MACHINE TOOL APPLICATION

GRINDING MACHINE

Traditionally, any machine we see is produced with the he help of another machine. These machines which are used to produce other machines are called MACHINE TOOLS.

The very first machines however were manually made by highly skilled men who could work within the required accuracy.

With time however, higher and consistent degree of accuracy came into demand, together with greater forces required, and with increased rate of production due to demand, machines became a requirement in the production process.

INTRODUCTION TO DIMENSION CONTROL AND INSPECTION

Any complete machine is composed of numerous parts, which are produced separately and then assembled. The processes of producing each of those parts involve careful dimension control to suit the required type of fit. When assembled, the two parts are fitted while bearing either of the following two points in mind:-

1) A fit that allows relative movement between the two (clearance fit)
2) A fit that does not allow relative movement between the two (interference fit)

There are three ways of achieving this.

1) Using individual assembly method,
2) Using selective assembly method,
3) Using Systems of Limits and Fits.

INDIVIDUAL ASSEMBLY

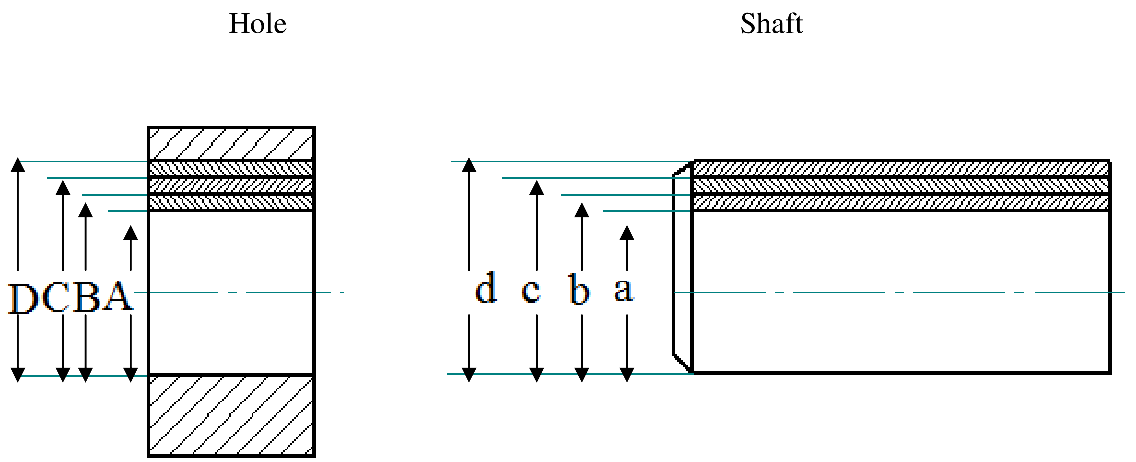
In this approach, one of the two parts to be assembled is first machined as close as possible to the required dimension in the working drawing. The second part is then machined while testing using the first piece until when the required fit is attained (clearance or interference).

The disadvantage of this method is that it is slow due to the numerous stoppages required for the frequent checks. It also needs highly skilled personnel for operating the machine. The parts are made for each other and may not fit properly with any other part made for the same purpose. All the above reasons make this method very costly.

SELECTIVE ASSEMBLY

This approach takes into account the fact that it is impossible to produce a particular size on many components and be consistently exact, yet the small variations do not necessarily render the work piece useless. All parts with sizes that fall within acceptable range (tolerance) must therefore be used by selecting the pairs, which fit with each other for the required fit (clearance or interference).

For this reason, all parts produced are carefully measured to find out the range of sizes in which they fall. It therefore becomes possible to sort them according to sizes that fall within the same range and therefore be able to determine which ones do produce the right fit when assembled.



For clearance fit		For interference fit	
B fits with a	(Red)	A fits with b	(Yellow)
C fits with b	(Black)	B fits with c	(Green)
D fits with c	(Blue)	C fits with d	(Grey)

Holes and shafts of particular ranges of sizes are separated in groups, which are marked, tagged or color-coded to make them readily identifiable. Groups of shafts and holes, which give the right fit when assembled, bear the same mark, tug or color code.

Much as this method may not require very high skill from a machine operator, making it slightly faster, it demands very high skill at the sorting stage, with measuring instruments of higher degree of accuracy. These instruments are also expensive.

Because parts are selected according to groups during assembly, for machines produced using this method, replacement of broken parts during repair are done by replacing the part with a whole assembly, which includes the broken part. If for example, the hole is worn out and the shaft is still in good condition, even the shaft is replaced.

SYSTEMS OF LIMITS AND FITS

In this method, sizes of all components are determined by the designer at the designed stage and given *limits* within which a particular size on a component must fall.

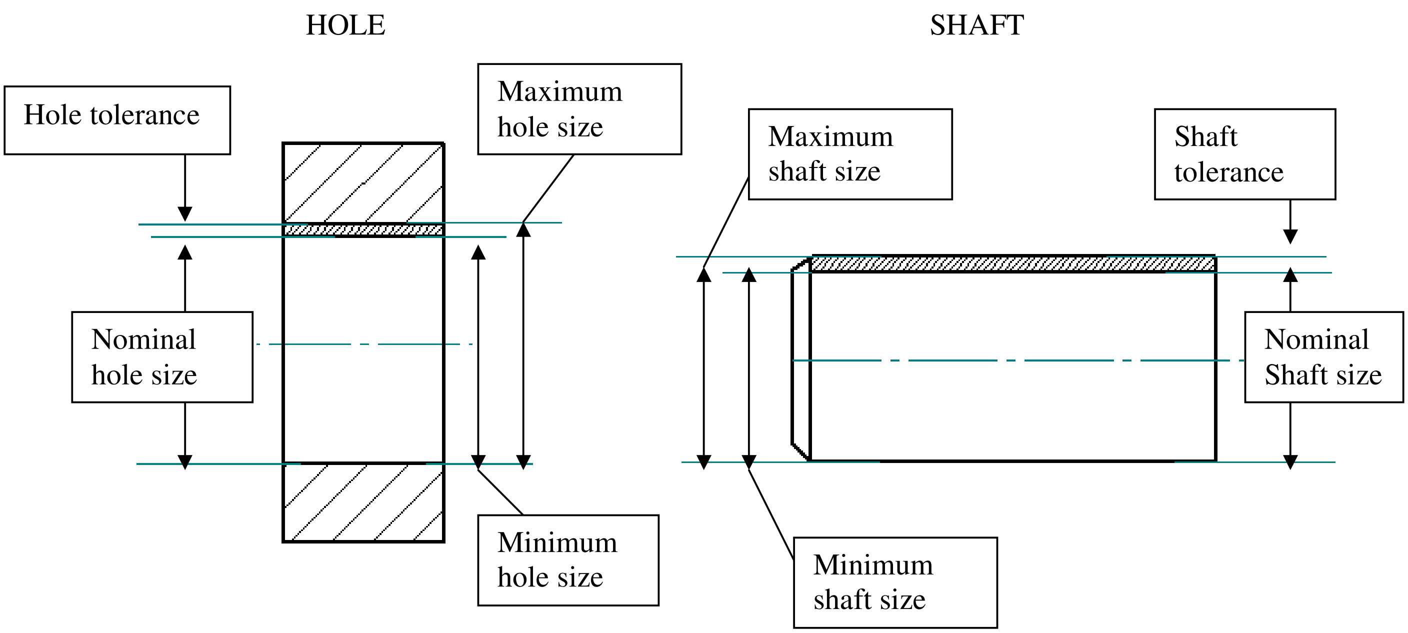
All these take place in the mind of the designer only. It becomes known to any other person only after the designer has put it down in drawing. This however can be transformed into components only if the designer produces a *working drawing* with the right limits determined by him.

What are limits?

Because of machine error that depends on the machine condition and human error that depends on several factors, it is impossible to do machining and produce a size and say with certainty that the size obtained is the actual size, because even if the size has actually been got, there is human error in taking the measurement from the workpiece onto the measuring instrument and another in reading correctly to get the size indicated on it. On top of that is the error of the instrument, which depends on its accuracy.

The problem is even compounded when dealing with hard materials like metals, since small size variations in the order of thousands of a millimeter do matter a lot at assembly stage, and obtaining the right fit may not be possible.

This is why setting limits is very important. It is only the designer who knows what limits to set for a particular size in order to obtain a fit, which works best on the machine when properly assembled.



Dimension control during material removal is directly related to the amount (volume or weight) of material that remains on the final product (the component). Therefore, by setting limits, the designer sets the maximum and minimum size (and therefore weight or volume) of a component. This makes it possible to produce from one working drawing any number of that component, and all of them will be acceptable to the designer as long as their sizes fall within the limits specified in the working drawing.

The implication is that the component has conditions of maximum amount of material acceptable *(maximum metal condition)*, and minimum amount of material acceptable *(minimum metal condition)*.

It is then up to the machine operator to use the working drawing and produce components with sizes that fall within these limits for them (the components) to be acceptable.

There are three ways of controlling the sizes:-

1) Direct measurements using measuring instruments of the right accuracy.

2) Gauging using limit gauges.
3) Comparing using comparators.

DIRECT MEASUREMENTS

In order to produce components whose sizes lie within the specified limits, the machine operator must not only know how to operate the machine for metal removal purposes, but also know how to take measurements properly using the instrument, and read the instrument down to the required accuracy. In this process, the operator stops the machine after passes of metal removal and takes the size of the remaining material *(shaft or hole)*. The main aim is to see if the size falls within the one specified in the drawing. However with each pass of metal removal one of the following three situations is likely to result in both shaft and hole cases:-

For shafts,

1) The size is above the upper limit, meaning that the component is not yet acceptable because the weight or volume is still more than the one specified and the metal removed is insufficient. The next action from the operator is to remove more material.
2) The size is within the limits, meaning that sufficient metal has been removed and the component is acceptable. The next action is to remove it from the machine and it is ready for use or storage.
3) The size is below the lower limit, meaning that the metal removed is in excess and the component has less weight or volume than the one specified. The next action is to remove the component from the machine and discard it off, it is scrap.

For holes,

1) The size is above the upper limit, meaning that the material removed is in excess and the component has less weight or volume than the one specified. The next action is to remove the component from the machine and discard it off, it is scrap.
2) The size is within limits, meaning that sufficient metal has been removed and the component is acceptable. The component is removed from the machine and it is ready for use or storage.
3) The size is below the lower limit, meaning that the component is not yet acceptable because the weight or volume is *still* more than the one specified and the metal removed is insufficient. The next action from the operator is to remove more material.

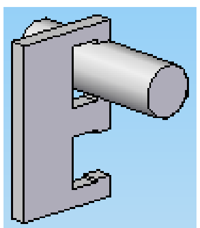
The main thing to note about direct measurement is that the *actual size* of the component is known because the operator reads it on the instrument to make sure that it falls within the required limit before accepting it. The operator must therefore be highly skilled.

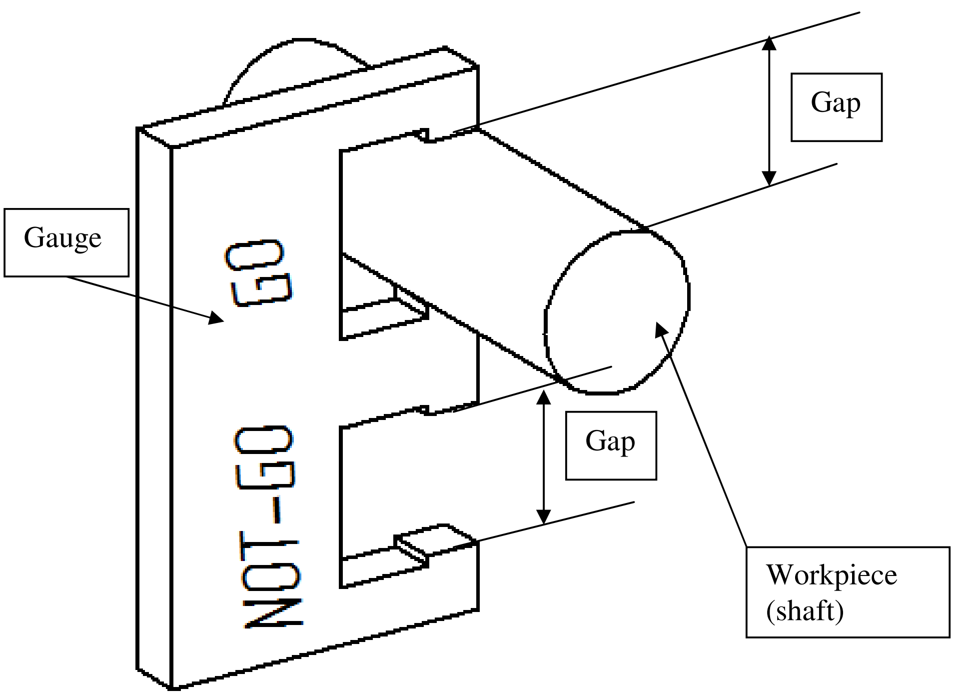
The next two methods however only check whether or not the size falls within the specified limit. The operator does not know the real size.

