TOOL LIFE

Tool life indicates the amount of satisfactory performance rendered by a fresh tool or a cutting point till it is declared failed.

Tool life is defined in two ways:

(a) In R & D: *Actual machining time (period) by which a fresh cutting tool (or point)* satisfactorily works after which it needs replacement or reconditioning.

(b) In industries or shop floor: *The length of time of satisfactory service or amount of* acceptable output provided by a fresh tool prior to its failure.

Assessment of tool life

- Span of machining time in Minutes.
- Number of pieces of work machined.
- Total volume of material removed.
- Total length of cut.

Cutting tools are subjected to

(a) high localized stresses at the tip of the tool,

(b) high temperatures, especially along the rake face,

(c) sliding of the chip along the rake face, and

(d) sliding of the tool along the newly cut workpiece surface.

These conditions induce **tool wear.**

Tool wear adversely affects

- tool life,
- the quality of the machined surface and dimensional accuracy,
- the economics of cutting operations.

There are three possible modes by which a cutting tool can fail in machining:

1. **Fracture failure**. Cutting force at the tool point becomes excessive, causing it to fail suddenly by brittle fracture.

2. **Temperature failure.**
   When Cutting temperature becomes too high the material at the tool point become soft leading to plastic deformation and loss of the sharp edge

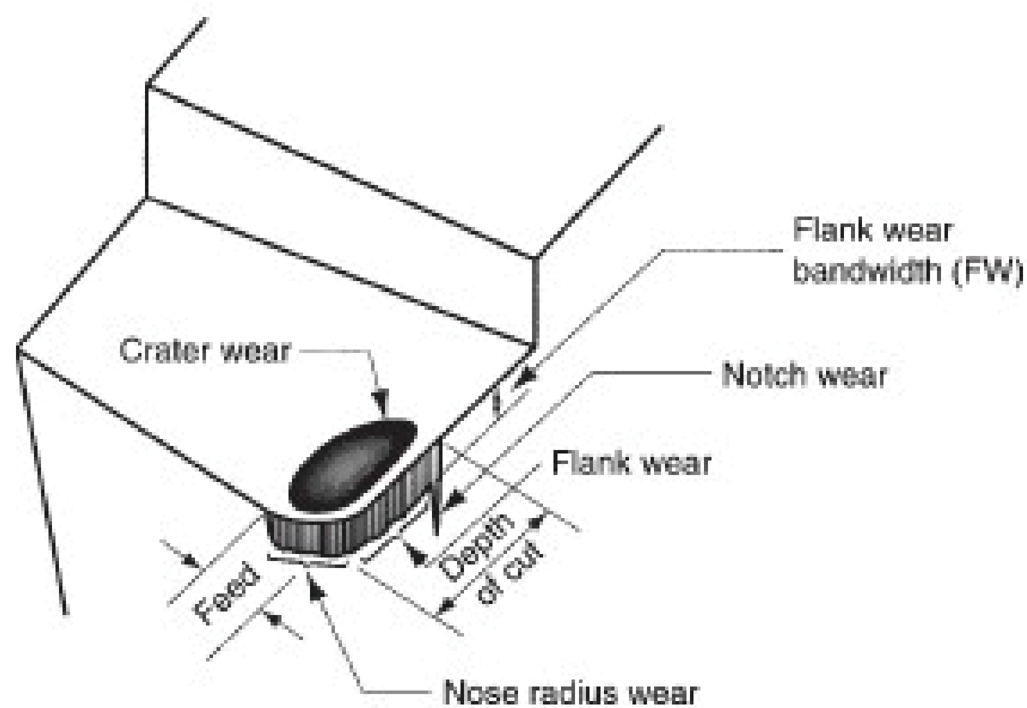
3 **Gradual wear.**
- This wear takes place gradually and causes loss of tool shape and reduction in cutting efficiency,
- wearing accelerates as the tool becomes heavily worn,
- finally tool fail in a manner similar to a temperature failure.

- Fracture and temperature failures result in premature loss of the cutting tool.
- Gradual wear is preferred over other two because it leads to the longest possible use of the tool.

Gradual wear occurs at two principal locations on a cutting tool: the **top rake face** and the **flank**.

