LECTURE # 6

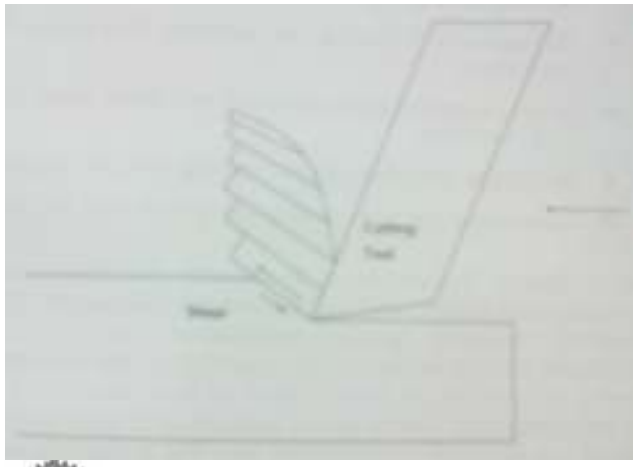
CAD/CAM COURSE

TOPIC OF DISCUSSION

AUTOMATED MACHINE TOOLS & CUTTING TOOLS

CNC & MANUFACTURING PROCESSES

- *CNC systems are used in a number of manufacturing processes including machining, forming, and fabrication*
- *Forming & fabrication processes encompass a great number of operations, including punching, shearing, bending, drawing, & cutting*
- *Machining is a material removal process where a hardened cutting tool is used to remove chips from the workpiece*



CNC & MANUFACTURING PROCESSES

- *Machining is a high precision affair in which features are typically created to tolerances of less than 0.001''*
- *These precisions standards make CNC so important to machining*
- *There are many different machining operations but they all undergo the same cutting process that creates chips*
- *Chips are formed by pushing a hardened tool into the softer workpiece until the material deforms*

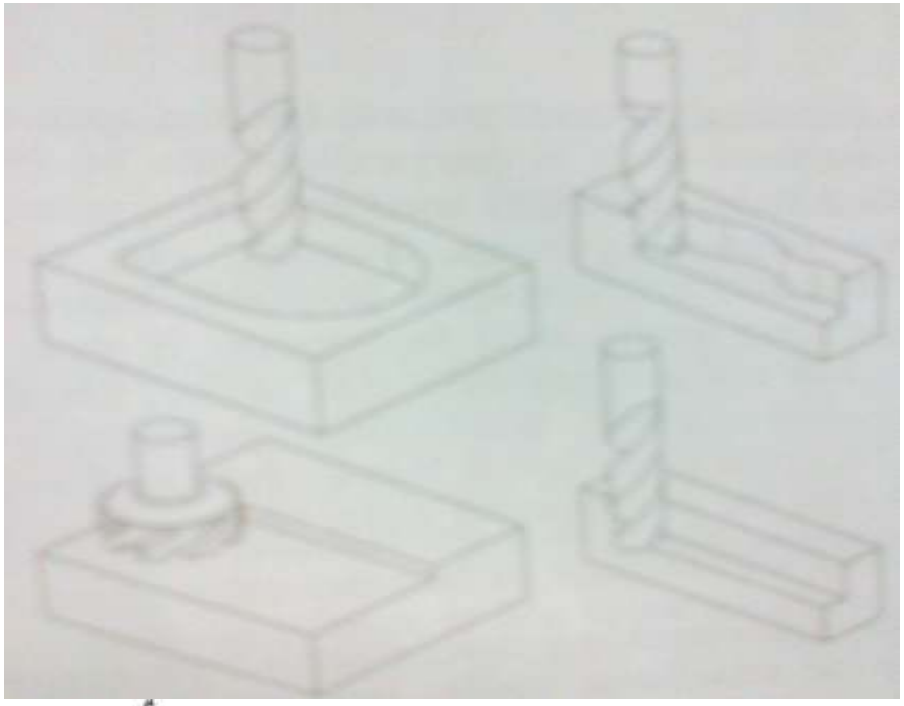
THE BASIC MACHINING OPERATIONS

- ***Milling***
  - *Milling is a process of using a rotating tool to remove material along a contour or line*
  - *Milling is tradiotionally used to create flat surfaces and straight edges on prismatic workpieces*
  - *Milling can also create curved contours. Creating curved contours on a conventional milling machine is an especially difficult task that requires a great amount of skill and specialized tooling*
  - *CNC machine tools have made curved contours much easier to create*

