VIT UNIVERSITY
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MEE432

Tool Design - Assignment

The mechanism of chip formation and the various types of chips formed in various metal cutting operations (Turning, Milling and Drilling).

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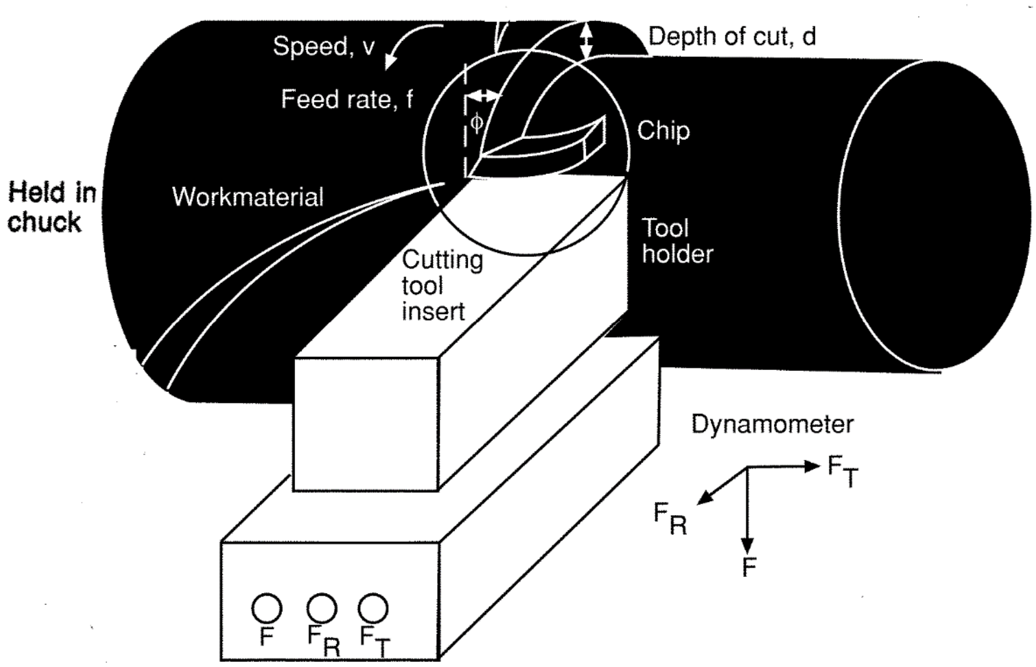
TURNING OPERATION

BASICS OF TURNING:

TURNING IS THE BASIC OPERATION OF ALL MACHINING PROCESS. THE TOOL IS HELD RIGIDLY IN A TOOL POST AND MOVED AT A CONSTANT RATE ALONG THE AXIS OF THE BAR, CUTTING AWAY A LAYER OF METAL TO FORM A CYLINDER OR A SURFACE OF MORE COMPLEX PROFILE



THE CHIP:

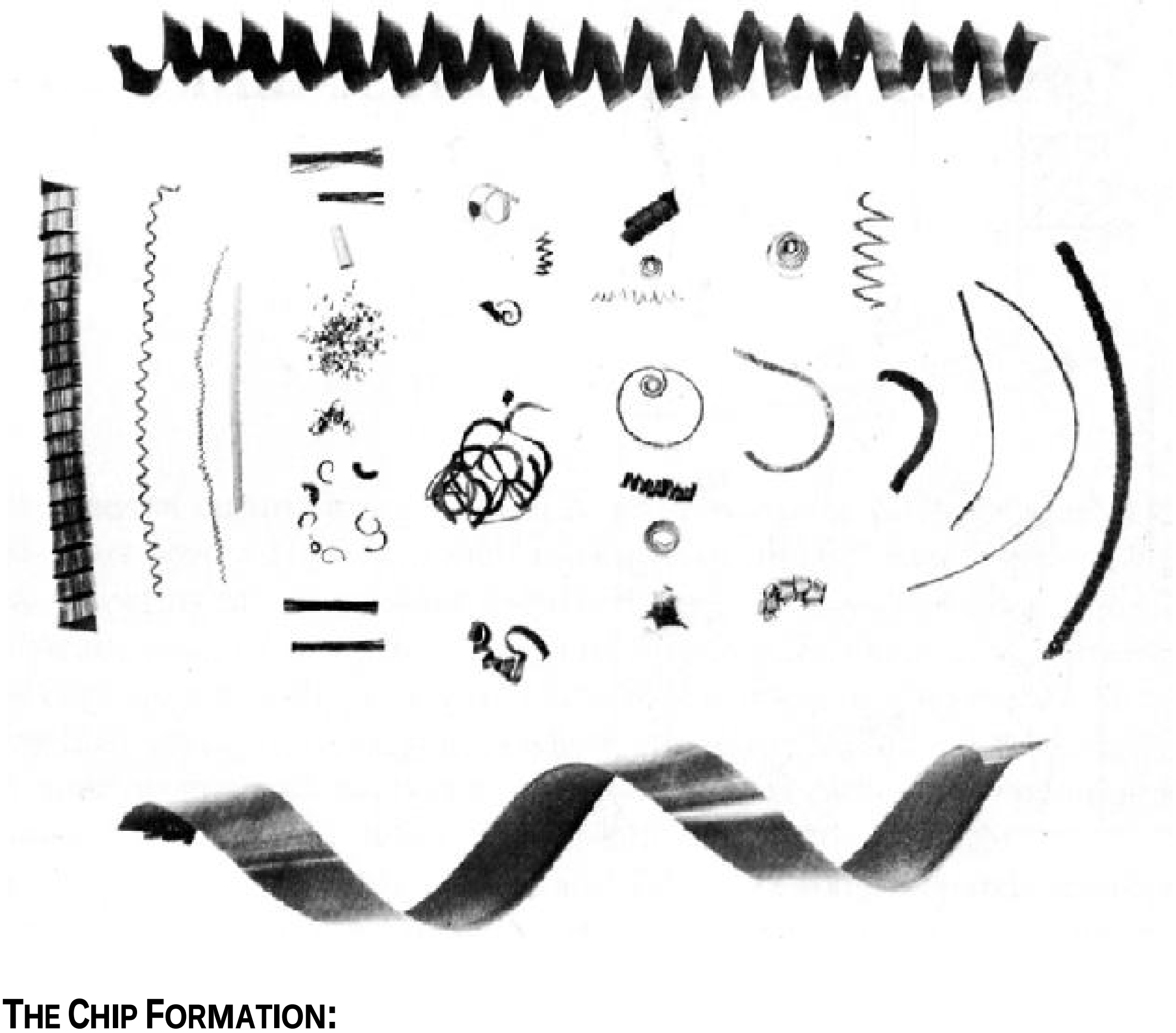
THE FORMATION OF ALL TYPES OF CHIPS INVOLVES A SHEARING OF THE WORK MATERIAL IN THE REGION OF A PLANE EXTENDING FROM THE TOOL EDGE TO THE POSITION WHERE THE UPPER SURFACE OF THE CHIP LEAVES THE WORK SURFACE.

A VERY LARGE AMOUNT OF STRAIN TAKES PLACE IN THIS REGION IN A VERY SHORT INTERVAL OF TIME, AND NOT ALL METALS AND ALLOYS CAN WITHSTAND THIS STRAIN WITHOUT FRACTURE.

GREY CAST IRON CHIPS, FOR EXAMPLE, ARE ALWAYS FRAGMENTED, AND THE CHIPS OF MORE DUCTILE MATERIALS MAY BE PRODUCED AS SEGMENTS, PARTICULARLY AT VERY LOW CUTTING SPEED. THIS DISCONTINUOUS CHIPIS ONE

OF THE PRINCIPAL CLASSES OF CHIP FORM, AND HAS THE PRACTICAL ADVANTAGE THAT IT IS EASILY CLEARED FROM THE CUTTING AREA.

DUCTILE METALS AND ALLOYS DO NOT FRACTURE ON THE SHEAR PLANE AND A CONTINUOUS CHIP IS PRODUCED. CONTINUOUS CHIPS MAY ADOPT MANY SHAPES - STRAIGHT, TANGLED OR WITH DIFFERENT TYPES OF HELIX.



THE CHIP FORMATION:

THE DIFFERENT STAGES IN CHIP FORMATION ARE,

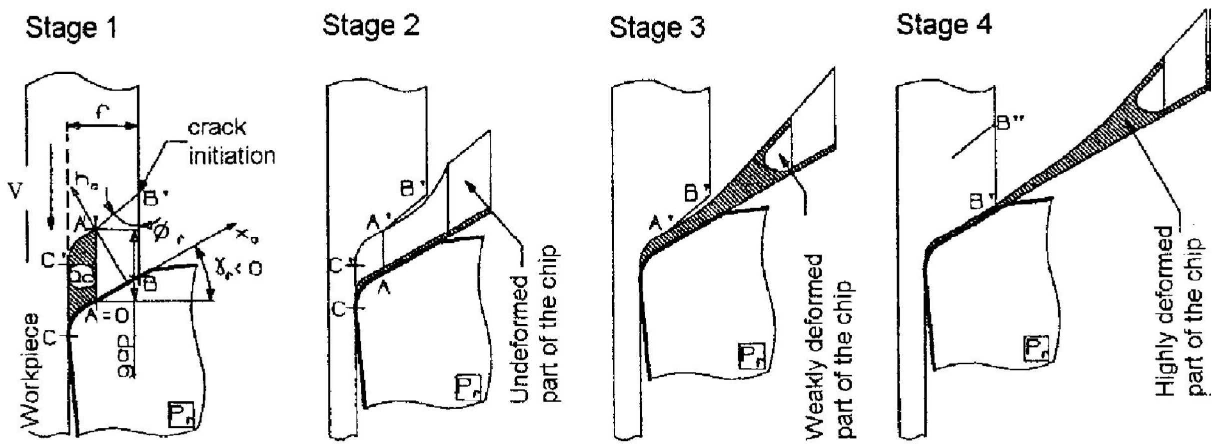
STAGE 1:

A NEGATIVE RAKE ANGLE GFINDUCES COMPRESSIVE STRESSES DISTRIBUTION IN A ZONE AROUND THE EDGE RADIUS RB . AT THE WORKPIECESURFACE BEFORE THE TOOL CHAMFER THE JOINT EFFECTS OF LOW VALUES OF COMPRESSION STRESSES AND OF HIGH SHEAR STRESSES INITIATE A CRACK,FOLLOWED BY A SLIP PLANE WHICH RUNS TOWARDS THE CUTTING EDGE. IS

A MICROGRAPH SHOWING THIS FIRST STAGE. THE CRACK ANGLE F FAND THE VOLUME QCCAN BE DETERMINED.

