Modelling and Optimization of Tool Life Parameters in Milling of E-Glass/Epoxy Composite Material

Y. Srinivasa Reddy
Assistant Professor
Department of Mechanical Engineering
PACE Institute of Technology & Sciences
Ongole-523272, India

S Asha Rani
Assistant Professor
Department of Mechanical Engineering
PACE Institute of Technology & Sciences
Ongole-523272, India

***Abstract*— Now a days, Major attention is given to tool life as it influence the cutting process and machinability. Milling machines are the principal machine tool used milling to assess the machining performance. In present study, an attempt has been made to optimize the tool life of a CNC milling machine. For cutting tool two different work materials named Tungsten Carbide and Poly Crystalline Boron Nitride (PCBN) are considered. E-Glass/Epoxy composite material is used as work piece material. Number of experiments was conducted by taking feed rate, cutting speed and depth of cut as input parameters and the tool life is calculated for the same set of input parameters. The relationship between the aforementioned parameters is studied and found it was concluded that depth of cut is the only parameter found to be significant.**

Keywords—Tool life, milling

I. INTRODUCTION

Milling and end milling are the most essential important milling operations in diversity of production and manufacturing plants including aviation and automotive divisions because of its ability of generating intricate shapes, ability to evacuate material quicker with equitable precision and surface finish [1]. In present industries CNC milling machine is exceptionally valuable for its adaptability and flexibility that permits manufacture of products in little time at low cost with high quality and good finish. Composites are a standout amongst the most generally utilized materials due to their versatility to various circumstances and the relative simplicity of combination with different materials to fill particular needs and unveil desirable properties. E-Glass/Epoxy composite considered to be an economic alternative to various materials. It is an advanced polymeric matrix composite material and having the wide range applications because of their light weight, high fracture toughness, chemical resistant and corrosion resistance [Hull et al. 1996].

Tool life is expressed in terms of time from start of a cut to termination point (defined by failure criterion). In other words, it is the time between regrinding and re-sharpening of tools. The CNC machines are automated version of conventional machines. The input parameters must be selected correctly, if not it will leads to shorter tool life. In order to establish an adequate functional relationship between the cutting tool life and cutting parameters (feed rate, cutting speed and depth of cut), a large number of tests are needed requiring a separate set of tests for each and every combination of cutting tool and work piece material. Most research has been done by investigating the effects of cutting parameters on tool life by varying one parameter at a time.

In this work, an attempt has been made to take the variation in all the input parameters simultaneously and by means of that predicting the tool life of the material. Cutting tool is made with Poly Crystalline Boron Nitride (PCBN) and Tungsten carbide. Taylor's tool life approach is used to analyze the effect of parameters on tool life while machining the E-Glass/Epoxy composite material.

II. POLY CRYSTALLINE BORON NITRIDE (PCBN) & E-GLASS/EPOXY COMPOSITE MATERIAL

Poly Crystalline Boron Nitride (PCBN) composites are produced by sintering micron cubic boron nitride powders with various ceramics, so as to produce extremely hard and thermally stable tooling materials. Most PCBN materials are integrally bonded to a cemented carbide substrate. Boron Nitride is the second hardest material known after diamond, but has high thermal and chemical resistance properties. PCBN provide extreme resistance better than the nearest ceramic materials. As mentioned boron nitride is harder than the oxide, nitride and carbide ceramics which are commonly used for abrasive applications. Where a poly crystalline material is required for cutting tools, boron nitride particles of order 1-10 microns are sintered with a variety of ceramic and metal phases using ultra high pressure and temperature to produce a solid, sizeable mass of ploy crystalline boron nitride.

Ep-134/Eh-369 is a two component cold setting epoxy system used for laminate/filament wound pipes along with glass roving's.

