R_{p0.2}$ (MPa)			960	
Minimum tensile strength R_m (MPa)			980-1150	
Elongation A_5(min %)			12	

The Johnson Cook (JC) material model which is required and widely used for simulations of machining processes, is given in Equation 1 [25].

$$\sigma^0 = (A + B(\varepsilon^p)^n)(1 + C\ln\left(\frac{\dot{\varepsilon}^p}{\dot{\varepsilon}_0}\right))(1 - (\frac{T - T_r}{T_m - T_r})^m) \qquad (1)$$

Parameters in Equation 1;
A: yield stress at temperature of room
B: strain hardening
C: constant of the strain rate
n: exponent of deformation hardening
m: exponent of sensitivity of deformation rate

Other parameters in the equation are εp, $\dot{\varepsilon} p$, $\varepsilon 0$, Tm, Tr and T, respectively, equivalent plastic strain, rate of plastic strain, rate of reference strain, melting temperature of the material, temperature of room and reference temperature. The specified $\varepsilon 0$ and C are values generally measured at and/or beneath the reference temperature. JC model parameters of S960QL structural steel are given in Table 3.

TABLE 3
JC MODEL PARAMETERS FOR S960QL [26].

A (MPa)	1034
B (MPa)	828
n	0.6539
c	0.015045
m (400 °C)	1.028
m (550 °C)	1.277
m (average)	1.154

The Finite Element Modeling design used is given in Table 4.

2.2. Cutting Tool

Kennametal EDCT 10T308PDERLD grade KC725M and TiAlN coated inserts were used as cutting tools in 3D milling simulations. The cutting tool has a corner radius of 0.8, a thickness of 3.75 mm, a cutting-edge length of 12.05 mm and

an approach angle of 15^0. In order for the cutting tool to be used in the finite element program, its three-dimensional scan was made and modeled in the CATIA program, and its positioning on the material is given in Figure 1.
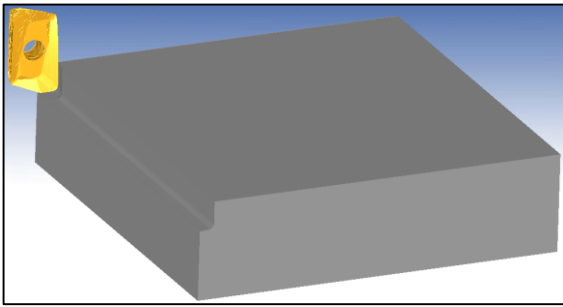

Figure 1. 3D model of Finite element.

TABLE 4
MACHINING PARAMETERS LEVELS.

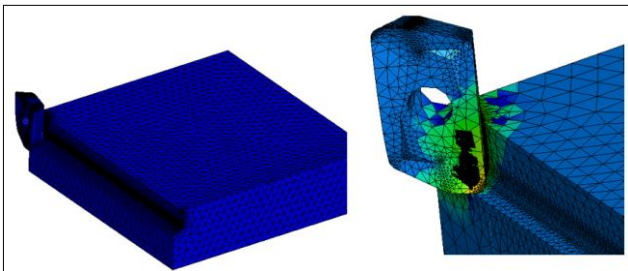| Radial Deep of Cut	Axial Deep of Cut	Cutting speed	Feed Rate
1	1	1	1
1	2	2	2
1	3	3	3
2	1	2	3
2	2	3	1
2	3	1	2
3	1	3	2
3	2	1	3
3	3	2	1

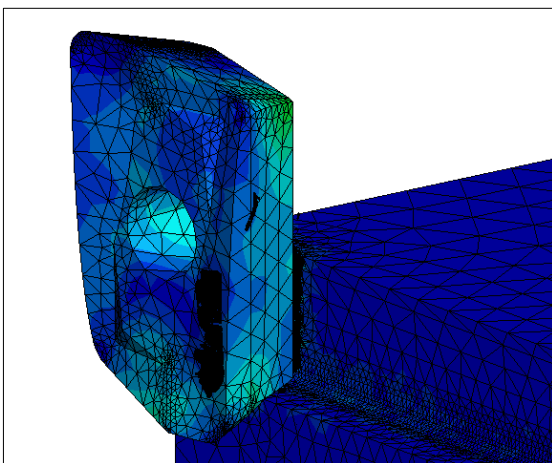**Figure 2.** Cutting scheme and mesh structure for simulations.