STAGE 2:

THE CHIP VOLUME MENTIONED AA'BB' ANDSITUATED BETWEEN THE CRACK AND THE EDGE CHAMFER IS EJECTED PRACTICALLYWITHOUT ANY DEFORMATION. THE GAP AA' CLOSES PROGRESSIVELY AS THE TOOL MOVES FORWARD, AND THE HEIGHT OFTHE CHIP HC, DECREASES.THE SPEED OF THE CHIP UPON THE RAKE FACE OF THE TOOL AND AT THECRACK TRANSITION POINT A' IS SO LARGE THAT IT WILL GENERATE A CONSIDERABLEINCREASE IN TEMPERATURE, NEAR THE TRANSFORMATION POINT A3SO THAT MARTENSITE PRODUCED BY FRICTION CAN OCCUR IN THE FORMOF WHITE LAYERS SURROUNDING THE CHIP SEGMENT; IN ADDITION, A SIMILARWHITE LAYER EXISTS ON THE GENERATED SURFACE, DUE TO THE INTENSEAND SEVERE FRICTION OCCURRING AT THE TOOL LAND FACE, AND THE HIGHVALUE OF THETHRUST FORCE FF)



STAGE 3:

THE WIDTH OF THE GAP AA'GETS SO NARROW THAT THEEJECTION SPEED AND THE PLASTIC DEFORMATION OF THE CHIP ARE VERY HIGH. THE INCREASE IN

TEMPERATURE IS VERY IMPORTANT,AND THE TWO PREVIOUS WHITE LAYERS JOIN TO FORM THE SECONDPART OF THE CHIP SEGMENT. HERE, THE CHIP THICKNESS IS VERY SMALLAND ITS COOLING IS EXTREMELY FAST.

STAGE 4:

THE CHIP SEGMENT IS NOW FORMED AND THE FREE GAP AA' IS CLOSED. THE COMPRESSIVE STRESSES DISTRIBUTION, WHICH HAD DECREASEDDURING THE STAGES 2 AND 3, BECOMES AGAIN MORE IMPORTANT,INDUCING A NEW CRACK AND THIS PERIODIC PHENOMENON WILL REPEATITSELF.

CHIP FORMATION IN HIGH-SPEED TURNING OFAUSTENITIC STAINLESS STEEL:

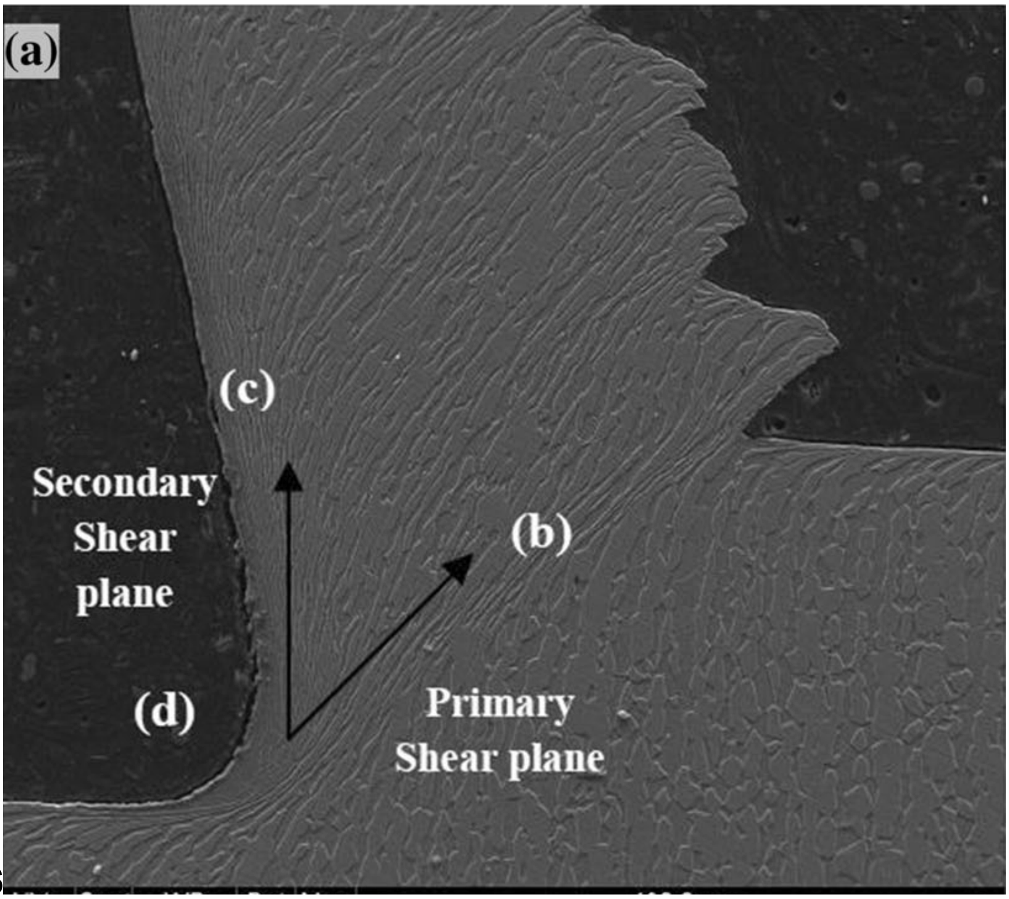
THE CUTTING MECHANISMS OF HARD STEELS AND HARD ALLOYS LEAD TO THE FORMATION OF SAW TOOTH CHIPS, WHICH CAN BE CLASSIFIED AS WAVY CHIP, SEGMENTAL CHIP, SHEAR LOCALIZED CHIP, AND DISCONTINUOUS CHIP.

SAW TOOTH CHIPS COVER LOCALIZED SHEAR, ADIABATIC SHEAR, AS WELL AS CATASTROPHIC SHEAR.

SUCH CHIPS ARE PERIODIC AND FORMED OF IDENTICAL SEGMENTS, THEIR MORPHOLOGY BEING THE RESULT OF INSTABILITY CONDITIONS DEPENDING ON:

1)THE MECHANICAL, THERMAL, THERMOMECHANICAL PROPERTIES OF THE MATERIAL,
2) THE CUTTING CONDITIONS,
3) THE DIVERGENCE OF SHEARING IN THE PRIMARY ZONE,
4)THE DIVERGENCE TRIBOLOGICAL CONDITIONS AT THE INTERFACE BETWEEN THE RAKE FACE AND THE INNER FACE OF THE CHIP,

5) THE POSSIBLE INTERACTIONS BETWEEN PRIMARY AND SECONDARY SHEARING ZONES

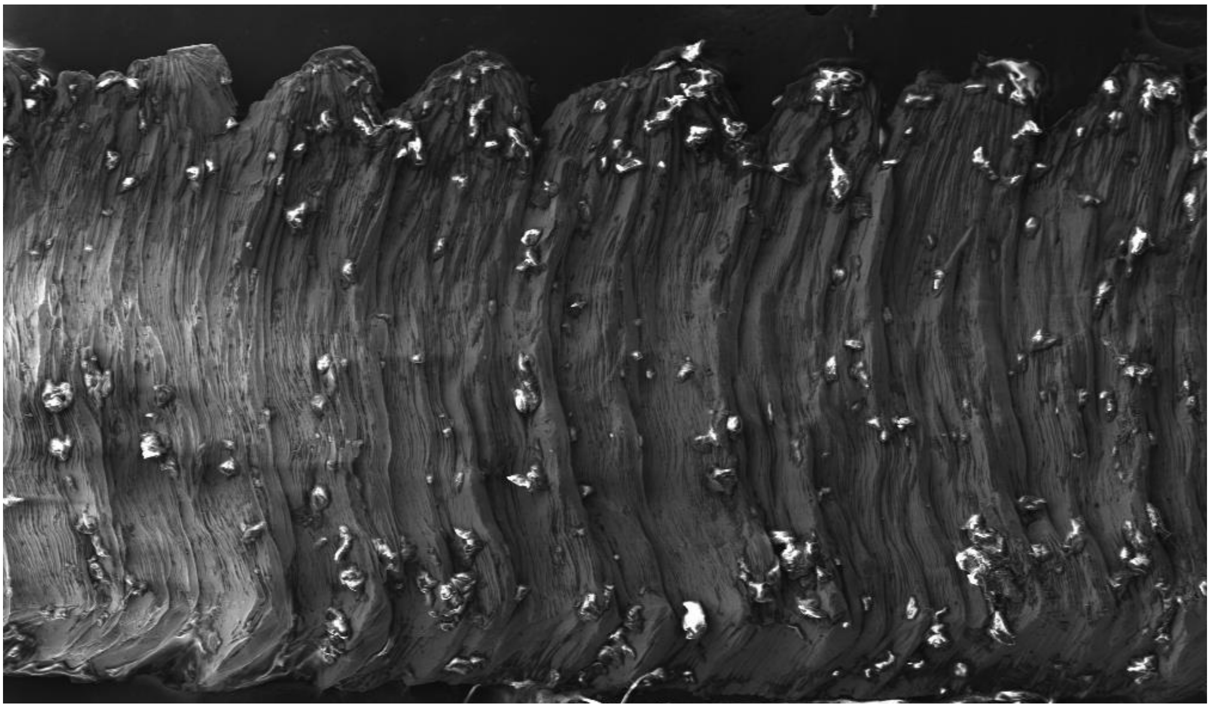


CHIP FORMATION IN HIGH-SPEED TURNING OF INCONEL

THE MECHANISM OF MACHINING OF INCONEL 718 IS KNOWN TO INVOLVESHEARINSTABILITY AND INTENSE LOCALIZED DEFORMATION IN THE PRIMARY DEFORMATIONZONE, WHICH RESULT IN FORMATION OF SERRATED OR SHEAR LOCALIZED CHIPS.