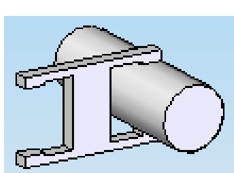
GAUGING

This is done using a special instrument called *gauge*, which has two sizes available on it. One size corresponding to the upper limit and the other one corresponding to lower limit. It is therefore possible to gauge using this instrument to see if the size produced on the component falls within the specified limit before accepting it.

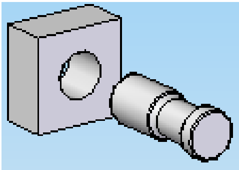
Using this method requires many gauges since every size must have its own gauge with the right limits.

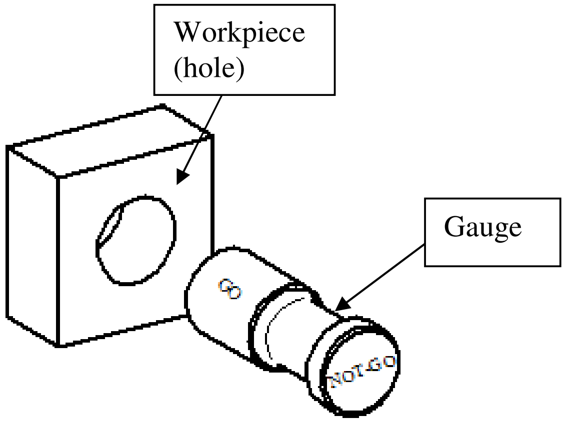




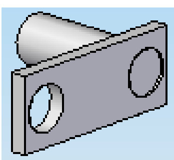


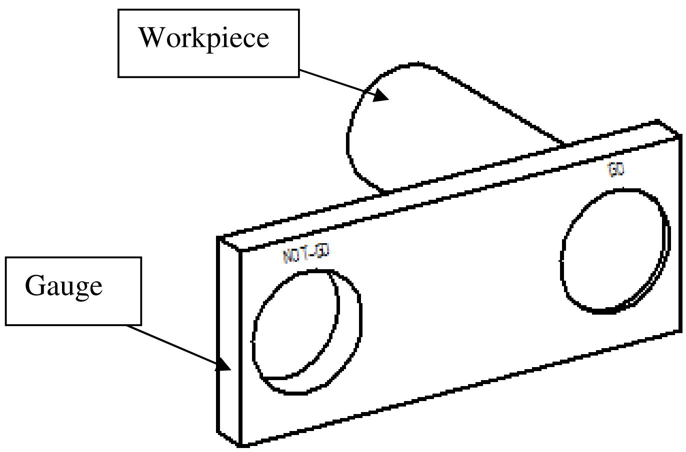
Gap gauge





Plug gauge





Ring gauge

The gauge is put in use during the metal removal process at the machining stage by the operator.

After some metal removal passes, the operator *offers* the *GO* side the gauge to the size being machined on the component. In so doing, the operator is expecting this side of the gauge to be accepted at the machined dimension. The process goes on in conjunction with metal removal until this side actually *goes*. This then marks the end of metal removal process for this dimension.

The big question is whether or not the size obtained falls within the limits specified by the designer. The answer to this question depends on what happens when the *NOT-GO* side of the gauge is offered to the same size on this work piece being machined and the work piece is still on the machine. This is what the operator wants to find out immediately, so he offers the *NOT-GO* side of the gauge to the dimension expecting it to either GO or NOT-GO depending on how much material he took care to remove in the *last* metal removal *pass* during the time he was checking the size using the *GO* side of the gauge. This is a crucial decision making moment and is done *only* by the machine operator who must interpret correctly the status of the work piece when the *NOT-GO* side of the gauge is offered to this machined size, *he must also be sincere* because any bad component taken as acceptable at this stage will be very difficult to detect with the naked eye. The effect can only be felt when it is put to use.

The act of checking with the *NOT-GO* side of the gauge is to make sure that this side of the gauge actually does not *go,* for the component to be acceptable because it will mean that the size produced as a result of metal removal in the last *pass* falls within the required limits.

If it happens so (does not go), the component is removed from the machine as a finished product, which is ready for use or storage.

The other observation expected by the operator when checking with the *NOT-GO* side of the gauge is for this side to also *go* the way the *GO* side did *go.* This would mean that the amount of metal removed in the last metal removal *pass* was in excess of what he should have, and therefore the size produce as a result falls outside the required limits. The component is a reject (SCRAP).

Since all components are made from some material whose original *weight* or *volume* is either *equal* or *more* than that of the component, it is not difficult to see that the *condition* in which the original material, *the work piece,* is left in is either the same or less in weight or volume. Where metal removal is not involved only the shape or the original material changes whereas both weight and volume remain the same. This means that the *condition* of the original material has not changed in terms of weight and volume. However where metal removal is involved, both weight and volume must *reduce*. Sizes therefore play a big role in determining *metal condition* of the finished component in terms of weight and volume. The limits set by the designer, in fact, set the maximum and minimum *metal condition* of the component.

These two conditions are therefore very easily checked using the gauge since the *GO* gauge checks the *maximum metal condition* acceptable by the designer and the *NOT-GO* gauge checks the *minimum metal condition* allowed. This is true for ALL gauges be it for shafts or for holes. Dimension control using gauges does not require high skill and it is fast and easy. However, the initial cost or capital input is enormous due to the total cost of gauges required since each size requires a separate gauge and gauges are very expensive. This method of dimension control is recommended only for mass production.

COMPARATORS

Comparators are more advanced measuring instruments, which are used, for either inspection in mass production of components produced using universal machine tools, or continuous dimension control in automatic machines tools or *machining centers.*

Their working principle is basically comparison. For a given dimension, the instrument is set using two sample pieces. One sample piece has the actual size equal to the *upper limit* size of the component and another sample with the actual size equal to the *lower limit* size of the component. Since the two sizes are different, the indicator on the instrument will assume *one* position when the sample with lower limit size is used and *another* position when the sample with the upper limit size is used. The signal from the sample is magnified, making it possible to see with the naked eye the difference between the sizes of the two sample pieces. This becomes a *zone* that represents the limits set by the designer on the working drawing. It therefore becomes very easy to compare the size of a component with the ones used for setting the two limits. Any size, which falls within the zone, is acceptable. Those that fall outside the zone are either corrected or scrapped.

In existence are mechanical, electrical, pneumatic and hydraulic comparators. Attempts are made to make the zone clearly visible using color zone or color liquid.

It is obvious, the fact that these instruments are very expensive although very easy to use and are very accurate. Just like in the case of using gauges, comparators are used only for quality control and mass production.

What are fits?

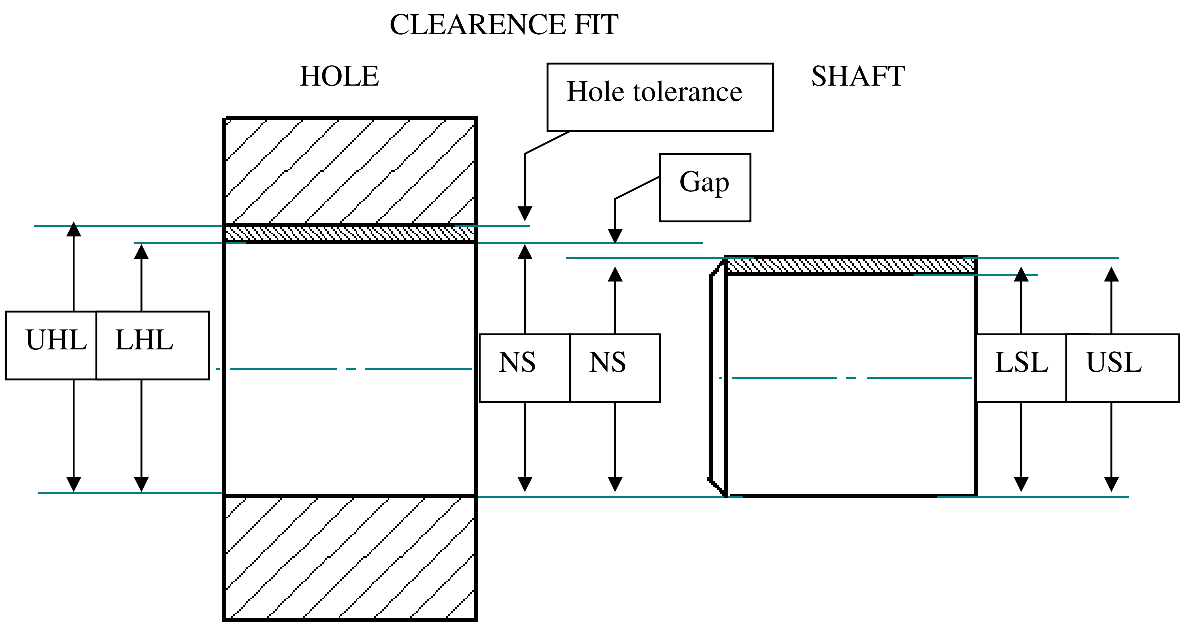
Parts are made to work together after assembling a complete machine. During assembly, the worker must pay attention to the fact that some parts are assembled to allow relative movement between each other and others do not allow relative movement.

In individual assembly, this is taken care of by the machine operator who is himself skilled.

In selective assembly, this is done at the sorting stage where parts are matched or selected and color-coded for storage. It is important to note that there are no rejects here since all parts are matched according to how they fit best.

In the system of limits and fits however, this is taken care of at the design stage by the designer who sets limits for every size. Therefore, ALL parts produced within their limits are *interchangeable,* and will fit perfectly during assembly and fully serve the purpose for which the machine was designed. This is because *only* parts whose sizes fall within the limits set by the designer are cleared as good by the machine operator. There are three types of fits technically known as CLEARENCE FIT, INTERFERENCE FIT and TRANSITION FIT.

The term FIT refers to *shaft* assembled with *hole* to produce either relative movement between each other or no relative movement at all between each other. The designer knows where relative motion is required and where it is not required. He therefore sets limits, which guarantees either free movement or no movement in the right places. It is therefore logical to try to see what goes on inside the designer's mind at this stage by studying the types of fit in detail.



UHL= Upper hole limit

LHL= Lower hole limit

NS= Nominal size

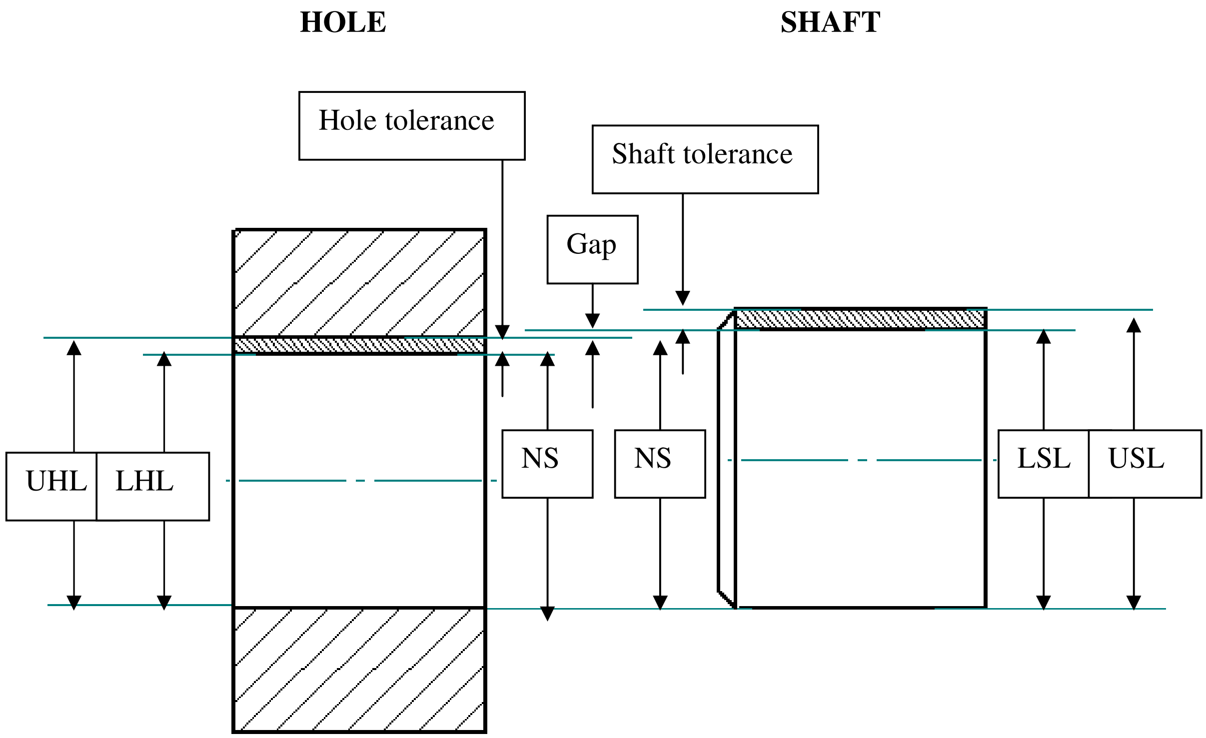
USL= Upper hole limit

LSL= Lower shaft limit

The *tolerance* zone of the hole is *above* that of the shaft and between them is a gap, which is a minimum *allowance* chosen by the designer to *guarantee* clearance fit between the two during assembly. Clearance fit is therefore an imaginary arrangement of shaft and hole working drawings brought together and assembled to show that the largest acceptable shaft is still *smaller* than the smallest acceptable hole or the smallest acceptable hole is still *larger* than the largest acceptable shaft. Designers know that this fit *allows relative* movement between the two parts.

