Metal Cutting - 2

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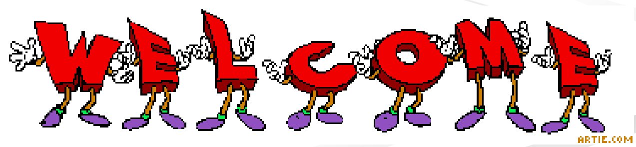

Content

3.0 Kehausan dan Hayat Alat Pemotong

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  - - Jenis-jenis kehausan
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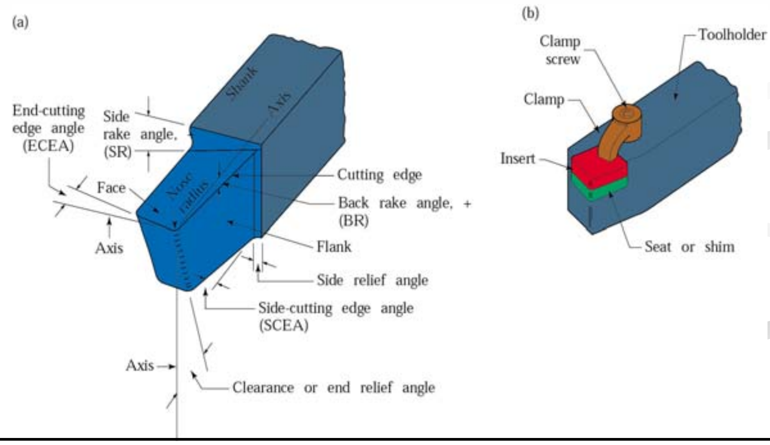
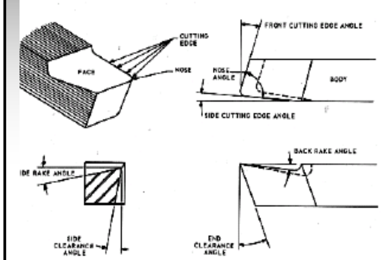
  - - Indications of excessive tool wear
- 3.2 Kegagalan mata alat
- 3.3 Hayat Alat Pemotong

Right-Hand Cutting Tool

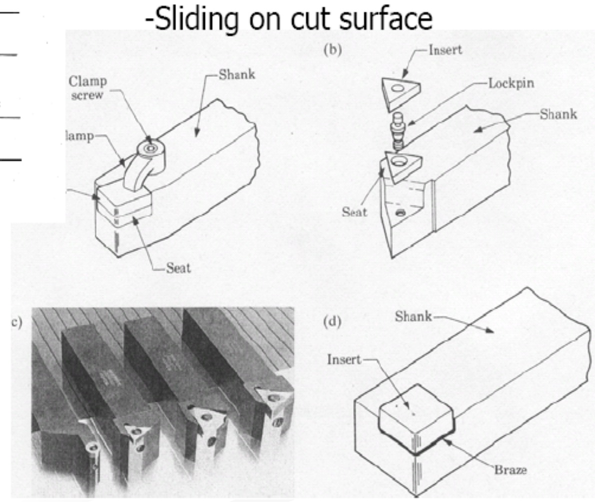
(a) Schematic illustration of a right-hand cutting tool. Although these tools have traditionally been produced from solid tool-steel bars, they have been largely replaced by carbide or other inserts of various shapes and sizes, as shown in (b)..



HSS (1-2 hours)



-High T
-High σ
-Friction
-Sliding on cut surface



Inserts

3.1 Tool Wear

- The change of shape of the tool from its original shape, during cutting, resulting from the gradual loss of tool material.
- Cutting tools are subjected to an extremely severe rubbing process. They are in metal-to-metal contact between the chip and workpiece, under condition of very high stress at high temperature.
- Wear will result in tool failure. When tool wear reach certain extent, the tool or edge change has to be replaced to guarantee the normal cutting action.