THE BASIC MACHINING OPERATIONS

- *For example, with a few simple instructions entered into the part program, a CNC machine tool can now produce a circular arc that once required a rotary table to create*

Fig: Pocketing, Contouring Facing and Side Milling



THE BASIC MACHINING OPERATIONS

- ***Turning***
  - *Turning is a word used to describe a number of different machining operations that are performed on a machine called a Lathe*
  - *In turning, tool is held stationary while the part is rotated, the resulting shape is cylindrical*
  - *Turning is used to create shafts, bearings, fastners, and many other machine components that require a very precise cylindrical and conical features such as outside diameters, bores, and tapers*
  - *Turning can also produce flat surfaces, grooves, and threads*

THE BASIC MACHINING OPERATIONS

- *Especially CNC machine tools have changed threading to a highly automated process that can be performed with little more than a few instructions and no operator intervention*

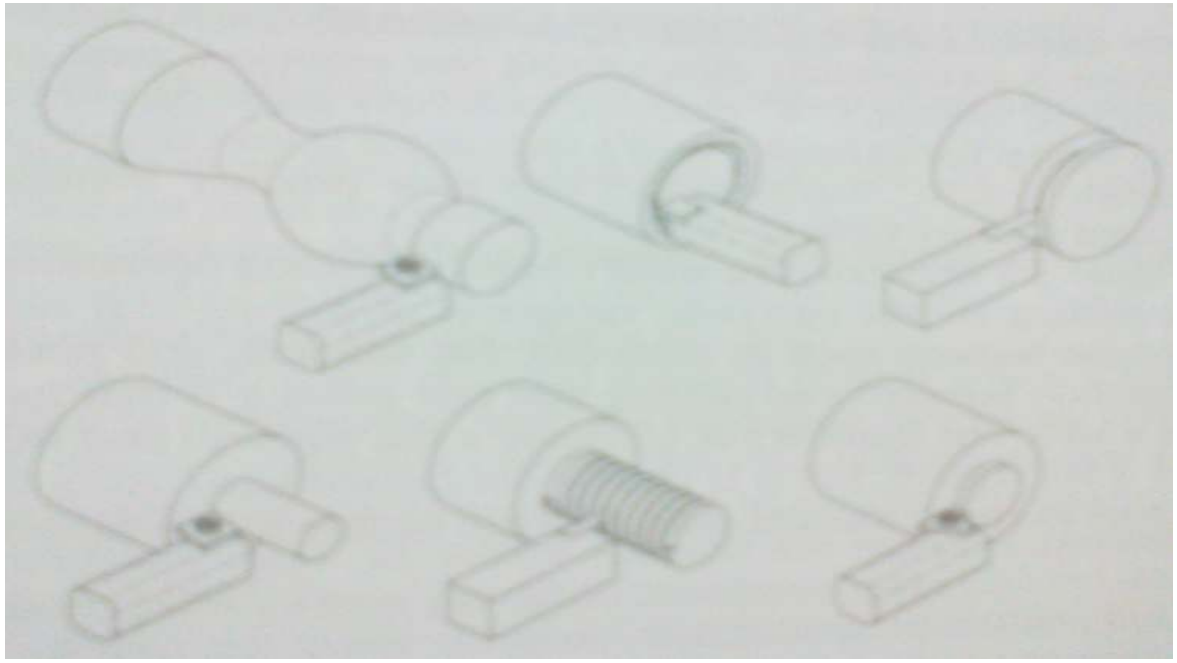


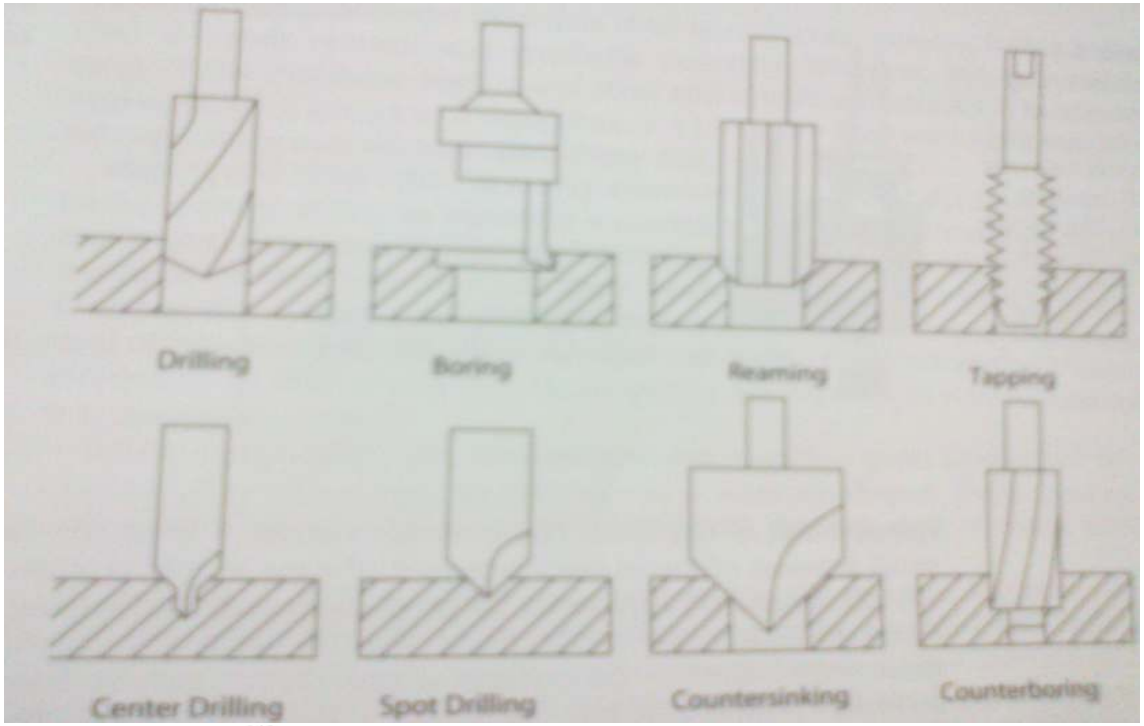
Fig: Profiling, ID Boring, Grooving or Parting, Facing, Threading and OD turning

THE BASIC MACHINING OPERATIONS

- ***Drilling & Reaming***
  - *Drilling and reaming are hole making operations that can be performed on a variety of machine tools, including milling machines and lathes*
  - *Drilled holes are seldom round. Straight or correct size & it is difficult to achieve high precision tolerances that are required in machining*
  - *Nonetheless, drilling is used to make way for other operations whose tools cannot cut on the centre (boring tools, reamers, and taps)*

THE BASIC MACHINING OPERATIONS

- *Reaming is an opeartion similar to drilling, but reaming produces a higher quality hole very quickly*
- *Reamed holes are cylindrical and have correct diameters*
- *The only disadvantage is that reamers are expensive*