Since any *shaft* or *hole,* whose size falls within the limits is acceptable it can easily be seen that the *minimum clearance allowance* possible for this fit is the difference between the smallest hole and the biggest shaft, and the *maximum clearance allowance* is the difference between the biggest hole and the smallest shaft. The magnitude of the allowance is very important and the designer takes care to make sure that the minimum allowance is there but as small as possible and the maximum allowance is big enough but does not affect the performance of the assembly. When clearance allowance is too big, some parts acceptable as good do assemble with too much ease to make very loose joints with short life span and very noisy when put to use.

INTERFERENCE FIT



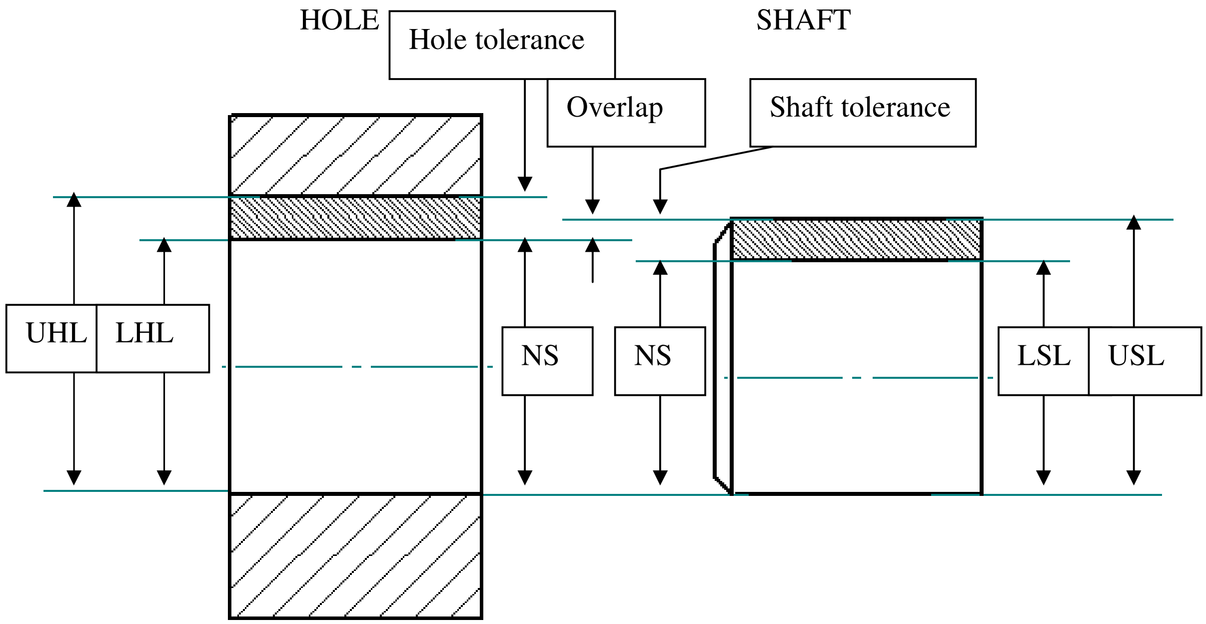
UHL= Upper hole limit NS= Nominal size USL= Upper shaft limit

LHL= Lower hole limit LSL= Lower shaft limit

The *tolerance* zone of the hole is *below* that of the shaft and between them is a gap, which is a minimum *allowance* chosen by the designer to *guarantee* interference fit between the two during assembly. Interference fit is therefore an imaginary arrangement of shaft and hole working drawings brought together and assembled to show that the smallest acceptable shaft is still *larger* than the largest acceptable hole or the largest acceptable hole is still *smaller* than the smallest acceptable shaft. Designers know that this fit *does not allow relative* movement between the two parts.

Since any *shaft* or *hole* whose size falls within the limits is acceptable, it can easily be seen that the *minimum interference allowance* possible for this fit is the difference between the biggest hole and the smallest shaft, and the *maximum interference allowance* is the difference between the smallest hole and the biggest shaft. The magnitude of the allowance is very important and the designer takes care to make sure that the minimum allowance is there but as small as possible and the maximum allowance is just enough and does not affect the assembly process or the performance of the assembly. When interference allowance is too big, some parts acceptable as good are impossible to assemble and if they do, the component with the hole is overstressed leading to either its cracking or excess strain to adjacent moving parts like balls or rollers of bearings. This can affect the performance of the assembly in many ways. Usually the efficiency is reduced and there is overheating which can drastically reduce the life of the machine. It also overloads the prime mover.

TRANSITION FIT



UHL= Upper hole limit NS= Nominal size USL= Upper shaft limit

LHL= Lower hole limit LSL= Lower shaft limit

The *tolerance* zones of hole and shaft overlap. Transition fit is therefore an imaginary arrangement of shaft and hole working drawings brought together and assembled to show that the biggest hole is *bigger* than the smallest shaft and the smallest hole is *smaller* than the biggest shaft.

Designers know that this fit exists only on the working drawing because in reality during assembly only clearance and interference fits are obtained with no effect at all on the performance of the machine.

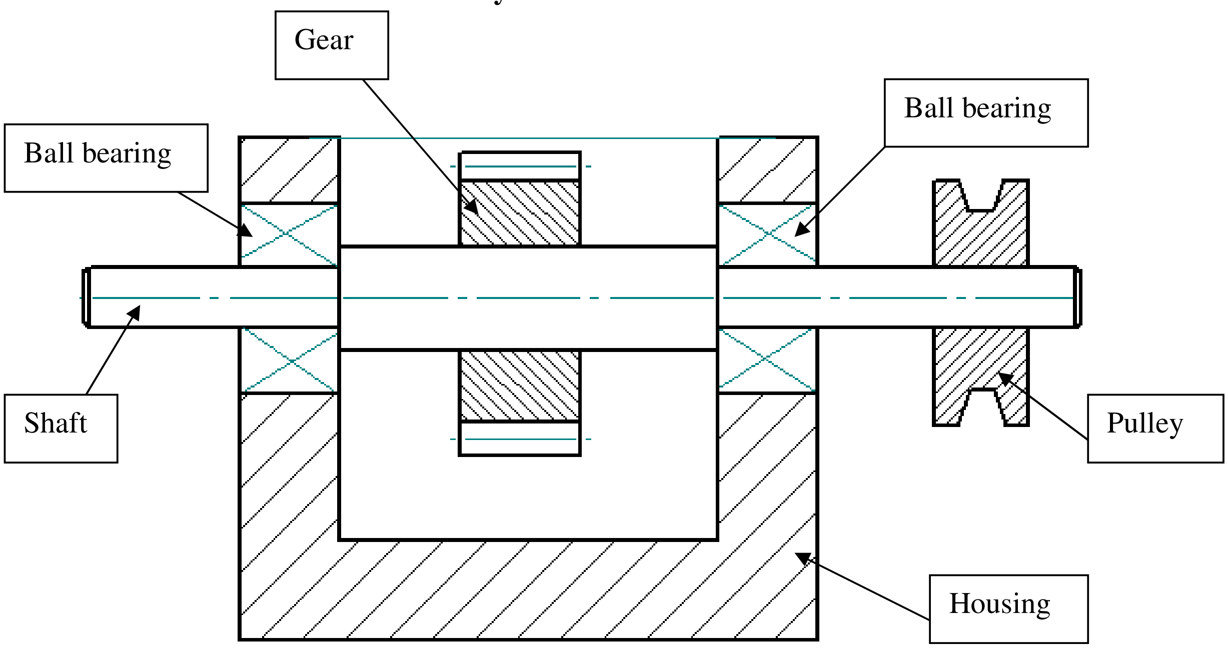
Since any *shaft* or *hole* whose size falls within the limits is acceptable, it can easily be seen that the *maximum clearance allowance* possible for this fit is the difference between the biggest hole and the smallest shaft, and the *maximum interference allowance* is the difference between the smallest hole and the biggest shaft.

Because of the overlap between the hole and shaft tolerance zones, there is no minimum clearance or minimum interference. Theoretically, however there is a possibility of obtaining *zero* clearance or interference. This happens only if the shaft and hole are of the same size, and is possible only within the area of *tolerance zone overlap*.

When shafts and holes are produced on machine tools available to the designer, tolerance limits can easily be controlled to produce components with the sizes required for the right fit. Machine building however involves the use of ready-made components like bearings and plain shafts. The designer then finds himself in a situation where he can control the limits of only one of the two parts involved in the fit. Holes are also produced easily and more accurately using standard size tools like reamers. Systems therefore refer to the methods used to obtain the required fit, either clearance or interference, when one size is already available and on machining operation is required, or when one size is produced using a standard size tool.

There are two systems for obtaining fits and they are based on either the hole or the shaft depending on which one is already available with its fixed size.

Hole basis system



Between ball bearings and shaft is interference fit.

Between gear and shaft is transition fit (either clearance fit or interference fit).

Between shaft and pulley is clearance fit.

Sizes of the holes already exist:-

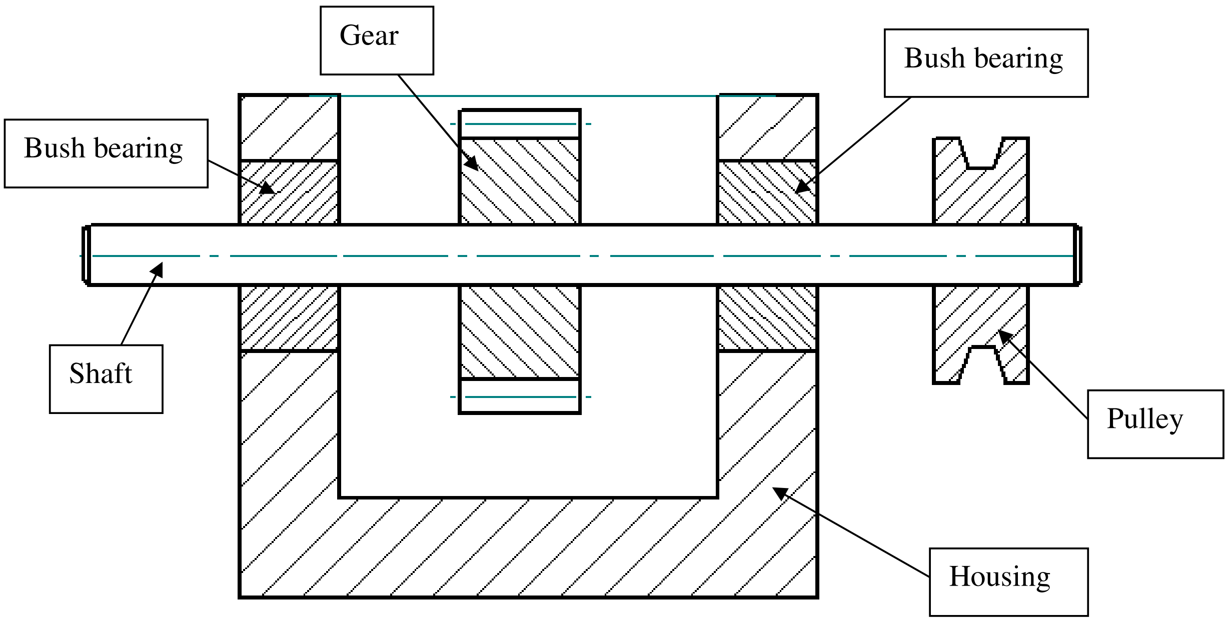
Ball bearings are ready made.

The hole in the gear is reamed using standard size reamer.

The hole in the pulley is reamed using standard size reamer.

The right fit is obtained by machining the shaft to the right size.

Shaft basis system



Between bush bearing and shaft is clearance fit.

Between gear and shaft is transition fit.

Between pulley and shaft is clearance fit.

The shaft is a plain one of standard size.

The required size is obtained by machining:-

The bush bearing for clearance fit

The gear for interference fit.

The pulley for clearance fit.

INSPECTION

In this section, inspection will refer to dimensions only. The methods used to inspect the sizes depend on the type of dimension control used in the production process.

Individual assembly method does not require any inspection since the operator does the right thing either independently or under supervision. Nothing is produced for storage, so there are no parts lying around for inspection. Vital components are stored in an assembled form.

Selective assembly method does require minimum inspection. This is because during the sorting process there are skilled personnel using more accurate measuring instruments. It is an extension of dimension control that ended during the machining stage since each and every component is again measured. Catastrophic errors however do happen, either by reading the measuring instrument wrongly or marking a component with wrong color code and therefore putting it in a different size group.

The use of limits and fits system however require strict inspection since the parts made within limit are assumed to work interchangeably with any other part made within limits for it. Because of this interchangeability concept, parts that are passed as good by the worker are taken straight for use or storage for sale.

Bearing in mind the fact that the workers are semi skilled, inspection methods used should minimize or bring to zero the number of bad components accepted as good and therefore put to use, sold or stored.

Here the most common approach is the use of gauges. The inspection gauges are more accurate than the ones used during production. Since gauges are also manufactured, they are also given tolerances, but the tolerance zones of inspection gauges are smaller and fall within the tolerance zones of the size being checked.