THE NATURE OF CHIPS AND MECHANISM OF THEIR GENERATION GOVERNSTHE EXTENT OF TOOL WEAR, CUTTING FORCE MAGNITUDE AND, SURFACE ANDSUB-SURFACE INTEGRITY OF THE RESULTING MACHINED SURFACES.

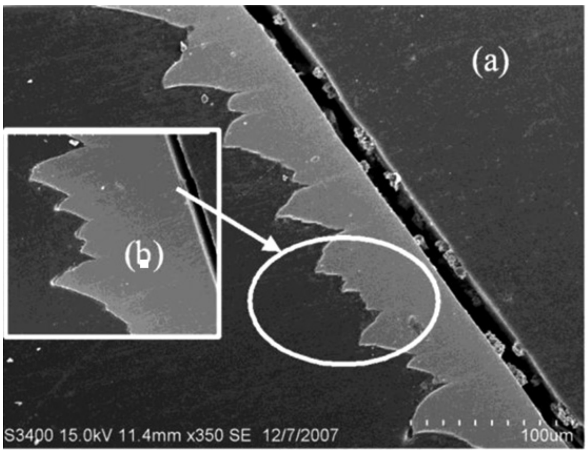
ALSO, IT IS KNOWN THAT A MINOR CHANGE IN CHIP FORMATIONPROCESS DUE TO A CHANGE IN MACHINING PROCESS, MAY LEAD TO PROBLEMSRELATED TO HIGHER CUTTING FORCES, SHORT TOOL LIFE, POOR MACHINEDSURFACE TOPOGRAPHY AND INTEGRITY.

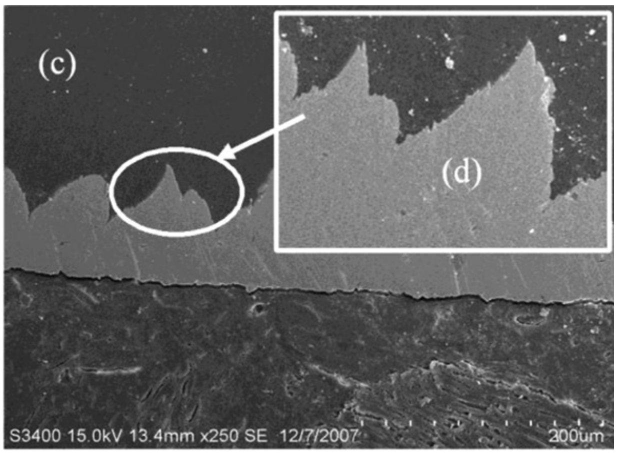


MECHANISM OF CHIP FORMATION:

THE FORMATION OF SERRATED CHIPS DURING MACHINING OF INCONEL 718 HAS BEENATTRIBUTED TO PREDOMINANT THERMALLY ASSISTED DEFORMATION DUE TO HIGHERMACHINING TEMPERATURE

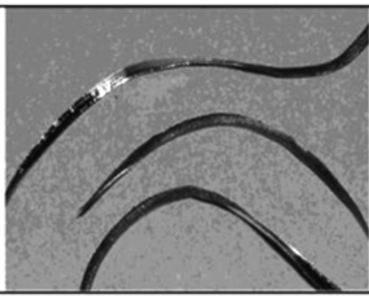
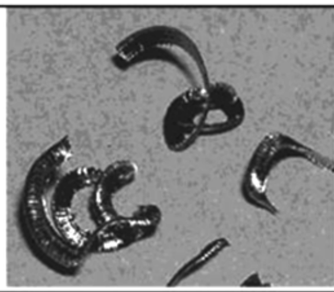
THE INITIATION AND PROPAGATION OF CRACKS INSIDETHE PRIMARY SHEAR ZONE AND THERMOPLASTIC INSTABILITY ARE RESPONSIBLE FOR THEFORMATION OF SAW-TOOTH EDGES ON THE CHIPS





Effect of Cutting Speed:

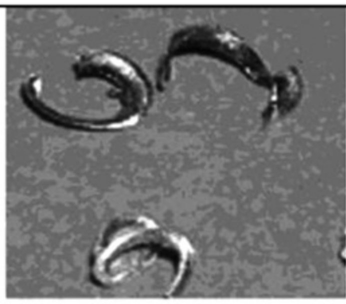
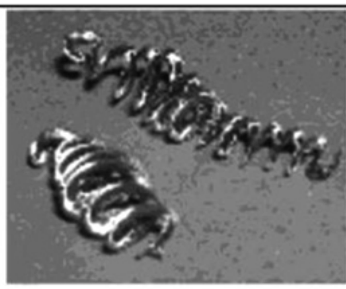
With increase in Cutting Speed the chipthickness ratio (t/tc) reduces significantly.

125 m/min	300 m/min	475 m/min
		
Continuous snarled ribbon	Continuous ribbon	Short snarled & connected arc

Effect of Feed rate:

With an increase in feed rate from 0.05mm=rev to 0.10mm=rev, thechip thickness ratio increases significantly

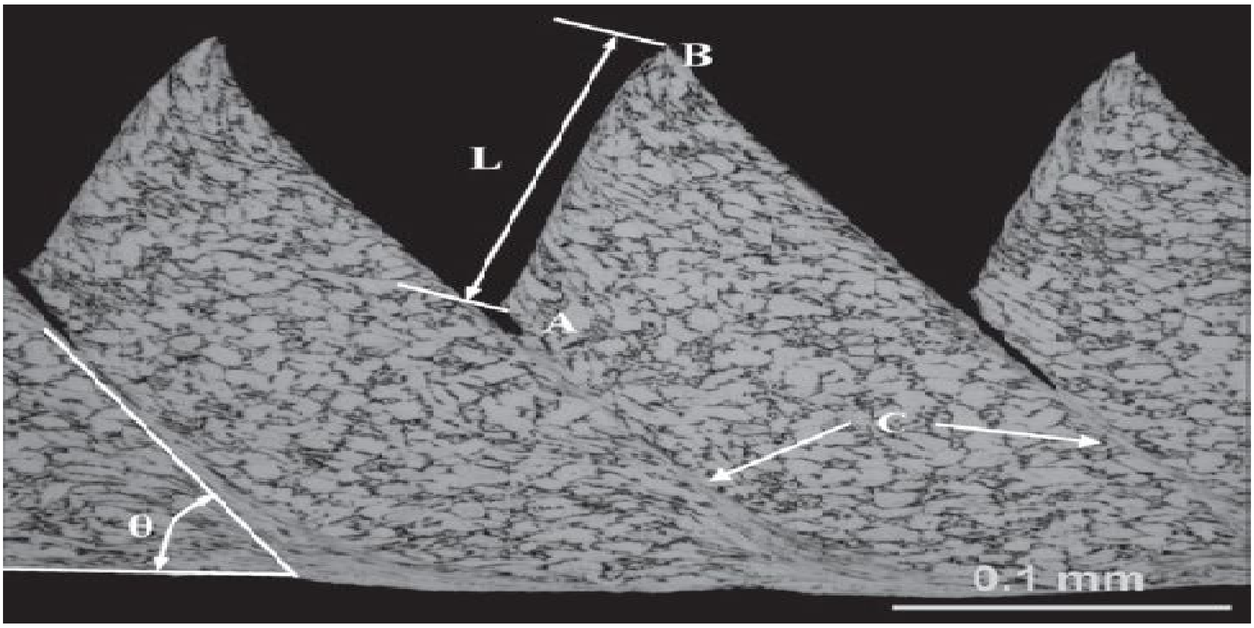
Chip morphology influences the quality of the machined surfaces.In this case, the machined surfaces show higher roughness

0.05 mm/rev	0.10 mm/rev	0.15 mm/rev
		
Connected arc & short snarled	Loose arc C- type	Tight coiled spring

CHIP FORMATION IN HIGH-SPEED TURNING OF TI6AL4V

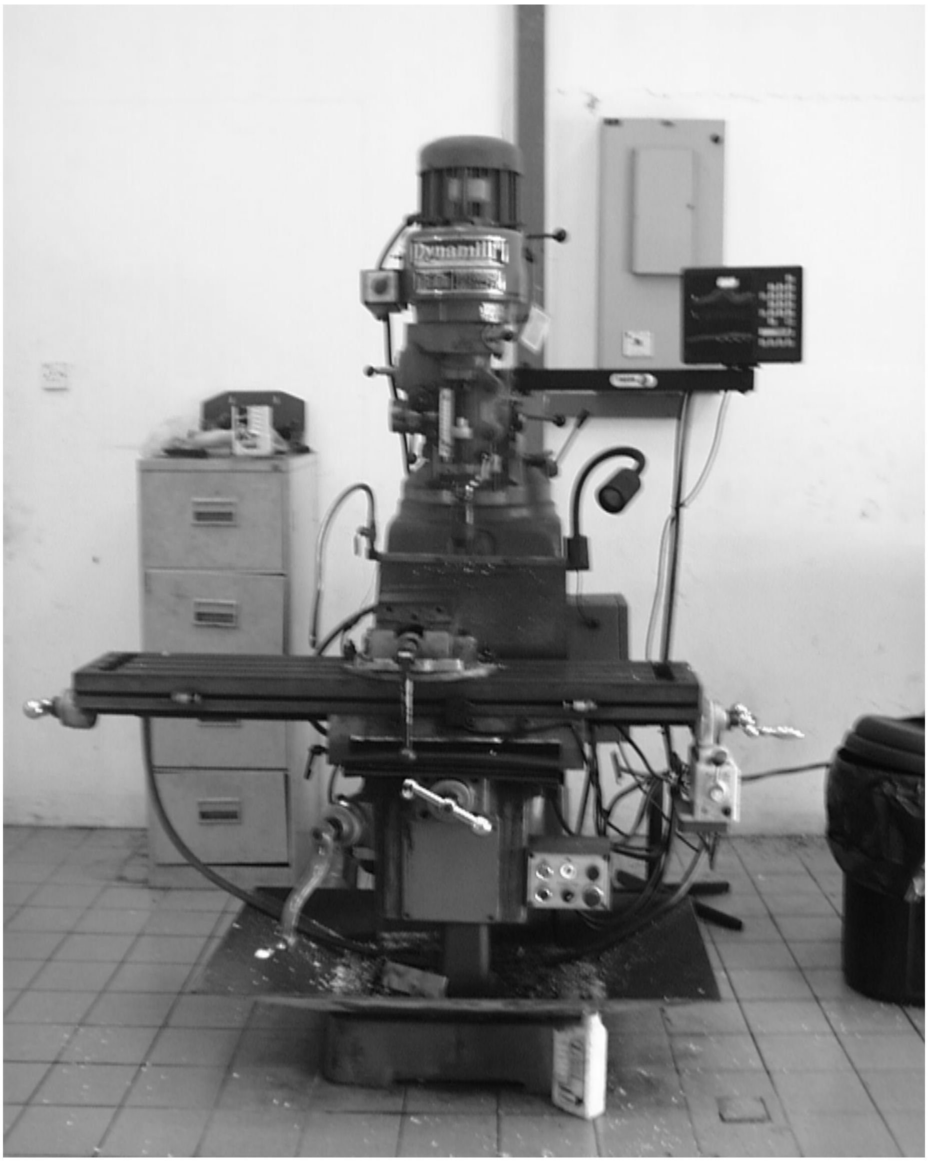
WHEN MACHINING TITANIUM ALLOYS, A SEGMENTED CHIP IS NORMALLY PRODUCED.

