Experimental Investigation on the Effect of Tool life using Different Materials like EN 9, EN 31 and Aluminum on CNC Turning Lathe Machine

Prajapati Yash Kamleshbhai[1] Prof. Panchal Nirmal J.[2]
[1]Department of Advance Manufacturing System (Mechanical) [2]Department of Mechanical Engineering
[1,2]Tatva Institute of Technological studies, Modasa, Gujarat, India

Abstract— In the current manufacturing industries, cost of the product is most important parameter and there are too many parameters that effects such as tool Life, Production of the component, Product quality. Tool life directly affects the product quality and productivity of the product. We have determined the tool life by the method of design of experiment. All the cutting parameter such as cutting speed, depth of cut, feed of the cutting tool has been taken into the account along with two different conditions as dry and wet Then the observed data has been studied on the Minitab software to develop the equation based on the material parameter. This has given the nearly precise idea for the cutting tool life.

Keywords: Tool Life, EN9, EN31, Cutting Feed, Cutting Speed, Depth of Cut, Coolant, Dry, Wet

I. INTRODUCTION

One persistent trend throughout the history of metal machining has been the use of higher and higher cutting speeds. In recent years, there has been renewed interest in this area due its potential for faster production rates, shorter lead times, reduced costs and improved part quality. In its simplest definition, high speed machining means using cutting speeds that are significantly higher than those used in conventional machining operations. To achieve approximately zero tolerance product higher configuration and expensive machine should be used. Major concern of this, it increases the final cost of the product. This project emphasis on how to reduce the cost of product without loss of the expected quality. And to reduce the cost of the product manufactured on these machines we need to reduce the cost of the quality setup as well as the initial setup done on the machine. Quality setup means the dimensional quality of the product with the expected productivity of the machine. To increase the productivity with the quality we have to develop such theory that suggest the setup parameter before loading the product on the machine. The set-up parameter means the life of the CNC turning tool, because the condition and finally the life of the tool is important to maintain the anticipated productivity as well as expected quality. To determine the life, Tool Wear Rate of the tool we have to perform the trial by changing the material with the CNC Carbide insert. Materials will be used in experiment: EN – 9, EN – 31, Aluminum

These are the most commonly used materials in the engineering industries. By performing the experiment we can determine the Tool Wear Rate. Before changing the material we will be able to know the how many tools are required to produce the required quantity, by these way we will be able to reduce the cost of quality setup and increase the productivity of the machine.

We can also calculate tool life by using Taylor's tool life equation and make a comparison with experimental observation.

II. EXPERIMENTAL PROCEDURE

The complete experimentation was conducted on LMW CNC lathe machine. For the following experimentation the mainly two conditions were carried out that is dry running and wet running using Multan B-204 as a coolant.

Initially the parameters were decided before performing the experiment. The parameters were decided for cutting speed of 210, 230 and 250 rpm and depth of cut as 0.5 and 1 mm and keeping feed rate constant as 0.14. The operation was performed for both the conditions that is dry as well as wet.

A. Machine Specification

LMW CNC Lathe used for the experimentation had a following set of fixed/Ranged Parameter. The entire experimentation was being conducted under the controlled conditions. The specifications of CNC Lathe were as follows:

Sr.	Element	Size / dimension
1	Name of equipment	CNC TURNING
2	Equipment serial no.	55-01252
3	Tag no.	TC-03
4	Application	TURNING
5	Model no.	SMART RUN
6	Make	LMWSMARTRUN
7	Swing over bed	480mm
8	Max. turning length	262mm
9	Max. turning dia.	200mm
10	Standard turning	169mm
11	Spindle motor	5.5Kw/7.5Kw
12	Spindle bor	53mm
13	Spindle nose	Flat dia. 140mm
14	Coolant motor	0.25Kw
15	Cheep conveyor	0.18Kw
16	Axis drive	SIMODRIVE
17	Ball screw x-axis	32 x 10 pitch
18	Ball screw z axis	32 x 10 pitch
19	Speed range	50-4500 rpm
20	Max rapid speed	20000mm/min
21	Weight	3800 kg
22	Floor space	2960*1685*1485
23	Standard access	165mm hydraulic chuck