3.1 Tool Wear

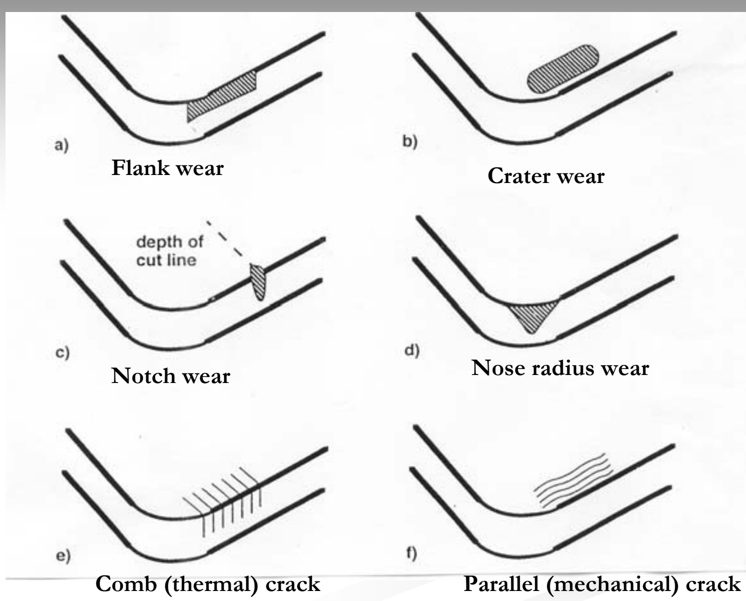
- Due to very high shear and normal stresses on the rake and the chip, it causes severe friction at the rake face as well as the friction between the flank and machined surface. Hence result in all sort of wears which can be observed at the rake face and flank face.

Types of Tool Wear

Can be classified according to the regions of the tool they affect as shown in Fig 9.1.

- flank wear
- crater wear
- notch wear
- nose radius wear
- comb (thermal wear)
- parallel (mechanical) cracks
- built-up-edge
- gross plastic deformation
- edge chipping or frittering
- chip hammering
- gross fracture

3.1 Tool Wear



a) Flank Wear

- Wear on the relief face of the tool edge.
- Results in the formation of a wear land (Fig 9.2)
- Rubbing of the wear land against the machined surface damages the surface and producing large flank forces which increase deflections and reduce dimensional accuracy.
- Most commonly results from abrasion of the cutting edge.
- Flank wear rate changes with time.
- Can be minimized by increasing the abrasion and deformation resistance of the tool material, and by the use of hard coating on the tool.

