ANALYSIS OF TOOL WEAR IN TURNING OPERATION OF ALUMINIUM

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ABSTRACT
The present work is the representation of the research work carried out by the authors to analyze tool wear in turning operation of Aluminium.. The objectives of the research was to specify specific speed, feed, depth of cut which results least tool wear while working with aluminium part & HSS tool. Also to find out the maximum & minimum wear occurring on HSS tool at different cutting speeds.

INTRODUCTION
The turning operation is one of the main operations used in machining of different parts. Mainly single point cutting tool is used in the turning operation. For this purpose, variety of cutting tools available in the market. These tools have different geometry and different materials to machine a variety of metals and alloys. Aluminium is widely used in the automotive construction and aerospace industries. It also finds application in different because of intrinsic properties of lightness and corrosion resistance. Cutting tools are subjected to an extremely severe rubbing process. They are in metal-to-metal contact, between the chip and work piece, under conditions of very high stress at high temperature. The situation is further aggravated due to the existence of extreme stress and temperature gradients near the surface of the tool. During cutting, cutting tools remove the material from the component to achieve the required shape, dimension and finish. However, wears are occurring during the cutting action, and it will result in the failure of the cutting tool. When the tool wear reach certain extent, the tool or edge change has to be replaced to guarantee the ordinary cutting action.

EFFECT OF TOOL WEAR ON TECHNOLOGICAL PERFORMANCE:
CONSEQUENCES OF TOOL WEAR
- Decrease the dimension accuracy;
- Increase the surface roughness;
- Increase the cutting force;
- Increase the temperature;
- Likely cause vibration;
- Lower the production efficiency, component quality;
- Increase the cost.

INFLUENCE ON CUTTING FORCES
Flank wear (or wear-land formation) and chipping of the cutting edge affect the performance of the cutting tool in various ways. The cutting forces are normally increased by wear of the tool. Crater wear may, however, under certain circumstances, reduce forces by effectively increasing the rake angle of the tool. Clearance-face (flank or wear-land) wear and chipping almost invariably increase the cutting forces due to increased rubbing forces.

SURFACE FINISH (ROUGHNESS)
The surface finish produced in a machining operation usually deteriorates as the tool wears. This is particularly true of a tool worn by chipping and generally the case for a tool with flank-land wear although there are circumstances in which a wear land may burnish (polish) the work piece and produces a good finish.

DIMENSION ACCURACY
Flank wear influences the plan geometry of a tool this may affect the dimensions of the component produced

in a machine with set cutting tool position or it may influence the shape of the components produced in an operation utilizing a form tool.

VIBRATION OR CHATTER

The vibration is another aspect of the cutting process which may be influenced by flank wear. A wear land increases the tendency of a tool to dynamic instability. A cutting operation which is quite free of vibration when the tool is sharp may be subjected to an unacceptable chatter mode when the tool wears.

LITERATURE REVIEW

The review of existing literature has provided the base for problem identification and also gave direction for further research work. The present study is carried out for different cutting parameters & its effects on machining of aluminium parts. The primary & secondary force which causes tool wear is analyzed. A number of tests are performed with different cutting speed and feed rates. Cutting forces and tool wear is measured from these experiments. This data will be assistive in analyzing cutting process. Various graphs of cutting forces Vs cutting speed and tool wear Vs cutting speed are premeditated and these graphs display the fluctuation of tool wear and cutting forces. Further SEM tests are taken to notice the tool wear surface of the carbide tool.

EXPERIMENTATION

Experiments were carried out on a turning lathe. A high speed steel turning tool was clamped in a two component strain gauge dynamometer using a tool holder. For the experimentation, Aluminium work piece of 100mm length was held in a three – jaw chuck. Tool height and tool overhang was set to the required level with the help of gauges. A rough turning pass was made initially to eliminate the run out of the work piece. The output flank wear was measured with the help of a Tool Maker's Microscope.

EXPERIMENTAL PROCEDURE

The experiments were made on the HMT LT-20 lathe using a bar turning process under dry conditions. For the range of cutting conditions (cutting speed, feed, and depth of cut) it was required to measure the force components Fx, Fy and Fz, and flank wear. A total of sixteen experiments were carried out, all with the same basic configuration and HSS cutting tools were replaced after performing a single test. The depth of cut is kept same in all experiments.