Figure 3. The stresses occurring at the tooltip.

2.3. Finite Element Simulations

The effects of processing parameters on power consumption were investigated with finite element modeling. The finite element program for machinability experiments uses an discretionary Lagrangian solver and has adaptable remeshing functionality to acquire more precise results though it takes more time. The length, width and height of the workpiece model used in the first stage of the simulations are 50, 50 and 10 mm respectively, and all simulations were carried out with these dimensions. The second step is to define the geometry of tool and tool material parameters. In the last step, after the meshing parameters and friction coefficient are set, necessary machining simulation parameters like cutting speed, lateral and axial depth and feed rate are entered into the software.

For 3D simulations, the interface friction coefficient between the workpiece and the cutting tool is modeled with a standard Coulomb friction of 0.5. Corner milling (cutting edge) and same-directional milling were selected in the simulation processes. A tetrahedral mesh type was used by choosing 0.01 mm as the element size.

For the effects of machinability parameters on power consumption, the workpiece material was cut 90^0 with a 16 mm tool diameter in the FE simulations. After the machining process, numerical results were obtained on the finite element model. Simulation model, mesh structure and cutting diagram for 3D simulations are given in Figure 2. In addition, images of stresses occurring at the tool tip are given in Figure 3.

3. RESULT AND EVALUATION

In this research study, simulations of 3D milling with FE method were made based on machining parameters. The results were obtained by defining the friction coefficient as 0.5 and the mesh dimensions as 0.1 mm. In the 3D milling simulations, the power consumption (P) was calculated by considering the resultant values of the forces F_x, F_y, F_z. The power consumption values calculated by multiplying the resultant cutting force and cutting speed were made with the formula in equation 2. This formula is generally used in machining processes [6,4,27].

$$P = Fx\frac{V}{60} \qquad (2)$$

Parameters in Equation 1;
P: Power (w)
V: Cutting speed (m/min.)
F: Force (N)

The resultant V in Equation 2 ($\sqrt{F_x^2 + F_y^2 + F_z^2}$) is the cutting speed and F is the cutting force. We can express the cutting speed equations in detail as follows.

$$V = \frac{\pi x D x N}{1000} \qquad (3)$$

Parameters in Equation 3;
V: Cutting speed (m/min.)
N: Spindle speed (rpm)
D: Tool diameter (mm)

The power values measured in physical experiments are based on measuring the magnetic field and voltage around the transmission cable [28]. However, it is measured with the package program used in the finite element method. A graphical example of the simulation result obtained from the finite element software is given in Figure 3. The simulated results for P and F are acquired from Figure 3 taking on the average value of a given interval. In general, it is known that with increasing feed rate and lateral and axial cutting depth, all

the cutting force components and power consumption increase [4,29].
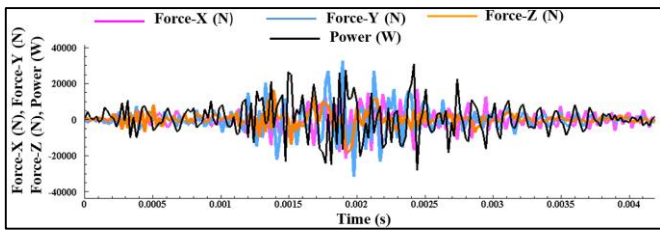

Figure 3. Graphical view of the simulation result.