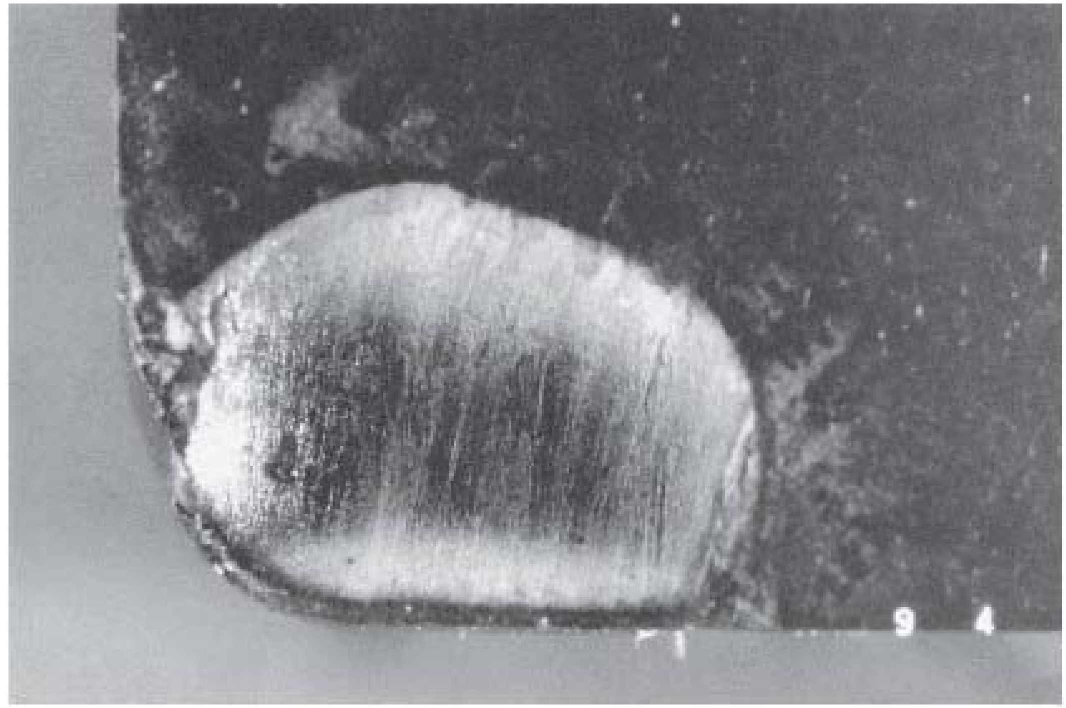
Accordingly, two main types of tool wear can be distinguished:

- **Crater wear**
- **Flank wear**



Crater wear, consists of a cavity in the rake face of the tool.

It forms from the action of the chip sliding against the surface.



- High stresses and temperatures at tool–chip contact interface, contributes to the wearing action.
- Predominant at high speed
- Mitigated by efficient use of carbides

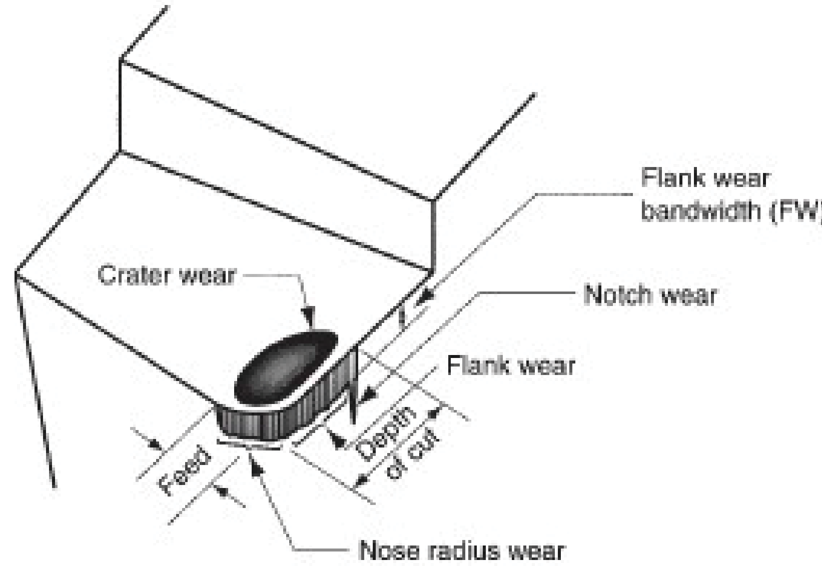
The crater can be measured either by its depth or its area.