THE BASIC MACHINING OPERATIONS

- ***Boring***

- *Boring is an internal turning process that is performed on a lathe*
- *Boring can also be performed on a milling machine with a tool called bore head*
- *A boring head uses a single point cutting tool called a boring bar*
- *The chief disadvantage of this process is that it is slow processs*

THE BASIC MACHINING OPERATIONS

- ***Tapping***
  - *Taping is the production of internal threads with a tool that is ground in the form of the finished thread*
  - *Tapping is an extremely fast and common operation that can be performed on either a CNC lathe or a CNC milling machine*
  - *One of the biggest obstacle to tapping in CNC machining has been the fact that taps must be reversed to be removed from the hole*
  - *This obstacle was first overcome by the production of a self-reversing tapping head that would reverse directions when pulled out of the hole*

CUTTING TOOL MATERIALS

- *There are many different materials used to cut tools, ranging from common steel to exotic ceramic and synthetic materials*
- *Howerver, two materials get most of the job done: high-speed steel and cemented carbides*
- *The ceramics and synthetics get lot of attention but in reality they are only a small percentage of the cutting tools used everyday*
- *High speed steel (HSS) is a very common cutting tool material. It gets its name from its ability to maintain a cutting edge at the elevated temperatures encountered during machining*

CUTTING TOOL MATERIALS

- *High Carbon Steels can have the same hardness as HSS, but they lose their hardness at the elevated temperatures found at the cutting edge*
- *HSS gets it hot hardness primarily due to addition of tungsten into the alloy*
- *HSS is inexpensive and versatile and can handle a great amount of shock*
- *HSS is easy to fabricate shapes*
- *Drills, end mills and taps are commonly made from HSS and perform well in cutting conditions*

