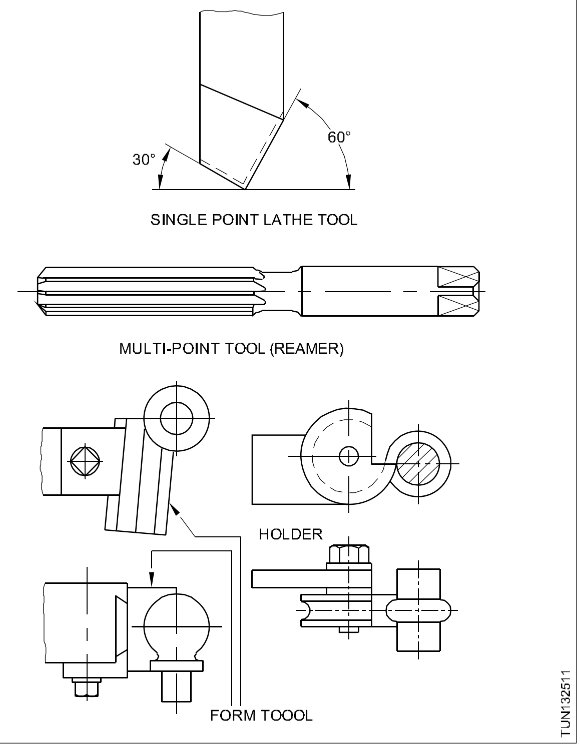
Lathe cutting tools - Different types, shapes, specification of lathe tools, good cutting tool material & material properties

Objectives : At the end of this lesson you shall be able to
- **classify lathe cutting tools**
- **list the types of lathe cutting tools**
- **state the features of each type.**

Cutting tool classification (Fig 1)

Fig 1



Cutting tools are classified as:

- single point cutting tools
- multi-point cutting tools
- form tools.

Single point cutting tools

Single point cutting tools have one' cutting edge which performs the cutting action. Most of the lathe cutting tools are single point cutting tools.

Single point cutting tools used on lathes may be grouped into:

- side cutting tools
- end cutting tools.(Fig 2)

Side cutting tools

Side cutting edge tools have their cutting edges formed on the side of the cutting tool, and are used on lathes for most of the operations. They are again classified as right hand tools and left hand tools. (Fig 3) A right hand tool operates from the tailstock end towards headstock and a left hand tool operates from the headstock end towards the tailstock. The cutting edge is formed accordingly.

Fig 2

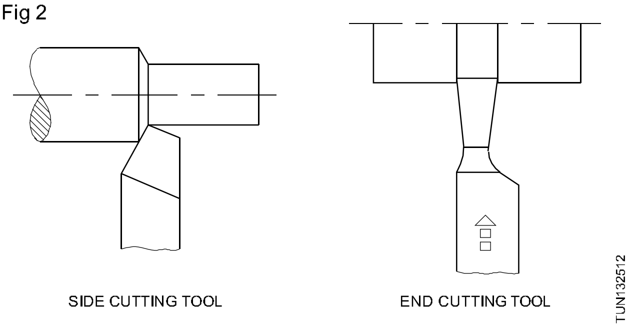
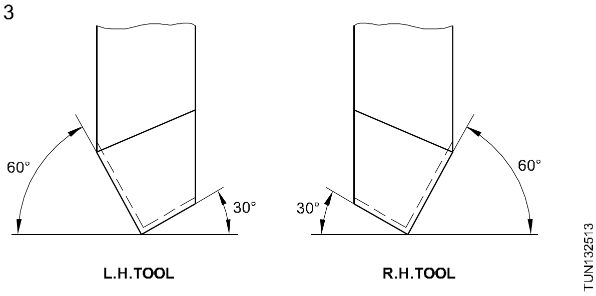


Fig 3



End cutting tools

End cutting tools have their cutting edge at the front end of the tools and are used on lathes for plunge cut operations.

Multi-point cutting tools

These tools have more than one cutting edge, and they remove metal from the work simultaneously by the action of all the cutting edges. The application of the multi-point cutting tools on the lathe is mostly done by holding the tool in the tailstock and feeding it to the work.

Form tools (Fig 4)

These tools reproduce on the work the form and shape of the cutting edge to which they are ground. The form tools perform the operations on the work by a plunging action, and are fixed on the tool post square to the axis of the work and fed by a cross-slide. They may have their cutting edges formed on square or rectangular section tool blanks acting radially. The form tools may be circular form tools and tangential form tools. They may require special holders to which they can be fixed, and the holders are clamped on the tool posts for operation.

