Improving Tools life and reducing fluid consumption with FUCHS Metal Removing Fluids

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Discussion Points

- Selection of Coolants for Each Cutting Tool Materials
- Causes of Cutting Tool Failures and Remedies
- Effects of Coolants to Cutting Tool Life
- Coatings for Cutting Tools
- Special Problems Related to Cutting Tools and Coolants
- Two Pack System

Selecting Right Coolant for Each Tool's Material

High Speed Steels:

For Low & Medium Cutting Speeds Use Water-Miscible & Non-Water-Miscible Coolants

For High Cutting Speeds Use Water-Miscible Coolants.

Cubic Boron Nitride (CBN):

If using coolants, neat oils are less risk to cause thermal shock and cracking; flood cutting area with coolant before, during and after cutting or grinding

Carbides & Polycrystalline Diamonds:

Can be used dry, with air blow to evacuate chips

If using coolants, neat oils are less risk to cause thermal shock and cracking; flood cutting area with coolant before, during and after cutting

Ceramic Materials:

Sensitive to fast temperature changes, many times are used dry

Water-Miscible coolants are used if cutting area is flooded continuously

Wear Mechanisms

Cutting-tool wear depends on tool composition, material being machined, cutter geometry, type and condition of machine, speeds, feeds and other working conditions, and cutting fluid or lubricant.

Regrinding is required when flank wear and cratering reach a level that effects surface finish and accuracy

Flank wear is unavoidable and is easy to measure - it is therefore often used as an indicator of tool life

Coolants plays a vital part in reducing or eliminating more gradual wear process.

ABRASION
CRATERING
WELDING
BREAKAGE

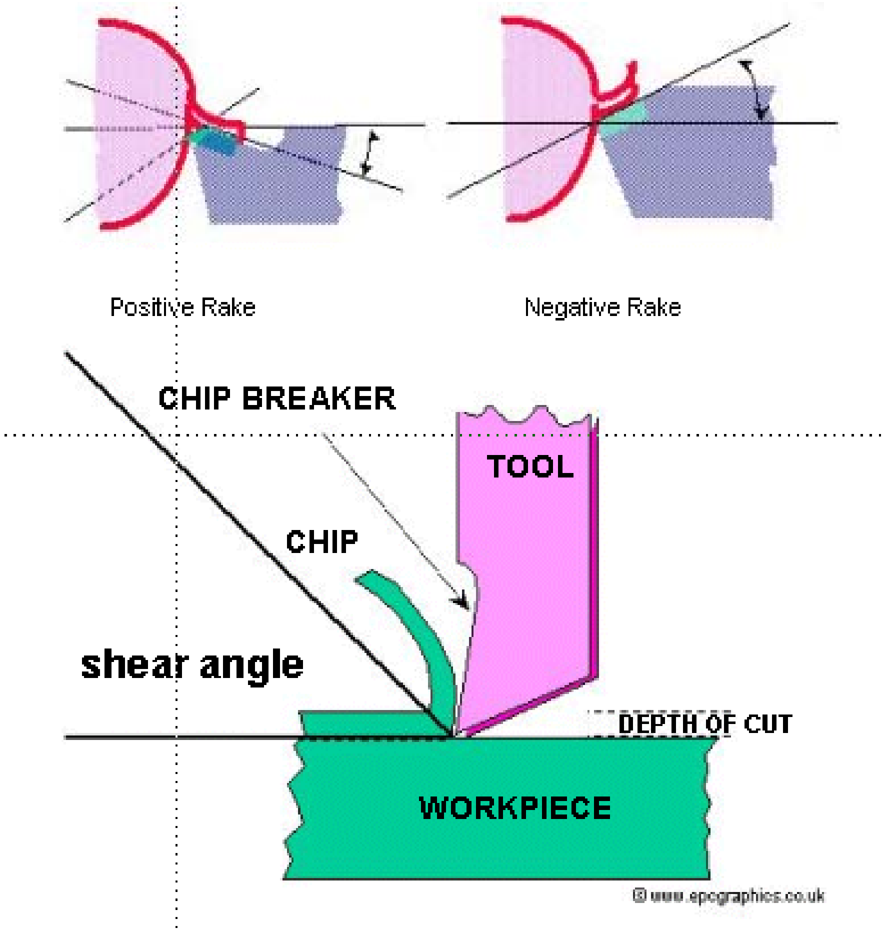
Heat and Shear Angles

Tools' Shear Angles are directly related to heat produced

1. Friction caused by tool and chip rubbing each other

2. Rake Angle of Tool to Material

Coolants Helps Dissipate Heat on Cutting Edges of Tool



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Why Cutting Tools Fail?

1. High Heat & Pressures

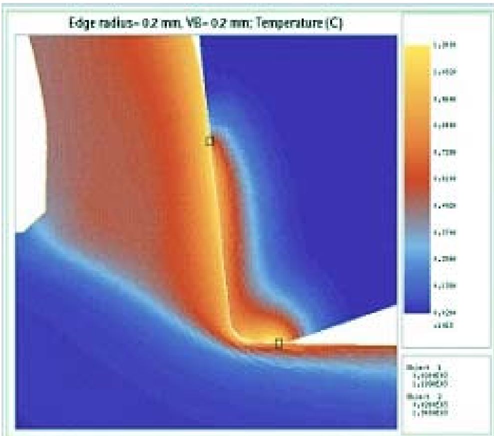
Temps Up to 985C (1800F)!

