
UNIT 2 BROACHING

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2.1 INTRODUCTION

Before understanding the process of broaching and the related machining tools it is required to know the clear difference between single point and multipoint cutting tool.

A single point cutting tool normally consists of a single cutting point or an edge used for cutting. The example of single point cutting tool is turning tool used for turning tool is generally has more than one cutting points or cutting edges in action at a time. Example of multipoint cutting tool are milling cutter or a broaching tool.

Broaching is one of the metal machining operations done by a multipoint cutting tool called broaching tool or broach. The tool is made reciprocating linearly relative to the workpiece in the direction of tool axis. The relative movement, necessary fixtures for workpiece and the broach are provided by a machine tool called broaching machine. The broaching operation is depicted in Figure 2.1. The broaching is a high productivity method as so many cutting edges work to machine the workpiece at a time. The tool may be pulled or pushed through the surfaces to be finished. Surfaces finished by broaching either internal or external. External broaching is performed on the outside surface of the workpiece to create a pre-decided shape with dimensional accuracy and high degree of surface finish. Internal broaching is done on the internal surfaces of the workpieces. This way internal surfaces are brought to exact size with the required surface finish. Examples of the different shapes produced by internal and external broaching are shown in Figure 2.2.

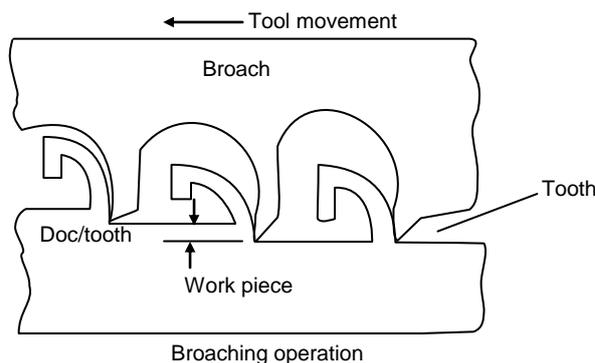


Figure 2.1 : Broaching Operation

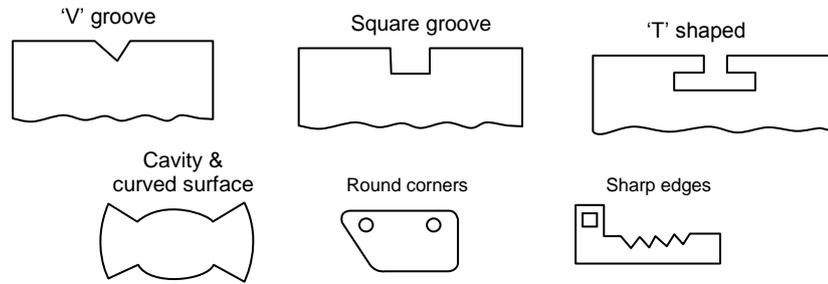


Figure 2.2 : Shapes Prepared by Internal Broaching

Objectives

After studying this unit, you should be able to understand

- know broaching operation, machining operation,
- understand about broach and various types of broaching tools,
- know main parts of a broach,
- know the different types of broaches,
- describe the broaching methods as different broaching operations,
- the merits and demerits of broaching operations,
- know about broaching machine and its operation, and
- classifications of broaching machines.

2.2 BROACH

As we know that the broach is a broaching tool, it consists of a series of distinct cutting edges called cutting teeth along its length. Feed is accomplished by the increased step between any two successive teeth on the broach. The total material removed in a single pass of the broach is the cumulative result of all the teeth in the tool in action (it is not necessary that all the teeth available in the broach in action at a time). The cutting speed of the broach is decided by the linear travel of the tool with respect to the workpiece. The shape of the cut surface (machined surface) is determined by the contour of the cutting edges on the broach. Generally broaches are made of high speed steel (HSS). In some cases the broaches are made of cast iron and their cutting edges are made of cemented carbide inserts. These inserts are fastened to the right place by mechanical means or brazed. A typical broach is shown in Figure 2.3 along with its nomenclature.

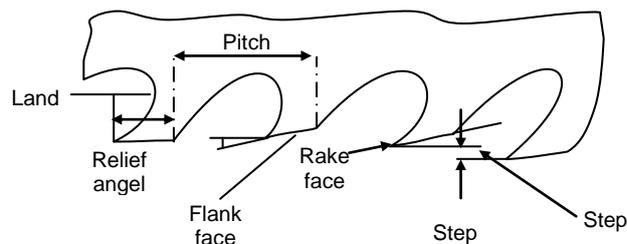


Figure 2.3 : Broach

Nomenclature of broach if expressed with its numerical values, called specification of broach. This nomenclature is explained below.