TABLE 1. Properties of Ep-134

Type	Diglycidyl ether of bisphenol – A based liquid epoxy resin
Appearance	Clear, pale yellow liquid
Viscosity at 25^0C	9000-13500 cP
Specific gravity at 25^0C	1.14-1.19
Storage stability	Up to 12 months

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 04, April-2017

TABLE 2. Properties of Eh-369

Type	Modified cyclo aliphatic polyamine
Appearance	Clear liquid
Viscosity at 25^0C	120-300 cP
Specific gravity at 25^0C	1-1.10
Storage stability	Up to 12 months

III. PREPARATION OF E-GLASS/EPOXY COMPOSITE MATERIAL

Epoxy compatible roving's impregnated with resin hardener mix. Then it is tensioned, oriented and wound on a mandrel, previously applied with mould releasing agent. The impregnated roving's wound on to the mandrel in a precisely defined geometrical pattern designed to make the fullest possible use of tensile strength of fibers. The excess resign hardener mix is wiped out and the wound structure is subsequently cured at room temperature for about 24 hours or cured at 70^0C for 4 hours.

Fig. 1. E-Glass/Epoxy composite

IV. EXPERIMENTATION

After through literature survey, the following parameters are considered as input parameters. The range of the selected process parameters were ascertained by conducting some preliminary experiments by varying one parameter with the time. The selected parameters were kept fixed during the entire experimentation.

- Cutting speed
- Feed rate
- Tool material
- Depth of cut

TABLE 3. Cutting parameters for PCBN & Tungsten Carbide

Material	Symbol	Cutting parameters	Level 1	Level 2
PCBN	V	Cutting speed (m/min)	628	942
	F	Feed rate (mm/rev)	1	1.25
	D	Depth of cut (mm)	1	1.5
Tungsten Carbide	V	Cutting speed (m/min)	188	125
	F	Feed rate (mm/rev)	0.1	0.15
	D	Depth of cut (mm)	0.25	0.5

Table 4. Experimental data

Material	Trail	Cutting speed (m/min)	Feed rate (mm/rev)	Depth of cut (mm)
PCBN	1	628	1	1
	2	628	1	1.5
	3	628	1.25	1
	4	628	1.25	1.5
	5	942	1	1
	6	942	1	1.5
	7	942	1.25	1
	8	942	1.25	1.5
Tungsten Carbide	9	188	0.1	0.25
	10	188	0.1	0.5
	11	188	0.15	0.25
	12	188	0.15	0.5
	13	125	0.1	0.25
	14	125	0.1	0.5
	15	125	0.15	0.25
	16	125	0.15	0.5

Now tool life can be calculated by using Taylor's tool life equation for above shown practical range of cutting parameters and results being tabulated manually. From Taylor's extended tool life equation, we have

$$VT^{n}f^{n1}d^{n2} = C$$

Where C --- Taylor's constant (From Data book)
= 3000 for PCBN
= 47 for Tungsten Carbide
V --- Cutting speed
T --- Tool life (Minutes)
f --- Feed rate (mm/rev)
d --- Depth of cut (mm)
n --- Tool constant (From Data book)
= 0.6 for PCBN
= 0.25 for Tungsten Carbide
n1 --- Feed exponent constant
= 0.21 for PCBN
= 0.25 for Tungsten Carbide
n2 --- Depth of cut exponent constant
= 0.26 for PCBN
= 0.20 for Tungsten Carbide

Afterwards the whole data is being entered into the Minitab software datasheet and optimization being carried out in Minitab software. According to the results being obtained by the Minitab, suitable suggestion will be made to improve the tool life.

Table 5. Calculated Tool life

Material	Trail	Cutting speed (m/min)	Feed rate (mm/rev)	Depth of cut (mm)	Tool life (min)
PCBN	1	628	1	1	13.54
	2	628	1	1.5	11.36
	3	628	1.25	1	12.53
	4	628	1.25	1.5	10.51
	5	942	1	1	6.89
	6	942	1	1.5	5.78
	7	942	1.25	1	6.37
	8	942	1.25	1.5	5.34
Tungsten Carbide	9	188	0.1	0.25	1.18
	10	188	0.1	0.5	0.68
	11	188	0.15	0.25	0.53
	12	188	0.15	0.5	0.30
	13	125	0.1	0.25	6.05
	14	125	0.1	0.5	3.48
	15	125	0.15	0.25	2.69
	16	125	0.15	0.5	1.54

V. RESULTS AND DISCUSSION

In order to know the relationship between the input parameters and the tool life the plots are plotted.