Tool Contract Pressures Up to 140 kgf/cm2 (2000 psi)

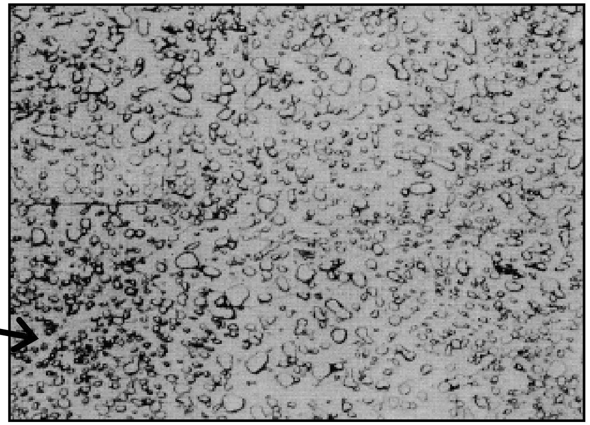
This causes cutting tool’s binder to soften, allowing the carbide grains to move

Thermal deformation progresses, heat and cutting pressure increase

Inconsistent part size and tool breakage can follow.



Carbides



Why Cutting Tools Fail?

2. Thermal & Mechanical Shock

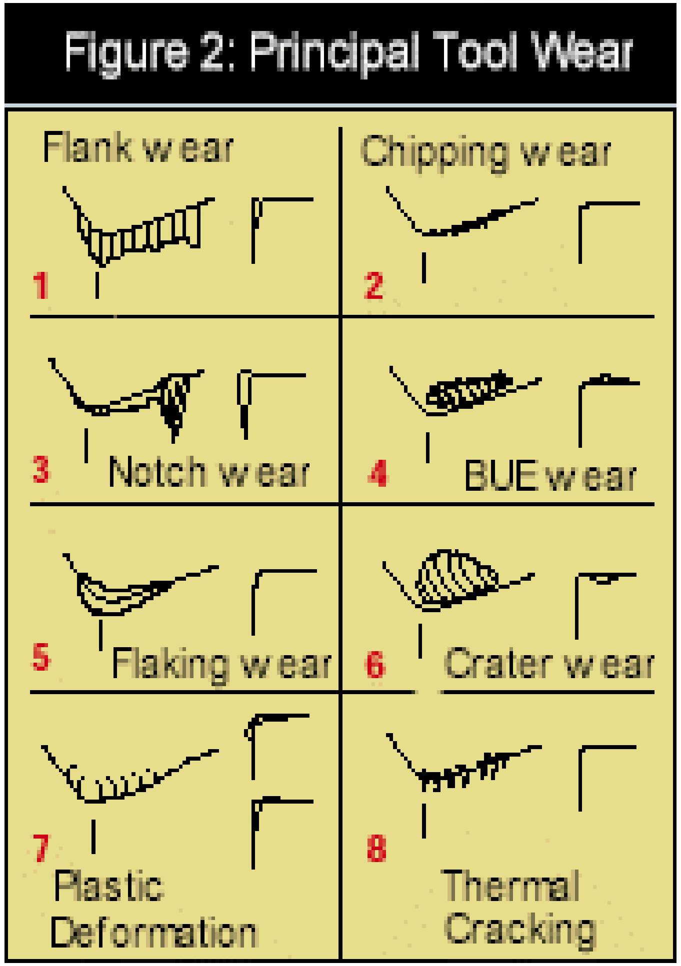
Thermal shock – rapid heating and cooling of the tool – is most common in milling operations, where insert heats up while cutting and then cools while away from the cut

Mechanical shock is also a factor in milling, in machining interrupted surfaces, and even in turning

Why Cutting Tools Fail?

3. Basic Failure Mechanisms

Basic failure mechanisms include flank wear, chipping wear, notch wear, built up edge (BUE) wear, flaking wear, crater wear, plastic deformation and thermal



Abrasive Flank Wear

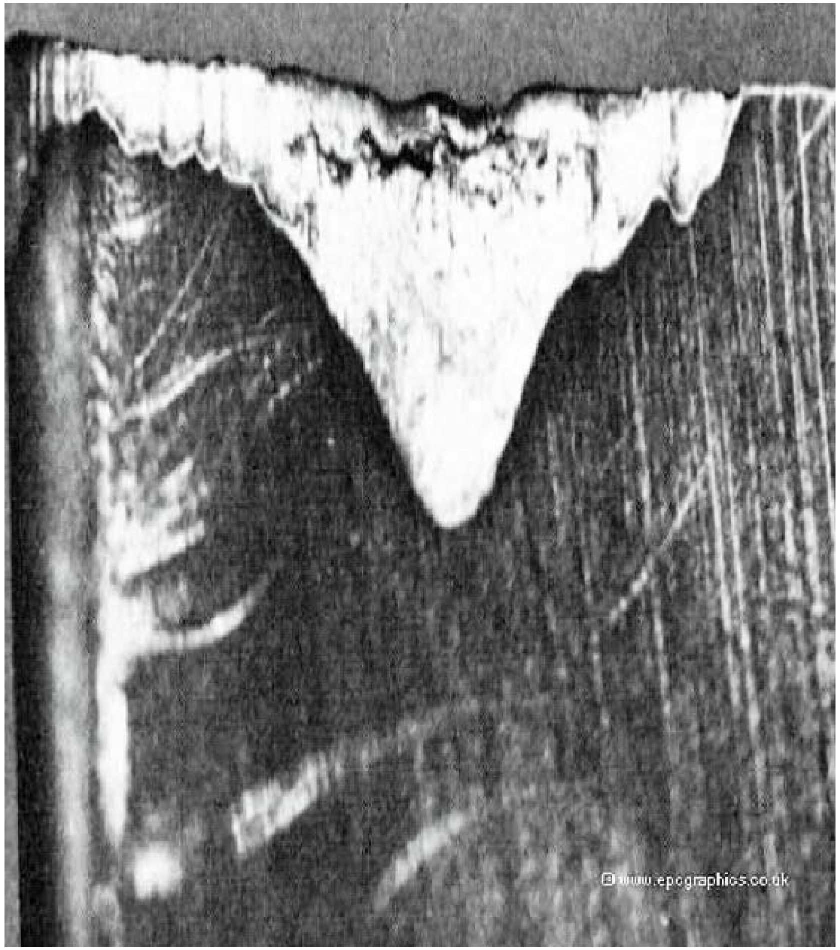
The most common form of wear on the tip and side of the tool and is viewed as normal type of wear

Its occurrence can be positive, in as much as it makes the edge sharper

After a certain amount of wear, continued friction against the machined surface causes abrasion, and deteriorates edge performance

The solution to excessive or premature flank wear is usually to ease up on cutting speed

Also select a more wear-resistant coating, such as TiCN.