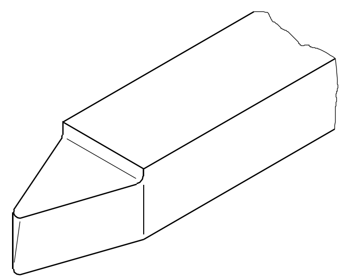
Lathe cutting tool types

The tools used on lathes are classified as :

- solid type tools
- brazed type tools
- inserted bits with holders
- throw-away type tools.

solid bits of square, rectangular and round cross sections. Most of the lathe cutting tools are of solid type, and high carbon steel and high speed steel tools are used. The length and cross-section of the tool depend upon the capacity of the machine, the type of tool post and the nature of the operation.

Fig 4

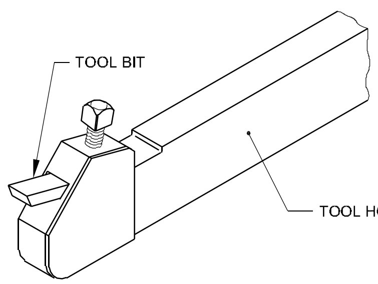


Inserted bits with holders (Fig 5)

Solid high speed steel tools are costly, hence they are sometimes used as inserted bits. These bits are small in sizes and inserted in the holes shaped according to the cross-section of the bit to be inserted. These holders are held and clamped in the tool posts to carry out the operations.

The disadvantage in these types of tools is that the rigidity of the tool is poor in the slot.

Fig 5

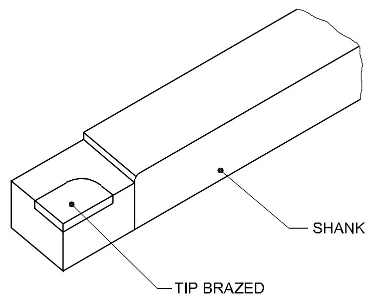


Brazed tools (Fig 6)

These tools are made of two different metals. The cutting portions of these tools are good cutting tool materials, and the body of the tools does not possess any cutting ability and is tough. Tungsten carbide tools are mostly of the brazed type. Tungsten carbide bits of square, rectangular and triangular shape with proportionately less thickness are brazed to the tips of the shank metal.

The tips of the shank metal pieces have machined top surface according to the shape of the bit to accommodate the carbide bits. These tools are economical and give better rigidity to the tools than the inserted bits clamped in the tool-holders. This is applicable to high speed steel brazed tools also.

Fig 6

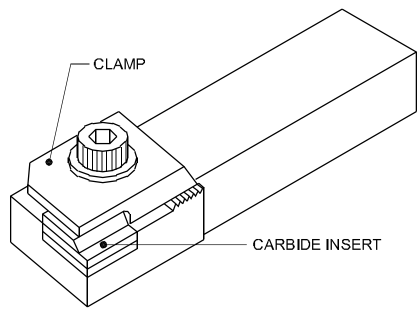


Throw-away type tools (Fig 7)

Carbide-brazed tools, when blunt or broken, need grinding which is time absorbing and expensive. Hence they are used as throw-away inserts in mass production. Special tool-holders are needed, and the carbide bits of rectangular, square or triangular shapes are clamped in the seating faces machined in these types of special holders.

The seating faces are machined such that the rake and clearances needed for the cutting bits are automatically achieved when the bits are clamped. As these tools are to be operated at very high cutting speeds, the capacity of the machine must also be high and the rigidity of the machine must be good as well.

Fig 7



HOLDER FOR THROW-AWAY CARBIDE INSERTS

Types and specifications of carbide tools

Objectives : At the end of this lesson you shall be able to
- **identify the different types of carbide tools**
- **state the specifications of carbide tools.**

Cemented carbide tools are available as brazed tipped tools and throw away tips held in specially designed tool holders.

Standard shapes of carbide-tipped turning and facing tools are shown in the Figs. Carbide tipped cut off and boring tools are also available. these tools are resharpened as needed using special silicon carbide and diamond wheels.

