

Chemical machining

Chemical machining (CHM) process is a controlled chemical dissolution (CD) of a workpiece material by contact with strong reagent (etchant). Special coatings called maskants protect areas from which the metal is not to be machined. It is one of the non-conventional machining processes.

The advancement of technology causes to the development of many hard-to-machine materials: stainless steel, super alloys, ceramics, refractories and fiber-reinforced composites due to their high hardness, strength, brittleness, toughness and low machinability properties. Sometimes, the machined components require high surface finish and dimensional accuracy, complicated shape and special size, which cannot be achieved by the conventional machining processes. Moreover, the rise in temperature and the residual stresses generated in the workpiece due to traditional machining processes may not be acceptable. These requirements have led to the development of non-traditional machining (NTM) processes. In these processes, the conventional cutting tools which are not employed. Instead, energy in its direct form is utilized. Chemical energy is used in chemical machining. This process is the precision contouring of metal into any size, shape or form without the use of physical force, by a controlled chemical reaction. Material is removed by microscopic electrochemical cell action, as occurs in corrosion or chemical dissolution of a metal.

This controlled chemical dissolution will simultaneously etch all exposed surfaces even though the penetration rates of the etch may be only 0.0005–0.0030 in./min. The basic process takes many forms: chemical milling of pockets, contours, overall metal removal, chemical blanking for etching through thin sheets; photochemical machining (PCM) for etching

by using of photosensitive resists in microelectronics; chemical or electrochemical polishing where weak chemical reagents are used (sometimes with remote electric assist) for polishing or deburring and chemical jet machining where a single chemically active jet is used.

Chemical machining offers virtually unlimited scope for engineering and design ingenuity, to gain the most from its unique characteristics, chemical machining should be approached with the idea that this industrial tool can do jobs not practical or possible with any other metal working methods. Chemical machining will likely prove to be of considerable value in the solution of problems that are constantly arising as the result of the introduction of new materials.

In comparison with other machining processes, chemical machining has many advantages, but with some limitations. The most important advantages are: weight reduction is possible on complex contours that are difficult to machine using conventional methods; decorative finishes and extensive thin-web areas are possible to be machined; CHM does have low scrap rates (3 percent); no burrs are formed; no stress is introduced to the workpiece, which minimizes the part distortion and makes machining of delicate parts possible; a continuous taper on contoured sections is achievable; the capital cost of equipment, used for machining large components, is relatively low; small thickness of metal can be removed; the good surface quality in addition to the absence of burrs eliminate the need for finishing operations.

The limitations of CHM are: Handling and disposal of chemicals can be troublesome; hand masking, scribing, and stripping can be time-consuming, repetitive, and tedious and design changes can be implemented quickly; metallurgical homogeneous surfaces are required for best results; slower process, very low MRR so high cost of operation; deep narrow cuts are difficult to produce; difficult to get sharp corner; hydrogen pickup and

intergranular attack are a problem with some materials; complex designs become expensive; simultaneous material removal, from all surfaces, improves productivity and reduces wrinkling; the straightness of the walls is subjected to fillet and undercutting limitations; difficult to chemically machine thick material (limit is depended on workpiece material, but the thickness should be around maximum (10mm)); porous materials and part designs that have deep, narrow cavities or folded-metal seams should be avoided.

1.2 Applications of CHM

Nontraditional machining processes are widely used to manufacture geometrically complex and precision parts for aerospace, electronics and automotive and many other industries. There are different geometrically designed parts, such as deep internal cavities, miniaturized microelectronics and nontraditional machining processes may only produce fine quality components. All the common metals including aluminum, copper, zinc, steel, lead, and nickel can be chemically machined. Many exotic metals such as titanium, molybdenum, and zirconium, as well as nonmetallic materials including glass, ceramics, and some plastics, can also be used with the process. CHM applications range from large aluminum alloy airplane wing parts to minute integrated circuit chips. The practical depth of cut ranges between 2.54 to 12.27 mm. Shallow cuts in large thin sheets are of the most popular application especially for weight reduction of aerospace components. Multiple designs can be machined from the same sheet at the same time. CHM is used to thin out walls, webs, and ribs of parts that have been produced by forging, casting, or sheet metal forming.

Further process applications related to improving surface characteristics include the following:

1. Elimination of alpha case from titanium forgings and super plastic formed parts.
2. Exclusion of the decarburized layer from low alloy steel forgings.
3. Taking away of the recast layer from parts machined by EDM (Electro Discharge Machining).
4. Removal of sharp burrs from conventionally machined parts of complex shapes.
5. Removal of a thin surface from forgings and castings prior to penetration inspection below the surface (required for the detection of hidden defects).

Chemical machining is an effective method for the machining of shallow holes and depressions, for profiling of the edges of sheet-metal workpieces, and for machining of shallow cavities of large surface areas (particularly in light alloys).