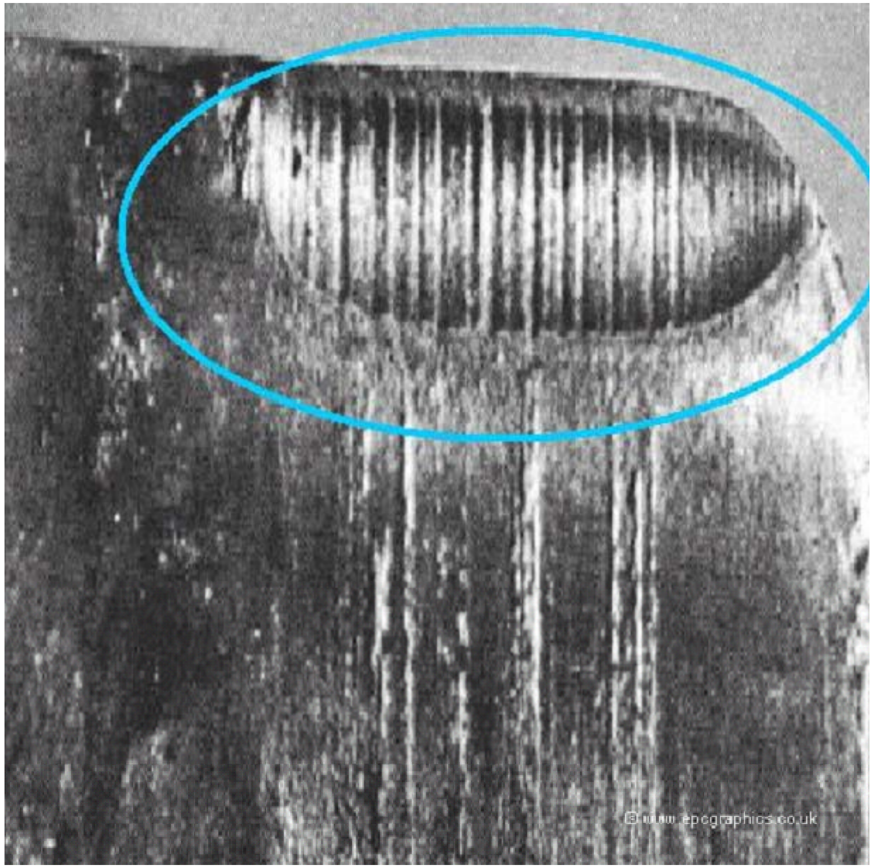
Cratering

Cratering occurs where there is very high friction between the metal being cut and the tool surface

As the chip passes back across the face of the tool, its temperature increases through friction when it reacts with the tool material; particles of the tool are absorbed by the chip and a depression or crater appears on the tool face

The first recourse is to reduce speed to lower the cutting temperature; reduce feed.

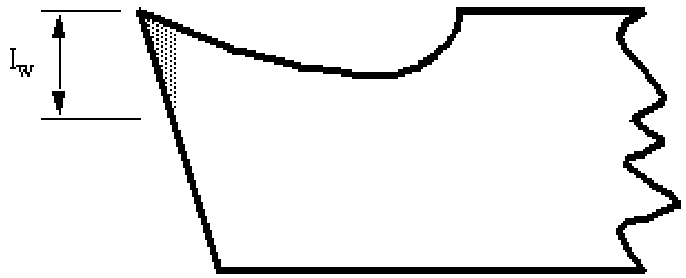
A medium temperature CVD or PVD coated tool with positive geometry will resist wear better.



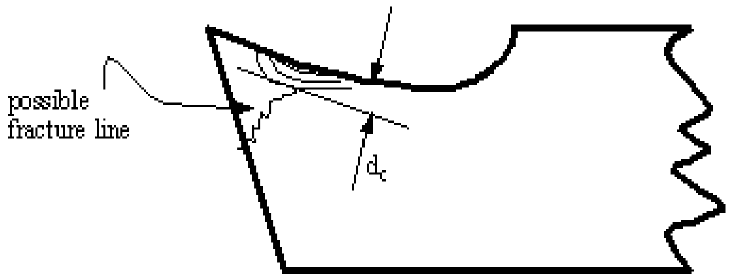
Tool Failures In Detail

Tool failures can typically be grouped under one of the following categories

- Complete Failure - the tool is unusable
- Flank Failure - this can be estimated with maximum lw values
    - **Roughing Cuts**
      0.03" for carbide tools (0.76mm)0.06" for high speed steel (1.52mm)
    - **Finishing Cuts**
      0.010" for carbides (0.25mm)0.015" for high speed steel (0.38mm)
- Work surface finish is inadequate
- Work dimension outside tolerance