Standard terms for carbide tools as specified in ISO

ISO 1 straight turning tool (Fig 1)

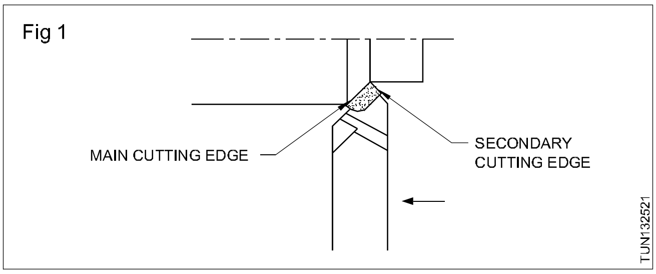


Fig 1

ISO 2 Cranked turning tool (Fig 2)

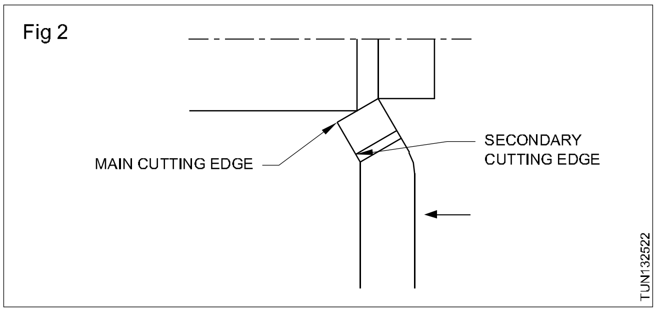


Fig 2

ISO 3 Offset facing tool (Fig 3)

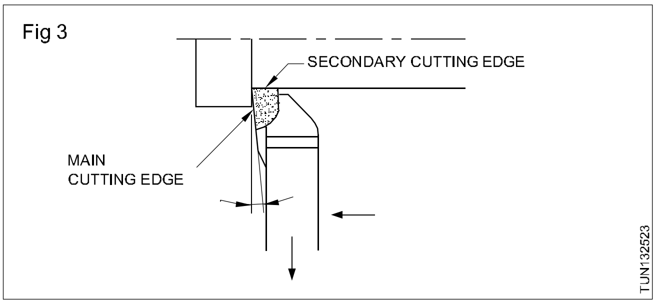


Fig 3

ISO 4 Wide nose square turning tool (Fig 4)

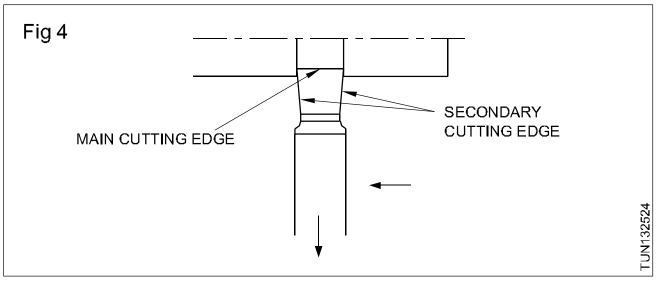


Fig 4

ISO 5 Offset turning and facing tool (Fig 5)

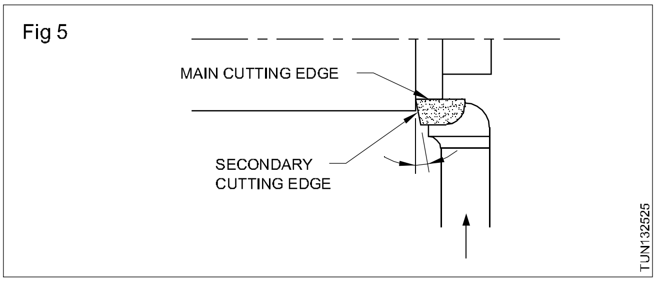


Fig 5

ISO 6 Offset side cutting tool (Offset knife tool) (Fig 6)

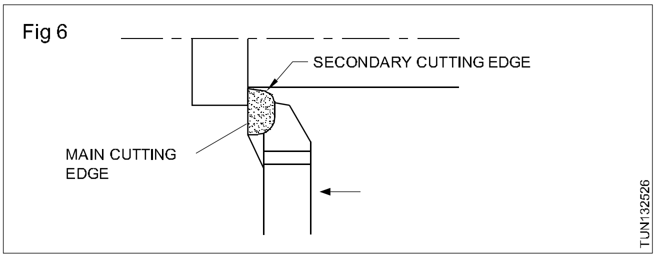


Fig 6

ISO 7 Recessing tool (parting tool) (Fig 7)

