Introduction - Fundamentals of Machining

Machining concerns removal of metal from a workpiece by means of various methods. The most common are mechanical mass reduction operations which involve removal of chips in form of ribbons or particles of various shapes. There are many ways to classify machining operations. For example they can be divided into following groups [4]:

Single-point cutting concerns:
- turning/facing
- boring
- shaping/planing
- parting/grooving
- single-point threading

Multi-point cutting concerns:
- drilling
- milling/routing
- broaching
- multi-point threading
- sawing
- filing
- gear cutting

Abrasive machining concerns:
- grinding
- honing
- lapping
- superfinishing
- abrasive jet machining

All methods presented above are usually considered as conventional machining. Some other applicable methods like EDM (Electro Discharge Machining), ECM (Electro Chemical Machining) or EBM (Electron Beam Machining) are unconventional and often involve many fields of knowledge e.g. physics, chemistry, optics to be explained. The most popular is EDM and its principles are explained in following chapters.
A good example of the implementation of various metal removal methods is gear manufacturing (single-point, multi-point and abrasive tools can be used)

1. Kinematics – Machining Motions

Kinematics is described by the tool and workpiece motions while machining. All motions are given in fig. 1.
Essential motions are the most important. They define the kinematics of each machining method. These motions are responsible for cutting phenomenon: primary - for cutting speed and feed – for volume of material removed in one pass (revolution).

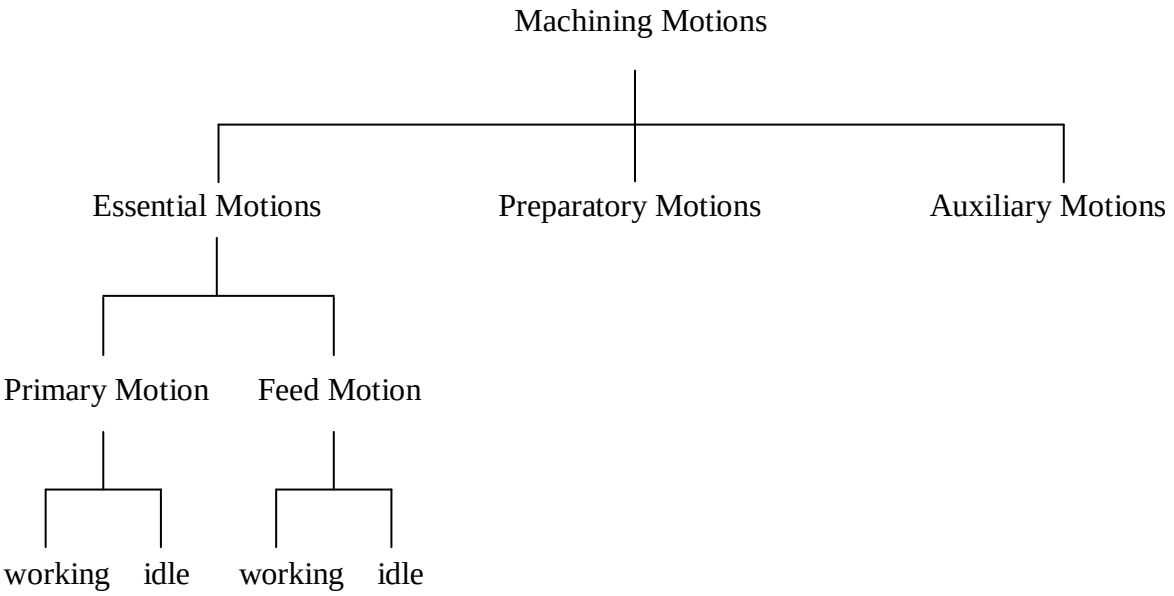

Fig. 1. Machining motions

2. Turning

Metal cutting is a complex task which can be discussed taking on turning as an example. Turning is a process using generally a single point tool with defined geometry that removes material to produce a surface of revolution (fig. 2.).

