Research Paper Engineering

Monitoring of Tool Wear Through Force Measurement in Milling Machine

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ABSTRACT

Wear of a cutting edge in milling is a complicated process that requires a reliable technique for in process monitoring and control of the cutter performance. To examine the effect of wear variation on the magnitude of the cutting force, a cutting force based set up of milling machine which is function of axial depth of cut, feed rate per tooth, specific cutting pressure of work material and instantaneous angle of rotation is made. A cutting force, which is generated during machining process, can be measured by a load cell; amplifier, data acquisition card and a computer were used to measure cutting forces. With the help of this set up the cutting forces were measured in the presence of cutting oil and inert gas and without cutting oil and inert gas at different feed on milling machine. The experimental set up was utilized to study the force signal and how it will be affected by different process parameters.

Keywords : Milling machine; Tool wear; Cutting force; Inert gas; Computer.

1. INTRODUCTION

In materials science, wear is erosion or sideways displacement of material from its “derivative” and original position on a solid surface performed by the action of another surface. Wear is related to interactions between surfaces and more specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface. There are two techniques for tool wear sensing: - direct and indirect. The direct technique includes measuring the actual wear, using radioactive analyses of the chip. Indirect technique includes measuring of cutting forces, torque, vibration, acoustic emission (stress wave energy), sound, temperature variation of the cutting tool, power or current consumption of spindle or feed motors and roughness of the machined surface. In this study, the cutting forces are used as the indicator of the tool flank wear variation. Finally a load cell based force monitoring system is constructed and force is calculated at different feed, rpm and different environmental condition with the help of this force wear is calculated .The results were plotted at various cutting conditions.

2. CUTTING FORCES IN MILLING MACHINE

3. In milling process, there are two components of cutting force on each tooth; the tangential and radial components. For steady cutting, the estimated tangential, radial forces acting on a single cutting straight edge can be obtained as follows [1]

$F_t = K_s\ a\ S_t\ Sinq + a\ C_w\ VB$

$F_R = R_1\ Ks\ a\ S_t\ Sinq + R_2\ a\ C_w\ VB$

$$\cos\theta = 1 - \frac{2a_e}{d_t}$$

Where,

(Ft) Tangential force (N).

(F_R) Radial force (N)

(R_1 and R_2) are force ratio constants

(a) Is the axial depth of cut (mm)

(S_t)Is the feed rate per tooth (mm/tooth)

(d_t)Is the diameter of the cutter (mm)

(V_B) Is the flank wear width (mm/day)

(C_w) Is the edge force constant (N/mm^2)

(a_e) Is the working engagement

(q) Is the instantaneous angle of rotation (deg.)

(Ks) Is the specific cutting pressure of work piece material (N/mm^2)

3. EXPERIMENTATION

To determine the nature of the effect of wear on the individual cutting force harmonics; the cutting parameters used in the simulation are as follows:-

Ks = 5300 N/mm^2, C_W =150 N/mm^2,

St = VF/Z rpm, a =0.5, 1 mm, Z = 4,

VF = 28, 42mm/min, R1=0.5, R2 = 1.0, Cutting speed =160,250,320rpm

Figure 3.1 Experimental setup using load cell

Figure 3.2 Experimental setup using load cell

Figure 3.3 Experimental setup with N_2 gas

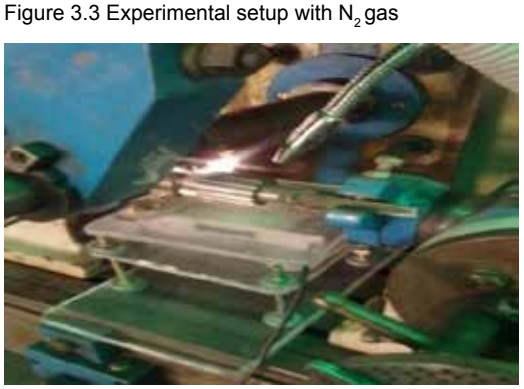


Figure 3.4 Experimental setup with cutting oil

4. RESULTS & DISCUSSION

The results were plotted at various cutting conditions in the force and wear domains. Figs. show the variation on the cutting force with wear under different cutting speed, different no. of teeth cutter and different

Process parameters.

Wear in normal condition
Wear in cutting oil condition
Wear in inert gas condition