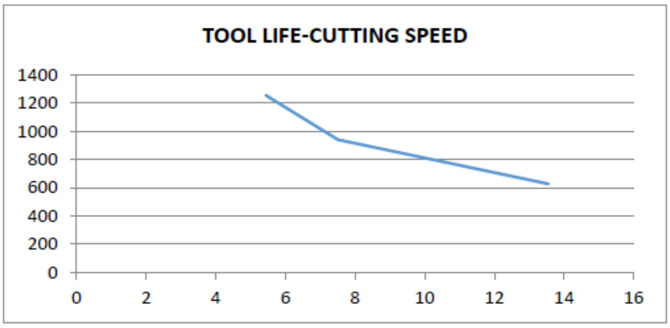

Fig. 2. Graph between cutting speed (m/min) and tool life (min) for PCBN

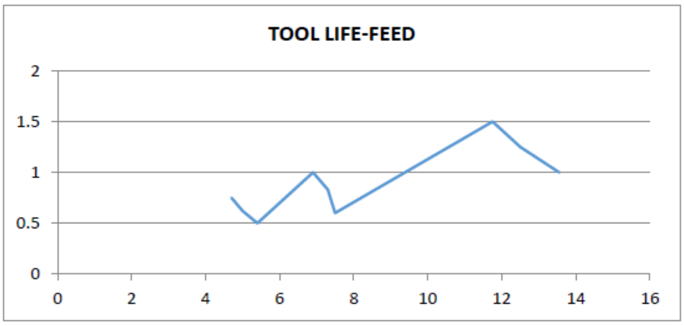

Fig. 3. Graph between feed rate (mm/rev) and tool life (min) for PCBN

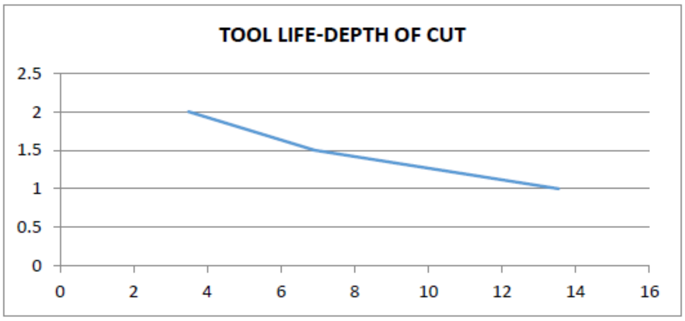

Fig. 4. Graph between depth of cut (mm) and tool life (min) for PCBN

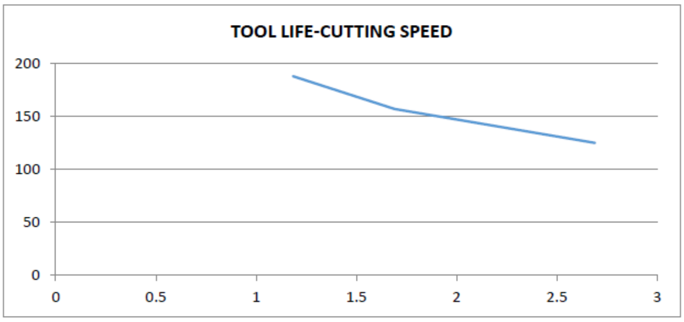

Fig. 5. Graph between cutting speed (m/min) and tool life (min) for Tungsten Carbide

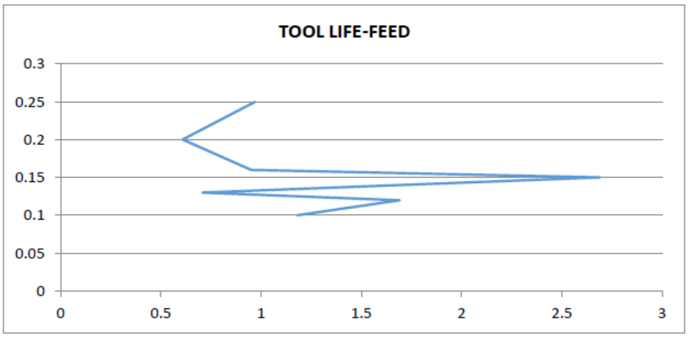

Fig. 6. Graph between feed rate (mm/rev) and tool life (min) for Tungsten Carbide

