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EFFECTS OF MACHINING PARAMETERS ON TOOL LIFE

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ABSTRACT

Cutting tools, which are used extensively in machining, are expected to have high performance and longer service life. Tool life term defines the time period between the starting of the cutting tool and the sharpening of the tool so that the tool is actively used. According to international standards, tool deterioration by wear is a specific criterion used to determine tool life. In this study, the effects of cutting parameters on the cutting performance and tool life of standard end mills with diameters Ø6, Ø8, Ø10, Ø12 which are used extensively in the die-making industry, were investigated. Detection of cutting-edge wear conditions was achieved by conducting detailed surface observations with a high-resolution camera of a three-dimensional (3D) digital microscope.

1. INTRODUCTION

There are numerous types of cutting tools depending on the industrial and engineering application areas. It is used extensively in applications such as die makers, machine manufacturers, aerospace and defense industries. Manufacturers need high quality, long service life and low cost in cutting tools. It is very difficult to obtain these requirements randomly, considering that the cutting tool expenses of the machining enterprises today correspond to 30% of the operating costs (60% in some enterprises). However, it is possible to optimize all these parameters in the best possible way with today's technology.

During the machining process, a certain load is applied on the workpiece by the cutting tool and the desired shape is given to the workpiece by removing chips from the surface. The main aim is to approach the ideal cutting process by providing the highest values in terms of tool life and surface quality, and the lowest cost and minimum machining time. The most important factors that directly affect tool wear the material of the cutting tool used and the cutting parameters such as the cutting speed, depth of cut and feed rate used at the time of cutting.

In this study, tool wear was investigated as a result of working with variable cutting parameters of standard end mills and inserts of different sizes.

Saleem et al. investigated tool life and surface integrity for Ni based superalloy materials. They used multi radii insert geometry and employed PVD coated carbide inserts with novel wiper edge geometry for face milling operation [1].

Dadgari et al. studied on tool wear and tool life prediction for micro-milling of Ti-6Al-4V material. Their study show that the low feed-rate enhances the plowing effect on the cutting zone, resulting in reduced surface quality and leading to burr formation and premature tool failure [2].

Some researchers studied tool life and wear mechanism relations according to the milling operation for different profiles [3-5].

Reichenbach analyzed tool wear behavior of micro tools [6].

The mathematical approach is also another useful tool to predict tool life for milling operations. Karandikar et al. used Bayesian method and Drouillet et al. applied neural network technique for tool life predictions [7, 8].

Krain and his research group studied for optimization of tool life and productivity for end milling operation. At first stage of their experiments, they used fixed tool material and geometry to examine the effects of feed rates and depth's of cut. At second stage, they examined reduced number of parameters for various tool materials and geometries [9].

Çakır et al. used DIN 1.2738 steel for different cutting parameters with different coating layers, and different coating layers were evaluated [10]. According to the research findings;

- If the depth of cut is increased by 50%, the tool life is reduced by 6%.
- If the feed rate is increased by 50%, the tool life is reduced by 60%.
- If the cutting speed is increased by 50%, it reduces the tool life by 90%.

Accordingly, it was stated that the changes in the depth of cut had little effect on the tool life, the changes in the feed rate had a greater effect on the tool life than the changes in the depth of cut, and the changes in the cutting speed had the greatest effect. The experiments with carbide burrs and inserts were calculated separately based on these principles.

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Çaydaşı et al. applied chip removal at 150, 200, 250 m/min cutting speeds under dry machining conditions of carbide and ceramic tools for AISI 52100 Bearing Steel. It was observed that tool life for both tool materials decreased in direct proportion to the increase in cutting speed. The highest tool life value is 80 min. in the tool working with V=150m/min speed was measured [11].

2. MATERIALS AND METHOD

DIN1.2344 ESR hot work tool steel, which has a very intensive use in the mold making industry, was used in the experiments. Machining experiments were carried out in Victor P106 CNC vertical CNC machine. In this study, TURCAR Akviya cutting tools with the diameter of Ø6, Ø8, Ø10, Ø12 mm 4-flute TiAlN coated end mills and 3-corner XPKT insert were used. The chemical composition of 2344 type tool steel is shown in the Table 1.

Table 1 *Chemical Composition of 2344 tool steel*

C	*Si*	*Mn*	*P max*	*S max*	*Cr*	*Mo*	*V*
0,35-0,42	*0,80-1,20*	*0,25-0,50*	*0,03*	*0,02*	*4,80-5,50*	*1,20-1,50*	*0,85-1,15*

In the experimental study, each tool machined a 10mm depth hole form the centerline of an aluminum block with the size of Ø200x35 mm. The chip thickness was kept as constant and was 2 mm. Cutting speed for each tool was selected to obtain optimum feed rate for obtaining longer service life. The higher cutting speed value is the actual cutting speed which was taken from the workshop and lower value is selected for experimental study to obtain efficient cutting condition. Feed rate per tooth value was measured as (0.062 – 0.08), (0.049 – 0.06), (0.025 – 0.045), (0.011 – 0.033) mm/tooth, respectively. Table 2 summarizes the parameters used in these experiments.