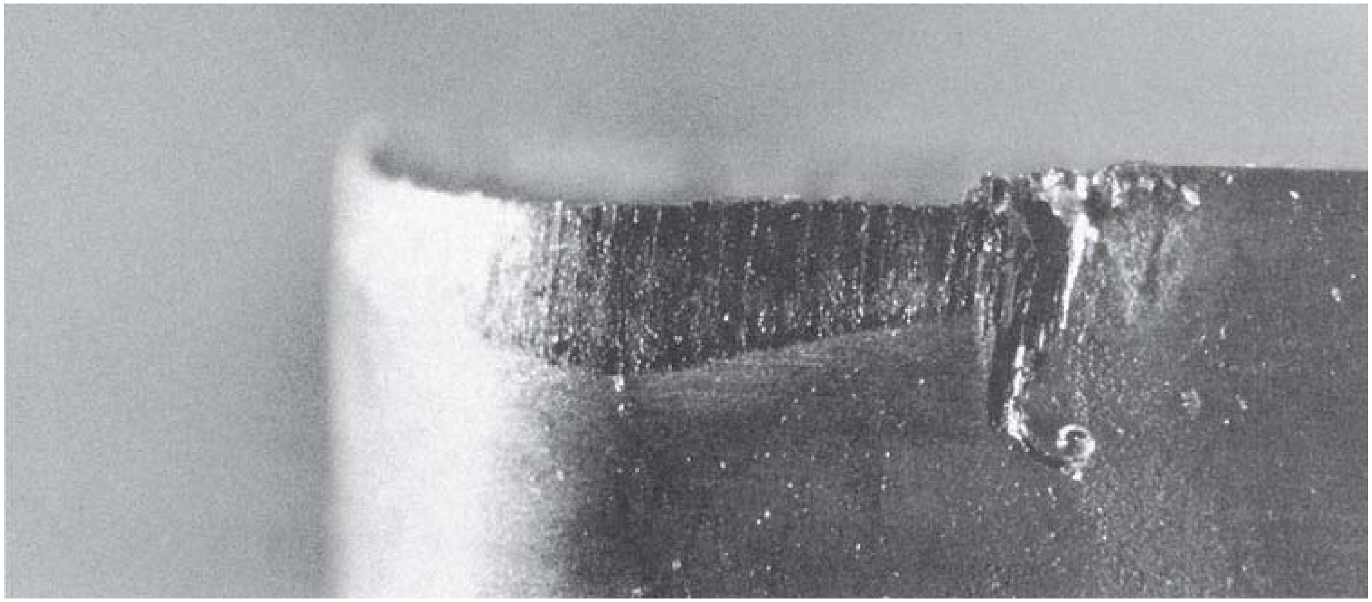
Flank wear, occurs on the flank of the tool.

It results from rubbing between the newly generated work surface and the flank face adjacent to the cutting edge.

Flank wear is measured by the width of the wear band, FW.

This wear band is sometimes called the **flank wear land.**





Features of flank wear:

i) Flank wear called **notch wear** often appears on the cutting edge at the location corresponding to the original surface of the workpart.

- original work surface is harder and/or more abrasive than the internal material.
- As a consequence of the harder surface, wear is accelerated at this location.
- The hardness could be caused by work hardening from cold drawing or previous machining, sand particles in the surface from casting, or other reasons.

ii) A second region of flank wear that can be identified is **nose radius wear**; this occurs on the nose radius leading into the end cutting edge.

Mechanisms that cause wear at the tool–chip and tool–work interfaces:

Abrasion.

- Hard particles in the work material gouging and removing small portions of the tool.
- It is a significant cause of flank wear.
- Occurs in both flank wear and crater wear;

Adhesion or welding

- When two metals are forced into contact under high pressure and temperature, adhesion or welding occur between them.
- These conditions are present between the chip and the rake face of the tool.
- As the chip flows across the tool, small particles of the tool are broken away from the surface.

Diffusion.

- An exchange of atoms takes place across a close contact boundary between two materials.
- It occurs at the tool–chip boundary
- It causes the tool surface to become depleted of the atoms responsible for its hardness.
- As this process continues, the tool surface becomes more susceptible to abrasion and adhesion.
- Diffusion is believed to be a principal mechanism of crater wear.