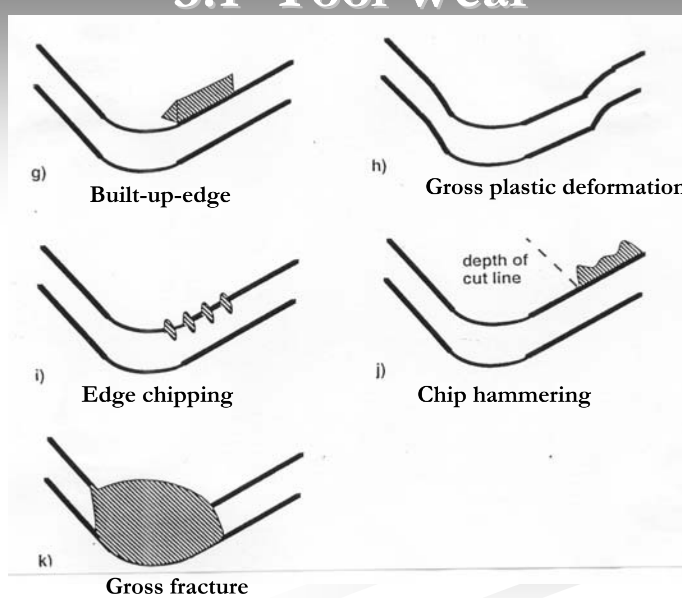
b) Crater Wear

- Wear on the tool rake face.
- Moderate wear does not limit tool life, in fact, increases the effective rake angle, thus may reduce cutting forces.
- Excessive crater wear weakens the cutting edge and can lead to deformation or fracture, and should be avoided because it shortens tool life and make resharpening the tool difficult.
- Crater wear also vary with time in a manner similar to flank wear.
- Severe crater wear usually results from temperature-activated diffusion or chemical wear mechanisms.
- Can be minimized by increasing the chemical stability of the tool material or by decreasing the tool's chemical solubility in the chip. This can be done by applying coatings.

c) Notch wear

- Tools used in rough turning often develop notch wear.
- Especially at the point of contact between the tool and the unmachined part surface.
- Results from abrasion especially common when cutting parts with a hard surface layer or scale or work hardening materials which produce an abrasive chip (eg SS and nickel-based superalloys)
- May also result from oxidation if a coolant is used
- Or by chemical reactions or corrosion at the interface between the tool and the atmosphere.
- Severe notch wear makes resharpening the tool difficult and can lead to tool fracture, especially with ceramic tools.
- Can be reduced by increasing the lead angle, which increases the area of contact between the tool and part surface, by varying the d.o.c. in multi-pass operations, increasing hot hardness and deformation resistance of the tool material.

3.1 Tool Wear



d) Nose Radius Wear

- Occurs on the nose radius of the tool, on the trailing edge near the end of the relief face.
- Resembles a combined form of flank and notch wear
- Results from abrasion and corrosion or oxidation
- Severe nose radius wear degrades the machined surface finish.

e & f) Thermal and Mechanical Cracking

- Usually results from cyclic loading of the tool in interrupted cutting or when machining materials which generate high tool-chip temperatures.
- Crack perpendicular to cutting edge – results from cyclic thermal load, esp. when coolant is used.
- Crack parallel to cutting edge – results from cyclic mechanical loads.
- Crack formation leads to rapid tool fracture or chipping.

i) Edge Chipping or Frittering

- Occurs when cutting with brittle tool materials, esp. ceramics, or
- When cutting work materials which include hard or abrasive particles, such as metal matrix composites or Al-Si alloys.
- Or vibration due to excessive cutting forces, or low system stiffness
- Chipping results in poor surface finish and increased flank wear and may lead to tool breakage.
- Can be controlled by changing the tool edge preparation or by increasing the fracture strength of the tool material

MEASUREMENT OF TOOL WEAR

Flank and crater wear are the most important and thus the most widely measured forms of tool wear. Flank wear is most commonly used for tool wear monitoring since it occurs in virtually all machining operations.

Tool wear is most commonly measured by examining the wear scar on the tool using;

- Microscope
  - Tool makers microscope
  - Video imaging system
- Stylus tracing measurement – similar to profilometer
- Photographs of the cutting edges at intervals to record flank wear progress.
- Reduction of volume of the cutting tool method.

Tool wear monitoring methods;

- On-line sensing method via optical, pneumatic, electric, displacement and force measurements.
- Those based on force and power measurements are the most practical. The axial and radial forces in turning are much more sensitive to flank wear than the tangential force. So the ratio of axial or radial force to tangential force is often strongly correlated to flank wear.

TOOL WEAR MECHANISMS

1. adhesive wear
2. abrasive wear
3. diffusion wear
4. oxidation wear
5. chemical wear or corrosion

1. Adhesive wear

- - Most significant at lower cutting speeds.
- - Occurs when small particles of the tool adhere or weld to the chip due to friction and are removed from the tool surface.
- - On the rake face of the tool and contribute to the formation of wear crater.