Table 2 *Machining Parameters for experiments*

Cutting Tool	*S (rotation)*	*F (feed rate)*	*Vc (cutting speed)*	*fz: (feed per tooth)*
Turcar Ø12 Milling tool	*4000*	*1000*	*152*	*0,062*
	3000	*1000*	*110*	*0,083*
Turcar Ø10 Milling tool	*5000*	*1000*	*160*	*0,049*
	3200	*1000*	*100*	*0,08*
Turcar Ø8 Milling tool	*6000*	*600*	*151*	*0,025*
	3600	*600*	*90*	*0,045*
Turcar Ø6 Milling tool	*6000*	*315*	*135*	*0,011*
	4250	*315*	*80*	*0,018*

In Turcar cutting tools with 4-flute TiAlN coated end mills with diameter of Ø6, Ø8, Ø10, Ø12 was used for the experiments. The cutting speeds were reduced by keeping the feed rate and depth of cut constant for each tool. Tool wear values as tool wear were observed under a microscope.

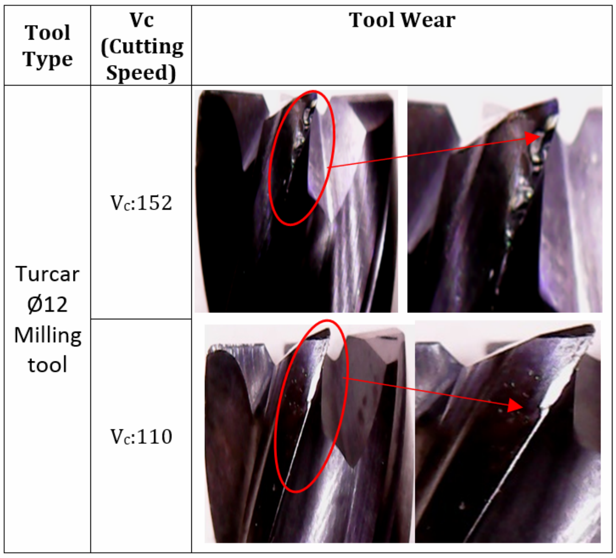


Fig 1. Tool wear for 45min. machining of Ø12 Turcar

The Fig. 1 represents the tool wear of the same cutting tool for two different cutting speed after 45 minutes machining operation. It can be seen from the figure 1. That tool wear for cutting speed of Vc: 152 m/min is much more severe comparing to the cutting speed of Vc: 110 m/min. The tool life for Vc: 110 m/min was measured 126 minutes when the tool life for Vc: 152 was only 455 minutes. The total tool life is almost 3 times higher than actual machining cutting speed parameter.

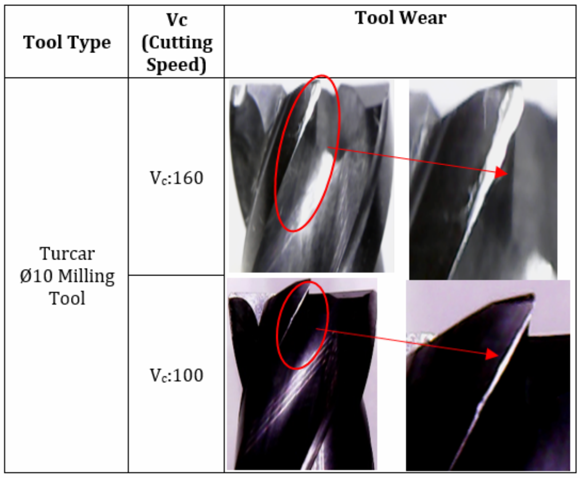


Fig. 2. Tool wear for 45min. machining of Ø10 Turcar

When the test results were examined, tool wear differences in the cutting edges were observed when the end mill products with the same diameter (Ø10 mm) were used for a certain time (45 minutes) for the same working conditions. The life of the tool working with Vc: 160m/min was 45 minutes, and the total measured tool life was 72 minutes for cutting speed is Vc: 100m/min.

The figure 3 gives the tool wear comparison for Ø8 mm end mill. The tool life for cutting speed of Vc: 151m/min was 45 minutes, while tool life of cutting speed for Vc: 90m/min was measured as 128 minutes.

In Fig. 4, the tool wear difference between cutting speed Vc: 135m/min and cutting speed Vc: 80m/min was given. Higher cutting speed leads more deformation on the cutting edges of the tool. The measured tool life of Vc: 80 m/min is three times higher than that of the actual machining parameter's tool life.