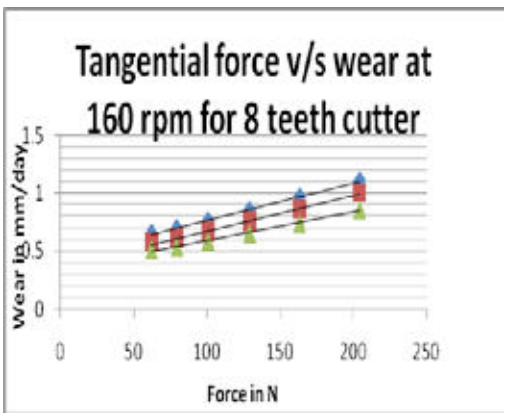


Figure 4.1 Tangential force v/s wears at 160 rpm

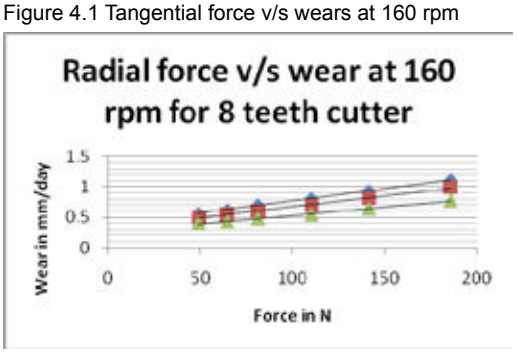


Figure 4.1 Radial force v/s wears at 160 rpm

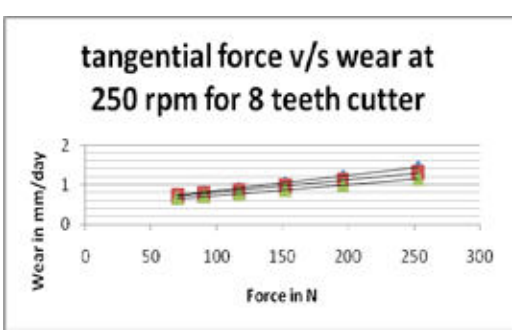


Figure 4.3 Tangential force v/s wears at 250 rpm

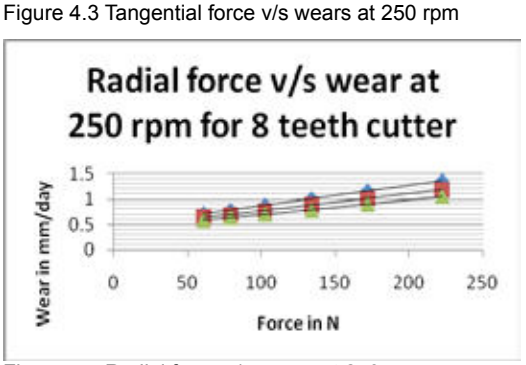
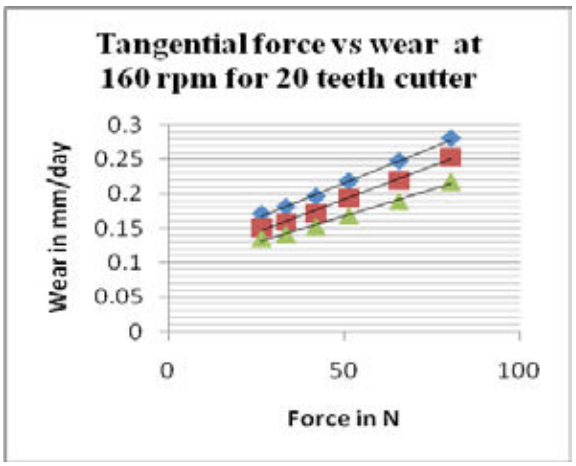


Figure 4.4 Radial force v/s wears at 250 rpm



Wear in normal condition
Wear in cutting oil condition
Wear in inert gas condition

Figure 4.5 Tangential force v/s wear at 160 rpm

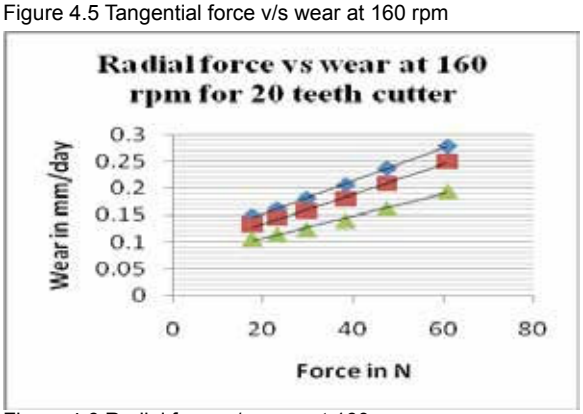


Figure 4.6 Radial force v/s wear at 160 rpm

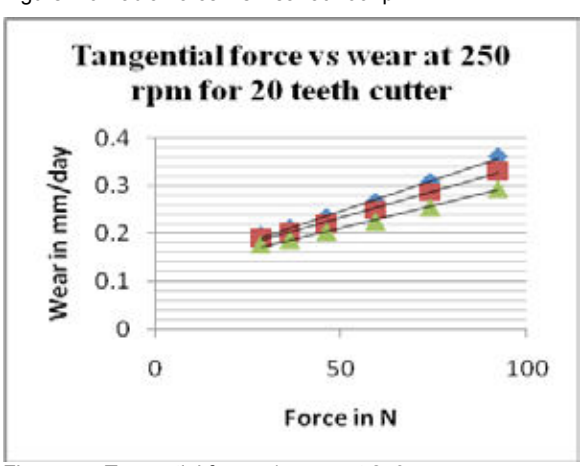


Figure 4.7 Tangential force v/s wear at 250 rpm

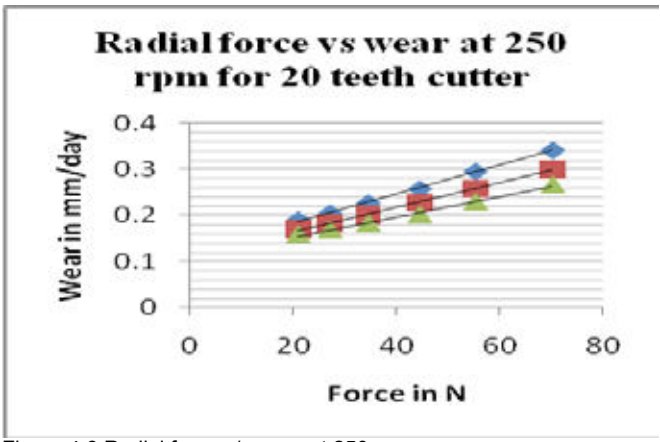


Figure 4.8 Radial force v/s wear at 250 rpm

CONCLUSIONS

This paper has presented the strategy for monitoring the amount of wear and interrelationships between Cutting force and variation and tool wear. Force increase significantly with the increase in wear. From the above result wear at different feed is more in normal atmospheric condition and less in the present of inert gas condition(due to reduction of tool oxidation) and intermediate in cutting oil condition. In this paper wear is also measured in an off line manner and compared with the calculated wear.

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