SEGMENTED CHIP FORMATION IS BELIEVED TO BE DUE TO EITHER THE GROWTH OF CRACKS FROM THE OUTER SURFACE OF THE CHIP OR ADIABATIC SHEAR BAND FORMATION WHICH IS CAUSED BY THE LOCALIZED SHEAR DEFORMATION RESULTING FROM THE PREDOMINANCE OF THERMAL SOFTENING OVER STRAIN HARDENING.



MILLING OPERATION

MILLING MACHINE



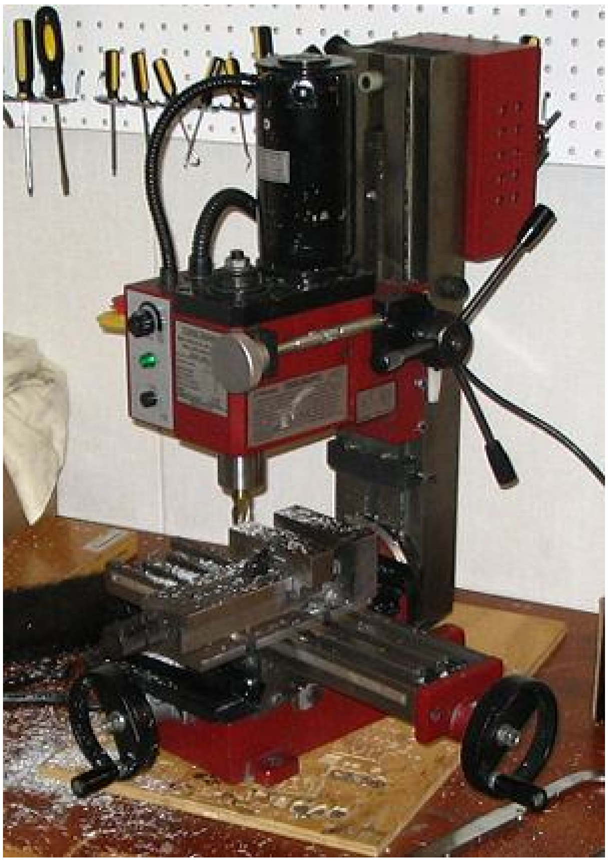
EXAMPLE OF A STANDARD MILLING MACHINE

EXAMPLE OF A CNC VERTICAL MILLING CENTER

A MILLING MACHINE IS A MACHINE TOOL USED FOR THE COMPLEX SHAPING OF METAL AND OTHER SOLID MATERIALS. ITS BASIC FORM IS THAT OF A ROTATING CUTTER OR ENDMILL WHICH ROTATES ABOUT THE SPINDLE AXIS (SIMILAR TO A DRILL), AND A MOVABLE TABLE TO WHICH THE WORKPIECE IS AFFIXED. THAT IS TO SAY, THE CUTTING TOOL GENERALLY REMAINS STATIONARY (EXCEPT FOR ITS ROTATION) WHILE THE WORKPIECE MOVES TO ACCOMPLISH THE CUTTING ACTION. MILLING MACHINES MAY BE OPERATED MANUALLY OR UNDER COMPUTER NUMERICAL CONTROL (SEE CNC VTL).

MILLING MACHINES CAN PERFORM A VAST NUMBER OF COMPLEX OPERATIONS, SUCH AS SLOT CUTTING, PLANING, DRILLING, REBATING, ROUTING, ETC.

CUTTING FLUID IS OFTEN PUMPED TO THE CUTTING SITE TO COOL AND LUBRICATE THE CUT, AND TO SLUICE AWAY THE RESULTING SWARF.



TYPES OF MILLING MACHINES

A MINIATURE HOBBYIST MILL PLAINLY SHOWING THE BASIC PARTS OF A MILL.

HAND MILLING MACHINE

PLAIN MILLING MACHINE

UNIVERSAL MILLING MACHINE

OMNIVERSAL MILLING MACHINE

THERE ARE TWO MAIN TYPES OF MILL: THE VERTICAL MILL AND THE HORIZONTAL MILL. IN THE VERTICAL MILL THE SPINDLE AXIS IS VERTICALLY ORIENTED. MILLING CUTTERS ARE HELD IN THE SPINDLE AND ROTATE ON ITS AXIS. THE SPINDLE CAN GENERALLY BE EXTENDED (OR THE TABLE CAN BE RAISED/LOWERED, GIVING THE SAME EFFECT), ALLOWING PLUNGE CUTS AND DRILLING. THERE ARE TWO SUBCATEGORIES OF VERTICAL MILLS: THE BEDMILL AND THE TURRET MILL. TURRET MILLS, LIKE THE UBIQUITOUS BRIDGEPORT, ARE GENERALLY SMALLER THAN BEDMILLS, AND ARE CONSIDERED BY SOME TO BE MORE VERSATILE. IN A TURRET MILL THE SPINDLE REMAINS STATIONARY DURING CUTTING OPERATIONS AND THE TABLE IS MOVED BOTH PERPENDICULAR TO AND PARALLEL TO THE SPINDLE AXIS TO ACCOMPLISH CUTTING. IN THE BEDMILL, HOWEVER, THE TABLE MOVES ONLY PERPENDICULAR TO THE SPINDLE'S AXIS, WHILE THE SPINDLE ITSELF MOVES PARALLEL TO ITS OWN AXIS. ALSO OF NOTE IS A LIGHTER MACHINE, called a mill-drill. It is quite popular with hobbyists, due to its small size and lower price. These are frequently of lower quality than other types of machines, however.

A horizontal mill has the same sort of x–y table, but the cutters are mounted on a horizontal arbor across the table. A majority of horizontal mills also feature a +15/-15 degree rotary table that allows milling at shallow angles. While endmills and the other types of tools available to a vertical mill may be used in a horizontal mill, their real advantage lies in arbor-mounted cutters, called side and face mills, which have a cross section rather like a circular saw, but are generally wider and smaller in diameter. Because the cutters have good support from the arbor, quite heavy cuts can be taken, enabling rapid material removal rates. These are used to mill grooves and slots. Plain mills are used to shape flat surfaces. Several cutters may be ganged together on the arbor to mill a complex shape of slots and planes. Special cutters can also cut grooves, bevels, radii, or indeed any section desired. These specialty cutters tend to be expensive. Simplex mills have one spindle, and duplex mills have two. It is also easier to cut gears on a horizontal mill.

A more complex form of the milling machine is the Universal milling machine, in which the rotating cutter can be oriented vertically or horizontally, increasing the flexibility of the machine tool. The table of the universal machine can be swiveled through a small angle (up to about 15 degrees), enabling the axis of the spindle to coincide with the axis of a helix to be milled with the use of a gear driven indexing head.

Milling machine variants

Box or column mills are very basic hobbyist bench-mounted milling machines that feature a head riding up and down on a column or box way.

Turret or Vertical ram mills are more commonly referred to as bridgeport-type milling machines. The spindle can be aligned in many different positions for a very versatile, if somewhat less rigid machine.

C-Frame mills are larger, industrial production mills. They feature a knee and fixed spindle head that is only mobile vertically. They are typically much more powerful than a turret mill, featuring a separate hydraulic motor for integral hydraulic power feeds in all directions, and a twenty to fifty horsepower motor. Backlash eliminators are almost standard equipment. They use large NMTB 40 or 50 tooling. The tables on C-frame mills are usually 18" by 68" or larger, to allow multiple parts to be machined at the same time.

Knee mill refers to any milling machine that has a vertically adjustable table.

Bed mill refers to any milling machine where the spindle is on a pendant that moves up and down to move the cutter into the work. These are generally more rigid than a knee mill.

Ram type mill refers to a mill that has a swiveling cutting head mounted on a sliding ram. The spindle can be oriented either vertically or horizontally, or anywhere in between. Van Norman specialized in ram type mills through most of the 20th century, but since the advent of CNC machines ram type mills are no longer made.

Jig borers are vertical mills that are built to bore holes, and very light slot or face milling. They are typically bed mills with a long spindle throw. The beds are more accurate, and the handwheels are graduated down to .0001" for precise hole placement.

Horizontal boring mills are large, accurate bed horizontal mills that incorporate many features from various machine tools. They are predominantly used to create large manufacturing jigs, or to modify large, high precision parts. They have a spindle stroke of several (usually between four and six) feet, and many are equipped with a tailstock to perform very long boring operations without losing accuracy as the bore increases in depth. A typical bed would have X and Y travel, and be between three and four feet square with a rotary table or a larger rectangle without said table. The pendant usually has between four and eight feet in vertical movement. Some mills have a large (30" or more) integral facing head. Right angle rotary tables and vertical milling attachments are available to further increase productivity.