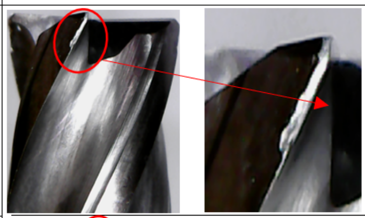
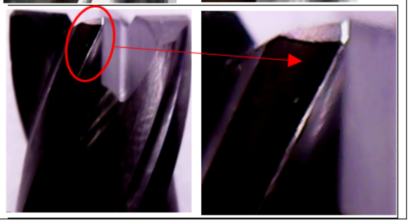
Tool Type	Vc (Cutting Speed)	Tool Wear
Turcar Ø8 Milling Tool	Vc:151	
	Vc:90	

Fig. 3. Tool wear for 45min. machining of Ø8 Turcar

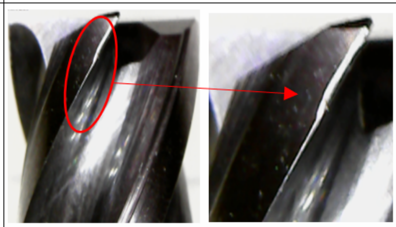
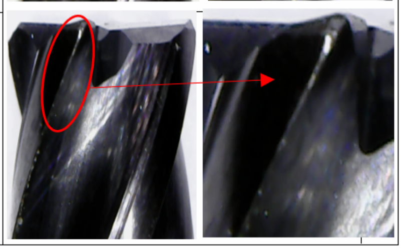
Tool Type	Vc (Cutting Speed)	Tool Wear
Turcar Ø6 Milling Tool	Vc:135	
	Vc:80	

Fig. 4. Tool wear for 45min. machining of Ø6 Turcar

3. CONCLUSIONS

The experimental results showed that proposed optimization method for cutting speed is efficient for tool life determination and following conclusions could be drawn as

• It has been observed that there is a proportional decrease in cutting tool wear due to the decrease in the cutting speed (Vc) of the cutting tools.

• A significant increase in tool life has been observed due to the decrease in cutting speeds (Vc) of the cutting tools.

• It was understood that cutting tool life can be increased by only reducing cutting speed (Vc) by keeping feed (F), depth of cut (Ap) and production time constant from cutting parameters.

REFERENCES

[1] Saleem M.Q., Mumtaz S., Face milling of Inconel 625 via wiper inserts: Evaluation of tool life and workpiece surface integrity, J. Manuf. Process, 56 (2020) 322–336 doi:10.1016/j.jmapro.2020.04.011

[2] Dadgari A., Huo D., Swailes D., Investigation on tool wear and tool life prediction in micro-milling of Ti-6Al-4V, Nami Jishu Yu Jingmi Gongcheng/Nanotechnology Precis. Eng. 1 (2018) 218–225 doi:10.1016/j.npe.2018.12.005

[3] Sortino M., Belfio S., Totis G., Kuljanic E., Fadelli G., Innovative tool coatings for increasing tool life in milling Nickel-coated Nickel-Silver alloy, Procedia Eng. 100 (2015) 946–952 doi:10.1016/j.proeng.2015.01.453

[4] Peña-Parás L., Maldonado-Cortés D., Rodríguez-Villalobos M., Romero-Cantú A.G., Montemayor O.E., Enhancing tool life, and reducing power consumption and surface roughness in milling processes by nanolubricants and laser surface texturing, J. Clean. Prod. 253 (2020) doi:10.1016/j.jclepro.2019.119836

[5] de Oliveira A.J., Diniz A.E., Tool life and tool wear in the semi-finish milling of inclined surfaces, J. Mater. Process. Technol. 209 (2009) 5448–5455 doi:10.1016/j.jmatprotec.2009.04.022

[6] Reichenbach I.G., Bohley M., Sousa F.J.P., Aurich J.C., Tool-life criteria and wear behavior of single-edge ultra-small micro end mills, Precis. Eng. 55 (2019) 48–58 doi:10.1016/j.precisioneng.2018.08.006

[7] Karandikar J.M., Abbas A.E., Schmitz T.L., Tool life prediction using Bayesian updating. Part 1: Milling tool life model using a discrete grid method, Precis. Eng. 38 (2014) 18–27 doi:10.1016/j.precisioneng.2013.06.006

[8] Drouillet C., Karandikar J., Nath C., Journeaux A.C., El Mansori M., Kurfess T., Tool life predictions in milling using spindle power with the neural network technique, J. Manuf. Process 22 (2016) 161–168 doi:10.1016/j.jmapro.2016.03.010

[9] Krain H.R., Sharman A.R.C., Ridgway K., Optimisation of tool life and productivity when end milling Inconel 718TM, J. Mater. Process. Technol. 189 (2007) 153–161 doi:10.1016/j.jmatprotec.2007.01.017

[10] Çakır M.C., Ensarıoğlu C., Demirayak I., Kesme parametrelerinin ve kaplama malzemesinin etkilerini değerlendirmek için yüzey pürüzlülüğünün matematiksel modellemesi Malzeme İşleme Teknolojisi Dergisi, 1 (2009) 102-109

[11] Çaydaşı U., AISI 52100 Rulman Çeliğinin İşlenebilirliğinin Yüzey Pürüzlülüğü, Takım Ömrü ve Sıcaklık Kriterlerine Göre Araştırılması, Fırat Üniversitesi Teknoloji Fakültesi Makine Mühendisliği Bölümü 23119 Elazığ Politeknik Dergisi 20(2) (2017) 409-417