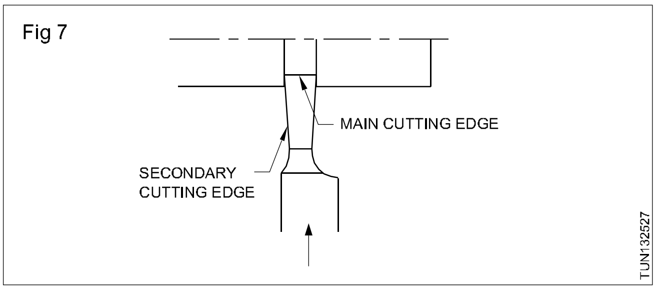


Fig 7

ISO 8 Boring tool (Fig 8)

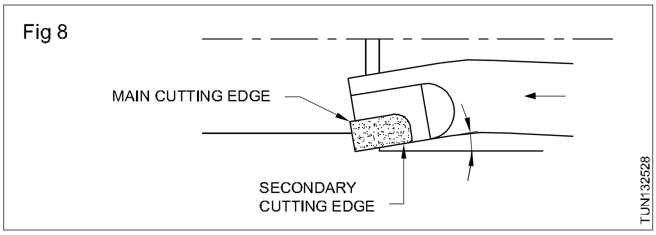


Fig 8

ISO 9 Corner boring tool (finishing) (Fig 9)

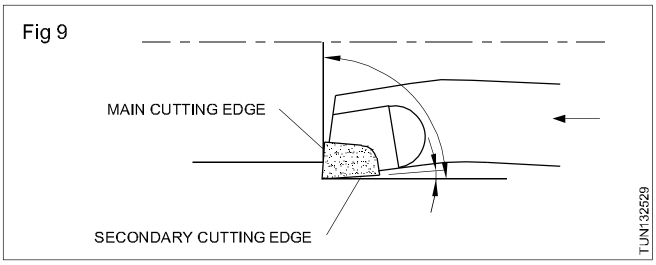


Fig 9

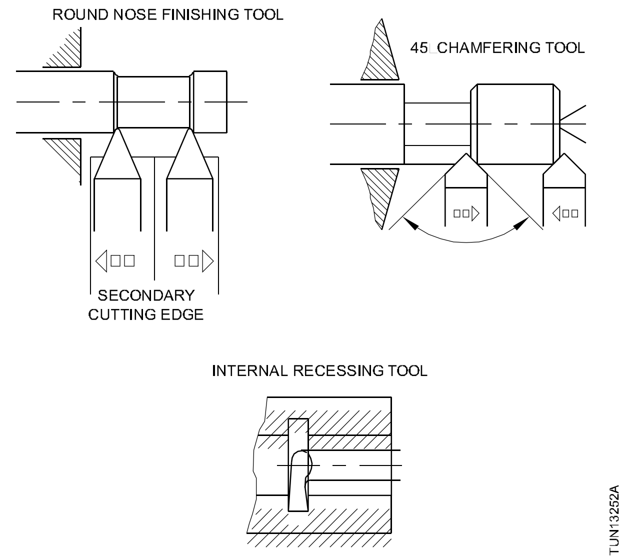
The carbide tools are specified according to (1) the operations (rough and finish) (2) right hand or left hand (3) material being turned and machining conditions. Refer to Table 1.

Kinds of lathe cutting tools (Fig 10)

The different types of lathe cutting tools are distinguished by the shape of the cutting edge and the operations which they have to perform. Some of the lathe cutting tools are listed here.

- Facing tool
- Knife edge tool
- Roughing tool
- Round nose finishing tool
- Broad nose finishing tool
- Chamfering tool
- Undercutting tool
- External threading tool
- Parting off tool
- Boring tool
- Internal recessing tool

Fig 10



- Internal threading tool

The tools and their application are illustrated in the figures.

Specification of lathe cutting tools, different type, shapes

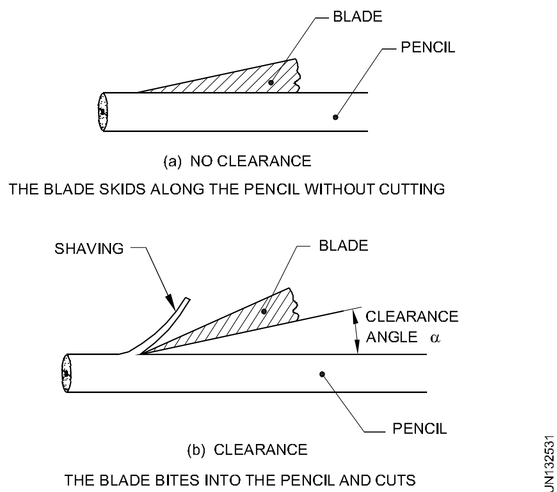
Objectives : At the end of this lesson you shall be able to
- **state the necessity of providing angles and clearances on cutting tools**
- **name the angles of a lathe cutting tool**
- **state the characteristics of a rake angle**
- **state the characteristics of a clearance angle**
- **refer to a chart to determine the recommended rake and clearance angles for turning different metals.**

Need to provide angles and clearances

The cutting action of a lathe tool during turning is the wedging action. The wedge-shaped cutting edge has to penetrate into the work and remove the metal. This necessitates the grinding of the solid tool bit to have the wedge formation for the cutting edge.

