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Optimization and Analysis of Tool Life Based On Flank Wear in a Turning Process

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Abstract--Owing to the numerous interacting variables involved in a turning process, it is extremely difficult to assess the performance of a machining operation. The mathematical models which are currently in use for predicting the parameters like surface finish, tool life, tool wear etc. are highly non-linear because turning process is complex, random and uncertain in nature. A new methodology for finding the tool life is discussed in this project. In turning process, the machinability and tool wear are mainly stochastic rather than deterministic because of its complexity in nature. Tool change strategies are now based on the most conservative estimate of tool life from the past tool wear data. Always a complex relationship exists between process parameters like speed, feed, depth of cut, cutting time, tool geometry and cutting forces. Hence there is a need to develop models, which can capture this complex interrelationship between the parameters. In this project an empirical relationship has been developed between the parameters based on the experimental data.

By taking speed, feed, depth of cut and cutting time as the input variables, the cutting forces and the flank wear are found out experimentally for a given tool material combination. Based on these experimental data, a mathematical model has been developed. This model can be applied to all circumstances to estimate the cutting forces and the flank wear.

An artificial neural network model has also been developed to estimate the flank wear under varying cutting conditions. The results achieved by both the approaches have been compared and found to be closely related.A tool life equation has been developed using Taylor's tool life criteria. Using the genetic algorithm technique, the cutting conditions have been optimized. For these optimized cutting conditions optimized tool life has also been estimated. A tool called ANOVA technique has been used for finding the percentage contribution of each cutting parameter.

Key words--Optimization; Analysis; Tool Life; Flank Wear; Turning Process;

I. INTRODUCTION

During any machining process the tool is subjected to three distinct factors : forces, temperature and sliding action due to relative motion between tool and the work piece. Due to these factors, the cutting tool will start giving unsatisfactory performance after some time (P. C. Sharma, 2000). The unsatisfactory performance may involve: loss of dimensional accuracy, increased surface roughness, and increased power requirements etc. the unsatisfactory performance results from tool wear due to continued use. When the tool wears out, it is either replaced or reconditioned, usually by grinding. This will result in loss of production due to machine down time, in addition to the cost of replacing or reconditioning the tool, thus, the study of the tool wear is very important from the stand point of performance and economics (A. Nadgir etal., 2000). Due to a large number of factors over which the tool wear depends (hardness and type of tool material, type and condition of work piece, dimensions of cut i.e.,feed, depth of cut, tool geometry, tooltemperature which in turn is a function of cutting speed, surface finish of the tool, temperature and cutting fluid), the majority of the studies in tool wear are based on experimental observations, since the analytical study will be very difficult (A, Ghosh etal., 1998).

A. Flank Wear

Flank wear is attributed usually to the following reasons:
Abrasion by hard particles and inclusions in the work piece.
Shearing of the micro welds between tool and work material(C.Robenstein,1976) .
Abrasion by fragments of built-up edge plowing against the clearance face of the tool(Yorem Koren etal., 1991).

B. Crater Wear

Crater wear usually occurs due to

Severe abrasion between the chip and tool face.

High temperatures in the tool-chip interface reaching the softening or melting temperature of the tool resulting in increased rate of wear(Geoffrey Boothroyd eial., 1989).

Crater wear is more common in cutting ductile materials, which produce continuous chips. Also it is more common in HSS (high speed steel) tools rather than ceramic or carbide tools which have much higher hot hardness. Fig.1 shows crater wear and flank wear.

II. TOOL LIFE CRITERIA

There is no exact and simple definition of tool life. The tool life between reconditioning or replacement can be defined in a number of ways, namely

Actual cutting time to failure. In the case of interrupted cutting process, such as milling it will be the total time to failure.

Volume of the metal removed to failure.

Number of parts produced to failure.

Cutting speed for a given time to failure.

Length of work machined to failure.

Each one of the above methods may be useful at one time or other. A tool fails when it no longer performs its function properly. This will have different meaning under different circumstances. In a roughing operation,(Jae-Woong Youn etal., 2001) where, surface finish and dimensional accuracy are of little importance, a tool failure can mean an excessive rise in cutting forces and the power requirements. In the case of finishing operation where the surface finish and the dimensional accuracy are most important, a tool failure will mean that the specified conditions of surface finish and dimensional accuracy can no longer be achieved. All these failures are principally related to the wear on the clearance face of the cutting tool. This method of complete tool failure or total tool destruction which occurs due to high cutting forces or shock loads, is usually not considered because of the total loss of cutting tool and possible damage to the component. It is clear that the tool life/tool failure is related to tool wear and condition of finished parts. Fig.2 shows Flank wear Vs. Cutting time .The various tool life criteria can be listed as given below:

Chipping or fine cracks developing at the cutting edge.