Floor mills have a row of rotary tables, and a horizontal pendant spindle mounted on a set of tracks that runs parallel to the table

ROW. THESE MILLS HAVE PREDOMINANTLY BEEN CONVERTED TO CNC, BUT SOME CAN STILL BE FOUND (IF ONE CAN EVEN FIND A USED MACHINE AVAILABLE) UNDER MANUAL CONTROL. THE SPINDLE CARRIAGE MOVES TO EACH INDIVIDUAL TABLE, PERFORMS THE MACHINING OPERATIONS, AND MOVES TO THE NEXT TABLE WHILE THE PREVIOUS TABLE IS BEING SET UP FOR THE NEXT OPERATION. UNLIKE ANY OTHER KIND OF MILL, FLOOR MILLS HAVE FLOOR UNITS THAT ARE ENTIRELY MOVABLE. A CRANE WILL DROP MASSIVE ROTARY TABLES , X-Y TABLES , AND THE LIKE INTO POSITION FOR MACHINING, ALLOWING THE LARGEST AND MOST COMPLEX CUSTOM MILLING OPERATIONS TO TAKE PLACE.

PORTICAL MILLS IT HAS THE SPINDLE MOUNTED IN A T STRUCTURE WHERE 2 OR 3 COMBINED TRAVELS CAN BE MADE DEPENDING IF THE WORK TABLE IS STATIC OR CROSS MOVED; THE CHOICE FOR ONE TYPE OR OTHER IN THIS CASE DEPENDS MOSTLY ON THE PART TO BE MACHINED I.E. ON ITS WEIGHT. THEREFORE THE "AP" OR "STEPDOWN" NEEDED ON THE AVERAGE WORK DONE, SHOULD BE CONSIDERED, TO WATCH FOR THE TORQUE ON THE MOVING AXIS;

MILLING MACHINE TOOLING

THERE IS SOME DEGREE OF STANDARDIZATION OF THE TOOLING USED WITH CNC MILLING MACHINES AND TO A MUCH LESSER DEGREE WITH MANUAL MILLING MACHINES.

HIGH SPEED STEEL WITH COBALT ENDMILLS USED FOR CUTTING OPERATIONS IN A MILLING MACHINE.

CNC MILLING MACHINES WILL NEARLY ALWAYS USE SK (OR ISO), CAT, BT OR HSK TOOLING. SK TOOLING IS THE MOST COMMON IN EUROPE, WHILE CAT TOOLING, SOMETIMES CALLED V-FLANGE TOOLING, IS THE OLDEST VARIATION AND IS PROBABLY STILL THE MOST COMMON IN THE USA. CAT TOOLING WAS INVENTED BY CATERPILLAR INC. OF PEORIA, ILLINOIS IN ORDER TO STANDARDIZE THE TOOLING USED ON THEIR MACHINERY. CAT TOOLING COMES IN A RANGE OF SIZES DESIGNATED AS CAT-30, CAT-40, CAT-50, ETC. THE NUMBER REFERS TO THE ASSOCIATION FOR MANUFACTURING TECHNOLOGY (FORMERLY THE

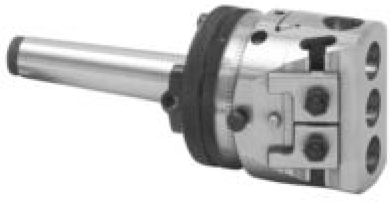
National Machine Tool Builders Association (NMTB)) Taper size of the tool.

CAT-40 Toolholder

An improvement on CAT Tooling is BT Tooling, which looks very similar and can easily be confused with CAT tooling. Like CAT Tooling, BT Tooling comes in a range of sizes and uses the same NMTB body taper. However, BT tooling is symmetrical about the spindle axis, which CAT tooling is not. This gives BT tooling greater stability and balance at high speeds. One other subtle difference between these two toolholders is the thread used to hold the pull stud. CAT Tooling is all Imperial thread and BT Tooling is all Metric thread. Note that this affects the pull stud only, it does not affect the tool that they can hold, both types of tooling are sold to accept both Imperial and metric sized tools.

SK and HSK tooling, sometimes called "Hollow Shank Tooling", is much more common in Europe where it was invented than it is in the United States. It is claimed that HSK tooling is even better than BT Tooling at high speeds. The holding mechanism for HSK tooling is placed within the (hollow) body of the tool and, as spindle speed increases, it expands, gripping the tool more tightly with increasing spindle speed. There is no pull stud with this type of tooling.

The situation is quite different for manual milling machines — there is little standardization. Newer and larger manual machines usually use NMTB tooling. This tooling is somewhat similar to CAT tooling but requires a drawbar within the milling machine. Furthermore, there are a number of variations with NMTB tooling that make interchangeability troublesome.



BORING HEAD ON MORSE TAPER SHANK

TWO OTHER TOOL HOLDING SYSTEMS FOR MANUAL MACHINES ARE WORTHY OF NOTE: THEY ARE THE R8 COLLET AND THE MORSE TAPER #2 COLLET. BRIDGEPORT MACHINES OF BRIDGEPORT CONNECTICUT SO DOMINATED THE MILLING MACHINE MARKET FOR SUCH A LONG TIME THAT THEIR MACHINE "THE BRIDGEPORT" IS VIRTUALLY SYNONYMOUS WITH "MANUAL MILLING MACHINE." THE BULK OF THE MACHINES THAT BRIDGEPORT MADE FROM ABOUT 1965 ONWARD USED AN R8 COLLET SYSTEM. PRIOR TO THAT, THE BULK OF THE MACHINES USED A MORSE TAPER #2 COLLET SYSTEM.

DRILLING OPERATION

DRILLING

DRILLING IS THE OPERATION OF PRODUCING CIRCULAR HOLE IN THE WORK-PIECE BY USING A ROTATING CUTTER CALLED DRILL.

THE MACHINE USED FOR DRILLING IS CALLED DRILLING MACHINE.

THE DRILLING OPERATION CAN ALSO BE ACCOMPLISHED IN LATHE, IN WHICH THE DRILL IS HELD IN TAILSTOCK AND THE WORK IS HELD BY THE CHUCK.

THE MOST COMMON DRILL USED IS THE TWIST DRILL.

DRILLING MACHINE

IT IS THE SIMPLEST AND ACCURATE MACHINE USED IN PRODUCTION SHOP.

THE WORK PIECE IS HELD STATIONARY IE. CLAMPED IN POSITION AND THE DRILL ROTATES TO MAKE A HOLE.

TYPES

1) BASED ON CONSTRUCTION:

PORTABLE,
SENSITIVE,
RADIAL,
UP-RIGHT,
GANG,
MULTI-SPINDLE

2) BASED ON FEED:

HAND DRIVEN

POWER DRIVEN

COMPONENTS OF DRILLING MACHINE

SPINDLE

THE SPINDLE HOLDS THE DRILL OR CUTTING TOOLS AND REVOLVES IN A FIXED POSITION IN A SLEEVE.

SLEEVE

THE SLEEVE OR QUILL ASSEMBLY DOES NOT REVOLVE BUT MAY SLIDE IN ITS BEARING IN A DIRECTION PARALLEL TO ITS AXIS. WHEN THE SLEEVE CARRYING THE SPINDLE WITH A CUTTING TOOL IS LOWERED, THE CUTTING TOOL IS FED INTO THE WORK: AND WHEN IT'S MOVED UPWARD, THE CUTTING TOOL IS WITHDRAWN FROM THE WORK. FEED PRESSURE APPLIED TO THE SLEEVE BY HAND OR POWER CAUSES THE REVOLVING DRILL TO CUT ITS WAY INTO THE WORK A FRACTION OF AN MM PER REVOLUTION.

COLUMN

THE COLUMN IS CYLINDRICAL IN SHAPE AND BUILT RUGGED AND SOLID. THE COLUMN SUPPORTS THE HEAD AND THE SLEEVE OR QUILL ASSEMBLY.

HEAD

THE HEAD OF THE DRILLING MACHINE IS COMPOSED OF THE SLEEVE, A SPINDLE, AN ELECTRIC MOTOR AND FEED MECHANISM. THE HEAD IS BOLTED TO THE COLUMN.

WORKTABLE

THE WORKTABLE IS SUPPORTED ON AN ARM MOUNTED TO THE COLUMN. THE WORKTABLE CAN BE ADJUSTED VERTICALLY TO ACCOMMODATE DIFFERENT HEIGHTS OF WORK OR IT CAN BE SWUNG COMPLETELY OUT OF THE WAY. IT MAY BE TILTED UP TO 90 DEGREE IN EITHER DIRECTION, TO ALLOW LONG PIECES TO BE END OR ANGLE DRILLED.

BASE

THE BASE OF THE DRILLING MACHINE SUPPORTS THE ENTIRE MACHINE AND WHEN BOLTED TO THE FLOOR, PROVIDES FOR VIBRATION-FREE OPERATION AND BEST MACHINING ACCURACY. THE TOP OF THE BASE IS SIMILAR TO THE WORKTABLE AND MAY BE EQUIPPED WITH T- SLOT FOR MOUNTING WORK TOO LARGER FOR THE TABLE.

HAND FEED

THE HAND- FEED DRILLING MACHINES ARE THE SIMPLEST AND MOST COMMON TYPE OF DRILLING MACHINES IN USE TODAY. THESE ARE LIGHT DUTY MACHINE THAT ARE OPERATED BY THE OPERATOR, USING A FEED HANDLED, SO THAT THE OPERATOR IS ABLE TO "FEEL" THE ACTION OF THE CUTTING TOOL AS IT CUTS THROUGH THE WORK PIECE. THESE DRILLING MACHINES CAN BE BENCH OR FLOOR MOUNTED.

POWER FEED

THE POWER FEED DRILLING MACHINE ARE USUALLY LARGER AND HEAVIER THAN THE HAND FEED ONES THEY ARE EQUIPPED WITH THE ABILITY TO FEED THE CUTTING TOOL IN TO THE WORK AUTOMATICALLY, AT PRESET DEPTH OF CUT PER REVOLUTION OF THE SPINDLE THESE MACHINES ARE USED IN MAINTENANCE FOR MEDIUM DUTY WORK OR THE WORK THAT USES LARGE DRILLS THAT REQUIRE POWER FEED LARGER WORK PIECES ARE USUALLY CLAMPED DIRECTLY TO THE TABLE OR BASE USING T –BOLTS AND CLAMPS BY A SMALL WORK PLACES ARE HELD IN A VISE. A DEPTH –STOP MECHANISM IS LOCATED ON THE HEAD, NEAR THE SPINDLE, TO AID IN DRILLING TO A PRECISE DEPTH.

