# EFFECT OF WEAR ON TOOL LIFE AND TOOL FAILURE

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*Abstract*

***Tool wear is loss of material on asperity or micro-contact, or smaller scale, down to molecular or atomic removal mechanisms. It usually progresses continuously. Tool wear describes the gradual failure of cutting tools due to regular operation. It is a term often associated with tipped tools, tool bits, or drill bit that is used with machine tools. Some general effects of tool wear include increased cutting forces; increased cutting temperatures, poor surface finish, and decreased accuracy of finished part may lead to tool breakage.***

*Keywords -* ***Wear, Tool life, Drill bit, Temperature, Accuracy.***

## 1. Introduction

Tool life is an important parameter in evaluating the performance of the cutting tools. Tool wear affects dimensions and surface quality of the work piece and it is also one of the important criteria in determining tool life. When the tool reaches the tool wear criterion, the cutting edge fails and cannot be used further. Machining studies have been conducted on hard granite stones. Tool wear is generally a gradual process, like the wear of the tip of an ordinary pencil, rate of tool wear depends on tool and work piece material, tool shape, cutting fluids and process parameters. Tool life can be defined as the time interval in which the tool works satisfactorily between two successive grindings. Experimental set up- A model is designed to get high quality surface finish by taking the process parameters like cutting speed, feed, depth of cut, coolants. As a part of this the power consumption, surface finish, temperature, tool wear are measured.

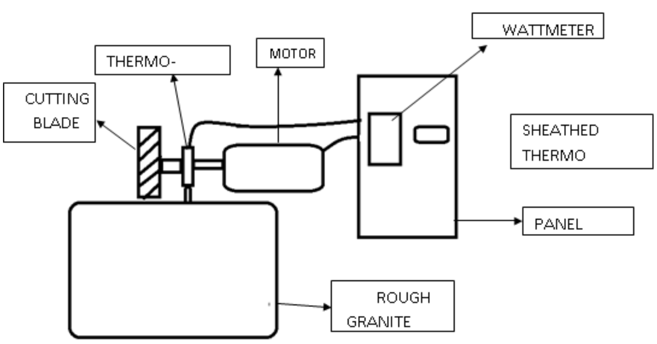


Figure 1: Showing line diagram of experimental setup

In experimental setup as shown in figure 4.1, the block is placed on the moving trolley which is driven by 15HP motor. The power was displayed in the wattmeter. The temperature at the cutting zone was measured by a sheathed thermo-couple. The thermo-couple of the two wires were arranged in between the two cut strips at the end of the block. Tool wear was measured by Vernier calipers before consumed and after consumed. The surface roughness was measured by portable surface roughness meter individually. The viscosity of the cutting fluids was measured by redwood viscometer.

**Description** - There are three common ways of expressing tool life:

1. As time period in minutes between two successive grindings.
2. In terms of number of components machined between two successive grindings. This mode is commonly used when the tool operates continuously, as in case of automatic machines.
3. In terms of the volume of material removed between two successive grindings. This mode of expression is commonly used when the tool is primarily used for heavy stock removal, formulated.

This method of assessing the tool life in terms of the volume of material removed per unit time is a practical one and can be easily applied as follows:

Volume of metal removed per minute $= \prod DtfN\ m^3/min$

D = diameter of work piece in m

t= depth of cut in m

f= feed rate in m/rev

N= No. of revolutions of work per minute.

If 'T' be the tool failure in minutes,

Therefore, tool life (TL) in terms of the total volume of the metal removed to tool failure is given by:

$$TL = (Vx1000xtxT)\ mm^3$$

Taylor's equation

The tool life TL in terms of cutting speed is

$$TL = VT^n = C$$

Where,

V= cutting speed m/min

d = depth of cut is in meters,

f = feed m/min

T = Tool life

n = index (depends on tool material, machine conditions, operational conditions and raw material. During the operation, a cutting tool may fail due to one or more of the following reasons a) Thermal cracking and softening, b) Mechanical chipping and c) Gradual wear.

## 2. Experimental Analysis

Table1.Average process parameters

| Sl. No | Viscosity of Coolant | Length of piece ( m) | Machining time (min) | Depth of cut (m) | Feed rate (m/min) | Power (kW) | Temperature (°C) | Surface roughness (Ra) (μm) | Tool wear (mm) | Experimental Tool life (min) | Predicted Tool life (min) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Water (1.00) | 1.06 | 12.85 | 0.30 | 0.0824 | 1.86 | 437 | 6.20 | 0.029 | 8862 | 8862 |
| 2 | Water + Oil (1.35) | 1.08 | 12.10 | 0.30 | 0.0892 | 1.86 | 421 | 5.10 | 0.023 | 11051 | 10521 |
| 3 | Water + Nirma (1.80) | 1.10 | 10.15 | 0.30 | 0.1084 | 1.78 | 417 | 4.15 | 0.017 | 12125 | 11941 |
| 4 | Water + ETA (1.40) | 1.08 | 11.95 | 0.30 | 0.0903 | 1.74 | 420 | 5.14 | 0.021 | 11380 | 11321 |
| 5 | Water + Surf Excel (1.85) | 1.10 | 10.05 | 0.30 | 0.1094 | 1.60 | 416 | 4.10 | 0.016 | 12563 | 12348 |
| 6 | Kerosene (2.20) | 1.10 | 9.25 | 0.30 | 0.1189 | 1.44 | 416 | 4.10 | 0.014 | 13214 | 13511 |
| 7 | Diesel | 1.06 | 9.15 | 0.30 | 0.1158 | 1.33 | 402 | 4.05 | 0.012 | 15250 | 16395 |