3.1. Power Consumption

The changes in power consumption accordingly the processing parameters are given in Figure 4. It has been concluded that the increase in feed rate, lateral and axial cutting depth and cutting speed increase the power consumption in general.
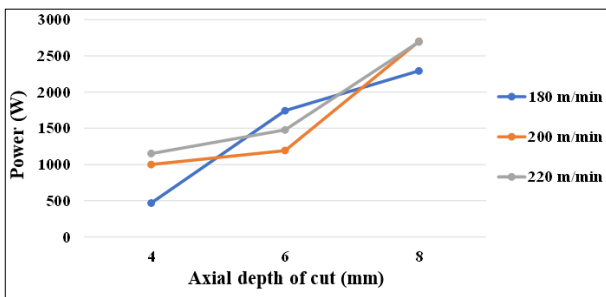

Figure 4. Power consumption variation graph based on axial depth and cutting speed.

By examining the graph based on axial depth and cutting speed, an increase in power consumption occurs with an increase in axial force and cutting speed in general. However, with each increase in cutting speeds, a fluctuating change has occurred in power consumption, not a parallel increase. In this case, fluctuating results may occur because the milling cutting mechanics process is different [30]. According to Figure 4, the highest power consumption (2700.299 W) occurred at a cutting speed of 200 m/min and an axial depth of 8 mm. The lowest power consumption (468.893 W) occurred at 180 m/min cutting speed and 4 mm axial depth. There was a 476% change between the highest and lowest power consumption.
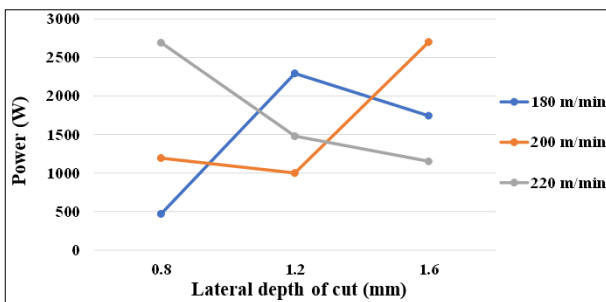

Figure 5. Power consumption variation graph based on lateral depth and cutting speed.

As a result of examining the effect of lateral depth and cutting speed in Figure 5, the highest power consumption occurred at a cutting speed of 1.6 mm lateral depth and 200 m/min. The lowest value was 0.8 mm lateral depth and 180 m/min cutting speed. The highest change occurred with the increase of lateral depth from 0.8 mm to 1.2 mm at 180 m/min

cutting speed with 389%. The lowest power consumption change occurred with an increase of lateral depth from 0.8 mm to 1.2 mm at 200 m/min cutting speed with a 19% change.
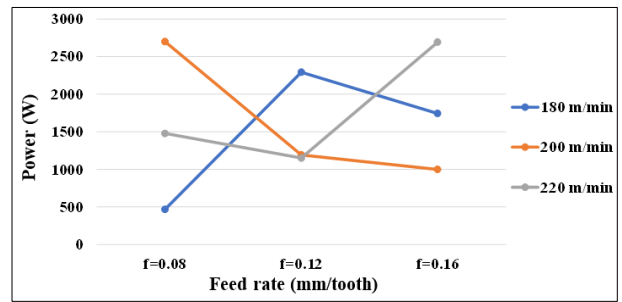

Figure 6. Power consumption variation graph based on feed rate and cutting speed.

By examining the graph in Figure 6, depending on the cutting speed and feed rate the highest power consumption value occurred at 0.08 mm/tooth feed rate and 200m/min cutting speed. The lowest power consumption value was observed at a cutting speed of 180 m/min and a feed rate of 0.08 mm/tooth. The highest rate of change between the parameters occurred in the increase from 0.08 mm/tooth advance to 0.12 mm/tooth advance amount. The lowest rate of change occurred in the increase from 0.12 mm/tooth advance to 0.16 mm/tooth advance amount. Generally speaking, an increase in power consumption is expected with an increase in the amount of feed [4]. However, in milling mechanics, it is acceptable to result in such a result, since the multi-toothed tools and the cutting edge are different from the single-edged tools.