TOOL WEAR MECHANISMS

2. Abrasive wear

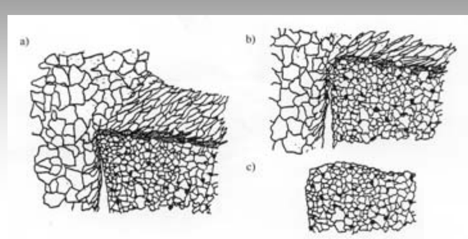
- Occurs when hard particles abrade and remove material from the tool.
- Abrasive particles may be contained in the chip, eg adhering sand in sand-cast products, carbide inclusions in steel or free silicon particles in Al-Si alloys.
- From the chip form or from a chemical reaction between the chips and cutting fluid, as with powder metal steels or cast iron alloyed with chromium.
- Occurs on the flank surface of the tool, causing flank wear, notch wear and nose radius wear, therefore, controls tool life, especially at low to medium cutting speeds.

TOOL WEAR MECHANISMS

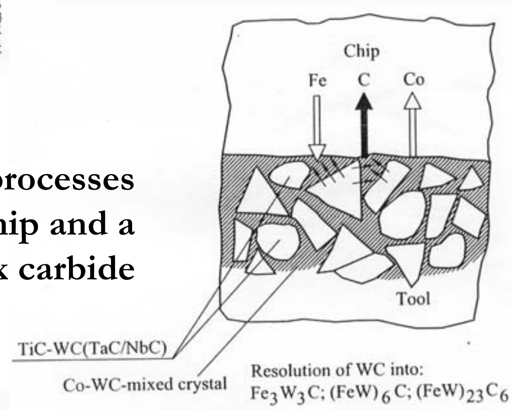
3. Diffusion or solution wear

- A constituent of the tool material diffuses into or forms a solid solution with the chip material. This weakens the tool surface and results in a wear crater on the rake face of the tool.
- Diffusion wear rate depends on the solubility of the tool material in the work material and the contact time between the tool and chip at elevated temperatures and increases exponentially as the cutting temperature increases.
- Diffusion wear can be reduced by changing tool materials to a less soluble grade.

TOOL WEAR MECHANISMS



Diffusion processes between chip and a complex carbide



TOOL WEAR MECHANISMS

4. Oxidation wear

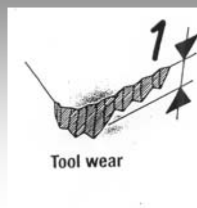
- Occurs when constituents of the tool (especially the binder) react with atmospheric oxygen. Most often occurs near the free surface of the part.
- Oxidation often results in severe d.o.c. notch formation and can be recognized because the tool material discolored in the region near the notch.
- Oxidation does not occur with aluminium oxide-based ceramic tools.

TOOL WEAR MECHANISMS

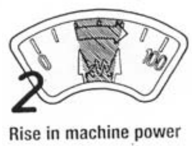
5. Chemical wear or corrosion

- Caused by chemical reactions between constituents of the tool and the workpiece or cutting fluid, produces both flank and crater wear, with flank wear dominating as the cutting speed is increased.
- Chemical wear scars are smooth compared to wear scars produced by other mechanisms.
- Commonly observed when machining highly reactive materials such as titanium alloys.
- May also result from reactions with additives (eg. free sulfur or chlorinated additives) in cutting fluid.
- Changing the tool material (or coating) or the additives in the cutting fluid will often reduce this type of wear.

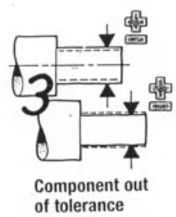
Indications of Excessive Tool Wear



1. Flank wear should be measured in relation to the time the cutting edge has been actually machining and maximum values established



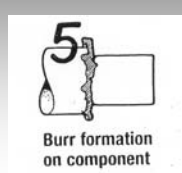
2. A rise in the power needed to take the cuts of an operation. Watch the meter.