CUTTING TOOL MATERIALS

- *Cemented carbide is another popular cutting tool material*
- *The term carbide refers to cutting tools made from carbides of tungsten, titanium and tantalum*
- *Carbides are extremely hard materials that can handle a great amount of heat and last long time*
- *The chemical and physical nature of carbides does not allow them to be directly melted and wrought into billets to make cutting tools*
- *Instead, the powdery carbides are mixed with another metal such as cobalt and sintered in an ovan*
- *The other metal will melt and act as a binder to cement the carbide particles together---- hence, cemented carbide*

CUTTING TOOL MATERIALS

- *Carbides are available in number of different grades (composition and hardness) based upon their intended use*
- *The grading system is a continuum from soft/tough to hard/brittle*
- *Some machining applications require a very hard but brittle material that can faithfully hold an edge*
- *Other applications require shock resistance and therefore must be softer and tougher*
- *The properties of cemented carbides can be manipulated by varying the ratio of cobalt binder to carbide and by using different metallic carbides*

CUTTING TOOL MATERIALS

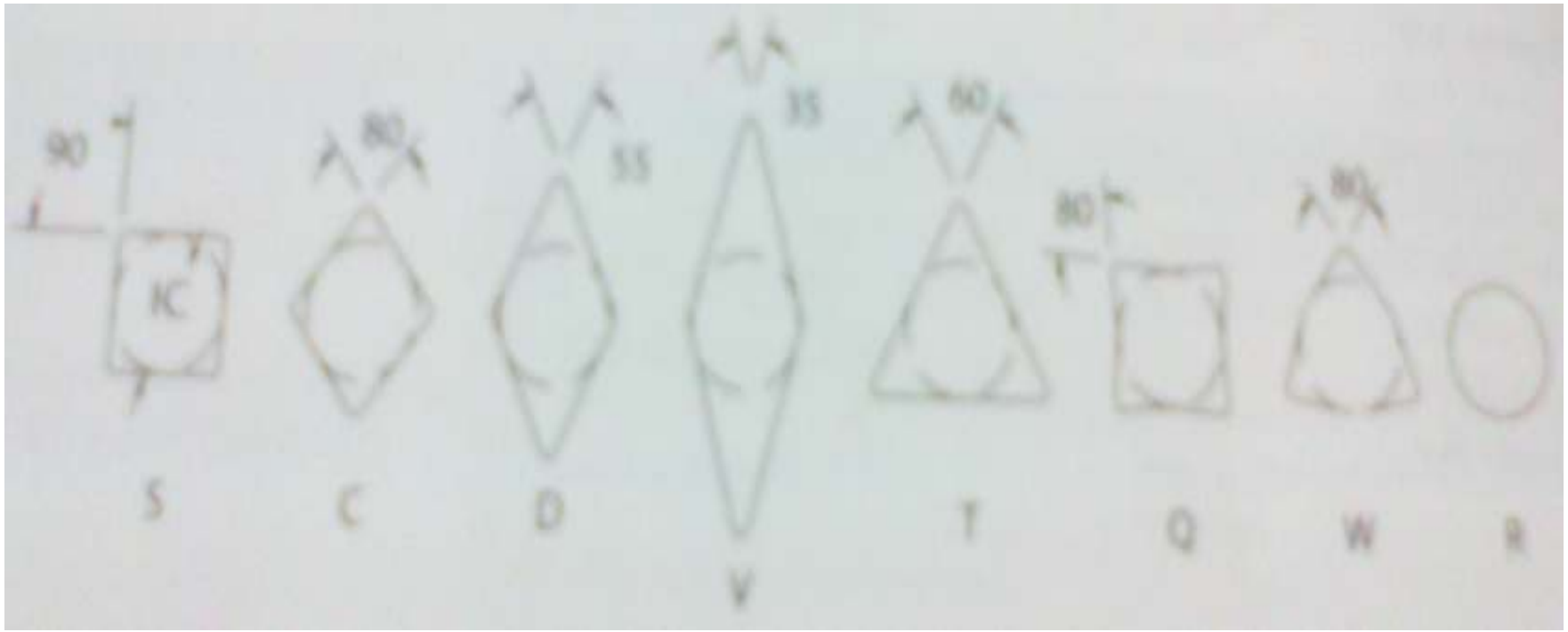
- *Industry Standard Carbide Grades*

	Grade	Primary Use	Toughness	Hardness
Grades for Aluminum, Cast Iron, and Non-metallics (~95% Tungsten Carbide)	C1	Heavy roughing	Tough	Soft
	C2	General purpose		
	C3	Finishing		
	C4	Fine finishing and boring	Brittle	Hard
Grades for Steel (~75% Tungsten Carbide, 5-10% Titanium Carbide, and 5-10% Tantalum Carbide)	C5	Heavy roughing	Tough	Soft
	C6	General purpose		
	C7	Finishing		
	C8	Fine finishing and boring	Brittle	Hard