This wear controls tool life, and will change work dimensions



where,

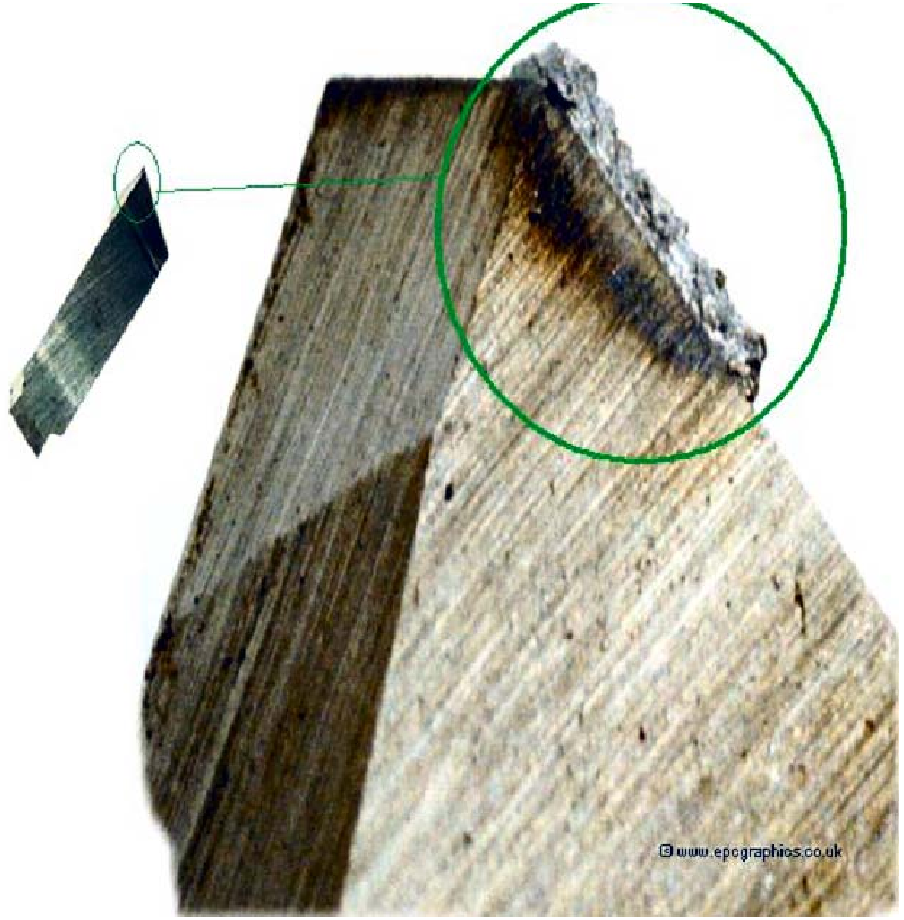
d_c = crater depth

Welding

Welding of the chip to the cutting edge of the tool causes a built-up edge that increases cutting pressures, adversely affects surface finish and may result in the breaking away of the entire edge

Pressure welding of this kind occurs within a critical range of speeds, depending on the cutting tool and work piece, and is especially injurious to carbide cutting tools

Increasing cutting speed usually reduces welding. Try switching to a tougher-grade, higher-rake tool. If tool life is too short, apply coolant in large quantities to keep the tool flooded.



Chipping:
damaged carbide inserts

Chipping (especially carbides & ceramics) are in three forms:

Crumbling cutting edges

Thermal cracking

'Crazing' of flank and face

Crumbling cutting edges are the result of weak edges caused by excessive rake and relief angles, and vibration

Thermal cracking is usually due to interrupted or intermittent coolant supply, which causes the tool tip to be alternately heated and cooled

'Crazing' of flank and face is usually the result of poor grinding techniques during preparation of the tool tip.

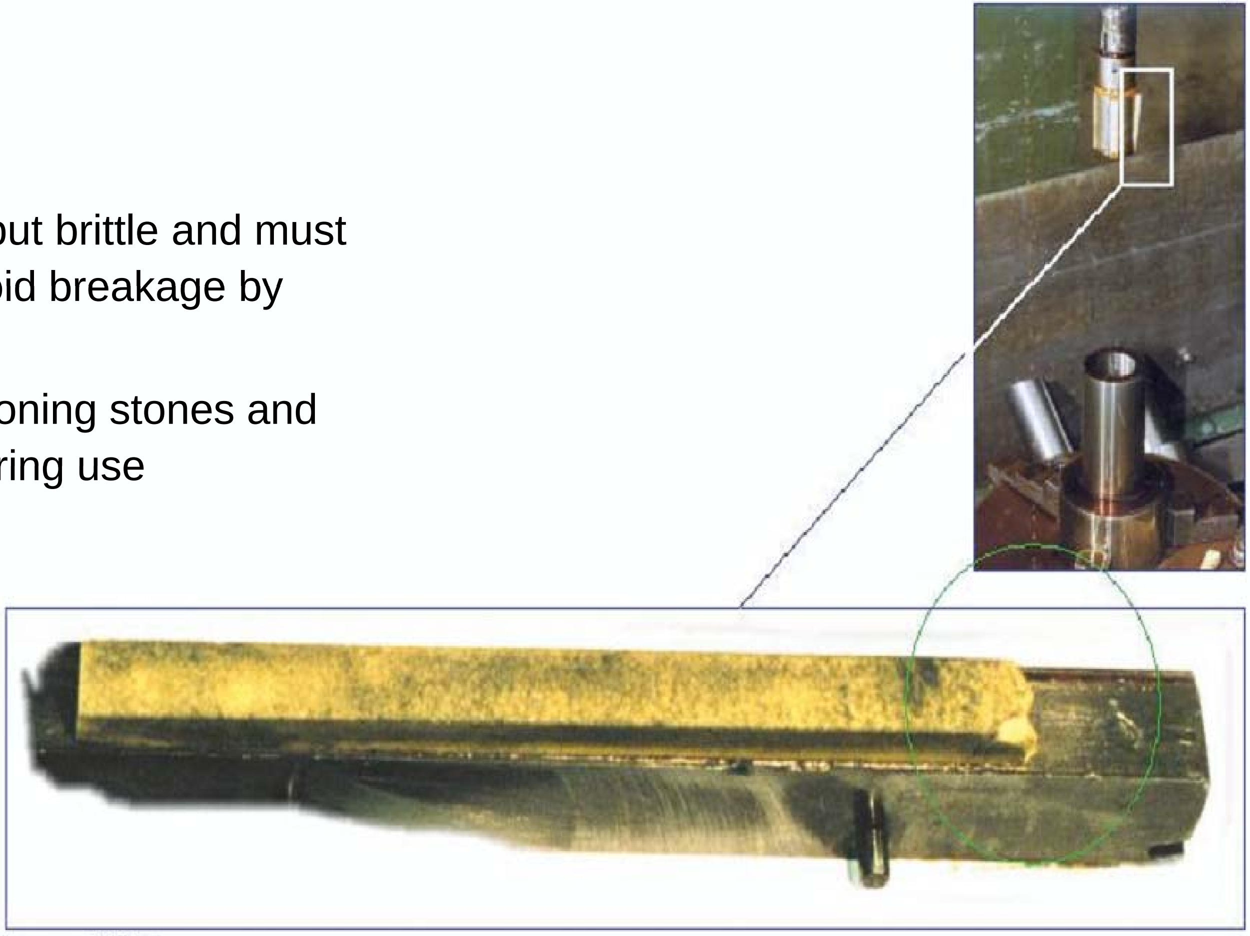
Solutions: Reduce feed rate, change the tool approach angle to ensure stability and select a tougher-grade insert