Fig. 1: Image of CNC Lathe

III. DESIGN OF EXPERIMENT

There are certain methods for the D.O.E. are available in the statics and are listed below Factorial, Response surface, Mixture, Taguchi, Select optimal design, Response optimizations. This are variables (also think of as ingredients or parameters) that have direct influence on the performance of the product or process under investigation. Factors are of two types: **Discrete** - Assumes known values or status for the level. Example: Container, Vendor, Type of materials, etc. **Continuous** - Can assume any workable value for the factor levels. Example: Temperature, Pressure, Thickness, etc. Levels: This is the values or descriptions that define the condition of the factor held while performing the experiments.

Combination: An instance of the experiment unit with a particular level from each factor applied.

For a full factorial design, if the numbers of levels are same then the possible design N is N = Lm

Where, L = Number of levels for each factor,

M = Number of factors

Fractional factorial designs are good alternatives to a full factorial design, especially in the initial screening stage of a project. It is used to simplify the experiment. Fractional factorial experiments investigate only a fraction of all the possible combinations. This approach saves considerable time and also money in case of costly material, but requires rigorous mathematical treatment, both in the design of experiment and in the analysis of the results.

A. Compilation of Data

Completion of various rounds of data collection and compilation, following data was received.

The data for EN9 was as follows

Run	Parameter			Flank Wear	The rate of flank wear	The volume of material removed	Tool Life
1	210	Dry	0.5	0.35	0.004	1250	87.2
2			1	0.35	0.0086	1560	40.26
3		Wet	0.5	0.49	0.0042	1410	116.54
4			1	0.33	0.0073	1629	45.1
5	230	Dry	0.5	0.35	0.0053	941	65.4
6			1	0.35	0.0115	1176	30.2
7	230	Wet	0.5	0.37	0.0042	1059	87.4
8			1	0.33	0.0097	1221	33.83
9	250	Dry	0.5	0.35	0.008	628	43.6
10			1	0.35	0.0173	784	20.13
11		Wet	0.5	0.37	0.0063	706	58.27
12			1	0.33	0.0146	815	22.55

The data for Aluminum was as follows

Run	Parameter			Flank Wear	The rate of flank wear	The volume of material removed	Tool Life
1	210	Dry	0.5	0.31	0.0002	50135	1355
2			1	0.32	0.0006	20054	542
3		Wet	0.5	0.42	0.0002	60165	1625
4			1	0.26	0.0006	24050	650
5	230	Dry	0.5	0.28	0.0002	37605	1016
6			1	0.25	0.0006	15100	408
7	230	Wet	0.5	0.24	0.0002	45125	1219
8			1	0.26	0.0006	18150	490
9	250	Dry	0.5	0.27	0.0002	31005	838
10			1	0.28	0.0006	12095	326
11		Wet	0.5	0.3	0.0002	36050	974
12			1	0.26	0.0006	14550	393

The data for EN31 was as follows

Run	Parameter			Flank Wear	The rate of flank wear	The volume of material removed	Tool Life
1	210	Dry	0.5	0.33	0.004	1250	70
2			1	0.32	0.0086	1560	30
3		Wet	0.5	0.46	0.0042	1410	90
4			1	0.30	0.0073	1629	38
5	230	Dry	0.5	0.32	0.0053	941	51
6			1	0.32	0.0115	1176	25
7	230	Wet	0.5	0.33	0.0042	1059	68
8			1	0.30	0.0097	1221	28
9	250	Dry	0.5	0.31	0.008	627	35
10			1	0.31	0.0173	784	16
11		Wet	0.5	0.33	0.0063	706	45
12			1	0.29	0.0146	815	17

B. Charts

Amongst all the parameters, the two parameters which will have effect on the tool life are cutting speed and depth of cut. While feed rate will also have an effect but as we have kept it constant the maximum effect on the tool life in both the condition (i.e. dry and wet) will be of cutting speed and depth of cut. The following charts show the tool life against cutting speed.