When we sharpen a pencil with a pen knife by trial and error, we find that the knife must penetrate into the wood at a definite angle, if success is to be achieved. (Fig 1)

Fig 1

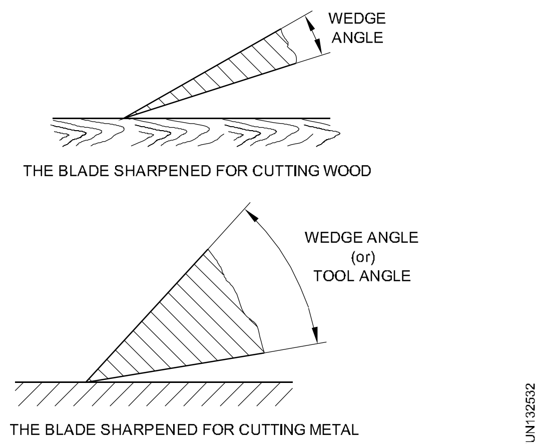


If, in the place of a wooden pencil, a piece of soft metal, such as brass is cut, it will be found that the cutting edge of the blade soon becomes blunt, and the cutting edge has crumbled. For the blade to cut brass successfully,

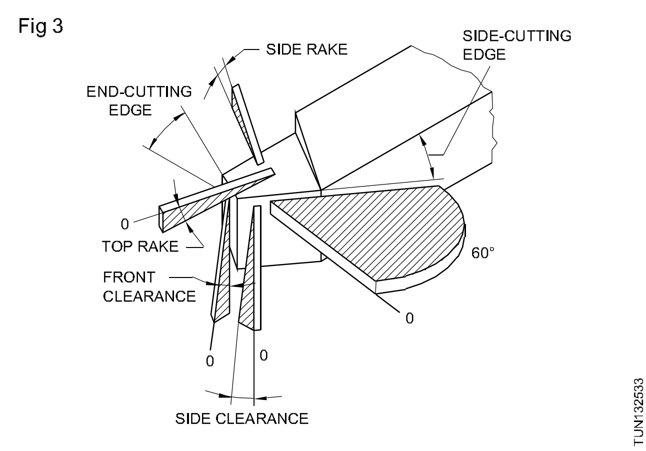
the cutting edge must be ground to a less acute angle to give greater strength as can be seen in Fig 2.

The angle shown in Fig 1 is known as a clearance angle and that shown in Fig 2 is a wedge angle.

Fig 2

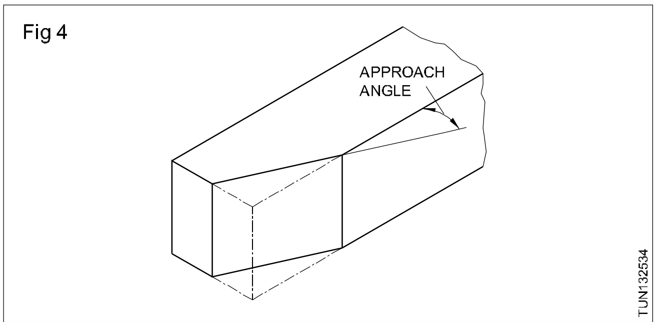


Angles ground on a lathe cutting tool (Fig 3)

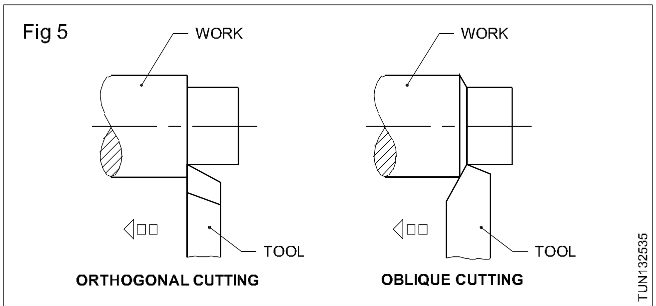


Side cutting edge angle

(Approach angle) (Fig 4)