WORK MATERIAL

The Aluminium was chosen for the present investigation with a diameter of 25 mm and 100 mm length.

Fig. 1. Aluminium bar work-piece

Fig. 2. Cutting Tool

TOOL MATERIAL

The tool material used should be capable of high speed machining with dry cutting conditions. In present investigation HSS cutting tool were used for performing the experiments.

TOOL GEOMETRIES

a) Tool size: 9.5 × 9.5 mm

b) Tool length: 50 mm
c) Nose radius: 0.2 mm

METHODOLOGY

A HMT LT 20 make lathe was used for turning experiment. The dynamometer is mounted on tool post with the help of a holder specially designed for this experimental work. Then the actual experiments have been carried out with the different input cutting conditions for different experiments for constant volume of material removal in each case.

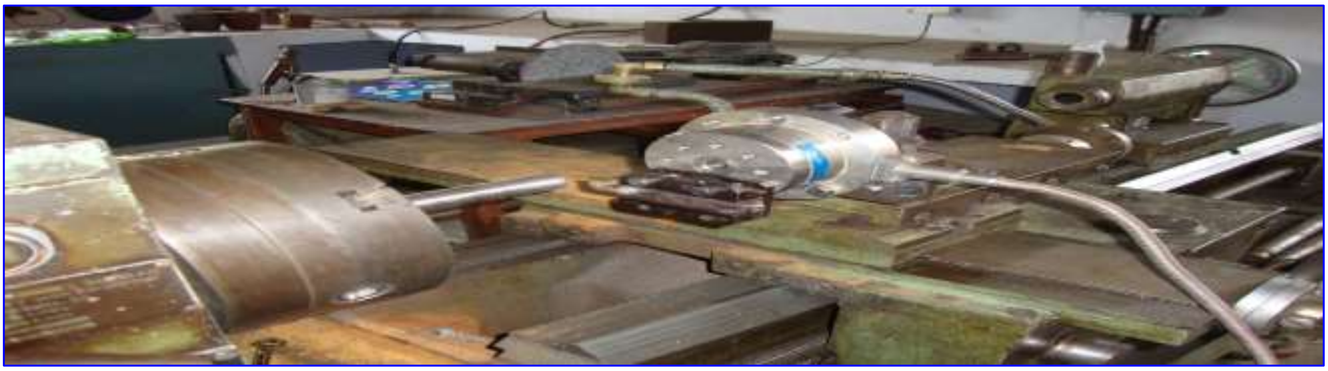

Fig. 3. Machine Setup

The experiments carried out are summarized as:

1. Carry out experiment on lathe machine using Aluminium as work piece and HSS turning Tool.
2. Machining is done with different sets of Cutting speed, depth of cut, & feed rates.
3. Measuring the cutting forces with dynamometer.
4. Measuring the flank wear of the HSS tool with microscope.
5. Observing the wear trends in SEM.

The flank wear is measured and value of cutting forces is given by dynamometer. These values of flank wear and cutting forces are plotted against cutting speed to obtain the wear trends.

RESULTS AND DISCUSSION

The present problem that is Analysis of tool wear in turning operation of Aluminium have been developed in accordance with the previously developed models for tool wear [1], [3] and [5]. The number of experiments has been conducted to find out the cutting forces and flank wear of the tool, made of HSS tool, at varying machining parameters, which are cutting speed (v), cutting feed (f) and keeping depth of cut (d) constant. Using this data various graphs are plotted and analyzed. Also cutting tool wear behavior is observed using SEM after various cuts.

MACHINING PARAMETERS USED FOR EXPERIMENTATION

Table 1: Cutting parameters

Cutting speed v (rpm) (Range)	Feed f (mm/rev) (Range)	Depth of cut d (mm) (Range)
198,295,431,634	0.05,0.11,0.22,0.45	0.4(constant)

The table 1 shows the numerical values of the various machining parameters (cutting speed, feed and the depth of cut), that have been selected for experimentation, for the measurement of cutting forces and flank wear. The Aluminium work-piece material has been used for experimentation**.** The cutting material used is High speed steel tool.