Taguchi analysis was performed to determine the parameters that significantly affect the power consumption in the simulation results. In order to find the optimum points of the processing parameters used in the study, the S/N ratios were determined by taking into account the smaller-the-better quality characteristic objective function (Table 5) [31,32].

TABLE 5
AVERAGE S/N RESPONSE FOR THE POWER CONSUMPTION.

Level	Radial Deep of Cut (mm)	Axial Deep of Cut	Cutting Speed (m/min.)	Feed Rate (mm/tooth)
1	-61.19	-58.22	-61.82	-61.82
2	-63.54	-63.26	-63.39	-63.33
3	-64.90	-68.15	-64.41	-64.48
Delta	3.71	9.93	2.59	2.66
Rank	2	1	4	3

According to the average smallest best S/N values found in Table 4, the values with the highest Delta levels specified for each level have the greatest effect on power consumption. Impact rankings in the tables are expressed with "rank". Thus, it has been determined that the most effective parameter in power consumption is axial depth. In addition, it was concluded that the lateral depth of cut 1, the axial depth of cut 1, the cutting speed 1 and the feed per tooth 1 level for the optimum power consumption value. Finally, it was concluded that

minimum cutting speed, lateral and axial cutting depth and feed rate should be used for less power consumption and therefore an environmentally friendly environment.

The graph of the S/N ratio responses for power consumption is given in Figure 7. The maximum points of the slopes in the figure give information about the efficiency levels of the processing parameters.
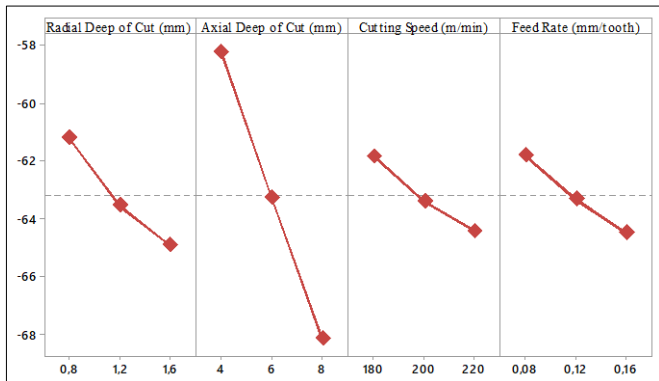

Figure 7. S/N chart for power consumption.

4. CONCLUSION AND SUGGESTIONS

In this study, the finite element method was used to increase the machinability of S960QL structural steel. Similar studies were previously an investigated by Bouzid et al. [29] and Korkmaz et al. [4] with finite element modeling and mathematical modeling to estimate the power consumption of processing parameters. In addition, a similar study was conducted by Günay et al. [33]. The summary of the work done is given below.

The power consumption increased with increasing cutting depth.

The highest power consumption (2700.299 W) occurred at an axial depth of 8 mm and a cutting speed of 200 m/min.

The lowest power consumption (468.893 W) occurred at an axial depth of 4 mm and a cutting speed of 180 m/min.

According to Taguchi analysis, it was concluded that the most effective parameter in power consumption is axial depth, and the parameter with the lowest effect is cutting speed.

It is concluded that lower power consumption can be achieved by optimizing the processing parameters.

It has been concluded that the processing parameters can be used for the estimation of power consumption with the finite element method.

The finite element method can be used to determine the machinability parameters of structural steels and materials with difficult machinability at the optimum level and to make the machining industry sustainable.

Comparisons can be made with experimental studies.

This study will contribute to the studies to be carried out with the finite element method.

ACKNOWLEDGEMENT

REFERENCES

[1] Kant, G. and Sangwan, K. S., Prediction and optimization of machining parameters for minimizing power consumption and surface roughness in machining, *Journal of Cleaner Production,* (2014), 83 pp. 151-164.