CUTTING TOOL MATERIALS

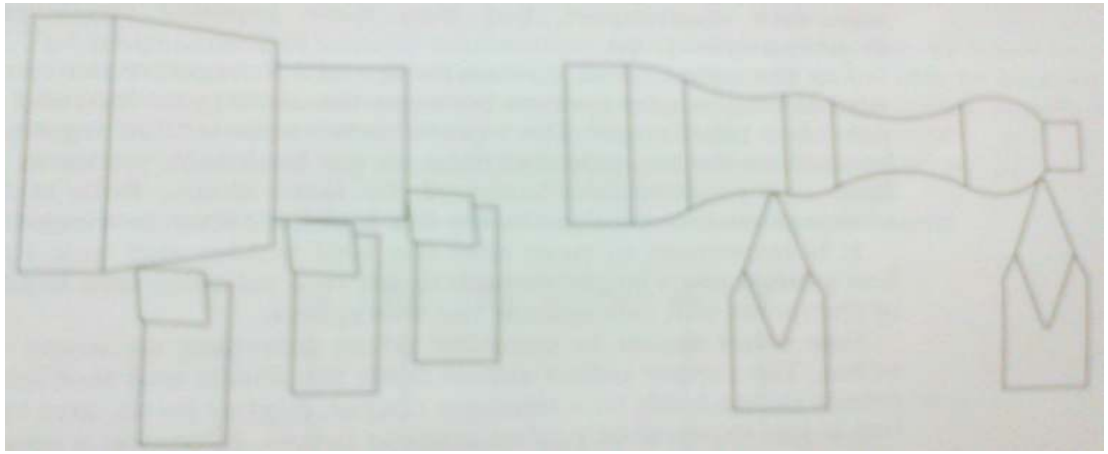
- *The majority of the carbides used today are manufactured as throwaway indexable inserts*
- *The inserts are held in a shank or tool body that is usually made from a good grade of steel*
- *As soon as the insert become dull, they are indexed to a sharp corner or replaced*
- *These inserts are available in many shapes and sizes, some of which are standardized*
- *The three major factors in inserts selections are the corner style, rake angle, and corner radius*
- *Insert strength is most affected by the angle of the corner*

CUTTING TOOL MATERIALS



CUTTING TOOL MATERIALS

- *S and C shapes have relatively broad, strong corners*
- *The V-shape, with its sharp, 35 Deg. angle, is relatively weak*
- *Broader corner angles will also allow the heat to be more quickly conducted away from the tip*
- *Ofcourse, the geometry of the tool holder and of the workpiece will also dictate the style of insert that we will be able to use*



CUTTING TOOL MATERIALS

- ***Cutting Tools for Milling***
  - *An end mill is a cutting tool designed to cut on both the end and the side*
  - *Standard end mills are perhaps the most common cutting tools used in conventional and CNC milling*
  - *The most common material for end mills is HSS, but end mills are also made from solid billets of cemented carbide*
  - *HSS end mills are inexpensive and used extensively to machine ferrous and non-ferrous materials*
  - *Carbides tend to be brittle; therefore, the sharp edges found on solid-carbide end mills do not tend to hold up very well for ferrous machining applications*

CUTTING TOOL MATERIALS

- *End mills are described by their geometric features, which include the number of teeth/flutes, the end-cutting style, and the edge profile*

From Left to right: Four flute, two-flute with high-helix angle, roughing, and ball end mill

CUTTING TOOL MATERIALS

- *The most obvious feature of a standard end mill is the outside cutting edges or teeth*
- *The spaces between the individual cutting edges, which are called flutes, are used to remove the chips*
- *Two flute mills usually have large flutes and therefore more room to accommodate chips*
- *They are used for machining aluminium and light metals because the chips tend to be larger due to the increased feed used on soft materials*
- *Four flute end mills have smaller flutes but they are stronger and stiffer than two flute mills*
- *Four-flute end mills have more cutting edges to do work*
- *These are used for machining steels*
- *Three flute mills have properties in between two and four flute end mills, they are a good compromise for materials particularly stainless steel that are somewhere between soft and hard steels*