The GO side of the gauge always wears with time and begins accepting *holes of smaller sizes* and *shafts of bigger sizes*.

This can be minimized or brought down to zero using different methods, depending on the volume and method of production. In general, active GO gauges should *never* be allowed to wear up to the *maximum tolerance size limits of shafts*, and *minimum tolerance size limits of holes*. Gauges must therefore be checked frequently using very accurate measuring instruments and replaced before they begin to accept sizes which are outside the tolerance limits.

The other approach is *random sampling* of finished components and replacing the measuring gauge if *a size* is found to fall *close* to the extreme limits of the sizes.

In this case, there is a possibility of *a wrong* size slipping through to assembly line, or even Sales Department.

In the assembly line, these cases are spotted out and handled either *individually* or *selectively*. However in the Sales Department, this is a source of *bad* reputation, which must be avoided at all costs.

Modern approach in production has introduced methods which require constant monitoring of sizes as they are being produced, and the measuring instruments best suited for this are comparators. They are fitted directly on the machine, making the constant size monitoring process possible.

Once the machine is set for a particular size, only tool wear remains basically the only factor in the size variations. As shafts become bigger and holes become smaller, a signal that switches off the machine is sent from a command within the machine before sizes that fall outside tolerance limit zone are produced and the tool is replaced.

Elements of inspection here are therefore the settings on the machine and the settings on the tool, and all parts produced are absolutely interchangeable and can be used, stored or soled without any worry.

MACHINING PRINCIPLES AND METAL CUTTING TOOLS

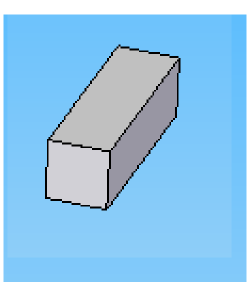
The following are daily life principles that equally do apply to machining of metals and cutting tools:-

1) For any tool to be able to cut another material, the tool must be harder than that material, just like knife cuts bread because it is harder than bread.

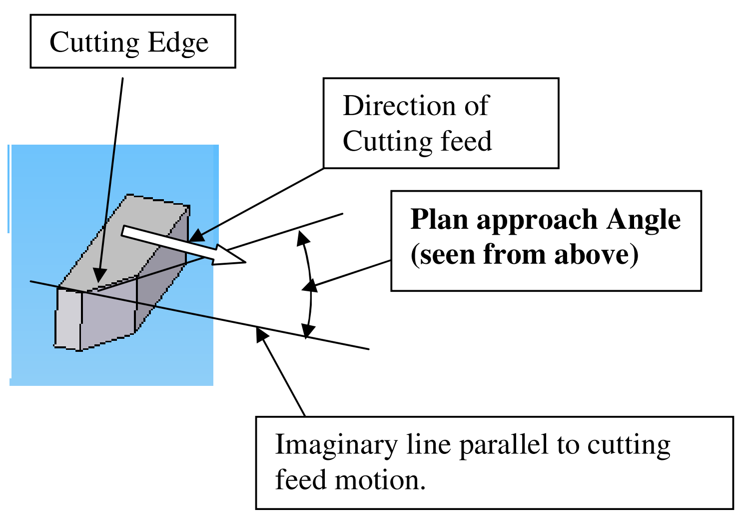
2) Two materials or objects will never occupy the same space at any one given time. If an attempt is made to force them into that one space, there must be collision or accident and the stronger material displaces the weaker one and occupies the space.
3) The tool must have angles around the cutting edge to make the cutting edge stand alone in space so that it touches the material at the cutting edge only for maximum cutting or tearing effect.
4) There must be an effective work holding provision, a device that leaves the work firm and rigid on the machine.
5) There must be an effective tool holding provision, a device that leaves the tool firm and rigid on the machine.
6) There must be controlled motions on the machine, to force work and tool into each other, with contact between work piece and tool at cutting edge only.

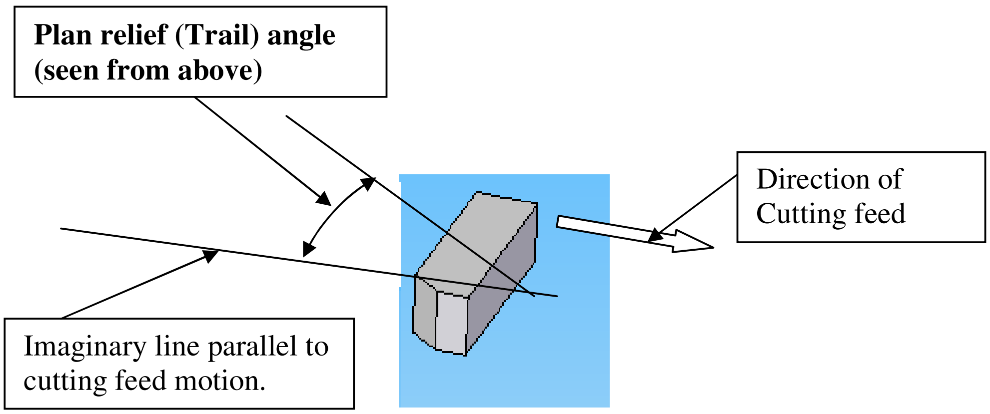
TOOL ANGLES

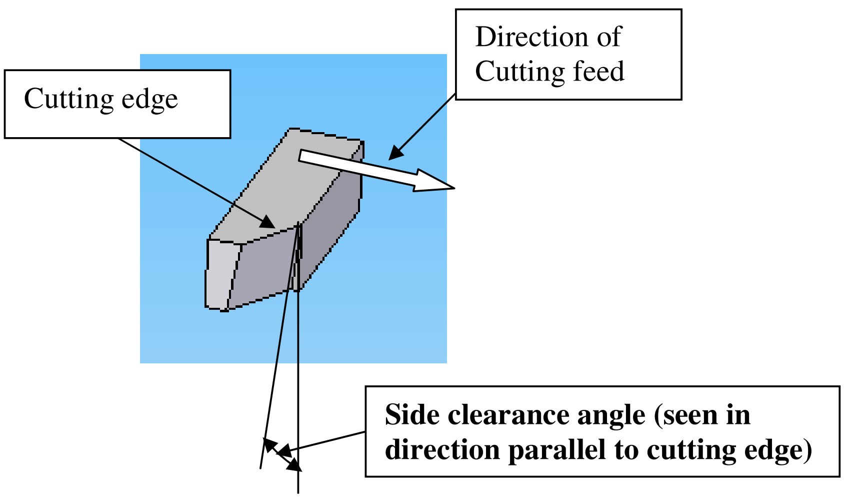
All attempts must be made to understand the position or location of the following angles in relation to the cutting edge of the tool and some particular motions on the machine. The angles are PLAN APPROACH angle, PLAN RELIEF (or TRAIL) angle, FRONT CLEARANCE angle, SIDE CLEARANCE angle, FRONT RAKE, and TRUE RAKE angles. These angles are shone on the turning tool below, but they can be identified on any other metal cutting tool.

