Behavior of flank wear during machining of alloy steel using carbide

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Abstract

Flank wear is the predominant wear that decides the economy of the machining. In this paper, Using MATLAB, the behavior of flank wear and temperature distribution is predicted by solving the analytical model proposed by Luo et al. Also, the tool wear and tool evaluation curves are described with causes of tool failure. It is found that the flank wear is increases with thrust force and temperature is increase with energy input per unit area

Key words- Flank wear, Tool life, Tool failure

1. Introduction

Carbide cutting inserts are extensively used in metal cutting industries as they provide fast cutting, better surface finish and withstand high temperature than HSS.The overall machining cost depends on many aspects like machining cost, tool cost, cost of regrinding etc. amongst this tool cost is the most influencing parameter which decides cost of machining, surface finish, and productivity. If worn tool is not identified at early stage, significantly degrade the work piece quality [1]. Therefore, tool flank wear land is often used to characterize the tool life. The first model of tool wear is proposed by F.Y.Taylor [2].it reported that, cutting velocity was the only parameter which decides the tool life. But later the effect of cutting parameters on flank wear was studies by many researchers [3, 4, 5]. various other flank wear model proposed by tool condition monitoring [6], control theory [7], neural network [8], slip line solution [9] etc. These studies have gained various degree of success in tool wear modeling but needs lots of experimental data. In recent studies tool life criteria is decided by ISO 3685 standards. The presented model is based on cutting force, cutting temperature simulation and empirical model.

2. Tool wear types

2.1 Tool definition

Tool failure occurs when it cease to function satisfactory. There are two ways to define tool life, one is based on R and D wherein tool need to replace when VB reaches 0.3 mm and crater wear reaches 0.15mm. While in industry it is the length of time of satisfactory service. Or amount of acceptable output provided by fresh tool.

2.2 Criteria of tool failure

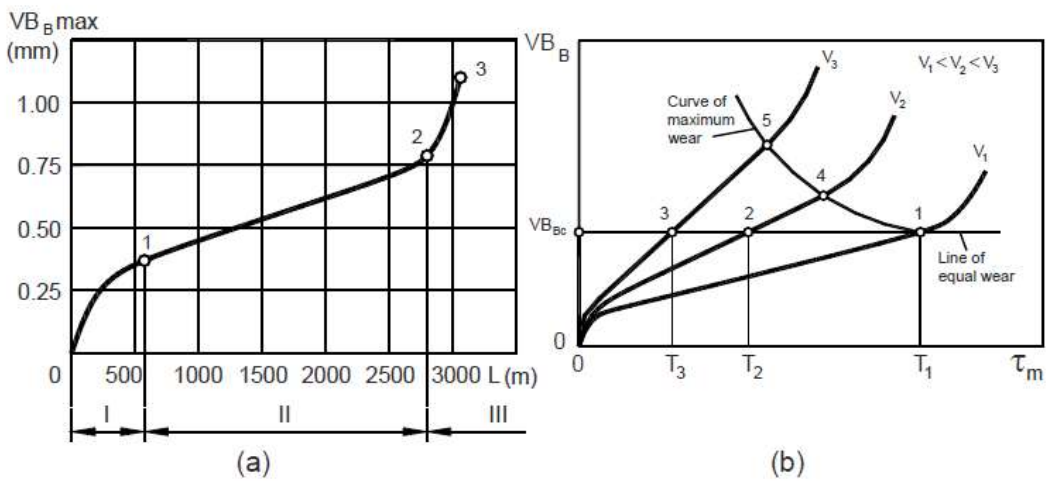
There are various ways in which one can ascertained the tool is worn out. These are as follows,

1. Total tool destruction/breakdown
2. Temperature failure
3. Increased feed
4. Poor surface finish

5. Increased noise level
6. Chipping of tool
7. Formation of crack

2.3 Tool wear evaluation

Tool wear curves illustrate the relationship between the amounts of flank (rake)Wear and the cutting time, Tm, or the overall length of the cutting path, L [10] as shown in fig (1).in this curve there are three regions (1) initial tool wear (2) region of steady state wear (3) accelerated wear region. Accelerated tool wear generally accompanied by high cutting forces, temperature and severe tool vibration. When the amount of wear reaches the permissible tool wear VBbc, the tool is said to be worn out. When the integrity of the machined surface permits, the curve of maximum wear instead of the line of equal wear should be used