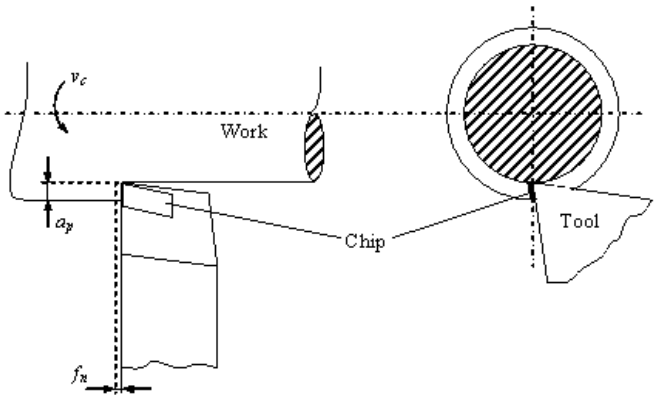

Fig. 2. Single point turning operations a)plain view b) side view [2]

Discussing turning operations one can understand the need for the classification of workpiece material, basic formulas concerning metal cutting, cutting parameters selection problem, the influence of the local environment on the whole process. These have been described in details in the following chapters.

3. Milling

Milling operations perform metal cutting by co-ordinate movement between rotating multi - edge tool and feed of workpiece. The milling cutters have several cutting edges and each edge takes a certain amount of metal. There are three principal types of milling cutters: plane, face, end cutters (fig. 3.).

The modern milling operations involve metal cutting with increased cutting speed and feed. This is called high speed machining (HSM). HSM requires high quality machine tools equipped with high-speed spindles (up to 40000 rpm) and tools with carbide inserts or made of solid carbide.

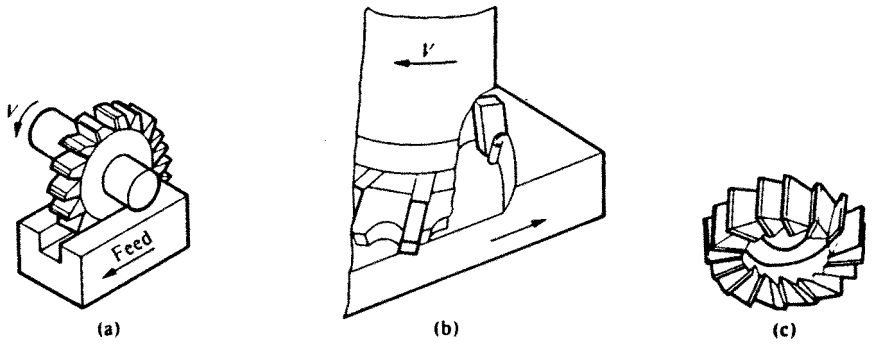

Fig. 3. Principal types of milling cutters. (a) plane, (b) face, (c) end. [2]

4. Drilling

Drill is a complex cutting tool used to produce rough holes. There are two cutting edges that produce chips similar to those produced in turning operations (fig. 4.). Both cutting edges of a drill operate with variable rake angle and clearance angle along the cutting edge.

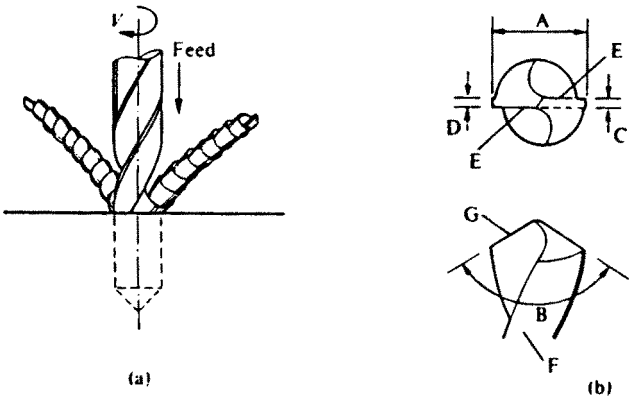

Fig. 4. Twisted drill [2]

Drilling can be used as a preliminary operation for making precise holes. Additionally, roughing and finishing roamers must be used.