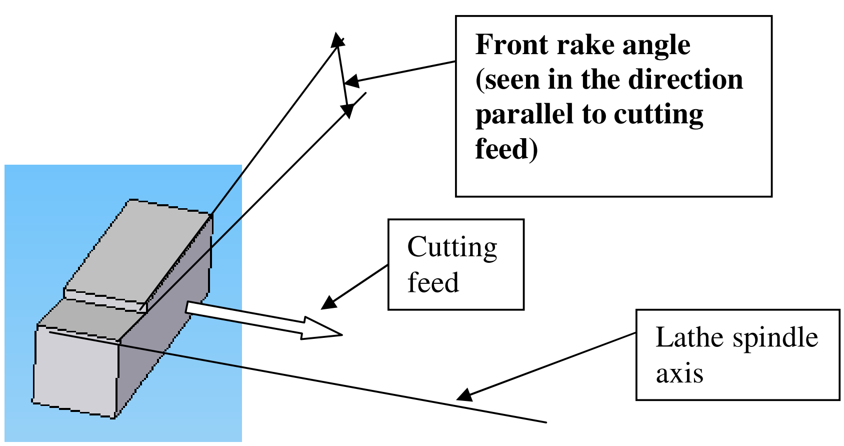


New tool without cutting edge

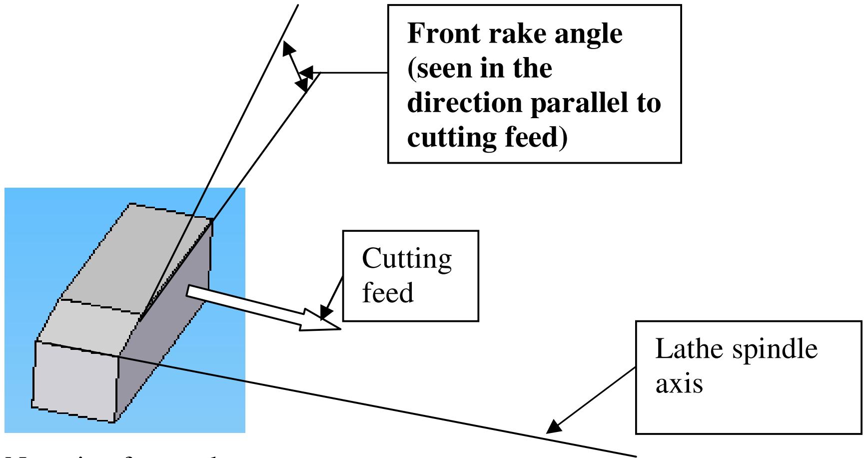




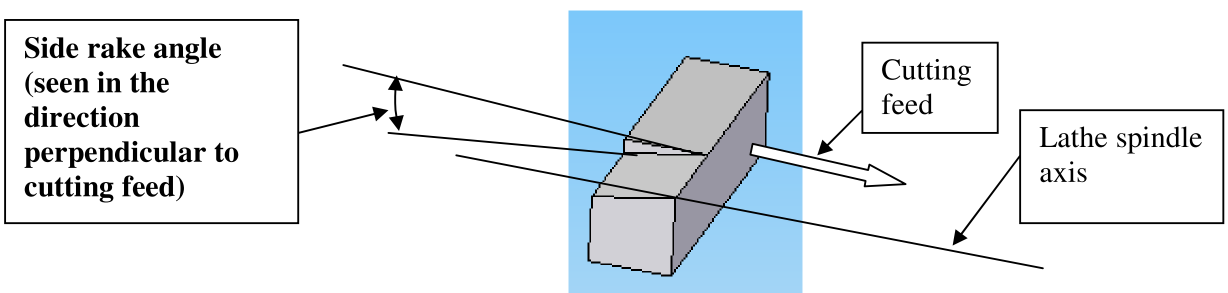




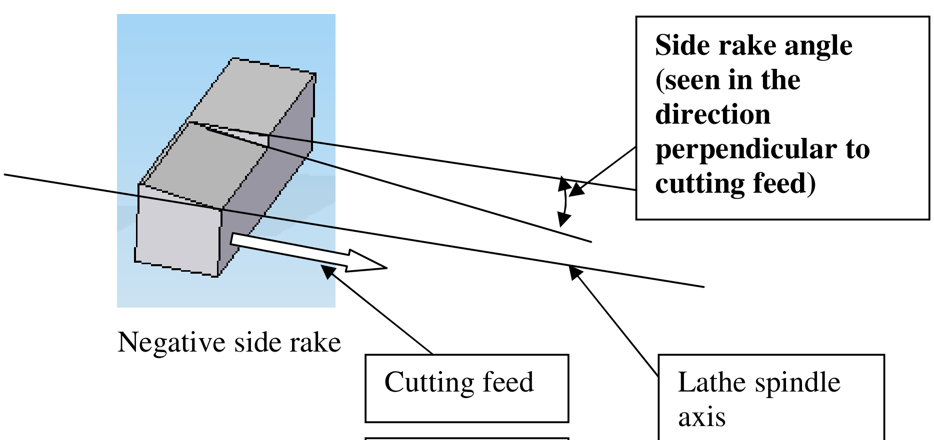
Positive front rake



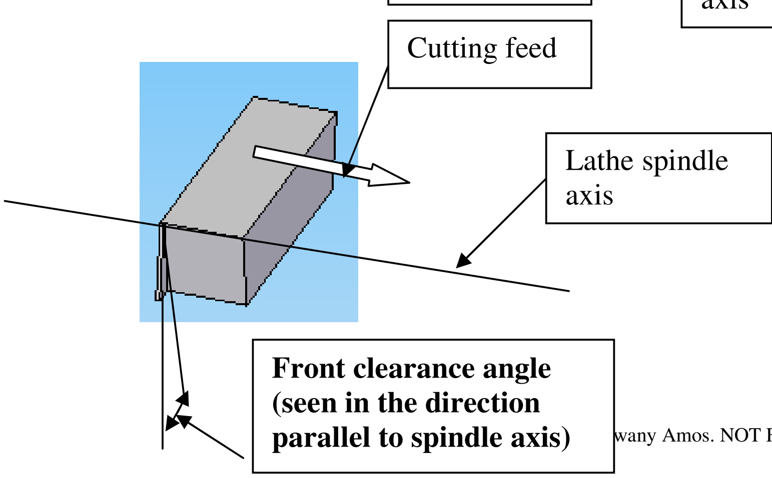
Negative front rake

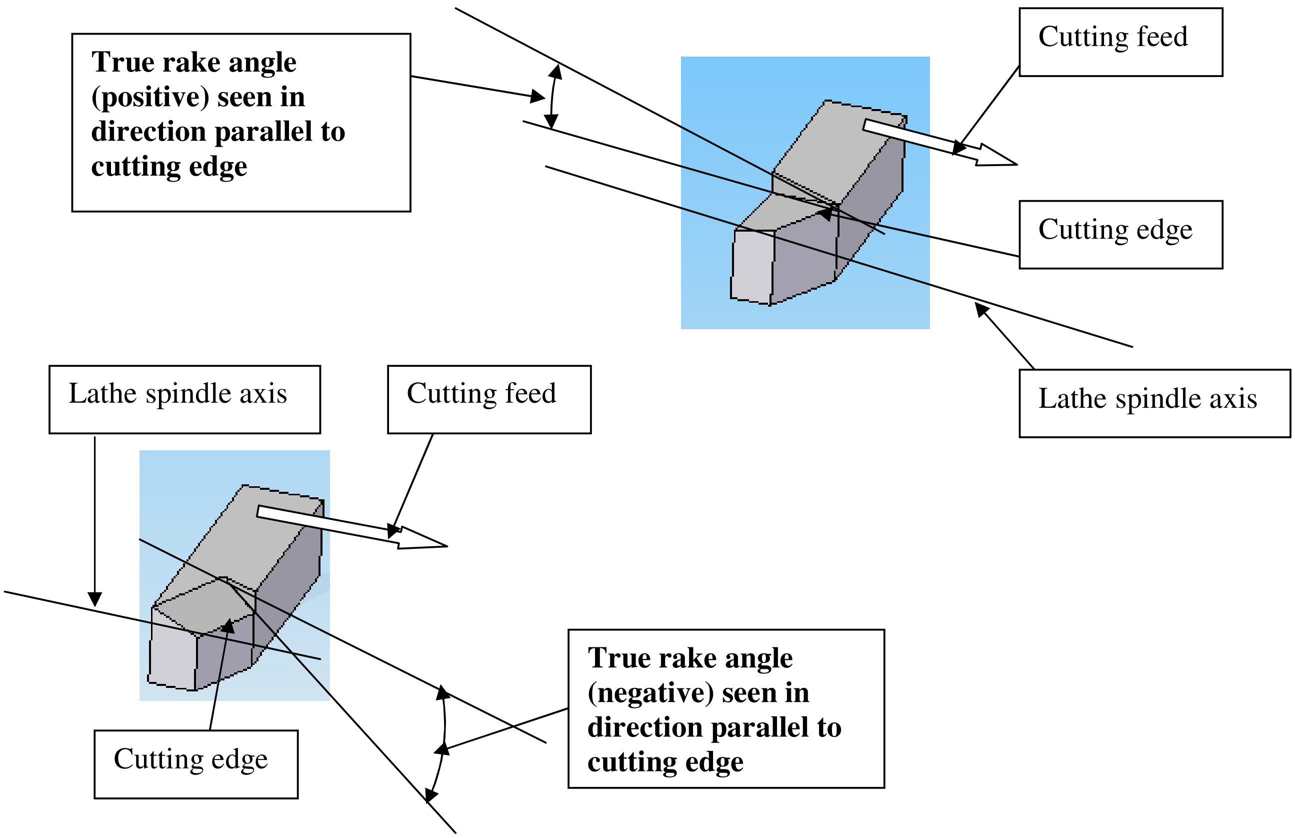


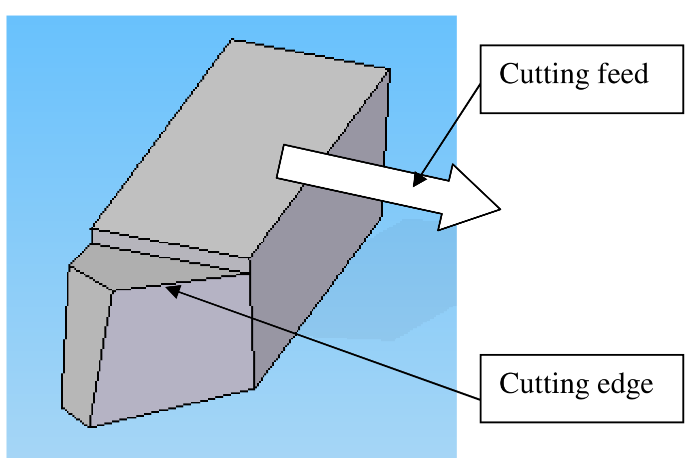
Positive side rake



Negative side rake







Finished tool

GRINDING MACHINES

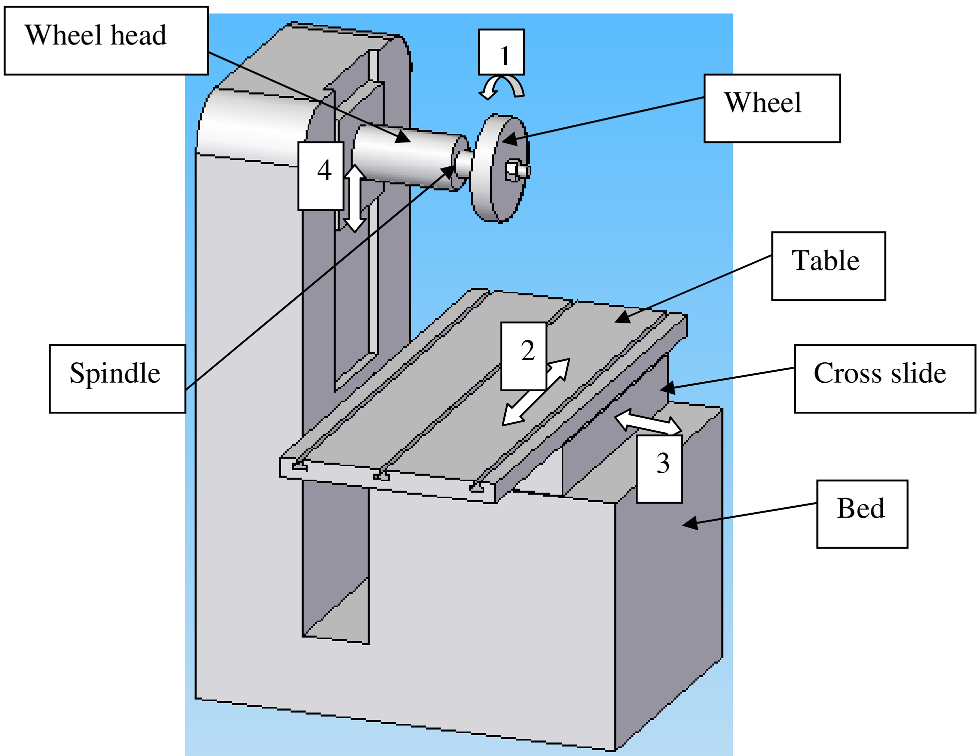
There are three types of grinding machines in common use:

1) Horizontal Grinding Machine.
2) Vertical Grinding Machine.
3) Universal Grinding Machine.

Horizontal Grinding Machine.

The machine acquire its name from the position of its spindle whose axis is horizontal.

General features.



Motions.

-Motion 1- Rotary wheel motion. This is the main motion.

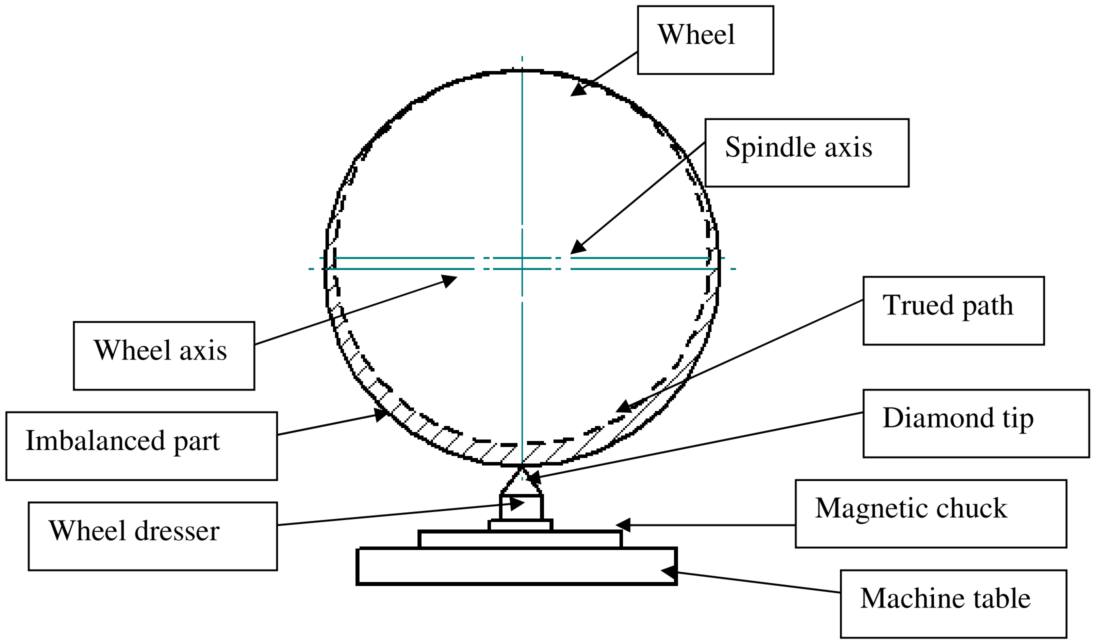
-Motion 2- Linear longitudinal motion of table. This motion is horizontal and parallel to table surface.

-Motion 3- Linear transverse motion of table. This motion is also horizontal and parallel to table surface, but perpendicular to motion 2.

-Motion 4- Linear vertical motion of wheel head, perpendicular to table surface.

Tool holding.

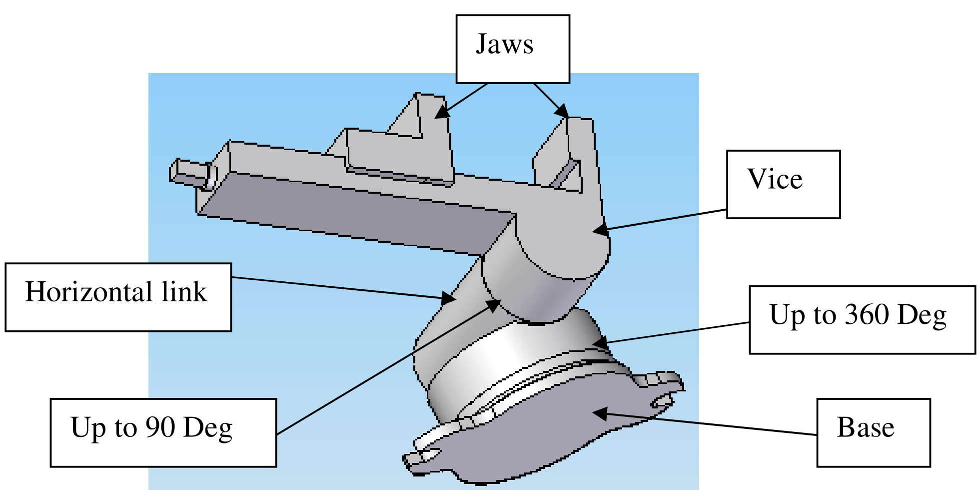
The tool on this machine is the grinding wheel. It rotates at very high speed and could be dangerous if not fitted properly. Only a qualified personnel is allowed to do this. Attention is drawn to the fact that it must not only be firm on the spindle but also well balanced. This is done using a truing tool which has a diamond tip. The operation is called truing.



This operation is also necessary to clean the tool when cutting ability is lost; it is called wheel dressing of a clogged wheel. Clogging occurs mostly when a hard wheel is used on a soft material.

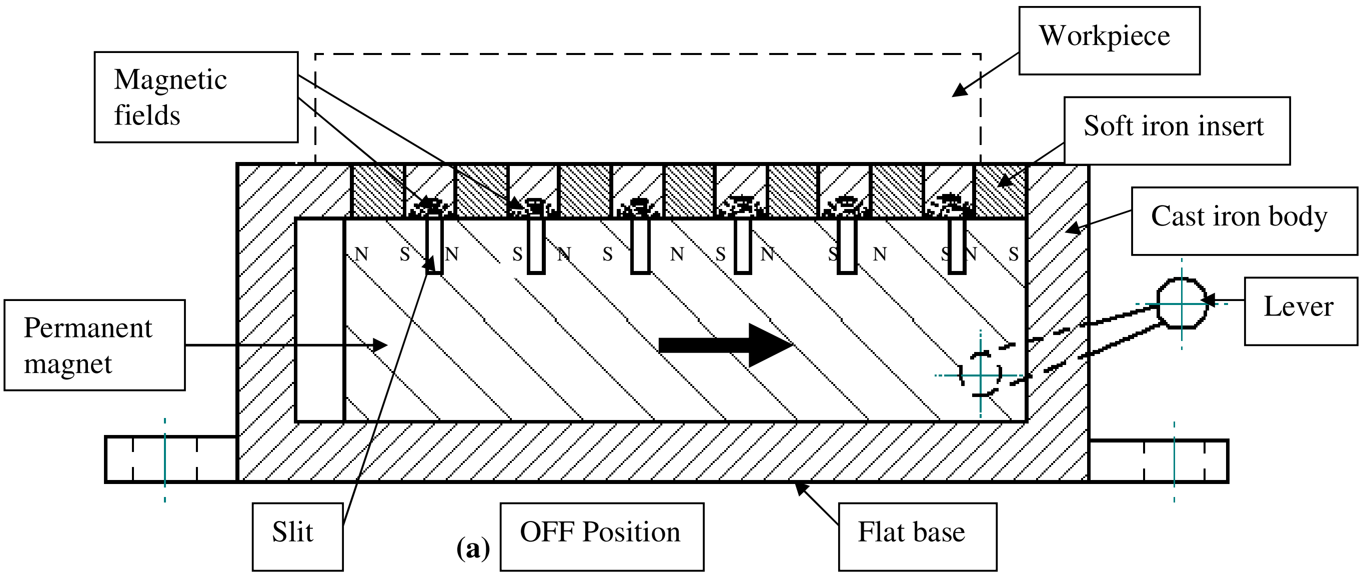
Work holding.