Fig(1) wear curves (a) normal wear curve (b) flank wear land [10]

2.4 Types of wear on cutting tool

Following are the types of typical tool wear during metal machining were observed. These are 1. flank wear 2. Crater wear 3. plastic deformation 4. notch wear 5. thermal cracking 6. mechanical fatigue cracking 7. Chipping 8. Fracture 9. built up edge (BUE)

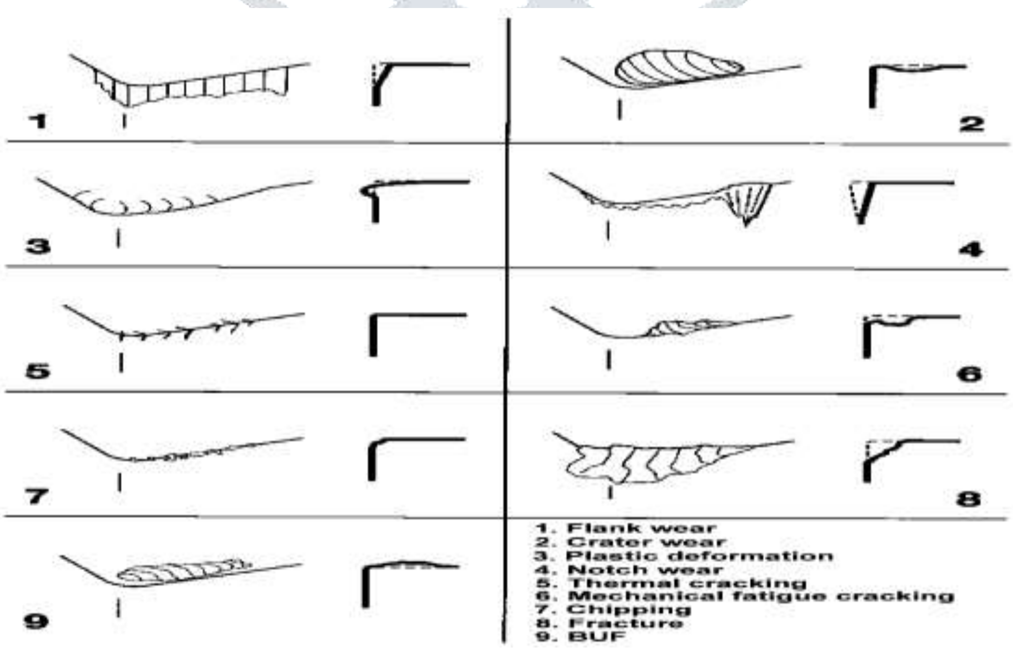


Fig (2) Types wear on cutting tools (adapted from Sandvik®)

3. Flank wear analysis

We solved and try to predict the behavior of flank wear and temperature distribution as a function of energy through MATLAB, the equation proposed by Luo et al[1]. From the above conditions, Merchant force diagram is applicable to calculate various forces involved in metal cutting as shown in Fig 3.

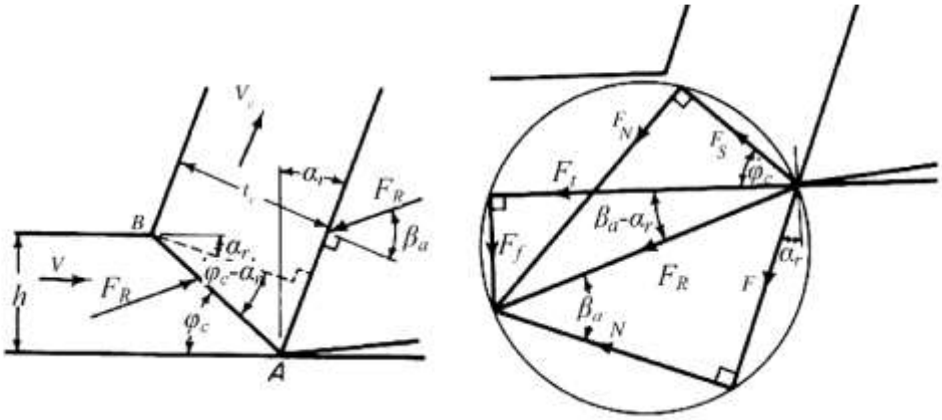


Fig (3) The diagram of cutting forces[1]