3. Component out of tolerance

4. Poor surface finish

Indications of Excessive Tool Wear

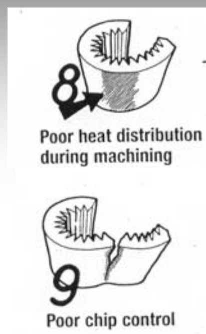


5. Burr formation, especially in SS machining. Excessive flank wear, plastic deformation and BUE can lead to the cutting edge becoming blunt, causing burr.

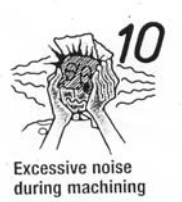
6. Excessive and growing amounts of heat

7. Insert chipping or broken. This tells of more serious problems – operational set-up, tool application, instability, vibrations

Indications of Excessive Tool Wear



8, 9 Signs on the chip and poor chip breaking come with tool wear that has been allowed to develop a long way. Changes in insert geometry through tool wear give rise to an inferior chip formation process, with incorrect heat distribution between workpiece, tool and chips are not correctly formed and broken as a result



10. Noise is widely recognized sign that something is not right with the metal cutting process

11. Vibration tendency in the machining process

3.2 TOOL FAILURE

There are three main types of toool failure

i) Premature or preliminary failure

This is an unexpected and immediate tool failure which can happen and should be avoided. Major causes could be poor tool geometry and material, poor tool grinding, poor selection of cutting conditions, wrong applications

ii) Failure due to gradual and controlled wear

This is an inevitable form of wear which leads to tool failure in a reasonable cutting time and can be controlled by the various process variables.

iii) Ultimate or catastrophic failure

The tool is ruined and unable to cut.

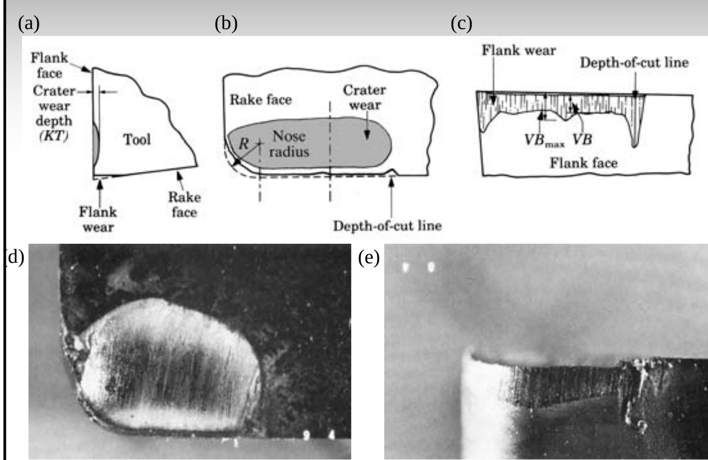
Defining tool failure

- Force/power increase to set limit
- Surface finish becomes unacceptable
- Wear land size for given process

3.3 TOOL LIFE

- Masa alat baru atau yang baru dicanai semula, digunakan untuk memotong bendakerja dengan memuaskan sehingga ia perlu digantikan atau dicanai semula.
- Diukur dalam minit, isipadu logam yang dimesin, bilangan komponen yang dimesin
- Menggunakan lebar haus kehausan rusuk sebagai asas

Flank and Crater Wear



(a) Flank and crater wear in a cutting tool. Tool moves to the left. (b) View of the rake face of a turning tool, showing nose radius *R* and crater wear pattern on the rake face of the tool. (c) View of the flank face of a turning tool, showing the average flank wear land VB and the depth-of-cut line (wear notch). (d) Crater and (e) flank wear on a carbide tool. *Source*: J.C. Keefe, Lehigh University.