Since the surfaces produced on this machines are similar to those done the milling machine, those methods are also used here conveniently. Cutting forces here are small therefore lighter versions are used. Apart from these, two other methods in common use are the compound vice and magnetic chuck.



This vice has a swivel base, which can be rotated in the horizontal plane about a vertical axis. On this swivel is attached a horizontal link which make it possible to rotate the jaws in the vertical plane about a horizontal axis.

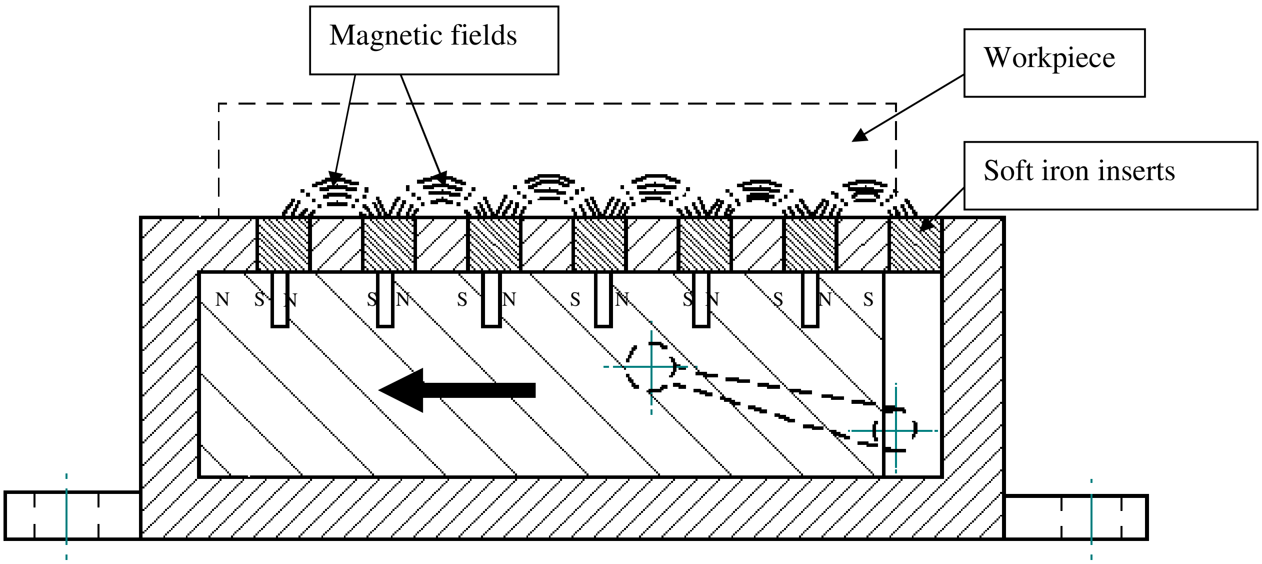
A work piece held in the jaws can therefore be swiveled by up to 360 degrees about a vertical axis and 90 degrees about a horizontal axis.



(a)

This is a flat cast iron surface with soft iron inserts across it and equally spaced along its length. Inside the chuck body is a permanent magnet, which can be moved by sliding to assume two different positions. One position is OFF position and the other is ON position. The magnet itself has slots on its upper surface, giving it a status of several separate magnets, each with a north and south pole. Magnetic fields are therefore created between north and south poles of each adjacent magnet.

In the OFF position the north and south poles fall outside the soft iron inserts and the magnetic fields fall below the surface of the table and therefore has little or on effect at all on the work piece placed on the table.



(b) ON Position

In the ON position the north and south poles fall inside the soft iron inserts and each of them become magnetized with a north and south pole, and the magnetic fields are transferred to the surface of the table and therefore has full effect on the work piece placed on the table, clamping it firmly onto the table.

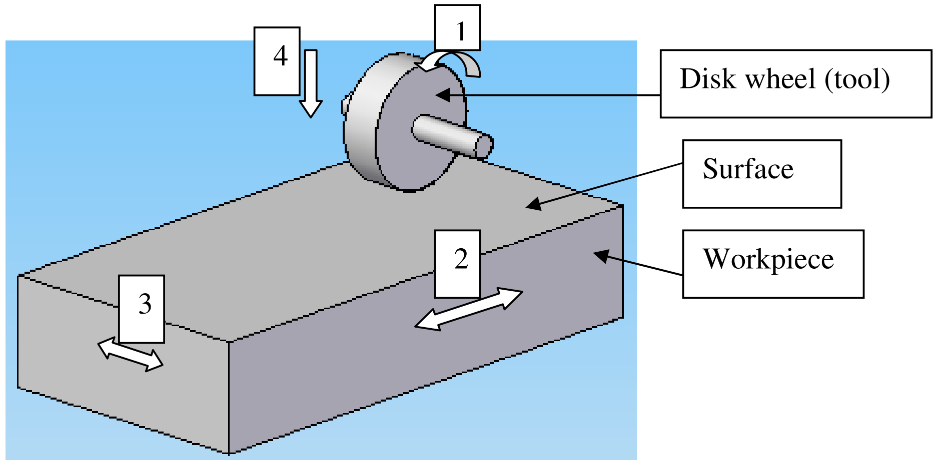
Operations.

All operations on this machine are known as surface grinding operations, and the surfaces are the same as those done on the milling machine.

The result of all operations is always a surface of some form produced. This comes about as a generated surface using single point tool or copying the form from the tool onto the work piece.

In both cases it is possible to produce a surface only if at least two motions of the machine are present at the same time. These are active motions, one of which must be spindle rotation, which is the main motion. Another motion, which is very important but does not exist during actual cutting process is the one used to set the cutting depth. This is passive motion. It is the motion used to give the work piece its size.

Flat horizontal surface.



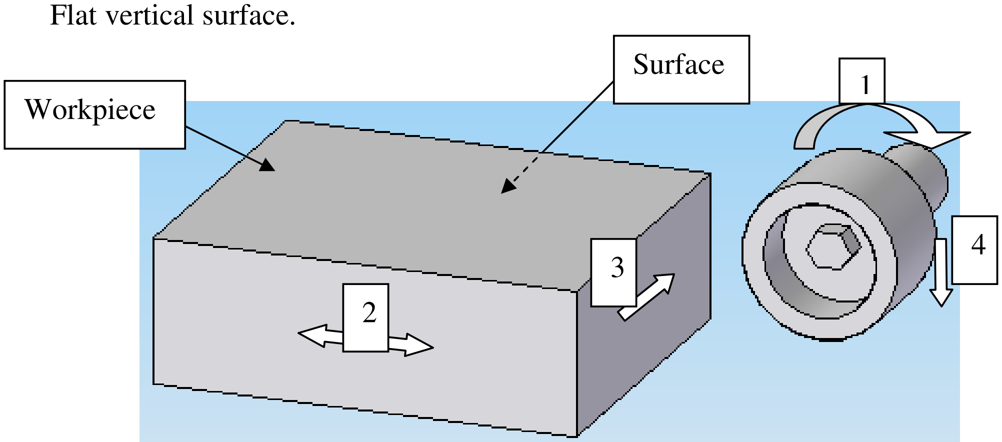
-Motion 1- Active. Main motion.

-Motion 2- Active cutting feed

-Motion 3- Passive sizing feed for covering surface width.

-Motion 4- Passive sizing feed for covering surface depth or thickness.

Flat vertical surface.



-Motion 1- Active. Main motion.

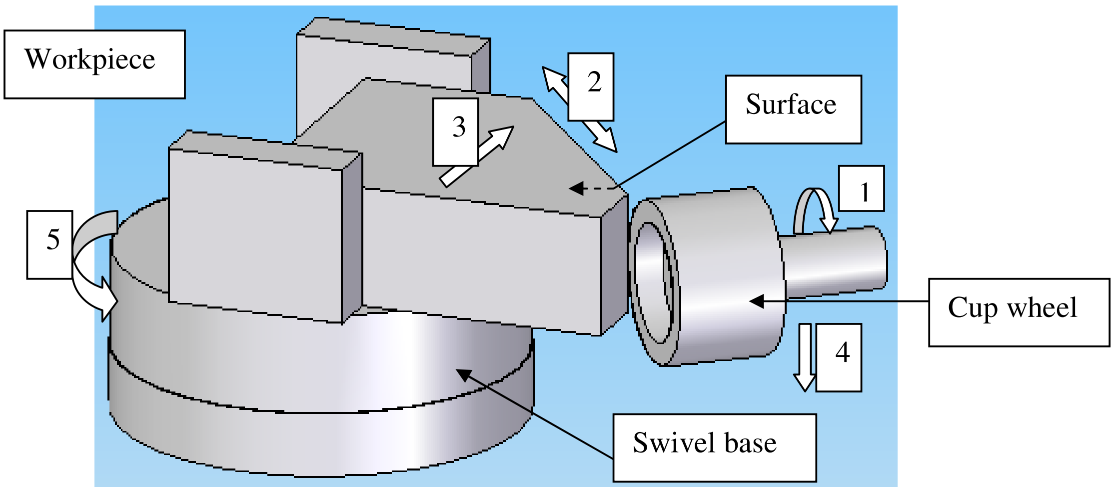
-Motion 2- Active cutting feed

-Motion 3- Passive sizing feed for covering surface depth or thickness.

-Motion 4- Passive sizing feed for covering surface width.

Flat angular surface.

Angular surface can be produced in a number of ways, depending on the work holding method and type of wheel used.



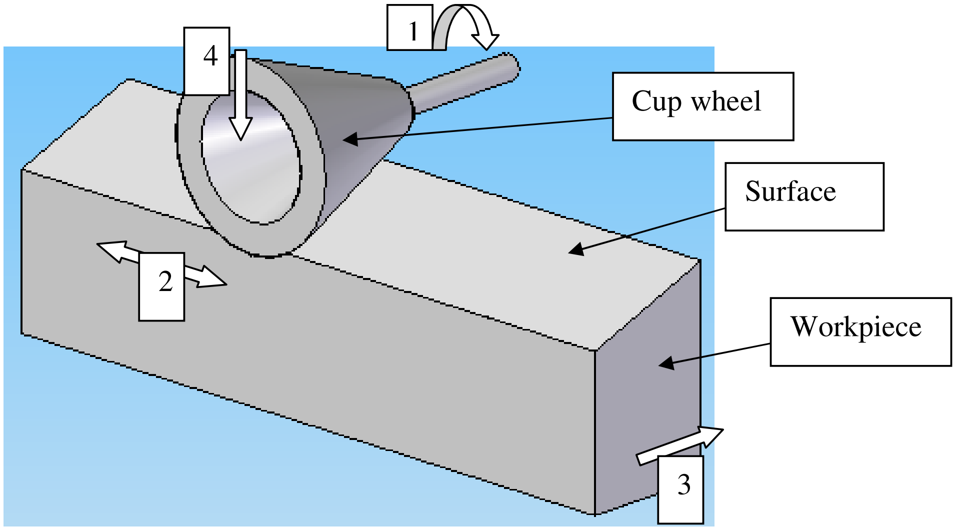
-Motion 1- Active. Main motion.

-Motion 2- Active cutting feed

-Motion 3- Passive sizing feed for covering surface depth or thickness.

-Motion 4- Passive sizing feed for covering surface width.

-Motion 5- Passive swiveling motion of vice base for setting angle.



-Motion 1- Active. Main motion.