Chemical reactions.

- The high temperatures at the tool–chip interface can result in chemical reactions, in particular, oxidation, on the rake face of the tool.
- The Softer oxidized layer is sheared away, exposing new material to sustain the reaction process.

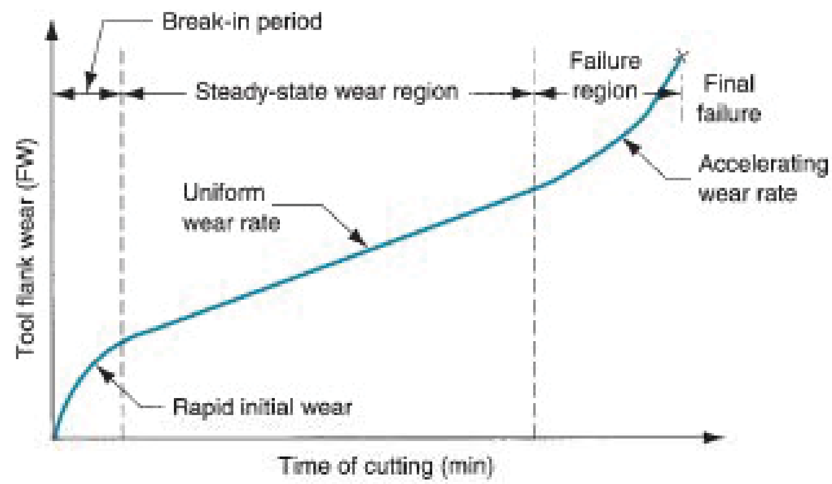
Plastic deformation.

- The cutting forces acting on the cutting edge at high temperature cause the edge to deform plastically, making it more vulnerable to abrasion of the tool surface.
- Plastic deformation contributes mainly to flank wear.

Effects of growing tool-wear:

- Ultimate failure of the tool
- Increase in cutting forces and power consumption mainly due to the principal flank wear.
- Increase in dimensional deviation and surface roughness mainly due to wear of the tool-tips and
- auxiliary flank wear.
- Odd sound and vibration.
- Worsening surface integrity.
- Mechanically weakening of the tool tip.

Tool wear as a function of cutting time:



Three regions in typical wear growth curve:

1. **Break-in period**, sharp cutting edge wears rapidly at the beginning of its use.

2. **Steady-state wear region,** in which wear occurs at a fairly uniform rate. This region is nearly linear function of time, although there are deviations in actual machining.

3. **failure region**, in this region wear reaches a level at which the wear rate begins to accelerate and Tool finally fails by temperature failure.

The slope of the tool wear curve in the steady-state region is affected by work material and cutting conditions.

- Harder work materials cause the wear rate (slope of the tool wear curve) to increase.
- Increased speed, feed, and depth of cut have a similar effect, **with speed being the most important of the three**.