From merchant force diagram cutting force (Fc, here is Ft) and Thrust force (Ft, here is Ff) is calculated from the following equations. The vibration will change the uncut chip thickness (h) and width of cut (w)

$$F_c = w(t)t_{1(t)}\left[\frac{Cos(\beta-\alpha)}{Sin\emptyset\,\cos(\emptyset+\beta-\alpha)}\,\tau_s\right] \text{ ------- (1)}$$

$$F_t = w(t)t_{1(t)}\left[\frac{Sin(\beta-\alpha)}{Sin\emptyset\,\cos(\emptyset+\beta-\alpha)}\,\tau_s\right] \text{--------- (2)}$$

Due to the interaction between tool and work piece generate heat by considering elliptical heat source with uniform flux distribution as

$$\Delta T_{f} = \frac{2qa_i}{K1\sqrt{\pi(1.273S_e+P_{e1}}} \text{ -----------(3)}$$

Where q =rate of heat supply per unit area

a_i=flank work piece contact length

P_{e1} = Peclet number of workpiece

Tool flank wear model is presented by considering both phenomenon i.e. abrasion wear and diffusion wear to predict flank wear model.it is expressed as

$$\frac{dw}{dt} = \frac{AF_tV_s}{HVf} + Bexp\left(\frac{-E}{RT_f}\right) - - - - (4)$$

4. Result and Discussion

Matlab programing is used to predict the temperature rise at tool flank face and flank wear.it is found that heat input per unit area is influencing parameter to temperature rise and thrust force is mostly affecting flank wear.

1. Flank wear estimation curve

A=0.00078

7.8000e-04

>> Ft=[165,195,225,255];

>> Vs=100.84;

>> H=30;

>> V=98.91;

>> f=0.3175;

>> W=A*Vs*Ff/(H*V*f)

W= [13.78 16.27 18.78 21.28]

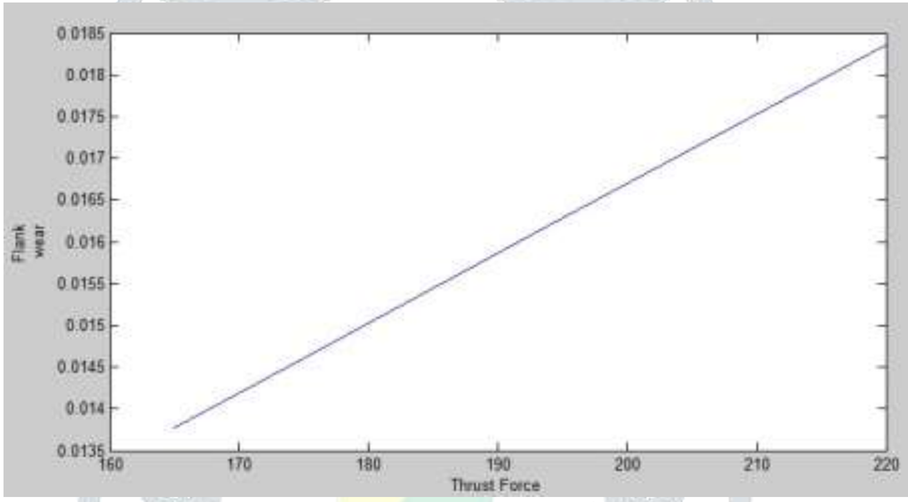


Fig5. Flank wear land width against thrust force (f=0.1375 mm/rev)

2. Temperature rise estimation

ai=6.2e-6;

>> q=[2099212598,2232614173,2440299213,2751826772]