5. Grinding

Grinding differs from described above cutting operations in a significant way (fig. 5.). The material is removed by a grinding wheel which consists of abrasive grain fixed in a binder. The geometry of a tool point is not defined. Chips are very small metal particles. Some popular kinds of grinding involve cylindrical grinding, surface grinding, face grinding. This is mainly a finishing kind of operation giving very good surface quality.

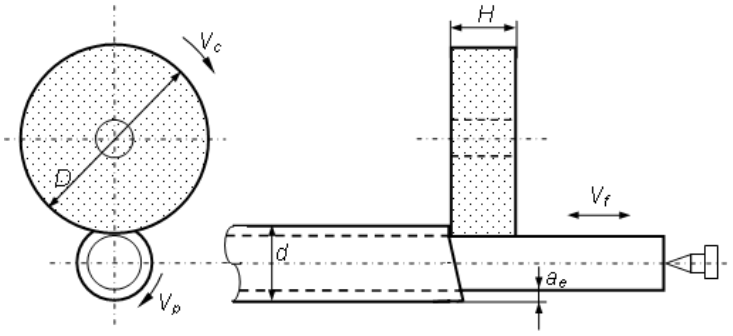

Fig. 5. Cylindrical grinding.

6. Manufacturing of gears

Since manufacturing of gears can involve many kinds of metal removing operations and requires using comparatively complicated and highly precise machine tools it deserves special attention.

Depending on size, material, application, gears are manufactured in various ways. Some significant types of gear drives are shown in fig. 6. Milling operations play the main task as well as grinding, hobbing, shaving and broaching. All methods can be divided into chip-producing and chipless production methods. Two main techniques of gear production are shown in fig. 7.

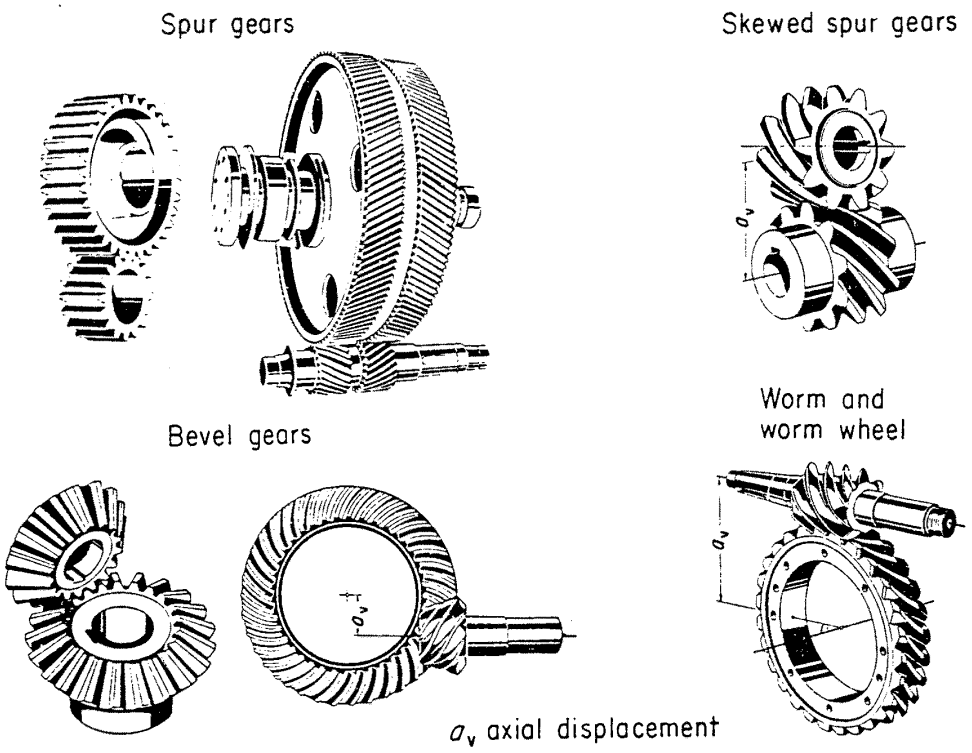

Fig. 6. Types of gear drives [3]