Coolant must be used in a generous and uninterrupted supply

Chipping: fracture damage caused by impact or fatigue

Ceramic material is hard, but brittle and must be treated with care to avoid breakage by impact.

Sometimes the edges of honing stones and ceramic tools can flake during use



Burning damaged caused by loss of effective lubrication & cooling

In any severe cutting process it is essential to ensure a plentiful supply of lubricant to the cutting surfaces at all times. In this example of deep-hole drilling, the lubricant flow was blocked only for a very short time. Resulting in overheating and re-tempering of the tool which had to be re-ground. Note the colour change in the overheated tool compared with the new undamaged bit.

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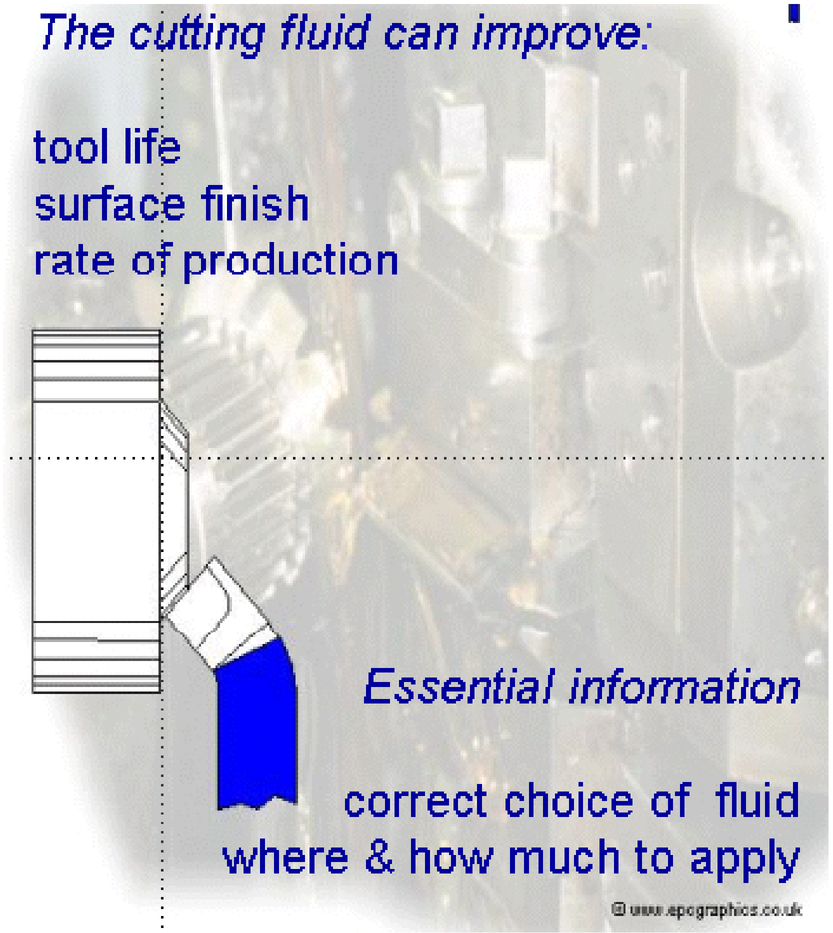
- Two Pack System

Cutting Fluid

Cutting fluid is a vital factor in the great majority of machining operations, reflected especially in tool life and performance and surface finish

It is important to know not only the type to be used, but also when, where and in what quantity it can be most effective



Cutting Fluid Effects on Tool Life

Coolants extends tool life primarily by preventing tools from exceeding their critical temperature range while in the cut. If cutting temperature is too high, the following can happen:

tools soften
wears rapidly
fail to meet tolerances for surface finish and part size

Effects of Coolants:

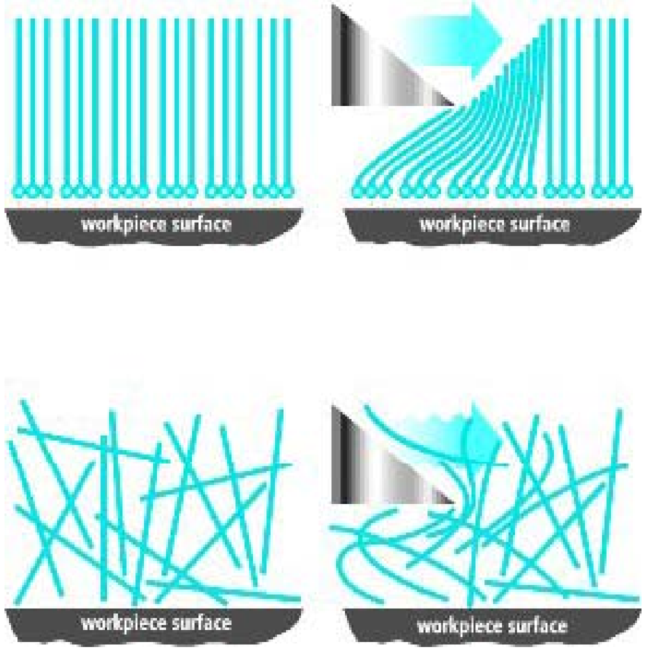
- Removes heat by carrying it away from the cutting tool and workpiece inter
- Prevents tools from exceeding their critical temperature range beyond which the tool softens and wears rapidly
- Lubricates cutting tool/work piece interface, minimizing the amount of heat generated by friction
- Removes chips and metal fines from the tool/work piece interface (To prevent the tool's coating surface to be damaged, cutting chips generated during machining operations must be continually flushed away from the cutting zone)