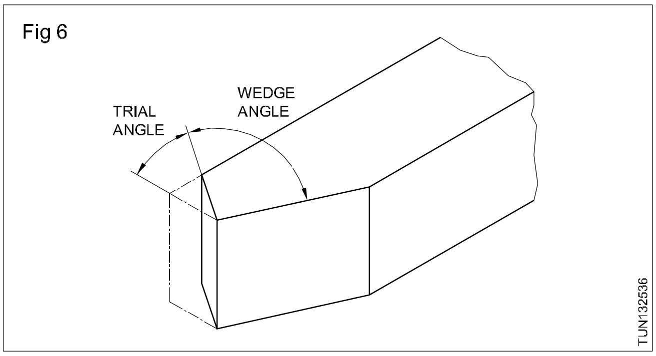


This is ground on the side of the cutting tool. The cutting will be oblique. The angle ground may range from 25°to 40° but as a standard a 30° angle is normally provided. The oblique cutting has certain advantages over an orthogonal cutting, in which the cutting edge is straight. More depth of cut is given in the case of oblique cutting since when the tool is fed to the work, the contact surface of the tool gradually increases as the tool advances, whereas, in the case of orthogonal cutting, the length of the cutting edge for the given depth fully contacts the work from the beginning itself, which gives a sudden maximum load on the tool face. The area, over which heat is distributed, is more in oblique cutting. (Fig 5)



End-cutting edge angle (Trial angle) (Fig 6)

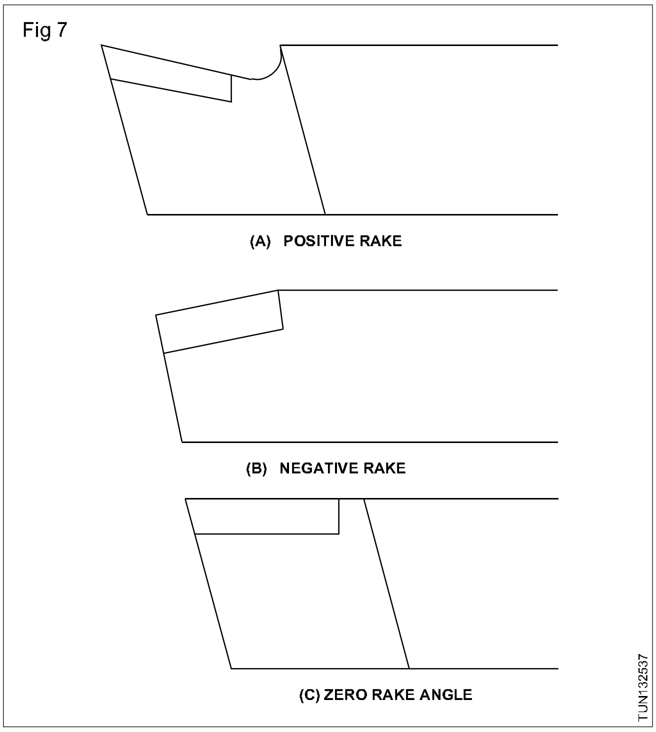
The end-cutting edge angle is ground at 30° to a line perpendicular to the axis of the tool, as illustrated in Fig 3. The side-cutting edge angle and the end-cutting edge angle, when ground, form a nose (wedge) angle of 90° for the tool.



Top or back rake angle (Fig 7)

The rake angle ground on a tool controls the geometry of chip formation for any given material. It controls the mechanics of the cutting action of the tool. The top or back rake angle of the tool is ground on the top of the tool, and it is a slope formed between the front of the cutting edge and the top face.

Resistive top rake angle (Fig 7A)



If the slope is from the front towards the back of the tool, it is known as a positive top rake angle. When turning soft materials which form curly chucks and good surface finish. Cutting tool life is very short.

Negative top rake angle (Fig 7B)

If the slope is from the back of the tool towards the front of the cutting edge, it is known as the negative top rake angle. When turning the hard brittle metals with carbide tools it is usual practice to give a negative top rake.

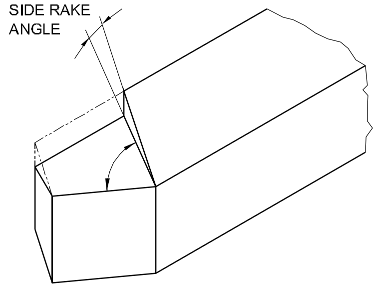
Negative top rake tools have more strong than positive top rake angle tools. Tool life is too long. Chip should be broken and rough surface finish.