Total destruction of cutting tool.

Wear land size on the flank of the tool.

Crater depth, width or other parameters of the crater wear on the rake face of the tool.

A combination of (3) and (4).

Volume of weight of material worn off the tool.

Limiting value of the surface finish produced the component.

Limiting value of change in component size.

Fixed increase in cutting forces or power required to perform a function.

III. RESULTS

The fig .3 represents the graph of tool life Vs cutting speed is a curve with increased slope. This shows that as the cutting speed (V) increases the tool life (T) decreases to a greater extent. The fig.4 represents the graph of tool life Vs feed is a curve with medium slope. This shows that as feed (f) increases the tool life (T) decreases. But it is comparatively less than that of cutting speed. The effects of cutting speed, feed and depth of cut on tool life were evaluated. Limit of Flank wear on the cutting tool has been taken as the criterion for the estimation of tool life. The results show that as cutting speed, feed and depth of cut increases, the flank wear increases. As cutting speed, feed and depth of cut increases, tool life decreases. The main objective is to determine the Extended Taylor Tool Life Equation (TTLE), and the flank wear of the High Speed Steel (HSS)cutting tool using Mild Steel work pieces. Also, the effects of different cutting speeds, feeds and depth of cuts, on the tool life will be observed.

IV. GENETIC ALGORITHM

In many technical fields, there is a relationship between a response variable y of interest and a set of controllable variables $\{x_1, x_2,...,x_n\}$. In some systems, the nature of the relationship between y and the x's might be known exactly, based on the underlying scientific principles. Then one can write a model of the form $y = g(x_1, x_2,...,x_n) + e$, where the term e represents the error in the system. This type of relationship is called a mechanistic model. However, in most practical situations, the underlying mechanism is either unknown or difficult to describe completely, and the experimenter (scientist or engineer) must approximate the unknown

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function *g (.)* with an appropriate empirical model $y= f(x1, x_2,\ldots, x_n) + e$. Usually the function *f (.)* is a first-order or second-order polynomial. Multiple variable regression is used to develop the empirical model by determining an optimal set of model coefficients. This empirical model is called a response surface model. After finding the optimal set of model coefficients, the empirical model *f (.)* is obtained. This empirical model can be used as a objective function for the optimization.

A. Objective Function for Cutting Force

The objective is to minimize the cutting force by varying the process parameters. Fig.5 shows Objective function for cutting force The objective function obtained from empirical model is given below:

Minimize Cutting force $f(y) = 11751.5 \times x_1^{-0.317} \times x_2^{0.79} \times x_3^{1.08} \times x_4^{0.45}$

$$30 \le x_1 \le 60$$
$$0.1 \le x_2 \le 0.3$$
$$0.5 \le x_3 \le 2$$
$$1 \le x_4 \le 60$$

Where, x_1=cutting speed in mm/min
x_2=feed in mm/rev
x_3=depth of cut in mm
x_4=cutting time in min

B. Objective Function For Flank Wear

The objective is to minimize the flank wear by varying the process parameters. Fig.6 shows Objective function for flank wear. The objective function obtained from empirical model is given below:

Minimize Flank wear $f(y) = 0.00117 \times x_1^{1.82} \times x_2^{0.74} \times x_3^{0.74} \times x_4^{0.32}$

$$30 \le x_1 \le 60$$
$$0.1 \le x_2 \le 0.3$$
$$0.5 \le x_3 \le 2$$
$$1 \le x_4 \le 60$$

Where, x_1=cutting speed in mm/min
x_2=feed in mm/rev
x_3=depth of cut in mm
x_4=cutting time in min

C. Objective Function For Tool Life

The objective is to minimize the tool life by varying the process parameters. The objective function obtained from empirical model is given below:

Minimize Flank wear $f(y) = 19.85 \times x_1^{-5.88} \times x_2^{-3.4} \times x_3^{-2.4}$

$$30 \le x_1 \le 60$$
$$0.1 \le x_2 \le 0.3$$
$$0.5 \le x_3 \le 2$$

Where, x_1=cutting speed in mm/min
x_2=feed in mm/rev
x_3=depth of cut in mm

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V. RESULTS AND DISCUSSIONS

Optimization of turning process (in terms of cutting force, tool wear and tool life) has been attempted with respect to process parameters to improve the productivity and the surface finish. The optimization has been made in such a way that the optimal design of the process operating condition yields the minimum part dimensional errors. The procedure of such design has been clearly illustrated by showing application of a genetic algorithm to the optimization of the process parameters. The genetic algorithm is implemented in 'C' language. The parameters of controlling the genetic algorithm include the crossover probability P_C and the mutation probability P_M. These values are chosen as 0.3 and 0.02, respectively, for the simulation. The size of the population, pop_size, also affects convergence of the algorithm. The simulation results indicate that pop_size = 20 yields the best solution with reasonable convergence speed,