Vegetable Oil Technology Improves Tool Life

The lubricating film layer provided by vegetable oils is intrinsically strong and lubricious; these coolants have lubricity that is significantly higher than that of mineral oil

Vegetable oil-based products provide more effective, durable lubrication than can be achieved with alternative coolants

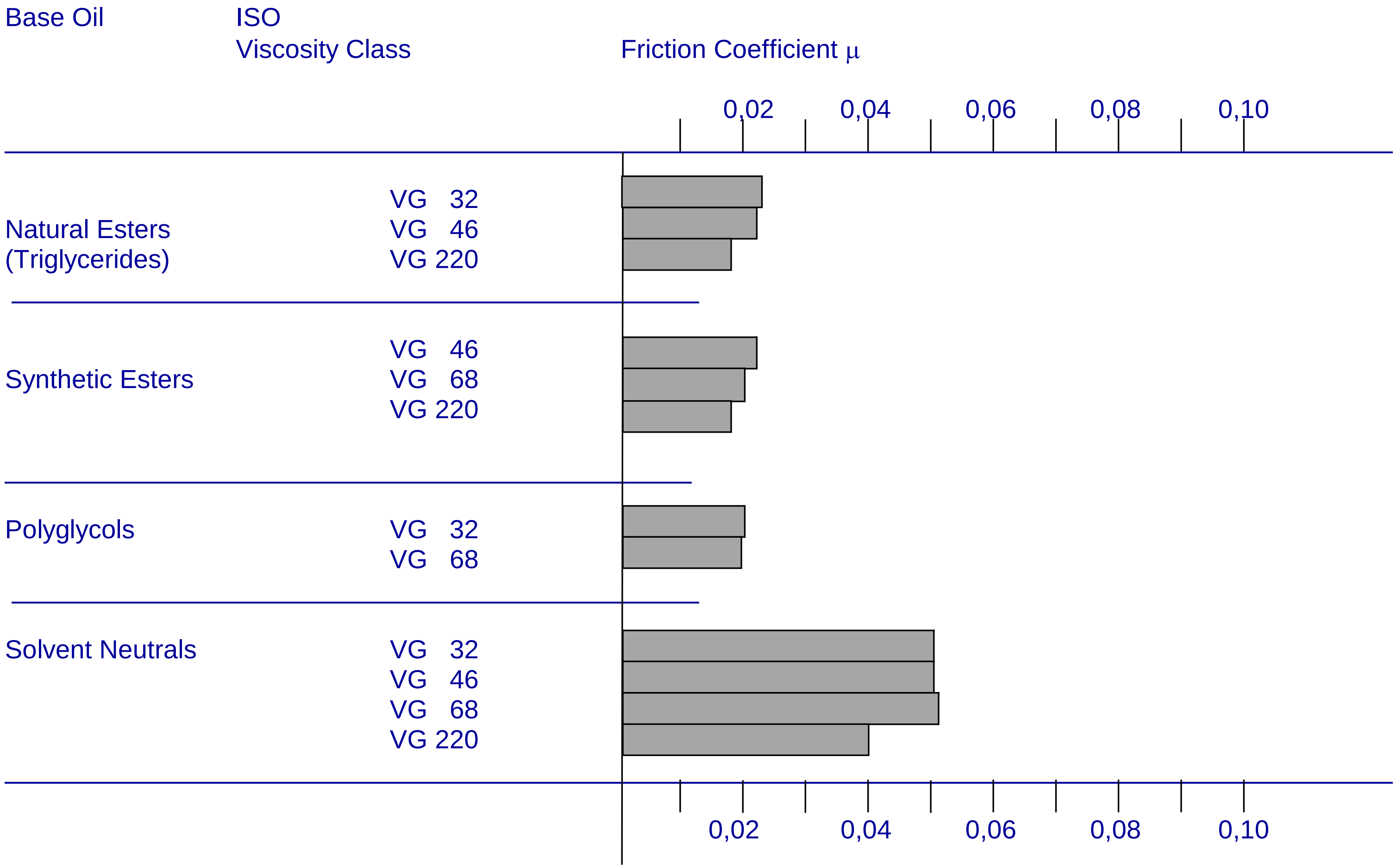
For heavy-duty machining of demanding material, vegetable-oil coolants can be utilized without requiring EP additives.