The table 2 shows the experimental values of wear, and cutting forces for different speed, feed and depth of cuts for the different set of experiments conducted on the HSS cutting tool. Total 16 experiments were conducted and depth of cut is kept constant in all the experiments. To eliminate the effect of wear on the experiments, the tools have been replaced after every cut of constant volume of work-piece material. In total 16 HSS cutting tool have been used for all the different set of experiments to be conducted. Tool edge has been made straight or parallel to the chuck to have an orthogonal cut. The experiments were conducted for constant volume. Constant volume signifies that equal amount of material was removed in all the different sets of experiment conducted. This has been done so that all the measurements should be taken correctly at the same operating conditions to have a good accuracy in results with minimum possible error.

Table 2: Experimental Results of measured parameters against parameters V, f and d

Sr. No.	Cutting Speed v (rpm)	Feed f (mm/rev)	Depth of cut d (mm)	Fx (N)	Fz (N)	Flank Wear(μm)
1	198	0.05	0.4	19.6	14.7	0
2	198	0.11	0.4	24.5	19.6	28
3	198	0.22	0.4	34.3	29.4	0
4	198	0.45	0.4	14.7	9.8	96
5	295	0.05	0.4	39.2	24.5	23.6
6	295	0.11	0.4	107.9	49	72.5
7	295	0.22	0.4	68.2	53.9	8.5
8	295	0.45	0.4	39.2	63.7	52.4
9	431	0.05	0.4	29.4	9.8	45.2
10	431	0.11	0.4	19.6	24.5	62.5
11	431	0.22	0.4	14.7	19.6	26.5
12	431	0.45	0.4	49	78.5	83
13	634	0.05	0.4	44.1	24.5	65
14	634	0.11	0.4	24.5	39.2	43
15	634	0.22	0.4	63.7	68.6	92
16	634	0.45	0.4	53.9	58.6	55.4

Fig 4. Work- piece after machining

Fig 5. HSS tools after machining

VALIDATION

In order to check the validity of the results various graphs are plotted between Cutting Speed and Force components (Fx and Fz) and between Cutting Speed and Flank Wear. These plots are compared with the results given by Thamizhmanii S. [1], for checking the validity of results. The results from the reference are well in accordance with the results of the present work.

VARIATION OF VARIOUS FORCES WITH CUTTING SPEED

Fig. 6.1 to 6.4 shows the variation of forces with cutting speed.