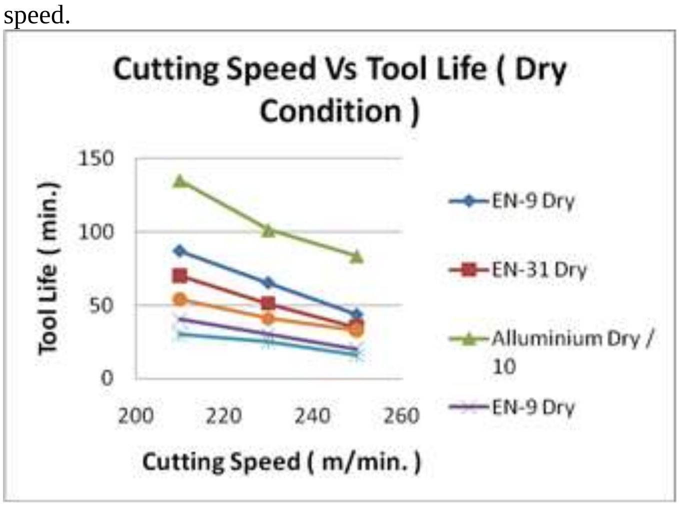

Chart 1: Dry Data Analysis

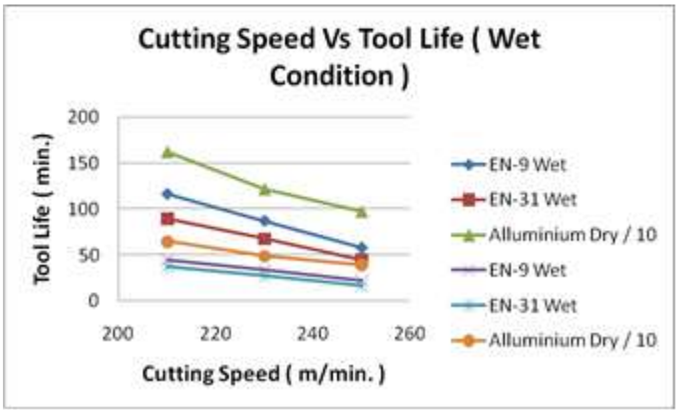

Chart 2: Wet Data Analysis

C. Theoretical vs Actual Data Analysis

By keeping the feed 0.14 mm/rev, the tool life founded experimentally and the theoretical equation to get the tool life on computer developed and validated with the existing tool life which is experimentally determined of cut. The following charts show the tool life against cutting speed Equation for EN-9 for dry condition:

(Feed / (cutting speed x depth of cut)) x exp $_{(1 / \text{Depth of cut})}$ x 0.42 x (cutting speed / cutting speed $_{max}$) and same thing is validated as mentioned in the below chart:

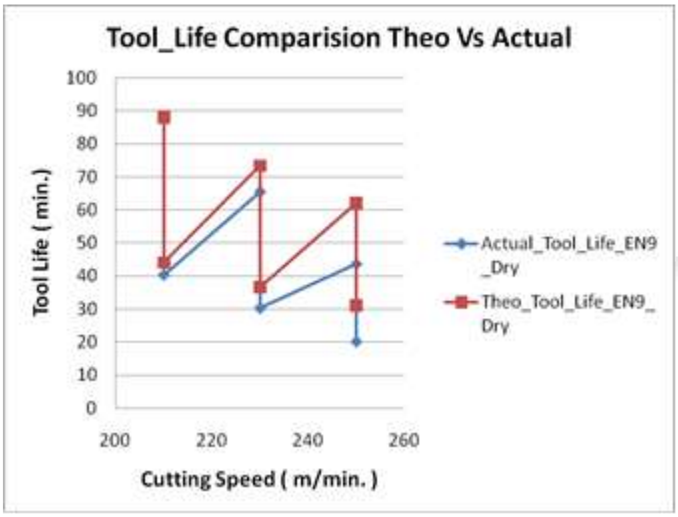

Chart 3: Theoretical vs Actual Analysis (Dry Condition)