Substantial improvements in performance have been reported in a variety of applications:

- Using vegetable oil-based coolant while drilling automotive gears resulted in a **threefold increase in tool life**
- Vegetable oil technology made it possible to increase **production volume by 10 percent**, while also **reducing tool cost by 50 percent**, in producing titanium and stainless steel medical implants
- Vegetable oil-based lubrication made possible a **15-fold increase in tool life** while tapping steel parts for an automotive application

Friction Properties of Several Base Fluids
Source: Michaelis,K., Höhn,B.-R. (1994)



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Special Problems Related to Cutting Tools & Coolants

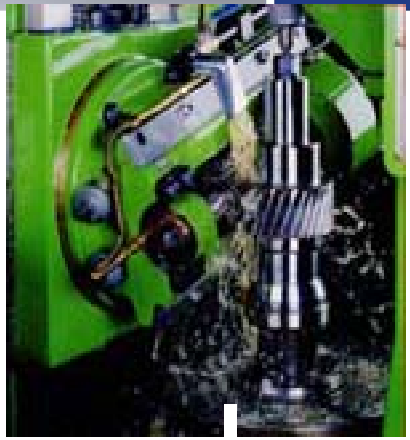
Hot, Cutting Chips (Swarf) Causing Tool Wear

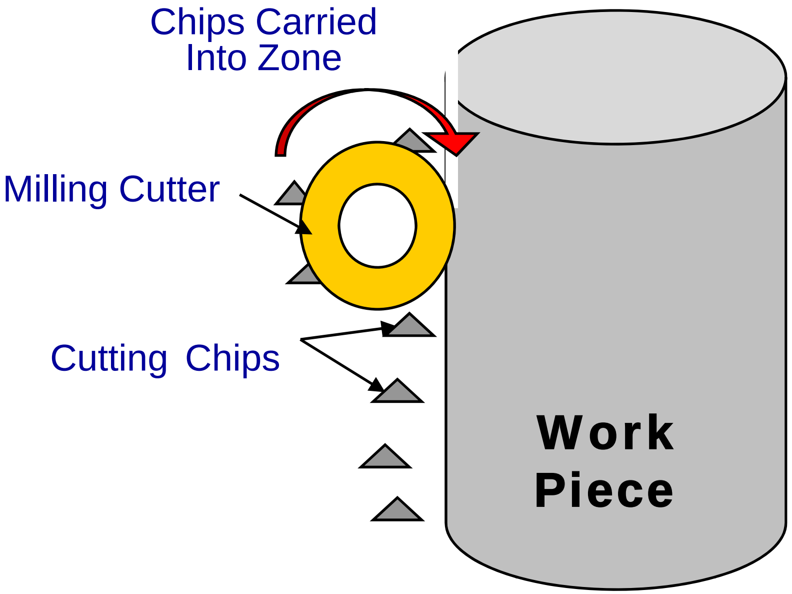
On milling cutters, hobs, grinding wheels, hot chips are carried back into the cutting zone

Causes:

- **Welding of chip on tooth – breaking off with coating or metal edge**
- **Scoring of tooth face & damage to coating surface**
- **Increase cutting pressure, friction and heat to flank (side) of tool leading to flank wear**

We can see similar tool problems with chips dragging back into cutting zone for inserts, drills and grinding tools





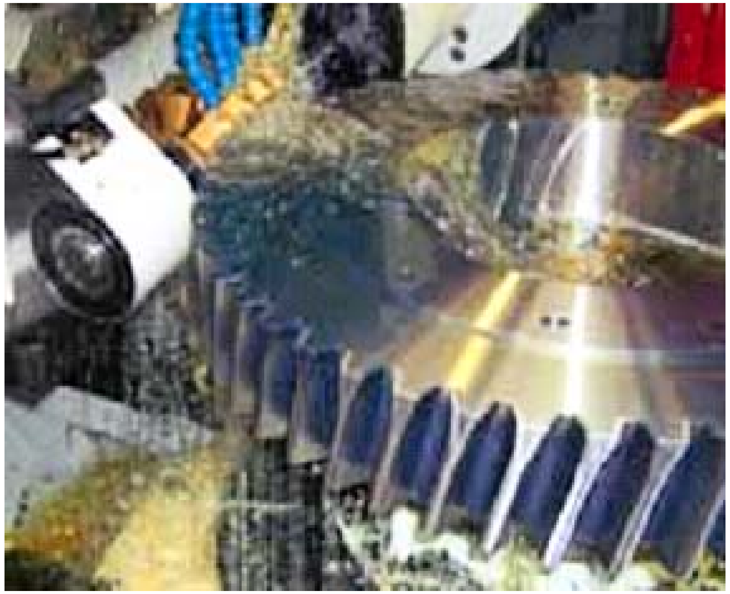
Special Problems Related to Cutting Tools & Coolants

Hot, Cutting Chips (Swarf) Causing Tool Wear

On milling cutters, hobs, grinding wheels, hot chips are carried back into the cutting zone

Solutions:

- **Increase volume of coolant into cutting zone by increase pump flow or adjust nozzles directly into cutting zone**
- **With more than two nozzles, set one nozzle on the back side of the tool against the rotation to push off the chips on the tool**
- **Change the coolant (lighter viscosity, less 'stickiness', additives)**



We can see similar solutions with chips dragging back into cutting zone for inserts, drills and grinding tools

Overheating Causing Tool Wear

Excessive heat on tool face and flank leading to cratering, chipping and edge welding

Causes:

- **Excessive feeds and speeds not matching tool's material and workpiece machinability**
- **Wrong type of coolant**
- **Coolant is not getting into the cutting zone**
- **Foaming of coolant can increase temperatures within machine, coolant and workholdings**

Picture shows effects on gear cutting hob after overheating (color distortion)

Special Problems Related to Cutting Tools & Coolants

Overheating Causing Tool Wear

Excessive heat on tool face and flank leading to cratering, chipping and edge welding

Solution:

- **Work with tool manufacturer for correct feeds & speeds**
- **Review coolant's viscosity, neat oil vs. water-base coolants, check level of tramp oil**
- **Check flow and pressure of coolant (pump flow, scale or fungi levels in machine bed & piping), placement of nozzles, and number of nozzles**
- **Check foaming of coolant and add anti-foaming additives if needed; or replace coolant**

Picture shows reduced area due to scale in coolant piping

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MODULAR FLUID CONCEPT

- ✓ Modular Cutting Fluid (MCF): contains the necessary additives for lubrication and special emulsifiers to incorporate the lubricant additives into the aqueous phase
- ✓ Synthetic (SYN): aqueous phase containing corrosion preventative additives and biocides
- ✓ ECOCOOL MCF 5000 + ECOCOOL SYN