SENSITIVE OR BENCH DRILLING MACHINE

THIS TYPE OF DRILL MACHINE IS USED FOR VERY LIGHT WORKS. FIG.1 ILLUSTRATES THE SKETCH OF SENSITIVE DRILLING MACHINE.
THE VERTICAL COLUMN CARRIES A SWIVELING TABLE THE HEIGHT OF WHICH CAN BE ADJUSTED ACCORDING TO THE WORK PIECE HEIGHT.
THE TABLE CAN ALSO BE SWUNG TO ANY DESIRED POSITION.

AT THE TOP OF THE COLUMN THERE ARE TWO PULLEYS CONNECTED BY A BELT, ONE PULLEY IS MOUNTED ON THE MOTOR SHAFT AND OTHER ON THE MACHINE SPINDLE.

VERTICAL MOVEMENT TO THE SPINDLE IS GIVEN BY THE FEED HANDLE BY THE OPERATOR.

OPERATOR SENSES THE CUTTING ACTION SO SENSITIVE DRILLING MACHINE.

DRILL HOLES FROM 1.5 TO 15MM

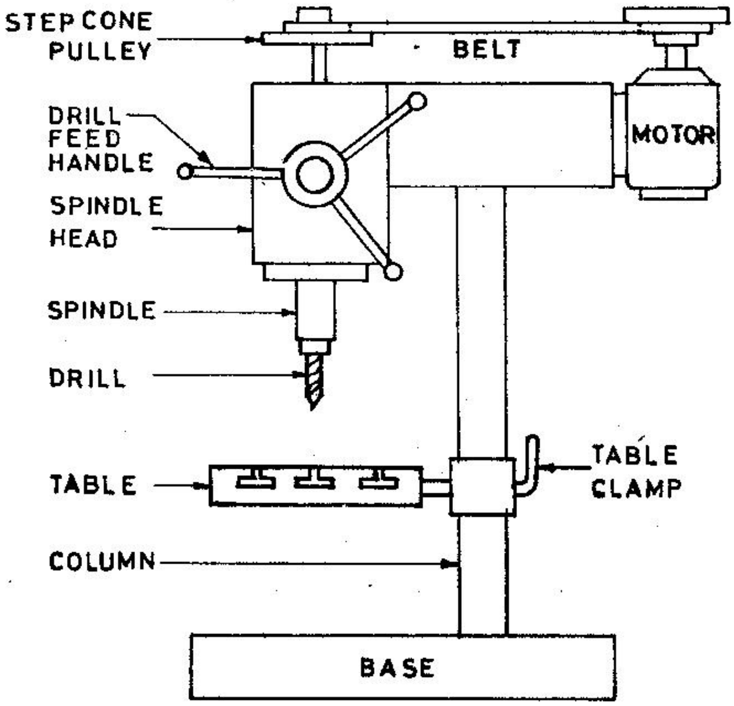


FIG.1. SENSITIVE DRILLING MACHINE

UP-RIGHT DRILLING MACHINE

THESE ARE MEDIUM HEAVY DUTY MACHINES.

IT SPECIFICALLY DIFFERS FROM SENSITIVE DRILL IN ITS WEIGHT, RIGIDITY, APPLICATION OF POWER FEED AND WIDER RANGE OF SPINDLE SPEED. FIG.2 SHOWS THE LINE SKETCH OF UP-RIGHT DRILLING MACHINE.

THIS MACHINE USUALLY HAS A GEAR DRIVEN MECHANISM FOR DIFFERENT SPINDLE SPEED AND AN AUTOMATIC OR POWER FEED DEVICE.

TABLE CAN MOVE VERTICALLY AND RADIALLY.

DRILL HOLES UP TO 50MM

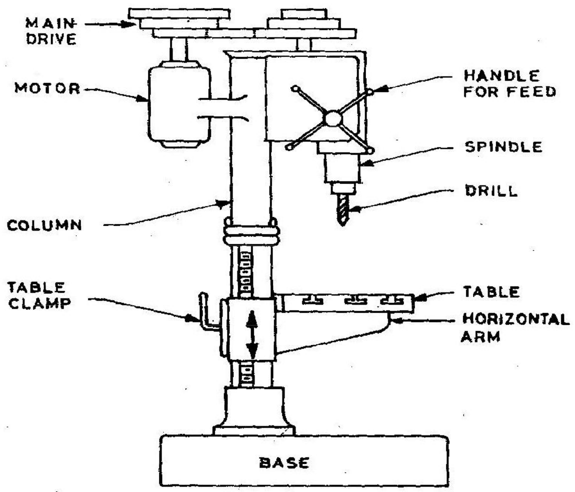


FIG.2 UP-RIGHT DRILLING MACHINE

RADIAL DRILLING MACHINE

IT THE LARGEST AND MOST VERSATILE USED FOR DRILLING MEDIUM TO LARGE AND HEAVY WORK PIECES.

RADIAL DRILLING MACHINE BELONG TO POWER FEED TYPE.

THE COLUMN AND RADIAL DRILLING MACHINE SUPPORTS THE RADIAL ARM, DRILL HEAD AND MOTOR. FIG.3 SHOWS THE LINE SKETCH OF RADIAL DRILLING MACHINE.

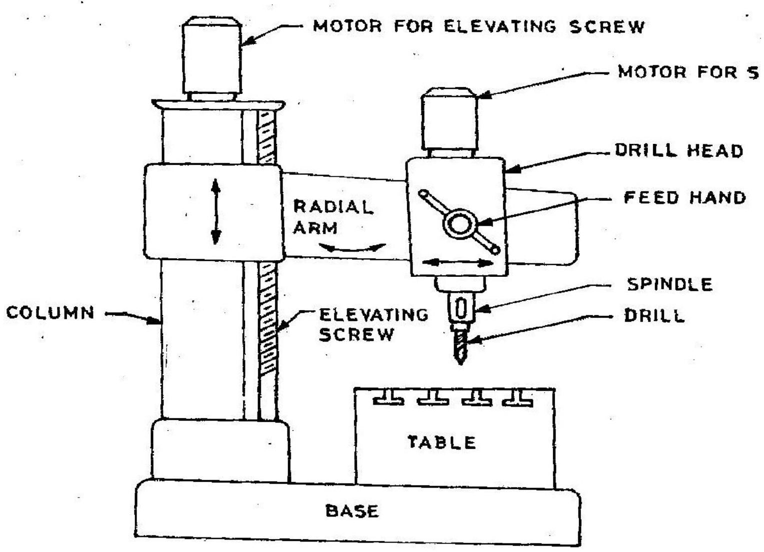


FIG. 3 RADIAL DRILLING MACHINE

THE RADIAL ARM SLIDES UP AND DOWN ON THE COLUMN WITH THE HELP OF ELEVATING SCREW PROVIDED ON THE SIDE OF THE COLUMN, WHICH IS DRIVEN BY A MOTOR.

THE DRILL HEAD IS MOUNTED ON THE RADIAL ARM AND MOVES ON THE GUIDE WAYS PROVIDED THE RADIAL ARM CAN ALSO BE SWIVELED AROUND THE COLUMN.

THE DRILL HEAD IS EQUIPPED WITH A SEPARATE MOTOR TO DRIVE THE SPINDLE, WHICH CARRIES THE DRILL BIT. A DRILL HEAD MAY BE MOVED ON THE ARM MANUALLY OR BY POWER.

FEED CAN BE EITHER MANUAL OR AUTOMATIC WITH REVERSAL MECHANISM.

DRILL MATERIALS

THE TWO MOST COMMON TYPES ARE

1. HSS DRILL

- LOW COST

2. CARBIDE- TIPPED DRILLS

- HIGH PRODUCTION AND IN CNC MACHINES

OTHER TYPES ARE

SOLID CARBIDE DRILL, TIN COATED DRILLS, CARBIDE COATED MASONRY DRILLS, PARABOLIC DRILLS, SPLIT POINT DRILL. FIG.4 SHOWS VARIOUS TYPES OF DRILLS