### 2.1 Model calculation:

For 1.35 diameter blade, water as coolant Average machining time=12.85min,

Depth of cut (d) = 0.30m, Average feed rate (f) = 0.0824 m/min

Average tool wear = 0.029mm

**Experimental tool life:**

Thickness of diamond segment = 20 mm Average tool wear = 0.029mm

Average machining time = 12.85 min

Total time taken for diamond wear is the tool life

$$= (12.85\ X\ 20)/0.029 = 8862\text{min}$$

**Predicted tool life**:

Modified Taylor's equation is given as $(V.\ d.\ f.\ T^{n})/R = C$

V= velocity (m/min) d= depth of cut (m)

f = feed rate (m/min) T= tool life (min)

R= viscosity ratio = (viscosity of coolant / viscosity of water)

n = index depends on material, machine cutting tool and cutting conditions. (Taking n=1).

C = constant

To determine the unknown constant C, predetermined tool life (experimental) is to be used

Experimental tool life = Predicted tool life = 8862 min

Velocity of blade = Π DN

D – Diameter of blade = 1.35 m, blade = 410 rpm

V= Π X 1.35 X 410 = 1739 m/min

Constant C = (1739 X 0.30 X 0.0824 X 8862) = 380960.365

Therefore the formulae for tool life is

Experimental tool life = (machining time X thickness of blade)/tool wear

= (12.1 X 0.2)/ 0.023 = 10521 min

Predicted tool life = (constant X R) /v.d.f

= (38060.365 X 1.35)/(1739 X 0.3X 0.0892) = 11051 min

Example: for (water + cutting oil), 1.35 diameter blade

The average machining time=12.10min.The average depth of cut (d)=0.30m

Feed rate (f) = 0.0892 m/min

The average tool wear = 0.029 mm

R= (viscosity of cutting oil / viscosity of water) = 1.35/1 = 1.35

From the above Experimental Results, it is observed that

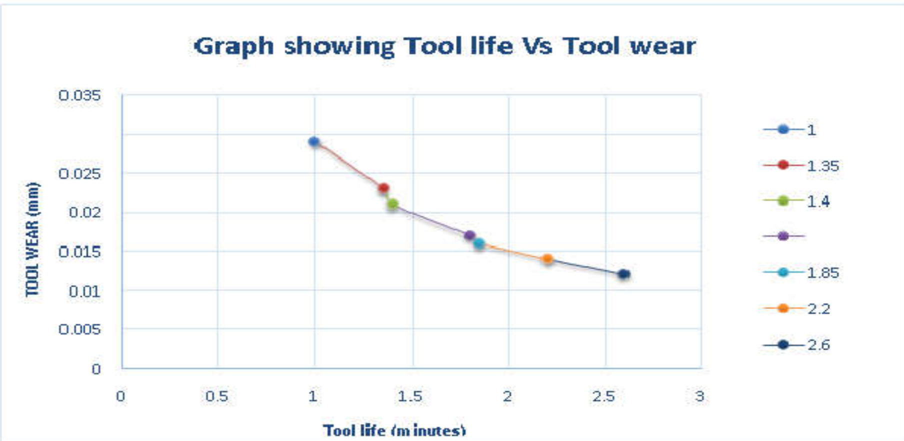


Figure1. Tools wear vs Tool life

## 3. Results and Discussion

The average tool wear is 0.029mm, the coolant is water 0.023 mm if the coolant is (water + cutting oil) 0.017mm the coolant is (water + nirma washing powder), 0.021 mm if the coolant is (water + eta washing powder) is 0.016, if the coolant is (water + surf excel) is 0.014 mm if the coolant is kerosene, 0.012 mm if the coolant is Diesel.

## Conclusion

Tool wear effects tool life, the quality of the machine surface and its dimensional accuracy, and consequently, the economic cutting operations.

A cutting tool is properly designed and ground expected to perform tool cutting operation effectively and smoothly. If it is not giving satisfactory performance it is indicative of the tool failure and the same is reflected by the following adverse effects observed during the operation:

1. Extremely poor surface finish on the work piece.
2. Higher consumption of power.
3. Work dimensions not being produced as specified.
4. Overheating of cutting tool.
5. Appearance of a burnishing band on the work surface.

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