VI. CONCLUSION

The new methodology to find out tool wear is discussed in the present study is a better alternative to traditionally known methods for assessing the tool wear. The flank wear can be quantitatively predicted for any given set of input cutting conditions. The methodology presented here is suitable in practice to any arbitrary machining work conditions. The solutions obtained by the proposed method are validated with conducting experiments. The results show that with the increase in speed, feed and depth of cut, the flank wear increases due to increase in the friction between tool and the work piece. The flank wear also increases with time. As the time proceeds the wear on the tool increases so that the forces on the tool face also increases. The proposed method is very much suitable for the estimation of tool wear under varying cutting conditions. Prediction of the flank wear without using any sensors would definitely improve the implementation of the present approach in the shop floor practice. A predetermined flank wear is set as the wear limit, so that whenever wear curve crosses that limit the corresponding time value gives the tool life at that cutting conditions.

It is concluded that, the cutting force will decrease for a given tool material-work piece material combination

as the cutting speed increases.

as the feed decreases

as the depth of cut decreases

The optimal cutting parameters with respect to cutting force for a given Mild steel-High speed steel tool material combination are as follows.

Cutting speed	----	59.9278 mm/min.
Feed	----	0.1 mm\rev.
Depth of cut	----	0.5 mm.

The coefficients in the Extended Taylor's tool life equation has been experimentally found out. For HSS-Mild steel combination, using this equation, the tool life can be found out under varying cutting conditions.

The derivation of the Extended Taylor's Tool life Equation enables enumeration of the factors effecting the tool life. A trained neural network system has been used in predicting the flank wear for various different cutting conditions. In addition to this, the neural network technique can be used in different areas like drilling, milling etc. based on the applications. The reason for including the neural network technique in the present study is that turning process is complex and uncertain in nature. The major advantage of the neural network method of tool wear prediction is that this algorithm can estimate the flank wear quite accurately.

REFERENCES

[1] Nadgir, T. O¨ zel, (2000) Neural network modeling of flank wear for tool condition monitoring in orthogonal cutting of hardened steels. In: Proceedings of 4th International Conference on Engineering Design and Automation, July 30–August 2, Orlando, Florida,USA,.

[2] A, Ghosh and A.K. Mallik .,(1998) "Manufacturing Technology"East-west press, NewDelhi.

[3] C.Robenstein,(1976) "An analysis of tool life based on flank face wear – part 11", ASME Journal of engineering for industry, vol.no 1, pp. 227 –232.

[4] Geoffrey Boothroyd and Winston A. Knight,(1989) "Fundamentals of machining and machine tools", Marcel Decker pub,US.

[5] Jae-Woong Youn, Min-Yang Yang,(2001) "A study on the relationships between static/Dynamic cutting force components and tool wear",ASME transactions, vol.no.123, May, pp.196-205.

[6] Laurence Fausett, 91997)"Fundamentals of neural networks" Prentice Hall, Englewood Cliffs, 1997.

[7] P. C. Sharma, (2000)" Production Engineering", SCHAND & Company.

[8] R. G. Khanchustambham, (1992)"A neural network approach to on-line monitoring of machining processes", System research center, University of MARYLAND.

[9] Tagrul Ozel and Abhijit Nadgir, (1994) "Prediction of flank wear by using back-propagation neural network modeling when cutting hardened H-13 steel with chamfered and honed CBN tools", International Journal of Machine Tools and Manufacturing 42 (5) 287–297.

[10] Yorem Koren, Tsu-Ren Ko, A. Galip Ulsoy, Kourosh Danai., (1991)"Flank wear estimation under varying cutting conditions" Transactions of ASME , vol.113, June, pp.300-307.