-Motion 2- Active cutting feed

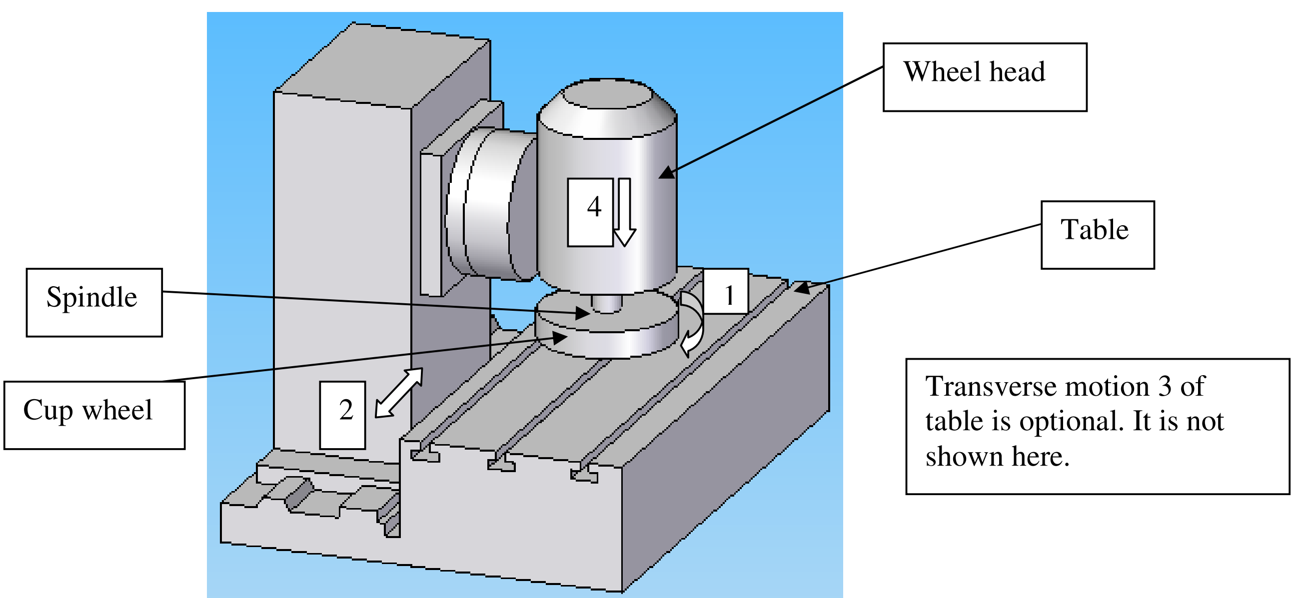
-Motion 3- Passive sizing feed for covering surface width.

-Motion 4- Passive sizing feed for covering surface depth or thickness.

Vertical grinding machine.

The machine acquires its name from the position of its spindle whose axis is vertical. The wheel diameter is large enough to cover the surface of any work piece that can fit on the table. Because of this, most machines do not have transverse table motion. It also removes material at a much faster rate than any other grinding machine.

General features.



Motions.

Motion 1- Rotary motion of spindle. This is the main motion.

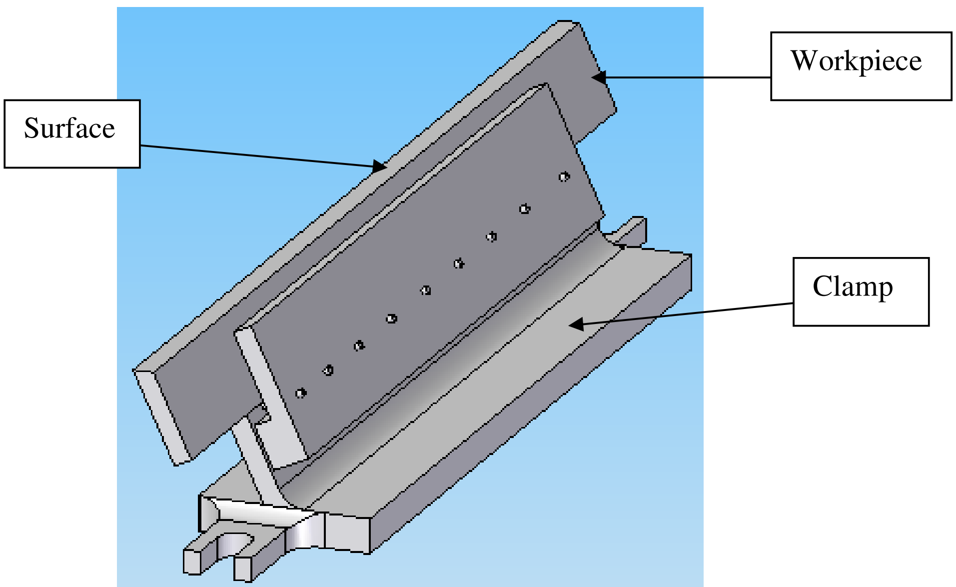
Motion 2- Linear longitudinal motion of table parallel to table surface and perpendicular to spindle axis. This motion is horizontal.

Motion 3- Linear transverse motion of table parallel to table surface and perpendicular to spindle axis. This motion is horizontal.

Motion 4- Linear vertical motion of wheel head perpendicular to table surface and parallel to spindle axis.

TOOL AND WORK HOLDING

Tool and work holdings for horizontal machines also apply on this machine. However special clamps can be made for holding long thin blades for grinding angular surface when sharpening them.



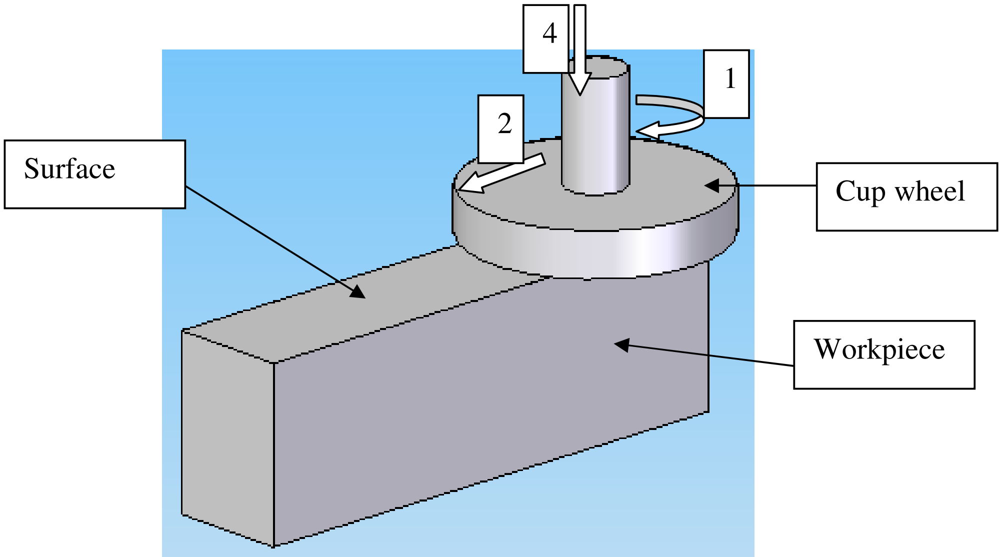
Operations.

The result of all operations is always a surface of some form produced. This comes about as a generated surface using single point tool or copying the form from the tool onto the work piece.

In both cases it is possible to produce a surface only if at least two motions of the machine are present at the same time. These are active motions, one of which must be the grinding wheel rotation, which is the main motion. Another motion, which is very important but does not exist during actual cutting process is the one used to set the cutting depth. This is passive motion. It is the motion used to give the work piece its size.

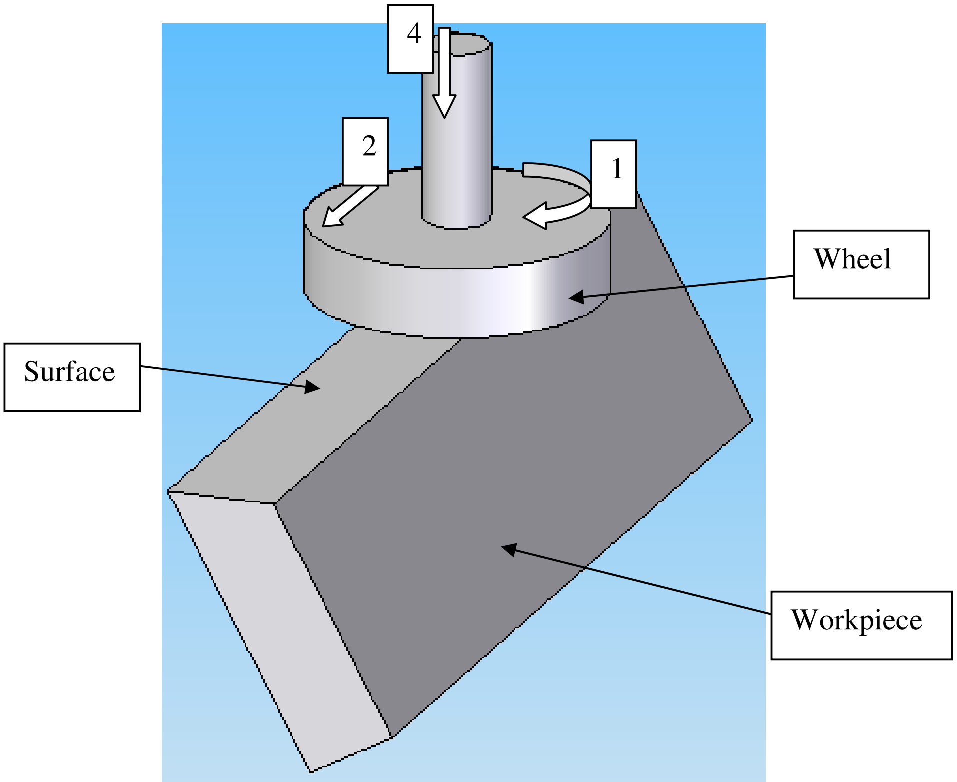
This machine is designed to grind horizontal surfaces only, therefore if a surface is to be ground at some angle to an existing surface, the existing surface must be clamped at the required angle relative to the horizontal plane or table surface.

Flat horizontal surface.



-Motion 1- Active, and main motion.
-Motion 2- Active cutting feed.
-Motion 4- Passive sizing feed for depth or thickness.

Flat angular surface.



-Motion 1- Active, and main motion.

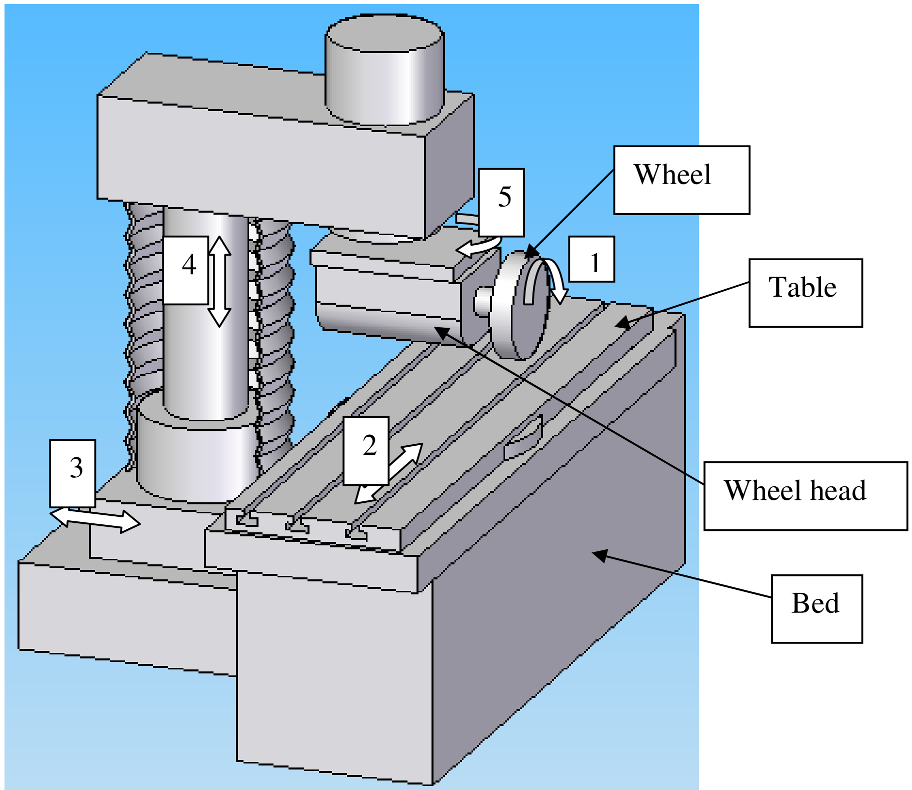
-Motion 2- Active cutting feed.

-Motion 4- Passive sizing feed for depth or thickness.

Universal grinding machine.

This machine is universal because all types of surfaces can be ground on it, including holes.

General features.



Motions.

Motion 1- Rotary wheel motion. This is the main motion.

Motion 2- Linear horizontal motion of table parallel to its own surface and spindle axis.

Motion 3- Linear horizontal motion of wheel head, parallel to table surface and its spindle axis.