By keeping the feed 0.14 mm/rev, the tool life founded experimentally and the theoretical equation to get the tool life on computer developed and validated with the existing tool life which is experimentally determined. Equation for EN-9 for wet condition:

(Feed / (cutting speed x depth of cut)) x exp $_{(1 / \text{Depth of cut})}$ x 0.52 x (cutting speed / cutting speed $_{max}$) and same thing is validated as mentioned in the below chart :

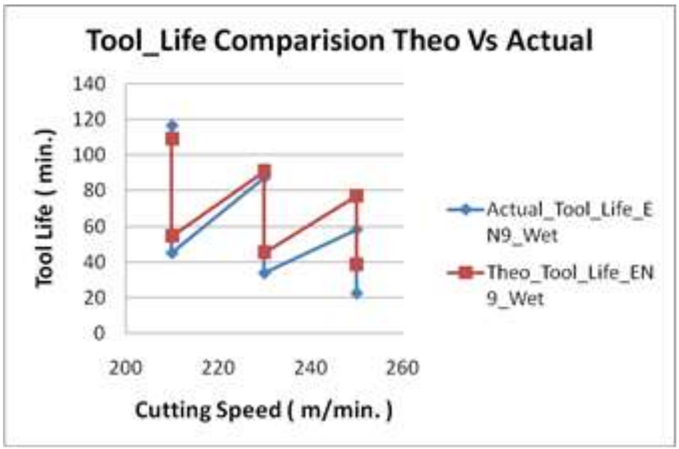

Chart 4: Theoretical vs Actual Analysis (Wet Condition)

IV. CONCLUSION

After completion of all the trials on CNC lathe turning machine for the different materials, for the different parameters and different running conditions. After each trial the flank wear and the amount of material removed were measured along with the time taken to remove it. The roughness in surface finish was the prime indication of the tool failure or end of tool life. The tool life on different material was found different. Also there was a difference in tool life for the different conditions. The tool life founded experimentally and the theoretical equation to get the tool life on computer developed and validated with the existing tool life which is experimentally determined. Equation for EN-9 for dry condition:

(Feed / (cutting speed x depth of cut)) x exp (1 / Depth of cut) x 0.42 x (cutting speed / cutting speed max) and same thing is validated.

The same equations are developed for the all of three materials for the both conditions and we derived the following conclusions:

1) As the conditions of the cutting changed from dry to wet, the tool life is increased by 33.64% for the EN-9 material.
2) As the conditions of the cutting changed from dry to wet, the tool life is increased by 28.57 % for the EN-31 material.
3) As the conditions of the cutting changed from dry to wet, the tool life is increased by 19.90% for the AL material.
4) The derived equation is matched with the existing condition of tool life and this will help to maintain the inventory of the tool insert to finish the batch of the production.
5) Estimated tool life has reduced the tooling cost by reducing the damage of the production.

V. FUTURE SCOPE

1) Further experimentation should be done on effect of different coolant on the tool life.
2) Tool analysis of the tool insert should be done on analysis software to strengthen the insert.
3) Effect of Work piece hardness on the tool life should be studied.

4) Effect of tooling material on the work piece should be studied.
5) Effect of residual stresses in work piece on tool life should be studied.