[2] Sangwan, K. S., Development of a multi criteria decision model for justification of green manufacturing systems, *Int. J. Green. Econ.,* (2011), no. 5, pp. 285-305.

[3] He, Y., Liu, B., Zhang, X., Gao, H. and Liu, H., A modeling method of task-oriented energy consumption for machining manufacturing system, *J. Clean. Prod.,* 23, (2012), pp. 167-174.

[4] Korkmaz, M. E. and Günay, M., Finite Element Modelling of Cutting Forces and Power Consumption, *Arabian Journal for Science and Engineering,* 43, (2018), pp. 4863-4870.

[5] Composeco-Negrete, C., Optimization of cutting parameters for minimizing energy consumption in turning of AISI 6061 T6 using Taguchi methodology and ANOVA, *J. Clean. Prod.,* 53, (2013), pp. 195-203.

[6] Black, J. T. and Kohser, R. A., DeGarmo's Materials and Processes in Manufacturing, 11th edition, *John Wiley&Sons*, Hoboken, 2013.

[7] Coşkun, M., Çiftçi, İ. and Demir, H., AISI P20S Kalıp Çeliğinin İşlenebilirliğinin İncelenmesi, *İmalat Teknolojileri ve Uygulamaları,* 2, (2021), 2, pp. 1-9.

[8] Uzun, M., Usca, Ü. A., Kuntoğlu, M. and Gupta, M. K., Influence of tool path strategies on machining time, tool wear, and surface roughness during milling of AISI X210Cr12 steel, *The International Journal of Advanced Manufacturing Technology,* (2022), pp. 1-12.

[9] Usca, Ü. A., Uzun, M., Sap, S., Kuntoğlu, M., Giasin, K., Pimenov, D. Y. and Wjciechwski, S., Tool wear, surface roughness, cutting temperature and chips morphology evaluation of Al/TiN coated carbide cutting tools in milling of Cu-B-CrC based ceramic matrix composites, *Journal of Materials Research and Technology,* 16, (2022), pp. 1243-1259.

[10] Haddag, B., Atlati, S., Nouari, M. and Moufki, A., Dry machining aeronautical aluminum alloy AA2024-T351: Analysis of cutting forces, chip segmentation and built-up edge formation, *Metals,* 6, (2016), 9, p. 197.

[11] Aggarwal, A., Singh, H., Kumar, P. and Singh, M., Optimizing power consumption for CNC turned parts using response surface methodology and Taguchi's techniqueda comparative analysis, *J. Mater. Process. Technol.,* 200, (2008), pp. 373-384.

[12] Daoud, M., Chatelain, J. F. and Bouzid, A., Effect of rake angle-based Johnson-Cook material constants on the prediction of residual stresses and temperatures induced in Al2024-T3 machining. *International Journal of Mechanical Sciences*, 122, (2017), pp. 392-404.

[13] Umbrello, D., M'saoubi, R. and Outeiro, J. C., The influence of Johnson–Cook material constants on finite element simulation of machining of AISI 316L steel. International Journal of Machine Tools and Manufacture, 47(3-4), (2017), pp. 462-470.

[14] Jain, A., Khanna, N. and Bajpai, V., FE simulation of machining of Ti-54M titanium alloy for industry relevant outcomes. Measurement, 129, (2016), pp. 268-276.

[15] Bouderbala, K. and Nouira, H., FEM and experimental investigation of the thermal drift in ultra-high precision measuring machines for dimensional metrology. Measurement, 90, (2016), pp. 250-264.

[16] Bhushan, R. H., Optimization of cutting parameters for minimizing power consumption and maximizing tool life during machining of Al alloy SiC particle composites, *J. Clean. Prod.,* 39, (2013), pp. 242-254.

[17] Yan, J. and Li, L., Multi-objective optimization of milling parameters e the trade tradeoffs between energy, production rate and cutting quality, *J. Clean. Prod.,* 52, (2013), pp. 462-471.