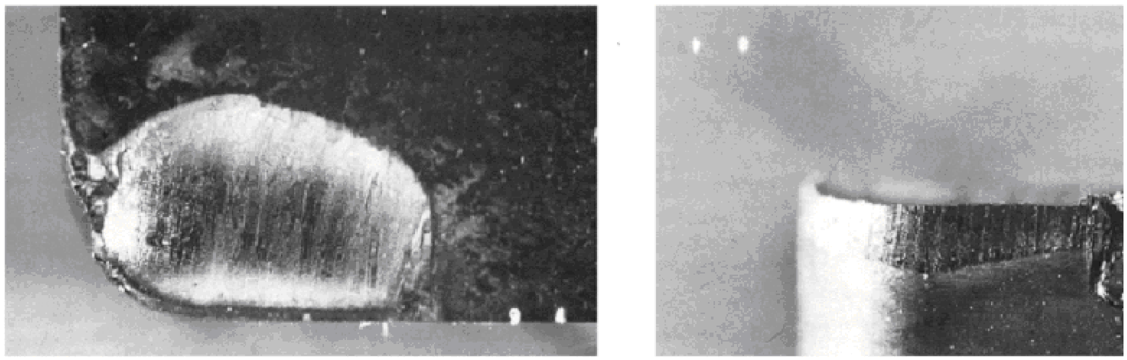

Figure .1. (a). Crater wear (b) Flank wear

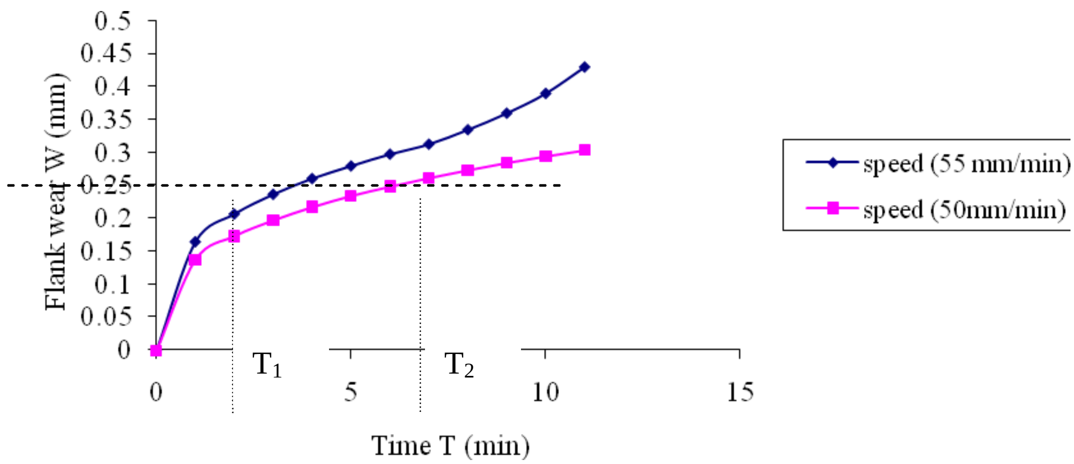

Fig .2. Flank wear Vs. Cutting time

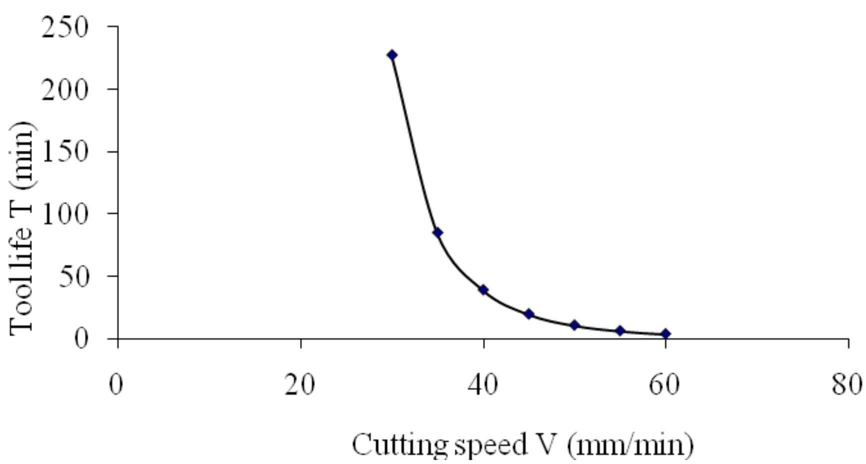

Fig .3.Tool life Vs Cutting speed

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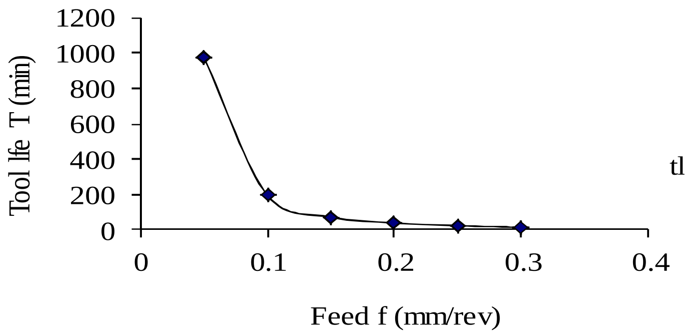