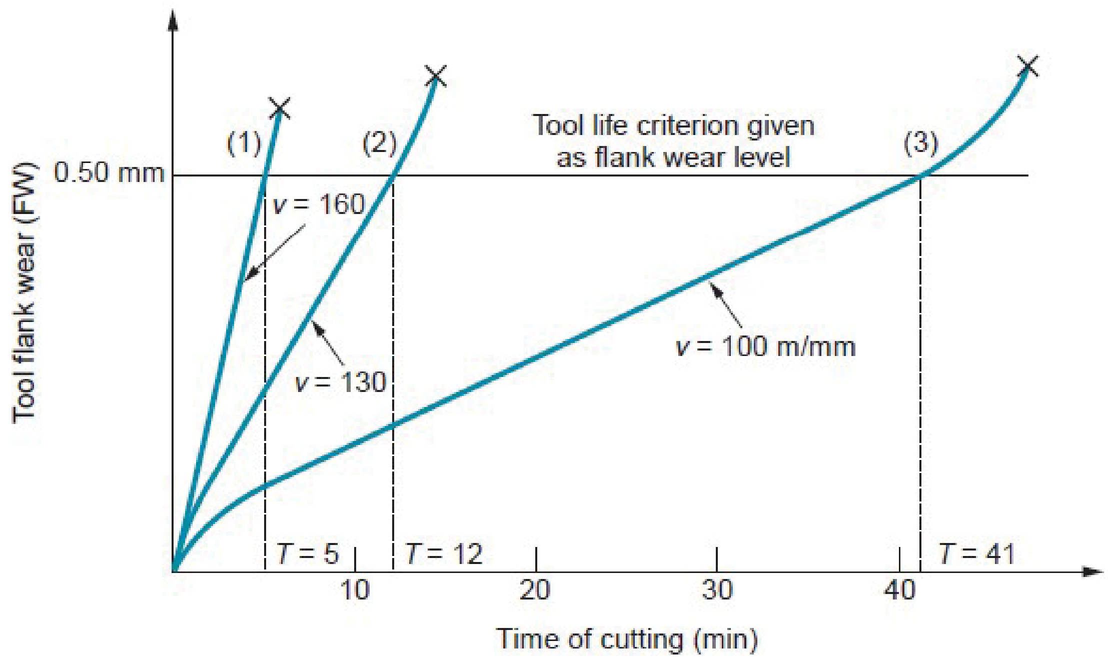
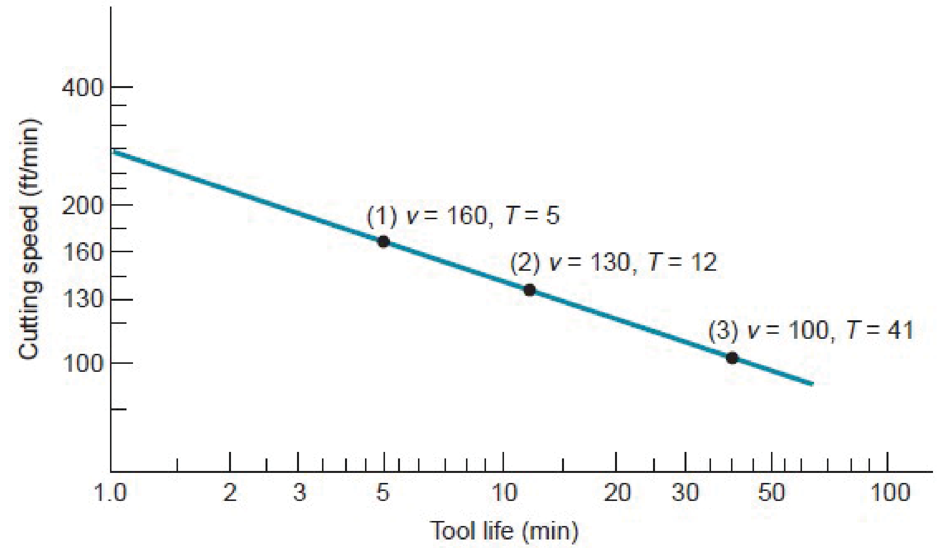


FIGURE 23.4 Effect of cutting speed on tool flank wear (FW) for three cutting speeds. Hypothetical values of speed and tool life are shown for a tool life criterion of 0.50-mm flank wear.

Taylor Tool Life Equation

If the **tool life values for different cutting speeds of a tool are plotted on a natural log–log graph** the resulting relationship is a straight line.



F.W. Taylor expressed this relationship in equation form in around 1900.

This equation known as Taylor tool life equation is expressed as:

$$vT^n = C$$

Where,

v =cutting speed, m/min (ft/min);

T = tool life, min;

n and C are parameters whose values depend on feed, depth of cut, work material, tooling (material in particular), and the tool life criterion used..

n is relative constant for a given tool material, whereas the value of

C depends on tool material, work material, and cutting conditions.

Basically, Taylor Tool Life Equation states that higher cutting speeds result in shorter tool lives.

Relating the parameters ***n*** and ***C*** to Figure,

- ***n*** is the slope of the plot (expressed in linear terms rather than in the scale of the axes), and
- ***C*** is the intercept on the speed axis. ***C*** represents the cutting speed that results in a 1-min tool life.

✓The problem with Taylor Tool Life is that the units on the right-hand side of the equation are not consistent with the units on the left-hand side.

✓To make the units consistent, the equation should be expressed in the form

$$vT^{n} = C\,(T_{ref}^{\,n})$$

where T_{ref} = a reference value for C.

T_{ref} is simply 1 min when m/min (ft/min) and minutes are used for v and T, respectively.