[18] Campatelli, G., Lorenzini, L. and Scippa, A., Optimization of process parameters using a Response Surface Method for minimizing power consumption in the milling of carbon steel, *Journal of Cleaner Production,* 66, (2014), pp. 309-316.

[19] El-Tamimi, A. M. and El-Hossainy, T. M., Investigating the machinability of AISI 420 stainless steel using factorial design, *Mater. Manuf. Process.,* 23, (2008), 4, pp. 419-426.

[20] Valiorgue, F., Rech, J., Hamdi, H., Gilles, P. and Bergheau, J. M., 3D modeling of residual stresses induced in finish turning of an AISI304L stainless steel, *Int. J. Mach. Tool. Manuf.,* 53, (2012), 1, pp. 77-90.

[21] Galanis, N. I. and Manolakos, D. E., Finite element analysis of the cutting forces in turning of femoral heads from AISI 316L stainless steel, *In: Proceedings of theWorld Congress on Engineering 2014*, London, 2014.

[22] Li, A., Pang, J., Zhao, J., Zang, J. and Wang, F., FEM-simulation of machining induced surface plastic deformation and microstructural

texture evolution of Ti-6Al-4V alloy. International Journal of Mechanical Sciences, 123, (2017), pp. 214-223.

[23] Budak, E. and Ozlu, E., Development of a thermomechanical cutting process model for machining process simulations. CIRP annals, 57(1), (2008), pp. 97-100.

[24] https://www.ssab.com.tr/products/brands/strenx/products/str enx-960-e-f

[25] Johnson, G. J. and Cook, W. H., A constitutive model and data for metals subjected to large strains, high strain rates and high temperatures, *In: Proceedings of the Seventh International Symposium on Ballistics*, The Hague, 1983.

[26] Cadoni, E. and Forni, D., Mechanical behaviour of a very-high strength steel (S960QL) under extreme conditions of high strain rates and elevated temperatures, *Fire Safety Journal,* (2019), pp. 1-14.

[27] Eren, N., Hayat, F. and Günay, M., Sertleştirilmiş 1.2367 Takım Çeliğinin İşlenmesinde Enerji Tüketiminin Analizi ve Modellenmesi, *İmalat Teknolojileri ve Uygulamaları,* 1, (2020), 3, pp. 41-49.

[28] Aslan, A., Tornalamada Akustik Emisyon ve Motor Akımı Optimizasyonu ve Analizi. Avrupa Bilim ve Teknoloji Dergisi, (25), (2021), pp. 50-57.

[29] Bouzid, L., Yallase, M. A., Chaoui, K., Mabrouki, T. and Boulanouar, L., "Mathematical modeling for turning on AISI 420 stainless steel using surface response methodology," *Proc. IMechE Part B J. Eng. Manuf.,* 229, (2015), 1, pp. 45-61.

[30] Binali, R., Sıcak iş takkım çeliğinin (TOOLOX 44) işlenebilirliğinin incelenmesi, MSc. Thesis, *Karabük Üniversitesi Fen Bilimleri Enstitüsü,* Karabük, 2017.

[31] Neşeli, S., Tırlama titreşimleri üzerine süreç sönümleme etkisinin analitik olarak araştırılması ve tornalamada kararlı kesme derinliği ile süreç sönümleme değerlerine bağlı parametre optimizasyonu, PhD. Thesis, *Selçuk Üniversitesi Fen Bilimleri Enstitüsü,* Konya, 2013.

[32] Vidal, C., Infante, V. and Vilaca, P., "Assessment of Improvement Techniques Effect on Fatigue Behaviour of Friction Stir Welded Aerospace Aluminium Alloys," *Procedia Engineering,* 2, (2010), pp. 1605-1616.

[33] Günay, M., Korkmaz, M. E. and Yaşar, N., Finite element modeling of tool stresses on ceramic tools in hard turning. Mechanics, 23(3), (2017), pp. 432-440.

BIOGRAPHIES

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