Zero top rake angle (Fig 7C)

If the cutting edge is straight line is called zero top rake angle when turning soft, ductile materials i.e. aluminium, brass, copper.

Side rake angle (Fig 8)

Fig 8



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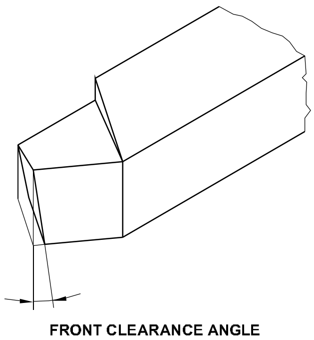
The side rake angle is the slope between the side of the cutting edge to the top face of the tool widthwise. The slope is from the cutting edge to the rear side of the tool. It varies from 0° to 20° according to the material to be machined. The top and side rakes, ground on a tool, control the chip flow and this results in a true rake angle which is the direction in which the chip that shears from the work passes.

Front clearance angle (Fig 9)

This angle is the slope between the front of the cutting edge to a line perpendicular to the axis of the tool drawn downwards. The slope is from the top to the bottom of the tool, and permits only the cutting edge to contact the work, and avoids any rubbing action. If the clearance ground is more, it will weaken the cutting edge.

Fig 9



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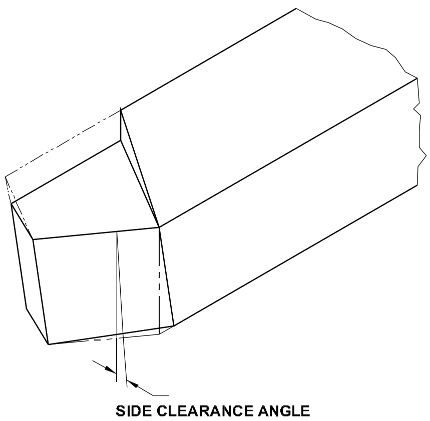
Side clearance angle (Fig 10)

Fig 10



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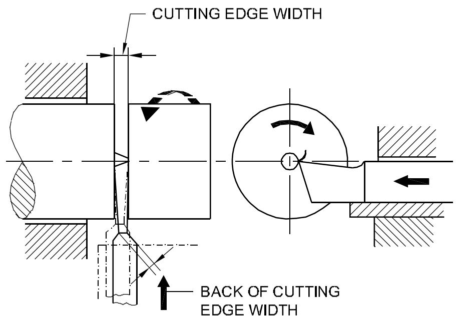
The side clearance angle is the slope formed between the side cutting edge of the tool with a line perpendicular to the tool axis drawn downwards at the side cutting edge of the tool. The slope is from the top of the side cutting edge to the bottom face. This is also ground to prevent the tool from rubbing with the work, and allows only the cutting edge to contact the work during turning. The side clearance angle needs to be increased when the feed rate is increased.

When grinding the rake and clearance angles, it is better to refer to the standard chart provided with the recommended values, and then grind. However, actual operation will indicate the performance of the tool and if any modification is needed for the angles ground on the tool.

Side relief angle (Fig 11)

Fig 11

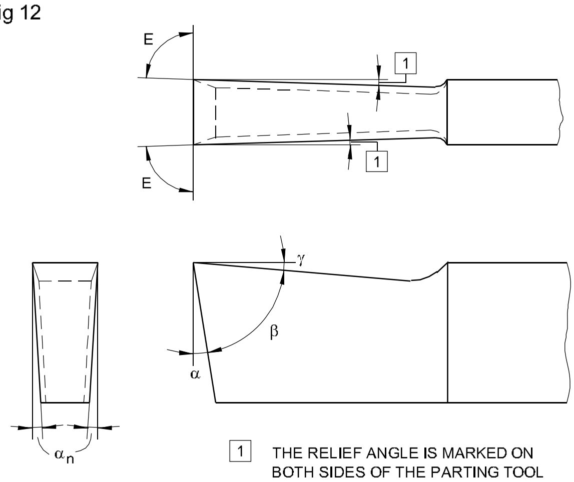


TUN13253B

This angle is ground on the parting and the undercutting tools on both sides. This will provide the width of the cutting edge slightly broader than the back of the cutting edge.