Fig.4.Too life Vs Feed

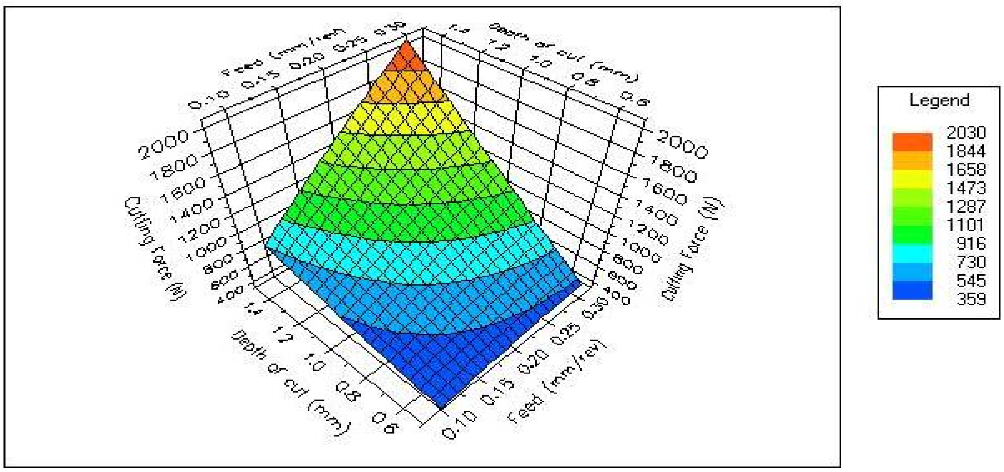

Fig.5. Objective function for cutting force

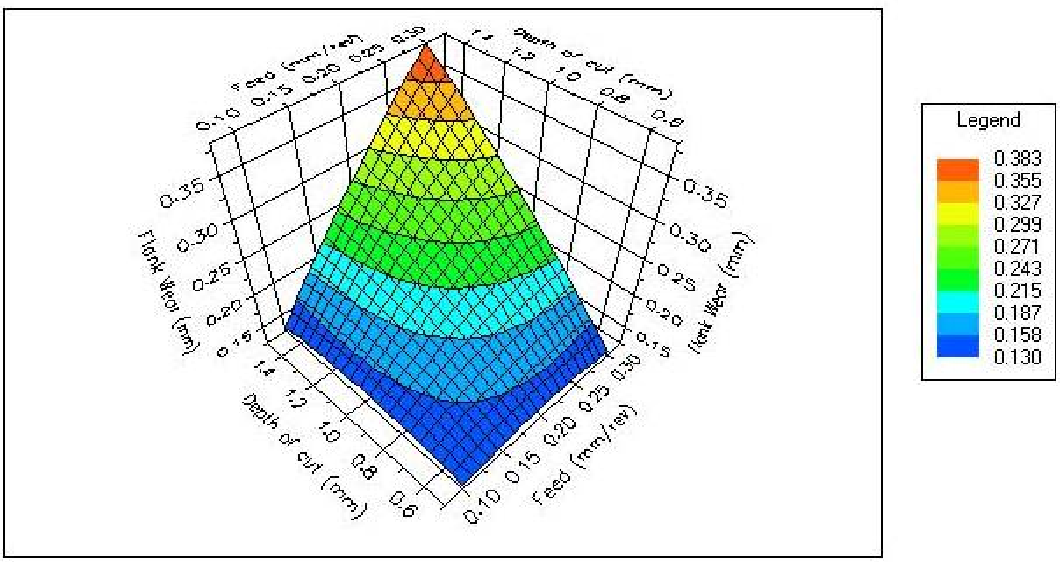

Fig.6. Objective function for flank wear

Table.1 The results of optimized tool life

S.No.	Parameter	Optimal parameter for tool life
1	Cutting speed (mm/min)	30
2	Feed (mm/rev)	0.1
3	Depth of cut (mm)	0.5
4	Objective function	233 min

Table.2 The results of optimized cutting force and the flank wear

No.	Parameter	Optimal parameter for Cutting force	Optimal parameter for Flank wear
1	Cutting speed (mm/min)	59.9278	30
2	Feed (mm/rev)	0.1	0.1
3	Depth of cut (mm)	0.5	0.5
4	Cutting time (min)	1	1
5	Objective function	246.30 N	0.0478 mm