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3.3 TOOL LIFE

- Dipengaruhi oleh beberapa faktor
  - i) Kelajuan pemotongan
  - ii) Kadar uluran (suapan)
  - iii) Suhu
  - iv) Kadar pembuangan logam
- Pengaruh paling besar ialah Kelajuan pemotongan, V

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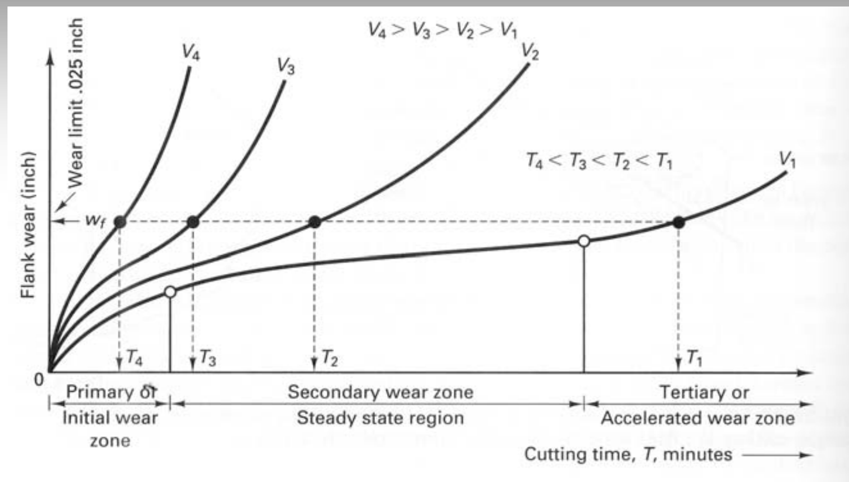
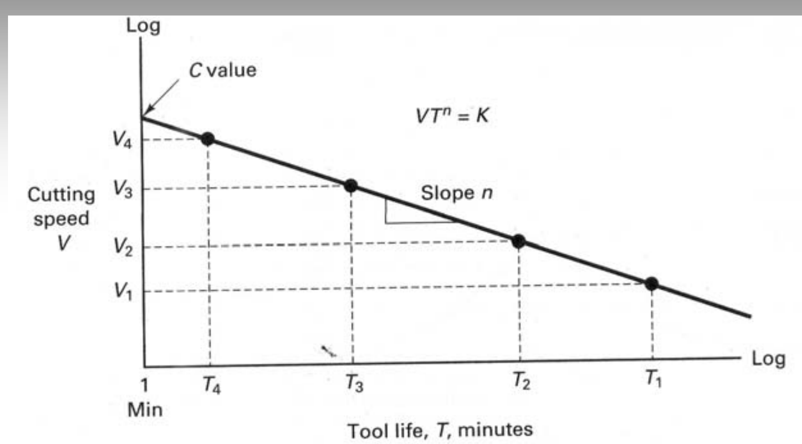
3.3 TOOL LIFE



Typical tool wear curves for flank wear at different velocities

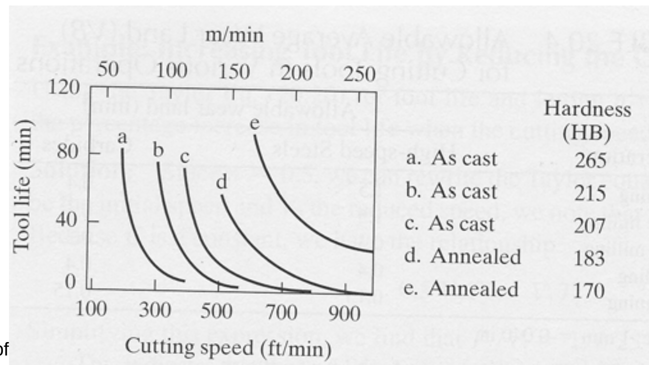
3.3 TOOL LIFE



Construction of the Taylor Tool Life curve using data from the tool wear plots like those in the previous figure

Taylor's wear relationship (flank wear)

- Relationship between tool life and cutting speed
  - Use to set optimum cutting speed for CFRQ
  - Represents a given wear condition
  - Define wear condition for failure