LUBRICANT PHASE: ECOCOOL MCF 5000

- ✓ **Mineral oil free, formulated with synthetic and vegetable-based esters**
- ✓ **Optimal lubrication in low concentrations. The lubricity index can be measured directly via the saponification index**
- ✓ **Reduced emulsifier quantity: No foam formation even in soft water**
- ✓ **Low COD in comparison with conventional fluids. The concentrate is biodegradable**
- ✓ **The concentration is measured by acid split**

FORD MCF

SYNTHETIC PHASE: ECOCOOL SYN

- ✓ **BORON free**
- ✓ **Secondary Amine free**
- ✓ **Compatible with all types of materials: provides a high level of corrosion protection**
- ✓ **Especially suitable for soft water**
- ✓ **Suitable on its own for grinding ferrous metals**
- ✓ **The concentration is measured by alkalinity titration**

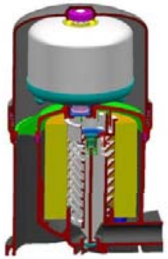
FORD MCF

MANN+HUMMEL (UK) LTD

PLANT: MANN+HUMMEL (UK) LTD
Oil Conditioning System Units

PRODUCT: ECOCOOL MCF 5000 (4,5%) + ECOCOOL SYN (2%)

DESCRIPTION: MAPAL REAMING BORE
Material: Aluminium (Si content 6%)



RESULTS:

- ✓ After 6 months in operation
- ✓ Zero quality problems
- ✓ Tool life Improved
- ✓ Optimum level of cleanliness in machine and tool

FORD MCF

MAPAL Dr. Kress KG

PLANT: Aalen (Germany)

PRODUCT: ECOCOOL MCF 5000 (4%) + ECOCOOL SYN (2%)

DESCRIPTION: Material: Steel CK 45, Cast Iron GG25, and Aluminium
CNC Hüller Hille nb-h 70
Milling, drilling and reaming using MAPAL tools

RESULTS:
- ✓ After 1 month in operation
- ✓ Zero quality problems
- ✓ Optimum level of cleanliness in machine and tool

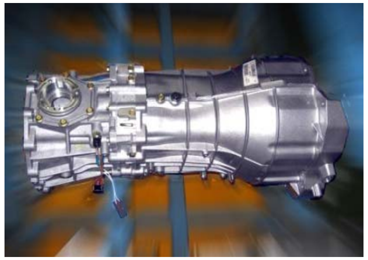
FORD MCF

NISSAN MOTOR IBERICA S.A.

PLANT: Transmisiones Barcelona

PRODUCT: ECOCOOL MCF 5000 (4%) + ECOCOOL SYN (2%)

DESCRIPTION: Gearbox machining
Material: Aluminium (Si content 12%)
CNC MAZAK & MITSUI
Tapping, drilling, milling and reaming using hard metal
Production of 960 gearboxes per day



RESULTS:

- ✓ After 2 months in operation
- ✓ Optimum level of cleanliness in machine and tool
- ✓ Zero quality problems

FORD MCF

TEKOR S.A.

PLANT: VIC (Barcelona)

PRODUCT: ECOCOOL MCF 5000 (4%) + ECOCOOL SYN (2%)

DESCRIPTION: Machining of hydraulic pump parts
Material: Aluminium (Si content 8-10%)
CNC KITAMURA 3XIH
Milling (stainless steel tools) and internal reaming (diamond tool, 20 bar)
Production: 30,000 parts/month

RESULTS:
- ✓ After 6 months in operation
- ✓ Zero quality problems
- ✓ Optimum level of cleanliness in machine and tool

FORD MCF

FORD SPAIN

- **Engine DURATEC HE 1.8 / 2.0 / 2.3 L**
  - Cylinder block, cylinder heads, camshafts, crankshafts and connecting rods
- **Production: 1,500 parts / day**
- **2 Central Systems:**
  - F1 – 110,000 L – Camshaft seats, valve guides and seats
  - F10 – 50,000 L – Crankshafts bore, Al cylinder blocks

FORD MCF

FORD SPAIN

- **Situation using MCF:**
  - Sys F1: Camshafts seats, valve guides and seats
  - Sys F10: Al cylinder blocks, crankshaft bore
    5,5% ± 0.5% ECOCOOL MCF 5000
    2% ± 0.5% ECOCOOL SYN
- **Results:**
  - Excellent surface finish
  - Increased tool life
  - Foam reduction at high pressures
  - Direct cost reduction > 40%
  - New contract - Coolant 4P+

MAPAL Tests with ECOCOOL MCF 5000

Machine: Hüller Hille nb-h 70

Cutting Fluid used: Ecocool MCF 5000

in use from March 23, 2007 until March 20, 2008

Trial No.	Work Piece	Customer	Material	Operation	Remarks
2007-063	Hydraulic block 38 CrNiMo	Starrag-Heckert	38 CrNiMo 6	drilling	requirements passed without any problems
2007-090	Plate 300 x 300	Bobst	C 45	drilling	requirements passed without any problems
2007-146	Actuator housing	Kern-Liebers	Pernifer	grinding	requirements passed without any problems
2007-158	Bracket	Kayaba	S 25C (unalloyed steal)	drilling	requirements passed without any problems
2007-179	Caliper	TRW	C45	drilling	requirements passed without any problems
2007-187	Coating test	MAPAL intern	Ck45	grinding	requirements passed without any problems
2007-195	Pump case	Bosch Bari	GGG60	drill-reaming	requirements passed without any problems
2007-202	Conrod	Honda Thailand	Aluminium	boring/grinding	requirements passed without any problems

THANKS FOR YOUR ATTENTION！

多谢关注！