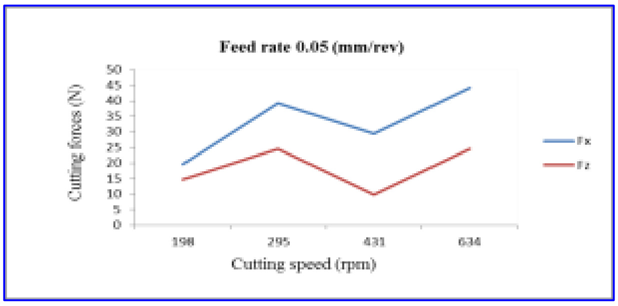

Fig. 6.1 Cutting Speed Vs Forces at 0.05Feed

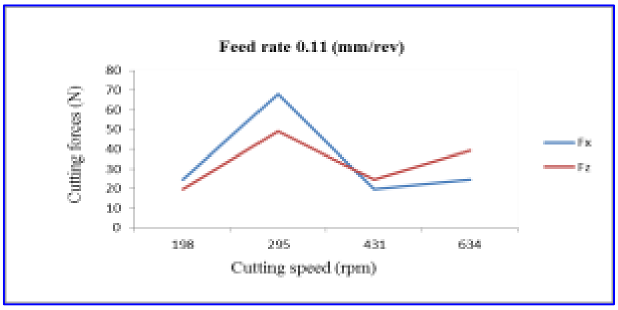

Fig. 6.2 Cutting Speed Vs Forces at 0.11 Feed

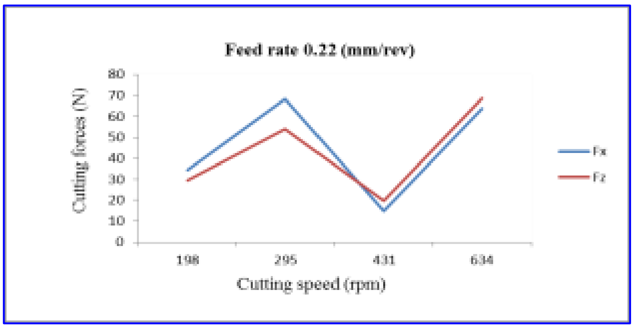

Fig. 6.3 Cutting Speed Vs Forces at 0.22 Feed

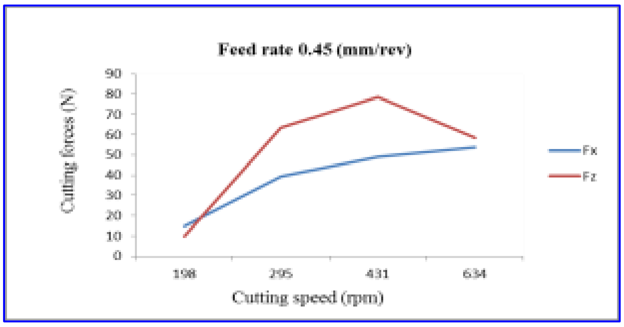

Fig. 6.4 Cutting Speed Vs Forces at 0.45 Feed

VARIATION OF FLANK WEAR WITH CUTTING SPEED

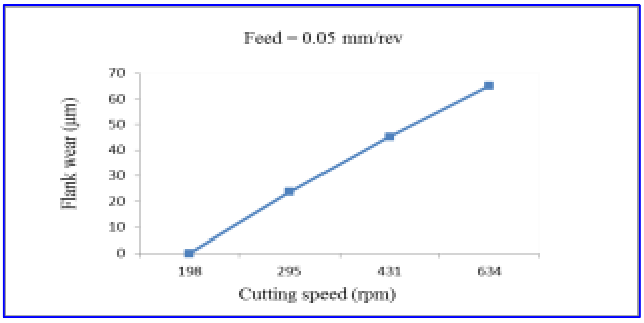

Fig. 6.5 Cutting Speed Vs Flank Wear at 0.05 Feed

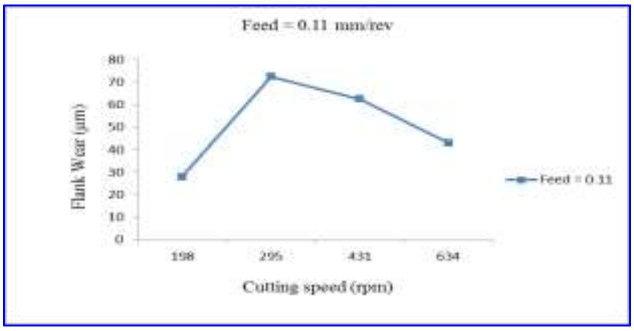

Fig. 6.6 Cutting Speed Vs Flank Wear at 0.11 Feed

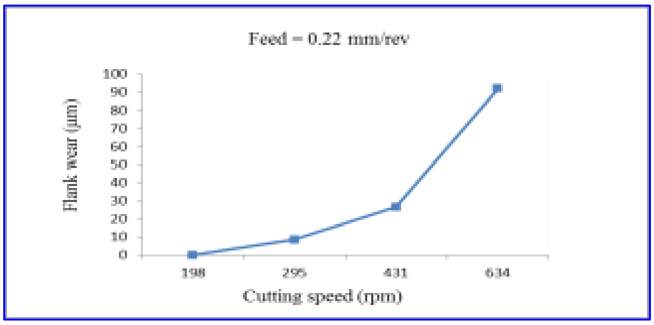

Fig. 6.7 Cutting Speed Vs Flank Wear at 0.22 Feed

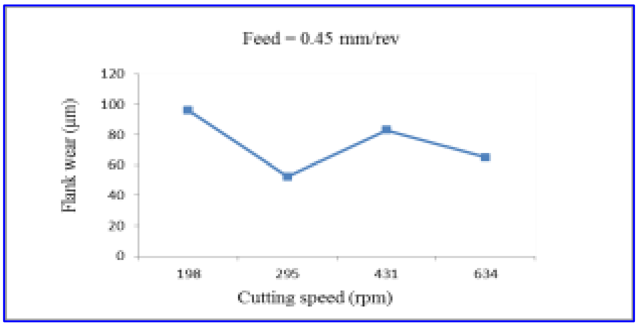

Fig. 6.8 Cutting Speed Vs Flank Wear at 0.45 Feed

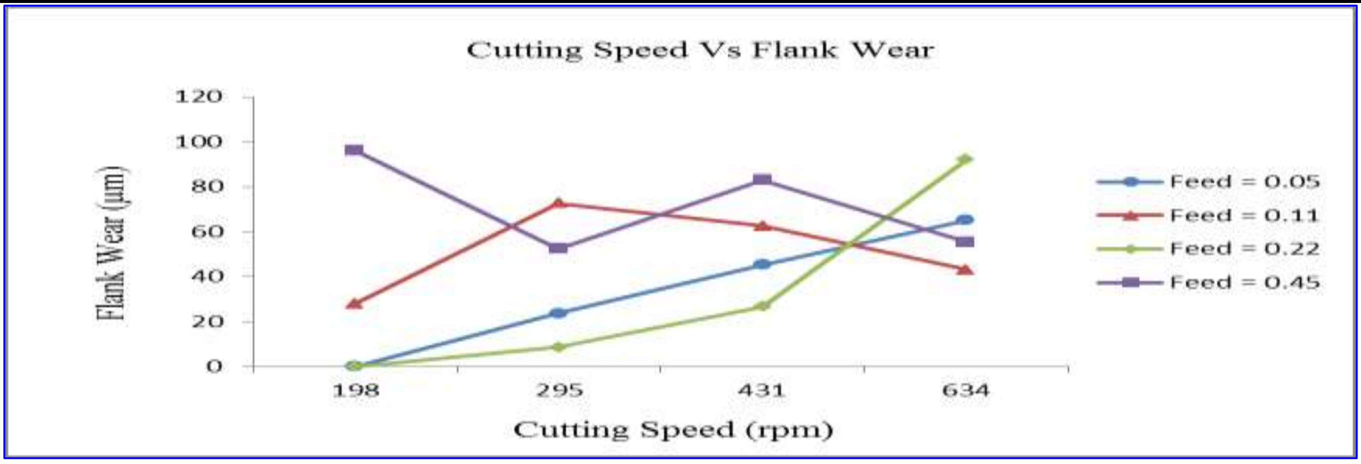

Fig. 6.9 Variation of Flank Wear with Cutting Speed

RESULTS AND DISCUSSIONS

CUTTING FORCES

There are two cutting forces which are acting on a single point tool in orthogonal cutting (Fx and Fz)**.** The Fx is the feed force which is acting on the X direction and Fz is the cutting force acting on the Z direction. The cutting forces were measured using 3 component dynamometer (Force measurement dynamometer). The figures above show the various cutting forces measured during turning. The cutting force Fz was low when cutting