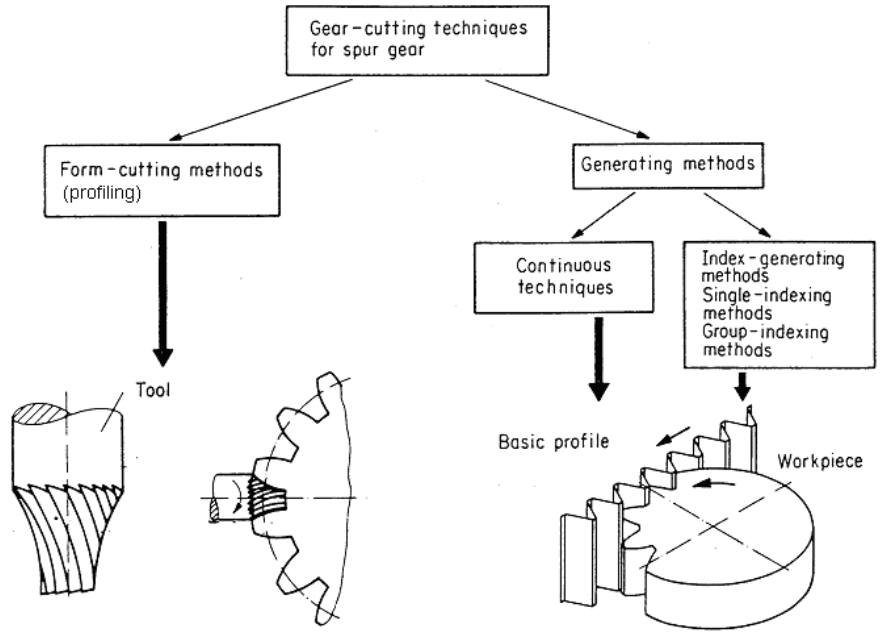

Fig 7. Basic gear cutting methods [3].

7. CNC Machine Tools

It is not possible to study machining without reference to machine tools. Various machine tools are described later in this book. Although most laboratory classes involve traditional machine tools to explain machining phenomena, it should be remembered that machine tools, like tools are evolving all the time. Nowadays machine tools are more complex and universal. Modern lathe equipped additionally with driven tools can often work as a milling machine. High performance multi-purpose machine tools become very popular. Development of microprocessors and computers has enabled to apply this technology into machine tools and build CNC (Computer Numerical Control) machine tools (fig. 8.). Modern machine tool has modular structure. This enables to produce machine tools cheaper, faster and according to customer requirements. Digital servomechanism has been applied, so traditional mechanisms (change gears mainly) have been significantly reduced. Modern mechanical parts/subsystems used in machine tool structures are very stiff, movable elements have very low coefficient of friction.

There are two ways of machine tools utilization. They can be used as a separate production units (a machining cell) or can be used as a part of FMS (Flexible Manufacturing System). Modern machine tools are usually equipped to fulfill this demand.