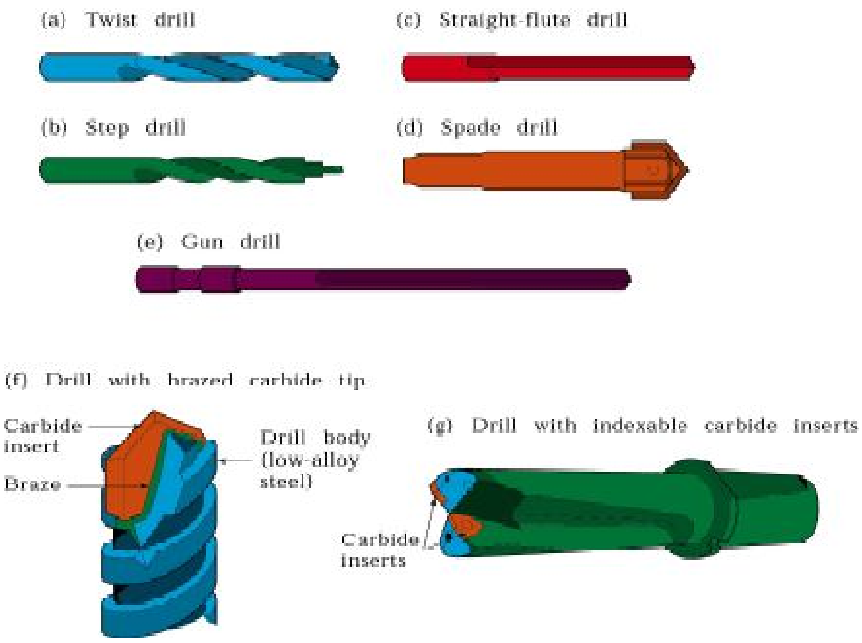


FIG. 4 VARIOUS TYPES OF DRILL

DRILL FIXED TO THE SPINDLE

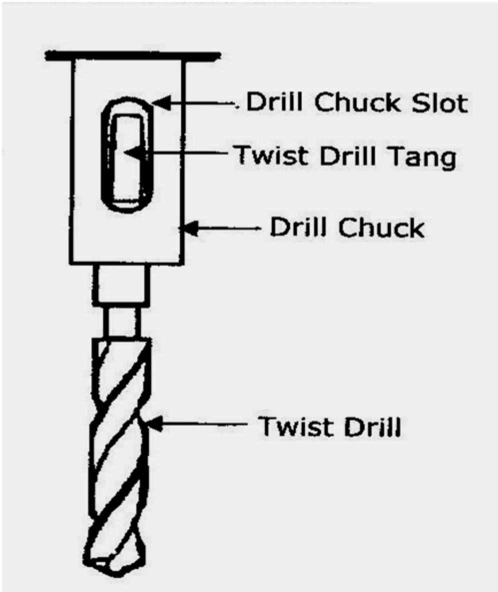


FIG. 5 DRILL FIXED TO A SPINDLE

TOOL NOMENCLATURE

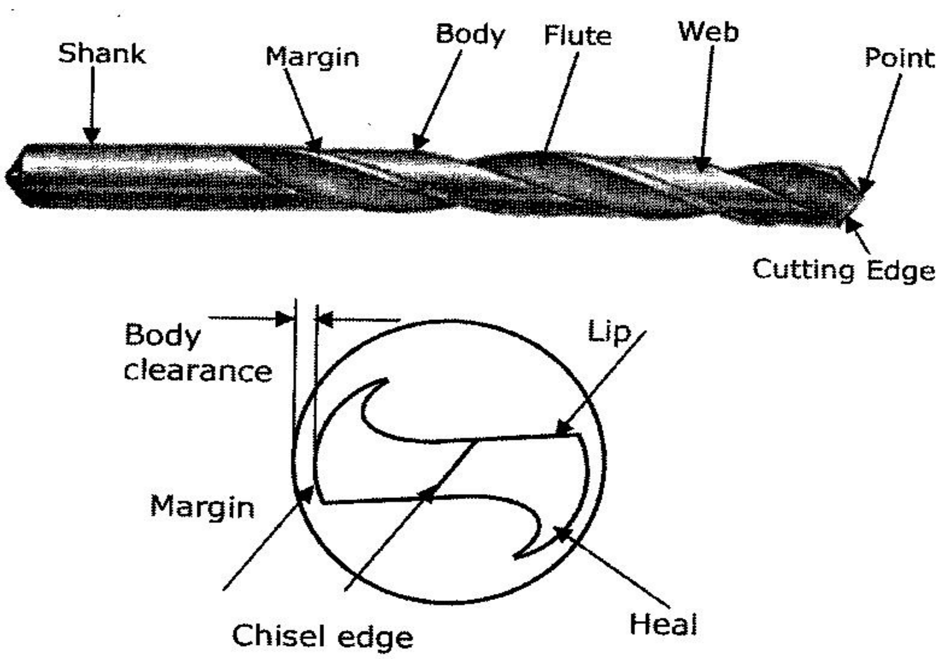


FIG. 6 NOMENCLATURE OF TWIST DRILL

TOOL HOLDING DEVICES

FIG.7 AND FIG.8 SHOWS THE DIFFERENT WORK HOLDING AND DRILL DRIFT DEVICE. THE DIFFERENT METHODS USED FOR HOLDING DRILL IN A DRILL SPINDLE ARE

BY DIRECTLY FITTING IN THE SPINDLE HOLE.
BY USING DRILL SLEEVE
BY USING DRILL SOCKET
BY USING DRILL CHUCK

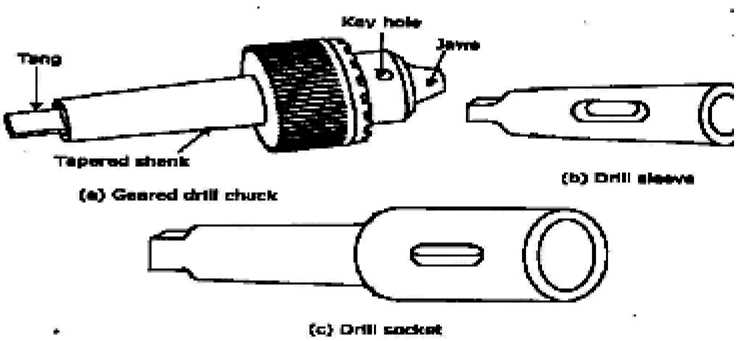


Fig. 7 Drill holding devices

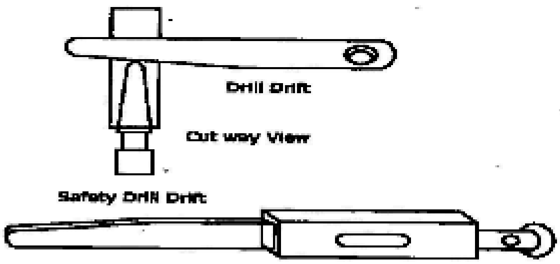


Fig. 8 Drill Drift

DRILLING OPERATIONS

OPERATIONS THAT CAN BE PERFORMED IN A DRILLING MACHINE ARE

DRILLING
REAMING
BORING

Counter boring
Countersinking
Tapping

Drilling:

It is an operation by which holes are produced in solid metal by means of revolving tool called 'Drill'. Fig. 9 shows the various operations on drilling machine.

Reaming:

Reaming is accurate way of sizing and finishing the pre-existing hole. Multi tooth cutting tool. Accuracy of ±0.005mm can be achieved

Boring:

Boring is a process of enlarging an existing hole by a single point cutting tool. Boring operation is often preferred because we can correct hole size, or alignment and can produce smooth finish. Boring tool is held in the boring bar which has the shank. Accuracy of ±0.005mm can be achieved.

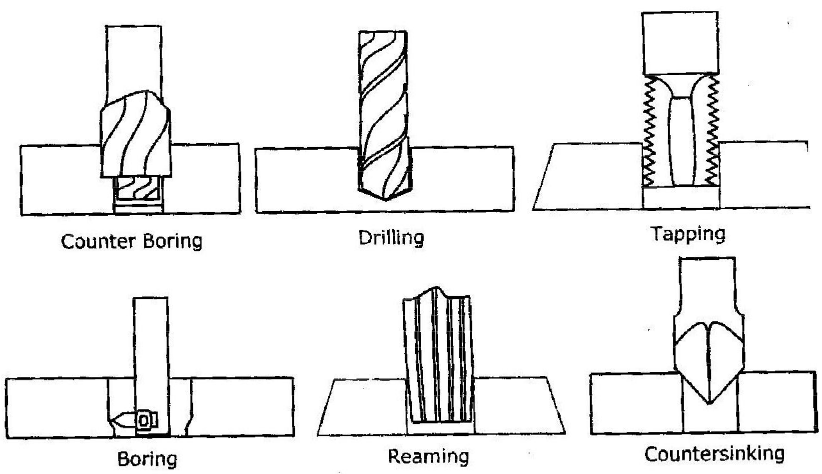


Fig. 9 Various operations on drilling machine

Counter Bore :-

This operation uses a pilot to guide the cutting action to accommodate the heads of bolts. Fig. 10 illustrates the counter boring, countersunk and spot facing processes.

Countersink:-

Special angled cone shaped enlargement at the end of the hole to accommodate the screws. Cone angles of 60°, 82°, 90°, 100°, 110°, 120°

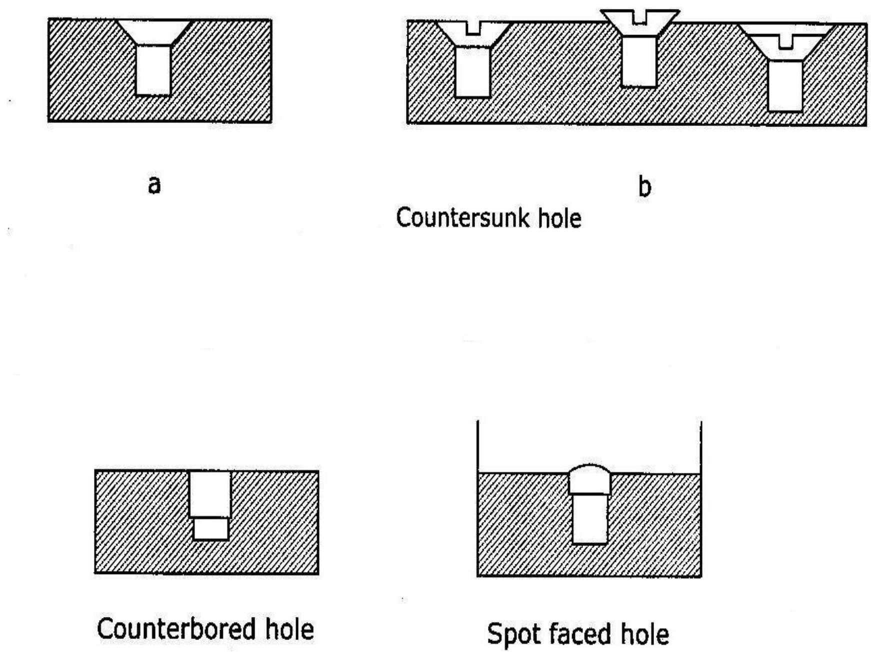


Fig. 10 Counter boring, countersunk and spot facing

TAPPING OPERATION

TAPPING IS THE PROCESS BY WHICH INTERNAL THREADS ARE FORMED. IT IS PERFORMED EITHER BY HAND OR BY MACHINE. MINOR DIAMETER OF THE THREAD IS DRILLED AND THEN TAPPING IS DONE. FIG. 11 SHOW THE TAPPING PROCESSES.