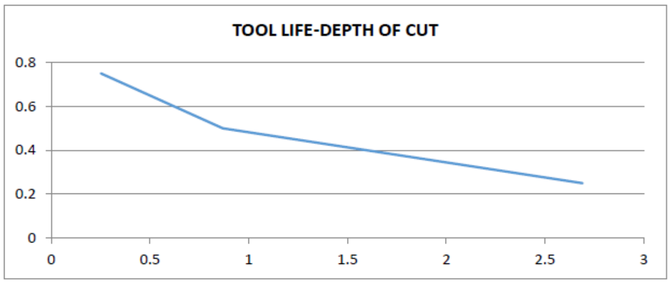

Fig. 4. Graph between depth of cut (mm) and tool life (min) for Tungsten Carbide

From the above plots, it is clear that the relationship between tool life and feed rate is unsteady. Even though the trend of tool life and cutting speed is alike but there is a quantified difference between the values of tool life.

From the plot of depth of cut and tool life, it is clear that the trend is steady and the tool life values are in a close zone. Hence it is clear that, the only parameter that is having significant relationship with the tool life is depth of cut.

VI. CONCLUSION

As there are numbers of parameters which affect the tool life of end milling cutters of CNC milling machine, this work mainly focused on three parameters named cutting speed, depth of cut and feed rate. In this case the experimental results demonstrate that the cutting speed and depth of cut are the main parameters that influence the tool life. Taguchi method approach was applied to find the best operation conditions for maximum tool life of the two work piece materials.

It was concluded that use of low depth of cut, low cutting speed and low feed rate are recommended to obtain better tool life as mentioned below.

For PCBN: Cutting speed = 628 m/min, Depth of cut = 1 mm and Feed rate = 1.25 mm/rev

For Tungsten Carbide: Cutting speed = 125 m/min, Depth of cut = 0.25 mm and Feed rate = 0.15 mm/rev.

VII. REFERENCES

[1] N. Suresh Kumar Reddy and P. Venkateswara Rao, “Selection of optimum tool geometry and cutting conditions using a surface roughness prediction model for end milling”, International Journal Advanced Manufacturing Technology, vol. 26, pp. 1202-1210, 2005.

[2] Vamsi Inturi and V. Gopinath, “Modeling of Process Parameters on Surface Roughness in Milling of Aluminum Metal Matrix Composite (Al-7075 & Sic) using RSM”, International Journal of Engineering Research & Technology, Vol. 3 Issue 9, September- 2014.

[3] Ishan B Shah, Kishore. R. Gawande, “Optimization of Cutting Tool Life on CNC Milling Machine Through Design Of Experiments-A Suitable Approach – An overview” International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-1, Issue-4, April 2012

[4] Anjan Kumar Kakati, M. Chandrasekaran, AmitavaMandal, and Amit Kumar Singh, “Prediction of Optimum Cutting Parameters to obtain Desired Surface in Finish Pass end Milling of Aluminum Alloy with Carbide Tool using Artificial Neural Network”, World Academy of Science, Engineering and Technology 81 2011.

[5] Mr. BallalYuvarajP,Dr. Inamdar K.H, Mr. Patil P.V., “Application Of Taguchi Method For Design Of Experiments In Turning Gray Cast Iron”, International Journal of Engineering Research and Applications.

[6] M. Aruna and V. Dhanalaksmi, “Design Optimization of Cutting Parameters when Turning Inconel 718 with Cermet Inserts”, World Academy of Science, Engineering and Technology 61 2012.

[7] Hari Singh, “Optimizing Tool Life of Carbide Inserts for Turned Parts using Taguchi‟s De sign of Experiments Approach”, Proceedings of the International MultiConference of Engineers and Computer Scientists 6288 Vol IIIMECS 6288, 1921 March, 6288, Hong Kong.