8. References

1. HAAS-catalogues
2. Shaw M.C.: Metal Cutting Principles. Oxford, Clarendon Press 1989
3. Weck Manfred.: Handbook of Machine Tools volume 1, Wiley Heyden Ltd., 1980
4. http:\\class.et.byu.edu (2005-05-30)

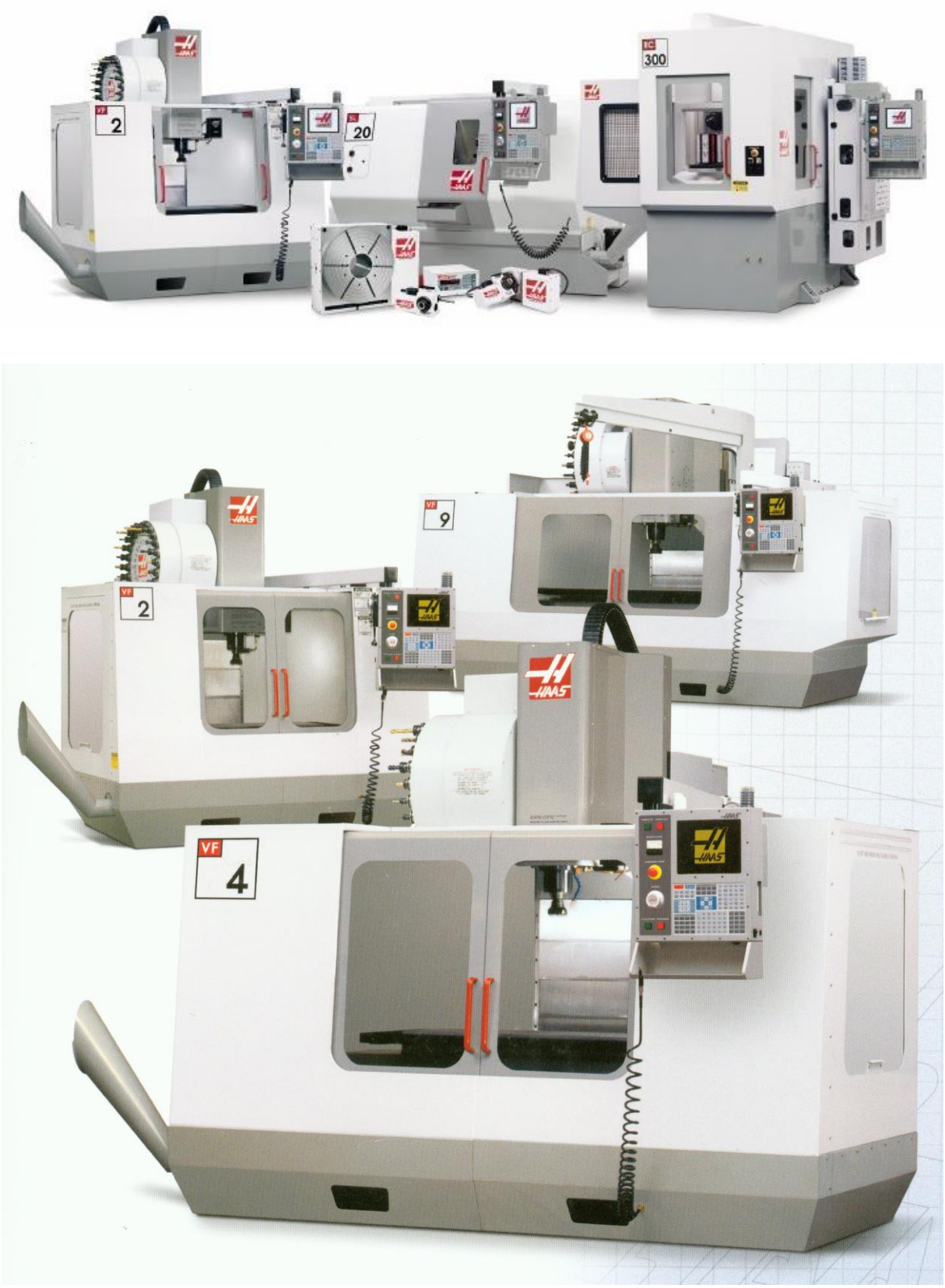

Fig. 8. CNC Machine Tools produced by HAAS (USA) [1]