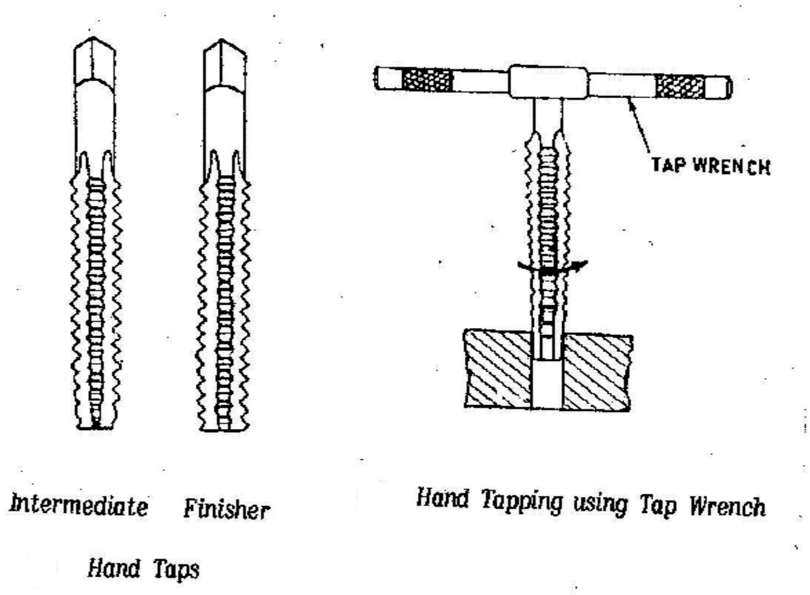


FIG. 11 HAND TAPS AND TAPPING PROCESS USING TAP WRENCH

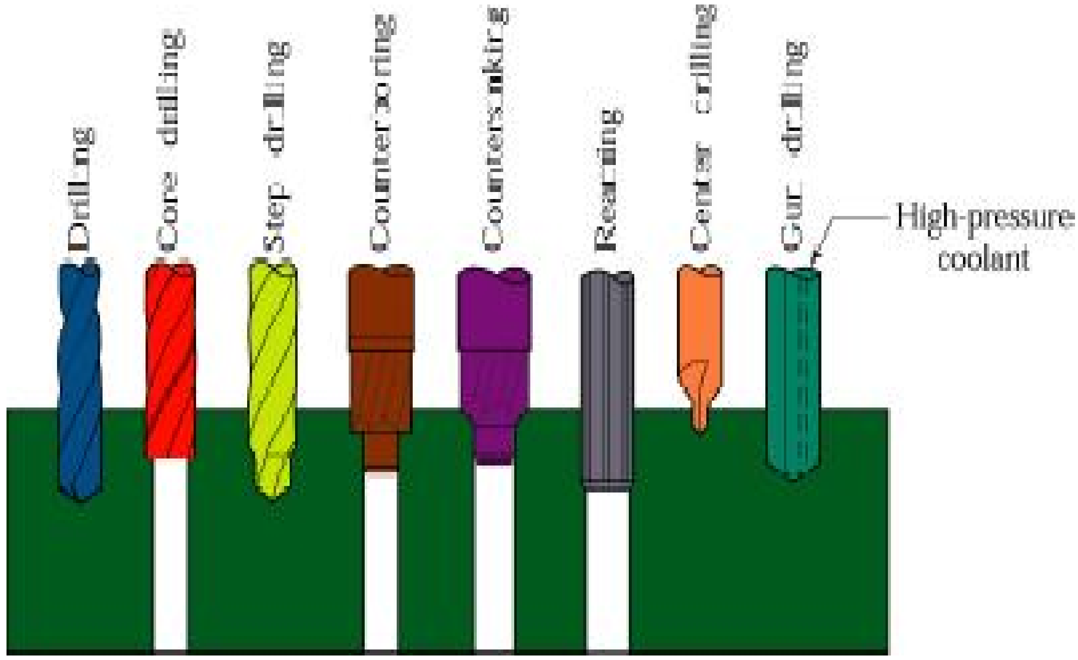


FIG. 12 VARIOUS OPERATIONS PERFORMED ON DRILLING MACHINE

WORK HOLDING DEVICES

MACHINE TABLE VICE

THE MACHINE VICE IS EQUIPPED WITH JAWS WHICH CLAMPS THE WORK PIECE. THE VICE CAN BE BOLTED TO THE DRILLING TABLE OR THE TAIL CAN BE SWUNG AROUND SWUNG AROUND. FIG. 13 SHOWS THE STANDARD AND SWIVEL VICE.
THE SWIVEL VICE IS A MACHINE WISE THAT CAN BE SWIVEL THROUGH 360° ON A HORIZONTAL PLANE.

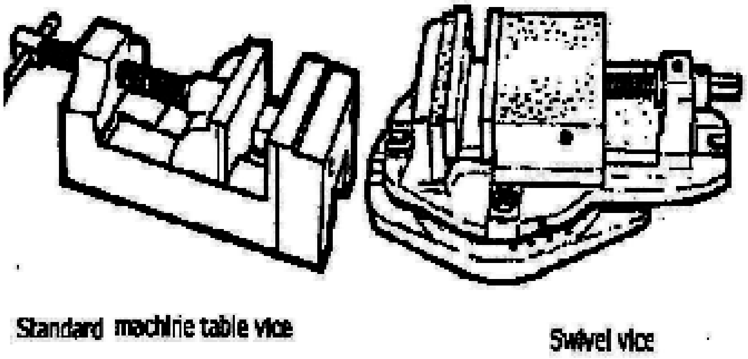


FIG. 13 MACHINE TABLE VICE.

STEP BLOCKS

THESE ARE BUILT TO ALLOW HEIGHT ADJUSTMENT FOR MOUNTING THE DRILLING JOBS AND ARE USED WITH STRAP CLAMPS AND LONG T-SLOT BOLTS.

CLAMPS

THESE ARE SMALL, PORTABLE VISES , WHICH BEARS AGAINST THE WORK PIECE AND HOLDING DEVICES. COMMON TYPES OF CLAMPS ARE C-CLAMP, PARALLEL CLAMP, MACHINE STRAP CLAMP, U-CLAMP ETC.. FIG. 14 SHOWS THE CORRECT AND INCORRECT METHODS OF MOUNTING THE WORK PIECE.

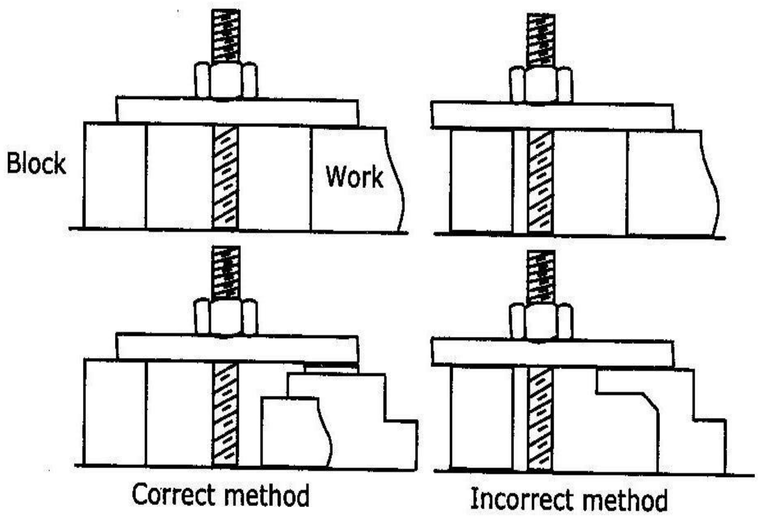


FIG. 14 CORRECT AND INCORRECT METHODS OF CLAMPING THE WORK PIECE.

V-BLOCKS

THESE ARE DESIGNED TO HOLD ROUND WORK PIECES.

ANGLES

ANGLE PLATES ARE MADE IN A 90°ANGLE WITH SLOTS AND BOLT HOLES FOR SECURING WORK TO THE TABLE.

JIGS

THE JIG GUIDES THE DRILL THROUGH A BUSHING TO LOCATE AND DRILL HOLES ACCURATELY.

T- SLOTS BOLT

THESE ARE SPECIAL BOLTS WHICH HAS A T SHAPED HEAD, WHICH SLIDES INTO THE T SLOTS OF DRILLING MACHINE WORK TABLE.

DEFINITIONS

1. CUTTING SPEED (V):-

IT'S THE PERIPHERAL SPEED OF THE DRILL.THE CUTTING SPEED DEPENDS UPON THE PROPERTIES OF THE MATERIAL BEING DRILLED, DRILL MATERIAL, DRILL DIAMETER, RATE OF SPEED, COOLANT USED ETC...

$V = \Pi * D * N$ WHERE

D = DIA OF THE DRILL IN M

N = SPEED OF ROTATION IN RPM

2. FEED RATE (F):-

IT'S THE MOVEMENT OF DRILL ALONG THE AXIS (RPM)

3. DEPTH OF CUT (D):-

THE DISTANCE FROM THE MACHINED SURFACE TO THE DRILL AXIS.

$d = D / 2$

AS THE DEPTH OF HOLE INCREASES, THE CHIP EJECTION BECOMES MORE DIFFICULT AND THE FRESH CUTTING FLUID IS NOT ABLE TO CUTTING ZONE. HENCE FOR MACHINING THE LENGTHY HOLE SPECIAL TYPE OF DRILL CALLED 'GUN DRILL' IS USED

.

4. Material Removal Rate:-

It's the volume of material removed by the drill per unit time

$$MRR = (\pi D^2 / 4) * f * N \ mm^3 / min$$

5. Machining Time (T) :-

It depends upon the length (l) of the hole to be drilled , to the Speed (N) and feed (f) of the drill

$$t = L / f N \ min$$

PRECAUTIONS FOR DRILLING MACHINE

LUBRICATION IS IMPORTANT TO REMOVE HEAT AND FRICTION.
MACHINES SHOULD BE CLEANED AFTER USE
CHIPS SHOULD BE REMOVED USING BRUSH.
T-SLOTS, GROOVES, SPINDLES SLEEVES, BELTS, AND PULLEY SHOULD BE CLEANED.
MACHINES SHOULD BE LIGHTLY OILED TO PREVENT FROM RUSTING

SAFETY PRECAUTIONS

DO NOT SUPPORT THE WORK PIECE BY HAND – USE WORK HOLDING DEVICE.
USE BRUSH TO CLEAN THE CHIP
NO ADJUSTMENTS WHILE THE MACHINE IS OPERATING
ENSURE FOR THE CUTTING TOOLS RUNNING STRAIGHT BEFORE STARTING THE OPERATION.
NEVER PLACE TOOLS ON THE DRILLING TABLE
AVOID LOOSE CLOTHING AND PROTECT THE EYES.
EASE THE FEED IF DRILL BREAKS INSIDE THE WORK PIECE.

ACKNOWLEDGEMENT

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