>> Tf=(2*q*ai/(268.41))+28

Tf =397.9794 404.1423 413.7369 428.1288

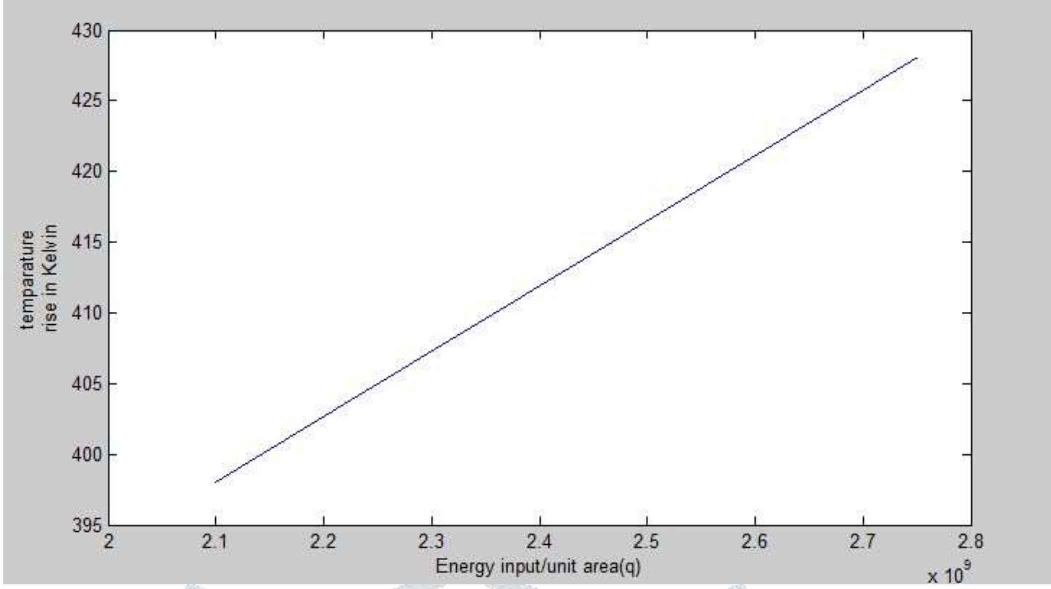


Fig 6. Temperature rise against energy input per unit area

5. Conclusions

It is found that flank wear rate increases with thrust force. Temperature rise at the tool flank face is within the limit with the selected cutting parameters. The effect of temperature in diffusion along tool flank face is negligible. It is concluded that the flank wear is prominently due to abrasion wear and temperature rise at work flank will not contribute any effect on flank wear.

References

1. Luo, X., K. Cheng, R. Holt, and X. Liu. "Modeling flank wear of carbide tool insert in metal cutting." Wear 259, no. 7-12 (2005): 1235-1240

2. El Wardany, T. I., and M. A. Elbestawi. "Prediction of tool failure rate in turning hardened steels." The International Journal of Advanced Manufacturing Technology 13, no. 1 (1997): 1-16

3. Cui, Xiaobin, Jun Zhao, and Yongwang Dong. "The effects of cutting parameters on tool life and wear mechanisms of CBN tool in high-speed face milling of hardened steel." The International Journal of Advanced Manufacturing Technology 66, no. 5-8 (2013): 955-964.

4. Hasan, S., and S. Thamizhmanii. "Tool flank wear analyses on AISI 440 C martensitic stainless steel by turning." International Journal of Material Forming 3, no. 1 (2010): 427-430.

5. Koren, Yoram, Tsu-Ren Ko, A. Galip Ulsoy, and Kourosh Danai. "Flank wear estimation under varying cutting conditions." Journal of dynamic systems, measurement, and control 113, no. 2 (1991): 300-307.

6. Siddhpura, A., and R. Paurobally. "A review of flank wear prediction methods for tool condition monitoring in a turning process." The International Journal of Advanced Manufacturing Technology 65, no. 1-4 (2013): 371-393.

7. Koren, Yoram. "Flank wear model of cutting tools using control theory." Journal of Engineering for Industry 100, no. 1 (1978): 103-109.

8. Özel, Tugrul, and Abhijit Nadgir. "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 Manufacture 42, no. 2 (2002): 287-297

9. Shi, T., and S. Ramalingam. "Slip-line solution for orthogonal cutting with a chip breaker and flank wear." International Journal of Mechanical Sciences 33, no. 9 (1991): 689-704

10 Astakhov, Viktor P., and João Paulo Davim. "Tools (geometry and material) and tool wear." In Machining, pp. 29-57. Springer, London, 2008