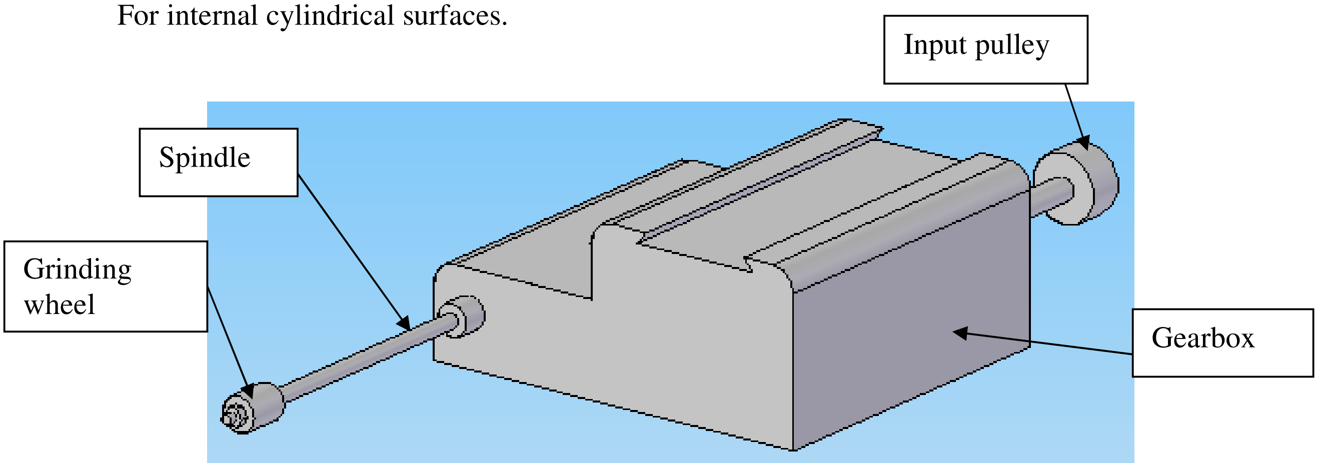
Motion 4- Linear vertical motion of wheel head perpendicular to spindle axis and table surface.

Motion 5- Angular motion for setting angle of spindle axis relative to motion 2 between 0 and 90 degrees.

Tool holding.

Tool holding for flat surfaces and external cylindrical surfaces are the same as on the other grinding machines.

For internal cylindrical surfaces.

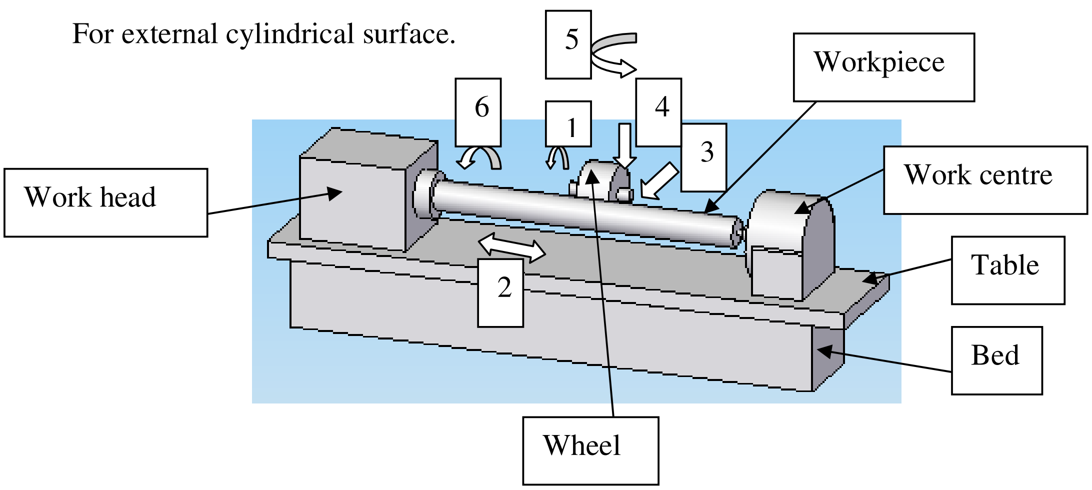


Another wheel head with a higher spindle speed is available as an attachment for this machine. Revolution per minute, RPM, is therefore higher for smaller wheels if cutting speed at contact surfaces of wheel and work piece it to be the same as that of the bigger wheels used for external surface grinding.

Work holding.

Work holding for flat surfaces are the same as on the other grinding machines.

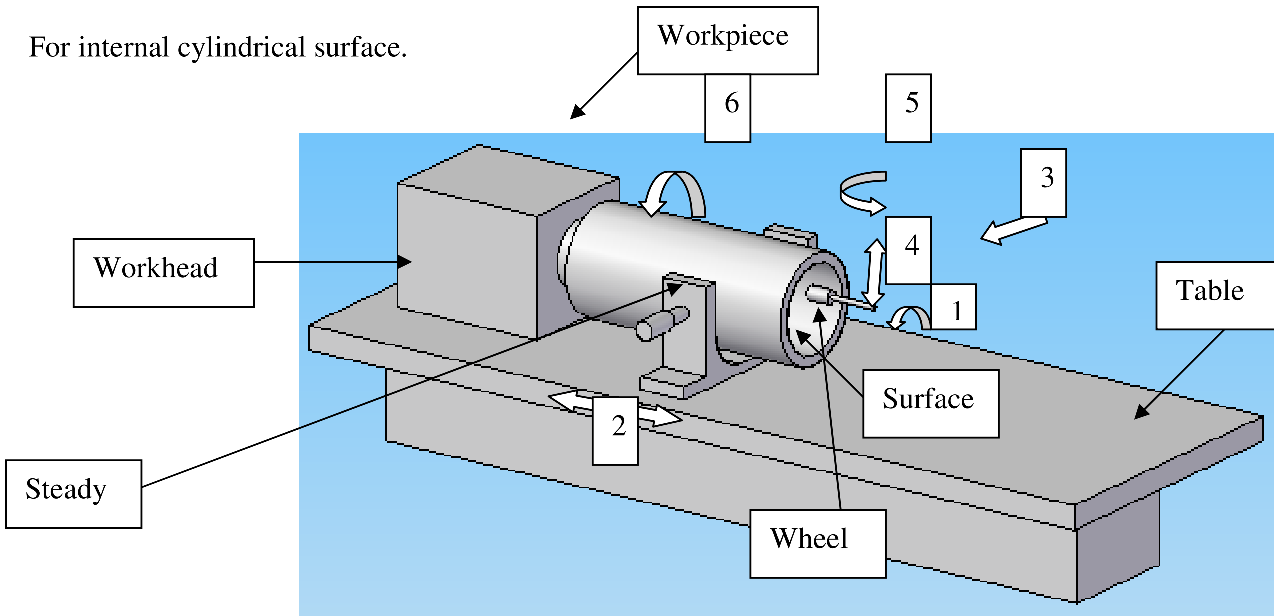
For external cylindrical surface.



-Motion 6- Rotary motion about workpiece about work head axis

The work is held on a work head, which is able to rotate it as grinding takes place round the cylinder. If the work piece is again slender and especially long, then a work center must be used to support it in position.

For internal cylindrical surface.



The same work head used, and where work support is necessary, a steady is used.

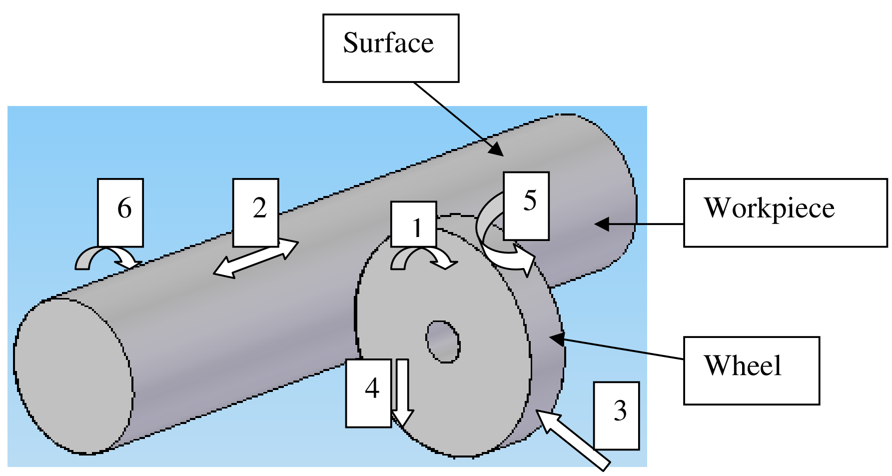
Operations.

The result of all operations is always a surface of some form produced. This comes about as a generated surface using single point tool or copying the form from the tool onto the work piece.

In both cases it is possible to produce a surface only if at least two motions of the machine are present at the same time. These are active motions, one of which must be the grinding wheel rotation, which is the main motion. Another motion, which is very important but does not exist during actual cutting process is the one used to set the cutting depth. This is passive motion. It is the motion used to give the work piece its size.

Operations for all flat surfaces are done in the same way as on the horizontal grinding machine, using the same motions.

For external cylindrical surface.



-Motion 1- Active main motion.

-Motion 2- Active cutting feed motion.

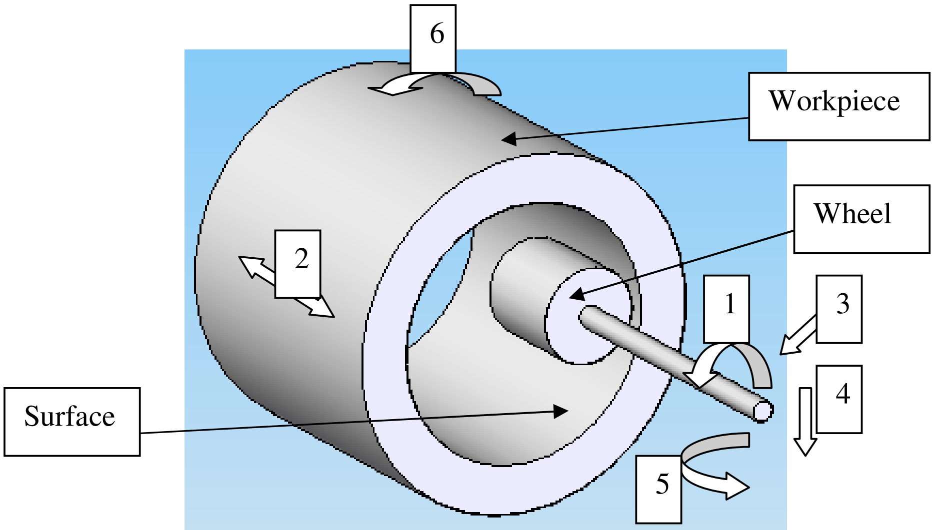
-Motion 3- Passive sizing feed motion.

-Motion 4- Passive motion for setting wheel and work piece axes to the same heights.

-Motion 5- passive motion for setting wheel side parallel to work piece axis.

-Motion 6- Active motion of wheel head.

For internal cylindrical surface.



-Motion 1- Active main motion.

-Motion 2- Active cutting feed motion.

-Motion 3- Passive sizing feed motion.

-Motion 4- Passive motion for setting wheel and work piece axes to the same heights.

-Motion 5- passive motion for setting spindle axis parallel to work piece axis.

-Motion 6- Active rotary motion of wheel head.

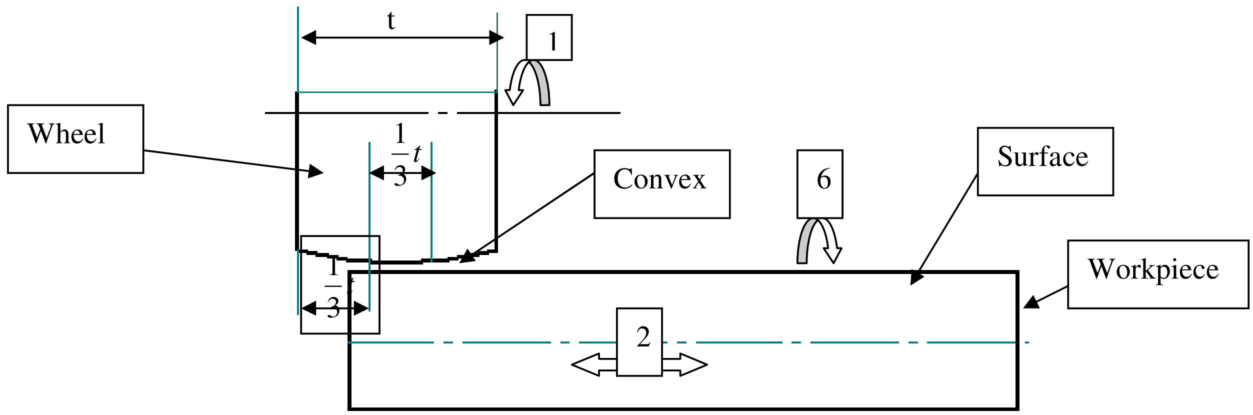
Grinding a cylindrical surface involves the rotation of both the grinding wheel and the workpiece. At the same time, the workpiece must move in a direction parallel to the wheel axis.

The wheel wears as grinding goes on, and it is important to note that the rate of ware is not the same across the thickness of the wheel. The intensity of wear across wheel thickness depends on the speed at which the workpiece moves across the wheel thickness.

If for every turn the workpiece makes, it also moves a distance equal to one third of its thickness, all the grinding is done by the first one third of the wheel thickness. The remaining two thirds of the wheel thickness simply trails and does on grinding at all when grinding is going on in one direction.

Since the workpiece moves back and forth in cylindrical grinding, only the first and last thirds of the wheel thickness do the grinding with the middle one third doing no work at all. Therefore, in this case wheel wear takes a convex shape. This brings about heal fouling effect which affects surface finish quality.

It must be avoided.



The other situation is when the workpiece moves a distance equal to two thirds of the wheel thickness. In this case, the middle one third of the wheel does work all the time as the workpiece moves back and forth. It therefore wears faster than the ends of the wheel and the wheel takes a concave shape. It is important to note that wear takes place along the full thickness of the wheel, no part of the wheel therefore fouls the surface, and surface quality is preserved.

This must be preferred.