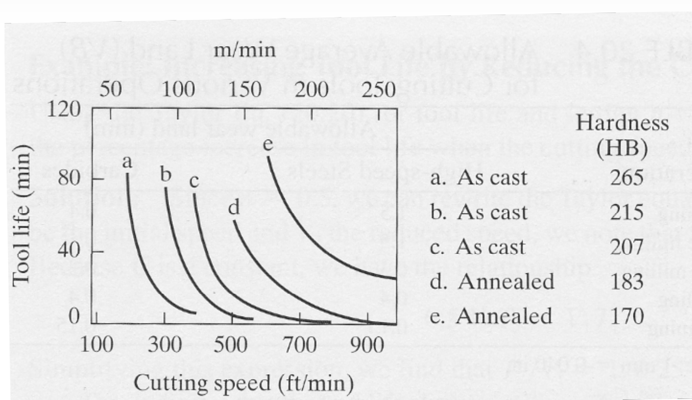


Taylor's wear relationship (flank wear)

C = constant & n = exponent (from experimental data)

$$v \cdot t^{n} = C$$

v = cutting velocity (fpm) t = time to failure (min)


m/min
50 100 150 200 250
120
80
40
0
Tool life (min)
a b c d e
100 300 500 700 900
Cutting speed (ft/min)
Hardness (HB)
a. As cast 265
b. As cast 215
c. As cast 207
d. Annealed 183
e. Annealed 170

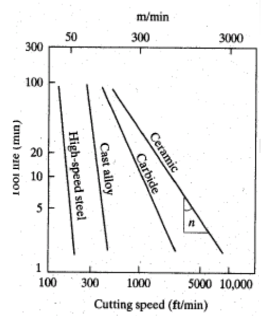
3.3 TOOL LIFE

Taylor's tool life curves (Experimental)

- Coefficient n varies from:

Steels	Ceramics
0.1	0.7

- As n increases, cutting speed can be increased with less wear.
- Given that, n=0.5, C=400, if the V reduced 50%, calculate the increase of tool life?



Log scale

Tool-Life Curves

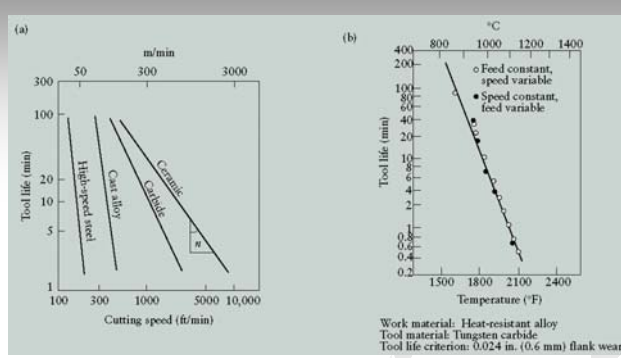
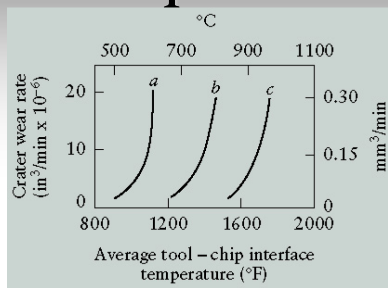


FIGURE (a) Tool-life curves for a variety of cutting-tool materials. The negative inverse of the slope of these curves is the exponent n in tool-life equations. (b) Relationship between measured temperature during cutting and tool life (flank wear). Note that high cutting temperatures severely reduce tool life.

Crater-Wear Rate/Average Tool Chip Interface Temperature



Relationship between crater-wear rate and average tool-chip interface temperature in turning: (a) C-1 Carbide; (c) C-5 carbide. Note that crater wear increases rapidly within a narrow range of temperature.

Interface of chip (left) and rake face of tool (right) and crater wear in cutting AISI 1004 steel at 3 m/s (585 ft/min). Discoloration of the tool indicates high temperature (loss of temper). Note how the crater-wear pattern coincides with the discoloration pattern.