This permits clearance between the sides of the tool and the groove walls formed by the plunging action of the tool, thereby, preventing the tool from getting jammed in the groove and causing breakage. The relief is kept as minimum as possible. Too much of relief will weaken the tool cutting edge, and also permit the chips to clog in the gap, causing the tool in both cases to break. Side relief is also provided sometimes to the main cutting edge of the facing tools, permitting only the cutting point performing the operation, when the tool axis is set perpendicular to the lathe axis. The side relief angle normally does not exceed 2°.

Fig 12



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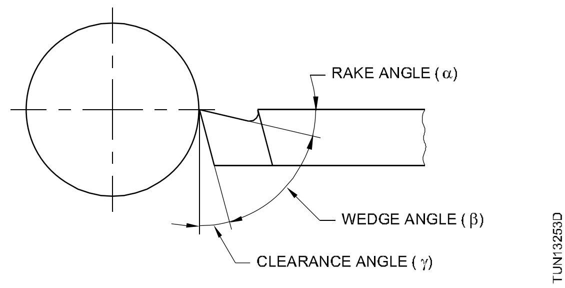
Relationship between rake, clearance and wedge angles (Fig 13)

The rake angle (∝), clearance angle (γ) and the wedge angle (β) have close relationship for efficiency in cutting. Excessive rake angle reduces the wedge angle, which helps in good penetration and it is particularly useful for cutting soft metals. A decreased wedge angle weakens the tool strength. Therefore, for cutting hard metals, the rake angle is zero or negative. The clearance angle is generally fixed depending on the geometry of the surface being cut.

Fig 13



Properties of good cutting tool materials

Objectives: At the end of this lesson you shall be able to
- **state the qualities of good cutting tool material**
- **distinguish between the characteristics of cold hardness, red hardness and toughness**
- **state the factors to be noted when selecting a tool material.**

Tool materials

Metal cutting tool materials perform the function of cutting. These materials must be stronger and harder than the material to be cut. They must be sufficiently tough to resist shock loads that result during cutting operations. They must have good resistance to abrasion and a reasonable tool life.

The three most important basic qualities that any cutting tool material should possess are:

- cold hardness
- red hardness
- toughness.

Cold hardness

It is the amount of hardness possessed by a material at normal temperature. Hardness is the property possessed by a materially which it can cut other metals, and has the ability to scratch on other metals.

When hardness increases, brittleness also increases, and a material which is having too much of cold hardness is not suitable for the manufacture of cutting tools.

Red hardness

It is the ability of a tool material to retain most of its cold hardness even at very high temperature. During machining due to friction between tool and work, tool and chip, heat is generated, and the tool loses its hardness, and its efficiency to cut diminishes. If a tool maintains its cutting efficiency even when the temperature during cutting increases, then that metal possesses the property of red hardness.

Toughness

The property possessed by a material to resist sudden load that results during metal cutting is termed as toughness. This will avoid the breakage of the cutting edge.

Points to be noted when selecting a tool material

- Condition and form of material to be machined.
- Material to be machined.
- Condition of the machine tool available.
- The total quantity of production and the rate of production involved.
- The dimensional accuracy required and the quality of surface finish.
- The amount of coolant applied and the method of application.
- The skill of the operator.

Different tool materials

Objectives : At the end of this lesson you shall be able to
- **classify the tool materials**
- **list the tool materials under each group**
- **state the merits and demerits of each tool material.**

Classification of tool material

The tool materials may be classified into three categories, namely:

- ferrous tool materials
- non-ferrous tool materials
- non-metallic tool materials.

Ferrous tool materials

Ferrous tool materials have iron as their chief constituent.

High carbon steel (tool steel) and high speed steel belong to this group.

Non-ferrous tool materials

Non-ferrous tool materials do not have iron, and they are casted by alloying elements like tungsten, vanadium, molybdenum etc. Stellite belongs to this group.

Carbides which are also of non ferrous tool material are manufactured by powder metallurgy technique. Carbon and tungsten are the chief alloying elements in this process.

Non - Metallic tool materials

Non-metallic tool materials are made out of non-metals. Ceramics and diamonds belong to this category.

High carbon steel is the first tool material introduced for manufacturing cutting tools. It has poor red hardness property, and it loses its cutting efficiency very quickly. By adding alloying elements like tungsten, chromium and vanadium to high carbon steel, high speed steel tool material is produced. Its red hardness property is more than high carbon steel. It is used as solid tools, brazed tools and as inserted bits. It is costlier than high carbon steel.

Carbide cutting tools can retain their hardness at very high temperatures, and their cutting efficiency is higher than that of high speed steel. Due to its brittleness and cost, carbide cannot be used as a solid tool. It is used as brazed tool bit and throw-away tool bit.