Pull End

Pull end is made to attach the broach to the broaching machine through the puller head.

Front Pilot

This centres the broach in the hole to be finished just before start of processing.

Roughing Teeth

These are the cutting edges which remove larger amount of stocks during cutting. Larger amount removal generates poor quality of surface finish but makes the operation faster.

Finishing Teeth

These are cutting edges removing smaller stocks of material. These are used for final finishing of the surfaces and their accurate sizing.

Rear Pilot and Follower Rest

This is a supporting device to the broach when it is likely to complete its operation of broaching.

Land

It is the width of flank face of the broach normally it is kept slightly inclined to give relief angle to the flank face of broach.

Pitch

It is the distance between two corresponding points on two successive teeth of a broach. Normally pitch of finishing teeth of a broach is kept comparatively smaller than the rough cutting teeth.

Height of the Teeth

Height of the roughing and finishing teeth gradually increases from the shank to the finishing teeth. This increment is called the cut per tooth, it depends on the material being machined. Normally the cut per tooth is taken from 0.01 or 0.2 mm for the finishing teeth and it may go up 0.2 mm for the cutting teeth.

2.3 DIFFERENT TYPES OF BROACHES

A broach is normally made in one piece and it is called a solid broach. Different types of the broaches are described below.

Progressive Cut Broaches

These broaches have cutting edges, a part of which are of the same height along the broach but have different widths. In progressive cut broaching, metal is removed in thick layers by each tooth from only part of the work surface. The last tooth of a progressive cut broach remove a very thin layer over the entire profile of the work surface as in ordinary cut broaching.

Rotor Cut Broaching

Rotor cut broaches are used for removing large amount of material in holes in forgings or castings where a primary cutting operation is not desired. Their teeth are staggered around the periphery at different sections so as to shear the work and allow chip clearance. This is recommended for making square holes from a round cost one.

Burnishing Broaches

Burnishing broaches are used for making glazed and finished surface on a steel workpiece. These are used for finish the hole too. Burnishing teeth are rounded and not cut but compress and rub the surface of metal. The amount of stock is intentionally left for burnishing. Its thickness should not be more than 0.025 mm.

2.4 BROACHING METHODS

On the basis of method of broaching the operation of broaching is classified as discussed below.

Pull Broaching

Workpiece is clamped to the broaching machine in stationary position and the broach is pulled through the work. Broaches are usually long and are held in a special head. Pull broaching is mostly used for internal broaching.

Push Broaching

Workpiece is held in the broaching machine in stationary position and broach is pushed through the portion of workpiece to be machined. Normally push broaching is done by hand and arbor presses (hydraulic press). This method is also recommended for internal broaching like for sizing and finishing the holes, cavities, and key ways.

Surface Broaching

Any one of two, either workpiece or the broach (tool) is kept moving and other is kept stationary. The method is widely used as surface finishing operation. In case of surface broaching, the broaching tool is specifically designed for the shape to be finished.

Continuous Broaching

In continuous broaching the broach is held stationary in the broaching machine and workpiece is moved continuously. The teeth of movement of the workpiece may be either straight, horizontal or circular. This is generally used for broaching a large number of similar workpieces at a time.

2.5 BROACHING OPERATION

Broaching operations are used for processing of various internal and external surfaces. This is also recommended for processing of round and irregular shaped holes ranging from 6 to 100 mm size which may have flat or contoured surfaces. Some of the cavities and holes are directly machined by broaching operations, the example is spline hole. Sometimes execution of broaching operation requires more than one pairs. The teeth of a gear or spline may be broached altogether or one or a few at a time. Normal indexing operation (see milling machine operation for details) is done for cutting teeth by broaching. After completion of broaching of one tooth indexing action is performed and another tooth is broached and this continues till all the teeth are broached.

2.6 FIXTURES USED IN BROACHING

Fixtures play an important role in broaching operation. Fixtures are used for providing an accurate pre-decided movement to broach with proper clamping action. Accuracy and rigidity of fixture make the operation of broaching repeatable and fit for mass production. Functions of broaching fixture are summarized as given below :

- (a) Fixture holds the workpiece accurately and rigidly and moves it to the exact cutting position.
- (b) Guide the movement of the broach in pre-decided manner relative to the workpiece.
- (c) Fixture is also responsible to give feed motion to workpiece after completion of the cut.