at feed of 0.05 and 0.11 and at cutting speed 198 and 431 rpm whereas the feed force Fx is low at the start and increased when the cutting speed increased. The feed force Fx and cutting force Fz is maximum at 295 and 431rpm cutting speed.

TOOL WEAR (FLANK WEAR)

The flank wear is a widely used criterion for evaluating tool life because of its importance in most applications. Flank wear is produced mainly due to abrasive wear of the cutting edge against the machined surface. The flank wear in this experiment was not present when machining at 198 rpm cutting speed and at 0.05 mm / rev feed, then increased to 65µm at 634 rpm speed having same feed rate. But flank wear 96 µm observed at speed 198 rpm having feed of 0.45 mm/rev. In other experiments, the flank wear was less than 150µm**.** Fig. 6.10 show flank wear at 634 rpm and 0.22 mm/rev feed and fig. 6.11 shows flank wear at 295 rpm and 0.45 mm/rev feed. The two main effects are responsible for tool wear are oxidation of the tool and inter diffusion of the constituting elements between tool and workpiece. Fig. 6.9 shows flank wear surface at 431 rpm and 0.05 mm/rev feed. Hard particles plough grooves into the cutting tool material. Excessive notch wear affects surface finish and weakens the cutting edge. Fig. 6.13 shows notch wear at 198 rpm and 0.45 mm/rev feed rate