REFERENCES

[1] Cutting tool technology - G. Smith (springer, 2008)
[2] (Introduction to Basic manufacturing processes and workshop technology – Rajendra singh)
[3] Tool life prediction in face milling machining of 7075 al by using artificial neural networks (ann) and taguchi design of experiment (doe) amir mahyar khorasani1, mohammad reza soleymani yazdi and mir saeed safizadeh
[4] Virtual cnc machining and implementation of optimum mrr with tool life control tian-syung lan
[5] Development of an intelligent system for tool wear monitoring applying neural networks a. Antić a, j. Hodolič a, m. Soković b faculty of technical sciences, university of novi sad, trg d. Obradovića 6, 21000 novi sad, serbia & montenegro, faculty of mechanical engineering, university of ljubljana, askerceva 6, si-1000 ljubljana, slovenia corresponding author: e-mail address: mirko.sokovic@fs.uni-lj.si received 15.11.2005; accepted in revised form 31.12.2005
[6] Optimization of machining parameters in cnc turning of martensitic stainless steel using rsm and ga, poornima, sukumar (second m.e (industrial engineering), kumaraguru college of technology, coimbatore) india (faculty of mechanical engineering, kumaraguru college of technology, coimbatore)india
[7] Parametric analysis of surface roughness (sr) and material removal rate (mrr) of harden steel on cnc turning using anova analysis: a review rakesh.k.patel1*, h.r.prajapati m.tech student, u. V. Patel college of engineering, assistant professor, mechanical department, u.v.p.c.e. kherva, mehsana, gujarat, india corresponding author (rakesh_motidau@yahoo.com)
[8] Statistical Analysis for Detection Cutting Tool Wear Based on Regression Model Jaharah A. Ghani, Muhammad Rizal, Mohd Zaki Nuawi, Che Hassan Che Haron, Rizauddin Ramli
[9] Performance of multilayer coated carbide tools when turning cast iron Recep Y˙I ˘G IT1, Fehim FINDIK2, Erdal C¸EL˙IK Dokuz Eyl¨ul University, Izmir Vocational School of Higher Education, Department of Technical Programs, 35150, Buca, ˙ Izmir, TURKEY e-mail: recep.yigit@deu.edu.tr 2Department of Metal Education, Technical Education Faculty, Sakarya University, Esentepe Campus, 54187, Sakarya, TURKEY 3Dokuz Eyl¨ul University, Faculty of Engineering, Department of Metallurgical and Materials Engineering, Tinaztepe Campus, 35160, Buca, ˙Izmir, TURKEY Received 15.04.2009
[10] Tool life performances, wear mechanisms and surface roughness characteristics when turning austenised and quenched AISI 52100 bearing steel with ceramics and CBN/TiC cutting tools Ali Riza Motorcu Canakkale Vocational College, Çanakkale Onsekiz Mart University, 17100, Çanakkale, Turkey Received 1 June 2010; accepted 1 March 2011
[11] Optimization of Cutting Tool Life on CNC Milling Machine Through Design Of Experimnets-A Suitable Approach – An overview Ishan B Shah, Kishore. R. Gawande
[12] optimization of surface roughness, material removal rate and cutting tool flank wear in turning using extended taguchi approach a thesis submitted in partial fulfilment of the requirements for the degree of Master of Technology In Production Engineering By UMESH KHANDEY
[13] m. kamruzzaman and n. r. dhar, studied on, “the influence of high pressure coolant on temperature tool wear and surface finish in turning 17crnimo6 and 42crmo4 steels” (august 2009):
[14] K. Kadirgama, M.M.Noor, K.A. Abou-E-Hossein, H.H.Habeeb, M.M. Rahman, B.Mohamad, R.A. Bakar,carried analysis on “Effect of Dry Cutting on Force and Tool Life When Machining Aerospace Material” (2010):
[15] Design And Analysis Of Experiments-narayan c. giri
[16] Help site minitab 16
[17] G. Eason, B. Noble, and I.N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529-551, April 1955. (references)
[18] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.
[19] I.S. Jacobs and C.P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G.T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271-350.
[20] K. Elissa, “Title of paper if known,” unpublished.
[21] R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.
[22] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740-741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
[23] M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