2.7 MERITS AND DEMERITS OF BROACHING OPERATION

Broaching is widely used for faster finishing operations in metal working so it is a fit case for mass production. Merits and demerits of broaching operations are described below.

- (a) It gives high rate of production so recommended for mass production.
- (b) Production run time in case of broaching is very large as a broach has very long life. The whole processing load is shared by so many teeth.
- (c) Due to faster operation and longer tool life, it is relatively cheaper.
- (d) Both rough cutting as well as finished cutting can be completed in a single pairs of tool.
- (e) Little skill or employment of semi-skilled manpower is sufficient to perform broaching operation.
- (f) Broaching provides accurate and excellent quality of surface finish. It is capable to maintain tolerance of the order of ± 0.007 mm and surface finish CLA value upto 0.8μ .
- (g) It is also capable to process internal and external surface including intricate shaped cavities.
- (h) Broaching makes the effective use of cutting fluids as it facilitates the flow of cutting fluid into the cuts.

In addition to the above merits the operation of broaching has some demerits, which are described below :

- (a) Broach is a multipoint cutting tool having multi cutting edges. Preparation of cutting edges is a costly affair. Its initial cost is quite high.
- (b) There is a limitation of size of workpiece in case of broaching. Very large sized workpieces can not be subjected to broaching operation.
- (c) Broaching is not possible for the surfaces having obstructions.
- (d) Application of broaching is restricted upto finishing and accurate sizing as it can remove only small stocks of material. Removal of larger stocks is not possible in broaching operation.
- (e) There is a urgent need of rigid clamping of workpiece in broaching operation to maintain its accuracy and finish. Clamping devices require frequent maintenance and cost.

2.8 MATERIAL OF BROACH

Common broach material is 18-4-1 stainless steel. As its name indicates, it has 4% chromium, 1% vanadium and 18% tungsten. This is corrosion and wear resistant steel. Carbide is also recommended for broach making, these broaches are used for broaching brittle material like cast iron in automobile industry. Inserted bit type and cemented carbide type broaches are also preferred to reduce the cost of broaches.

2.9 BROACHING MACHINES

Broaching machines act as facilitators between broach and workpiece. Broaching machines provide fixture to the broach, central (precise) to all motions of broach and

workpiece and required relative motions between broach and workpiece. These machines are very simple as they only have to move the broach tool in a linear motion at a predetermined speed and provide a means for handling the broach automatically. These machines can be categorized on the basis of different criterion as described below.

Working principle can be criteria of classification of broaching machine as described below :

- (a) Hydraulic broaching machine
- (b) Mechanical broaching machine
- (c) Electro-mechanical broaching machine
- (d) Computer controlled broaching machine

Construction of a broaching machine can also be another criteria of classification like :

- (a) Vertical broaching machine
- (b) Horizontal broaching machine
- (c) Rotary broaching machine

Application of a broaching machine can also be criteria of classification of a broaching machine :

- (a) internal broaching machine
- (b) external broaching machine

Hydraulic Broaching Machine

Hydraulic broaching works with the help of high pressure fluid called hydraulic fluid. The fluid pressure and its precise variation provides motive power to various components of the machine. This fluid pressure is distributed and controlled directly and automatically by control valves and hoses and tubes. Advantage of hydraulic system is its precise control and capability to transfer huge power through small tubes and flexible hoses.

Mechanical Broaching Machine

In mechanical machine power is generated electrically at its motor and then it is transferred to its various components like broach holder, worktable feed mechanism, etc. through belt, gears, etc.

Electromechanical Broaching Machine

Electromechanical broaching machine is a move towards automation. In this machine all the central of process parameters are controlled with the help of electronic control. However, generation of power and transmission of power from the place of generation to various components is like hydraulic machine or mechanical broaching machine. There are possibilities of development of computer controlled broaching machine. There are possibilities of entering program which can execute more than one operation in proper sequence without any time gap. Process capability and accuracy of electromechanical or computer controlled broaching machines are very good as compared to other machines.

On the other basis of construction different type of broaching machines are described below.

Vertical Broaching Machine

In case of vertical broaching machine movement of broach is in vertical direction. These machines may have the stroke length more than 1.5 meter. Vertical broaching machines can be designed for push broaching, pull down broaching, pull-up broaching or surface broaching. Normally surface broaching is done by vertical broaching machine.

Horizontal Broaching Machine

In case of horizontal broaching machine, movement of broach is in horizontal direction. These machines are normally designed for pull broaching, surface broaching, continuous broaching and rotary broaching. These machines are not so popular as the vertical broaching machines.