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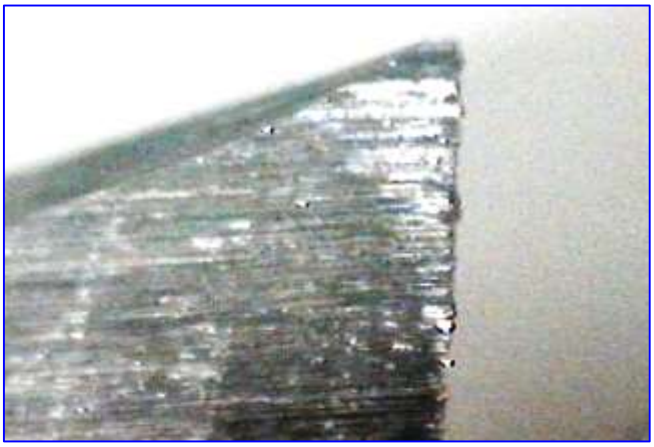
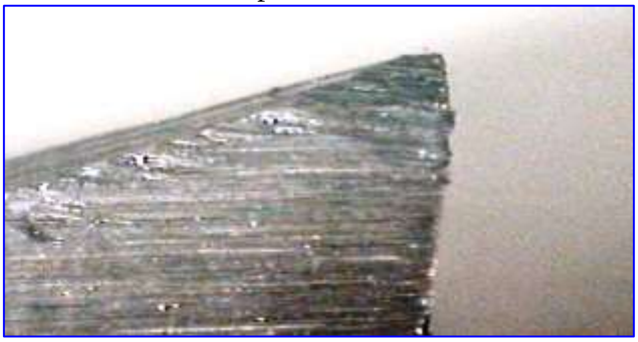


Fig. 6.10 Micrograph shows Flank Wear at 634 rpm and 0.22 mm/rev feed

Fig. 6.11 Micrograph shows Flank Wear at 295 rpm and 0.45 mm/rev feed



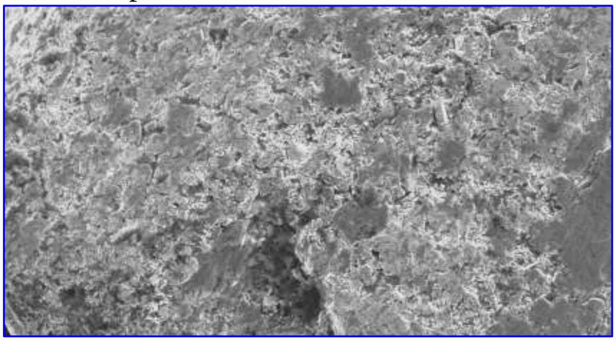


Fig. 6.12 Micrograph shows Flank Wear at 431 rpm and 0.05 mm/rev feed

Fig. 6.13 Micrograph shows Notch Wear at 198 rpm and 0.45 mm/rev feed

CONCLUSION

Based on the results presented in previous sections, the following conclusions have been observed:

1) The cutting forces have significantly less value at the cutting speed of 431 rpm for all feed rates except the feed rate of 0.45 mm/rev.
2) The tangential feed force Fx at 0.45 mm/rev shows an increasing trend at different cutting speeds.
3) The flank wear at feed rate 0.05 mm/rev and 0.22 mm/rev is zero at low cutting speed.
4) Maximum flank wear 96 µm observed at speed 198 rpm having feed rate of 0.45 mm /rev.
5) The flank wear at feed rate 0.05 mm/rev and 0.22 mm/rev shows an increasing trend.
6) Flank wear at feed rate 0.11 mm/rev and cutting speed 295 rpm is maximum and shows a decreasing trend.

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