Rotary Broaching Machines

Generally a rotary broaching machine requires two important tooling components a tool holder and a broach. The broach is mounted in the tool holder that facilitates it to freely rotate. The tool holder is specially designed so that it can hold the tool keeping its axis of rotation slightly inclined (1 to 2°) to the axis of rotation of the workpiece. This small misalignment helps the broach in cutting. The cutting action is named as “wobbling” and the broach mounted in this way is called “wobbling broach”. It is not necessary to use broaching machine in case of rotary broaching. This can be done with the help of lathe machine. The required rotary motion to the broach can be given by the clutch of the lathe.

On the basis of application the broaching machines are classified as described below.

Internal Broaching Machine

Internal broaching refers to broaching of inner surface of a round hole, slot or groove. Internal broaching machines are not different but it can be carried out on any of the above type of machines. Internal broaching is also used for making internal gears. Smoothing of gun barrel bore is also done by internal broaching. In case of internal broaching the workpiece is clamped into a special holding fixture called work holder which is inbuilt in the broaching machine. Elevator is another part (component) of the broaching machine that moves the broach above the work holder, then lower the broach through the workpiece. Once through, the broaching machine’s puller essentially a hook, grabs the pilot of the broach. The elevator then releases the top of the pilot and the puller pulls the broach through the workpiece completely. The workpiece is then removed from the machine and broach through the workpiece completely. The workpiece is then removed from the machine and the broach is raised back up to re-engage with the elevator.

External Broaching Machine

These are also called surface broaching machines. These machines are used to process external surfaces of workpiece. External broaching machines are also used for contour broaching. Contour broaching involves preparation of concave or convex surfaces or any other shape with extremely close tolerances.

Continuous Broaching Machine

Continuous broaching machine is a different type of classification. These machines can be horizontal or vertical type. The concept of continuous broaching machine is concerned with continuity. This continuity of operation can be maintained by keeping the broach stationary and moving workpiece through the tool (broach) to perform cutting. In case of horizontal continuous broaching machines two sprockets, one on each side of the machine, are maintained. On the sprockets, there is continuous travel of an endless chain having a series of fixtures mounted on it. The broaches are rigidly hold on the machine in horizontal position over the chain. Workpieces are loaded on the fixtures on one side of the machine and unloaded on its over sides shown in Figure 1.4.

In case of vertical type continuous broaching a number of platens are mounted on a continuous chain. Broach holders are mounted on these platens to carry the broaches workpieces are clamped on the horizontal table of the machine which is are kept stationary. Broaches are moved across the workpieces by the chain.

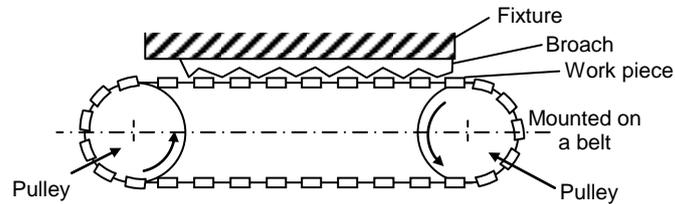


Figure 2.4 : Horizontal Continuous Broaching Machine

There is one more type of continuous broaching machine that is rotary table horizontal continuous broaching machines which is already described.

2.10 SUMMARY

Broaching is one of the machining operations which uses broach as tool. Broach is a multipoint cutting tool and works on the same principle as that of a single point cutting tool in lathe machine. It is a high productivity method as so many cutting edges work together to machine a workpiece. In broaching operation any one of two either broach or workpiece reciprocates and other remains stationary. Broaching can be done on internal surfaces as well as external surfaces of workpiece so accordingly the broaching operation is named as internal broaching and external broaching respectively. Generally three parameters are controlled in a broaching operation which are cutting speed, feed rate and depth of cut. Broach material can be any from low hardness material cast iron to very high hardness material cemented carbide depending upon what type of workpiece is to be processed by it. Nomenclature of a broach is explained in the unit. Depending upon the working broaches are classified as progressive cut, rotor cut, and burnishing broaches. Different type of broaching methods are described in the unit depending upon the type of work to be done on a workpiece. The broaching operations have their major advantages as longer tool life, faster machining work and limitation is special fixture and machine are required to carry out this operation. Depending upon the working principle, construction and applications, broaching machines are categorized into different categories. The detailed categorization of the broaching machines is described in the unit.

2.11 ANSWERS TO SAQs

Refer the preceding text for all the Answers to SAQs.