Material Removal Processes

25.1 Introduction

The majority of the forming processes described in the three preceding chapters give products in their final, or near final shape. The aim, in many instances, is to produce a finished product with the elimination of machining operations. The term *machining* refers to the forming or generating of shapes by means of a material removal process. The range of machining processes includes both traditional cutting techniques such as drilling, milling, turning and grinding, in which chips are formed, and a large number of non-traditional chipless machining processes, including electro-chemical and electro-discharge machining. During a machining process, amounts of costly material are removed from the part, this often being converted into chips, a form of material scrap which is frequently difficult to handle and recycle. However, although much progress has been made in forming net or near net shapes by precision casting and plastic deformation and moulding techniques, there is still a major requirement for machining operations as it is possible, through their use, to create shapes, surface finishes and dimensional accuracies which may not be achievable by other means.

The majority of machining is carried out on metals and alloys but plastics materials and composites are machineable and some material removal processes are applicable to ceramics.

25.2 The cutting process

Metal cutting is a cold working process in which a cutting tool forms chips. The cutting tool presents a wedge-shaped point to the work. In ideal orthogonal cutting, the cutting edge of the tool is normal to the direction of motion. There is severe deformation by shear in a plane, the shear plane, resulting in the formation of a chip (Figure 25.1). Considerable compression occurs in the deformed material and the thickness of the deformed chip produced will be greater than the depth of cut. There are two aspects of the tool geometry which are of importance, these are the rake angle and the clearance angle. The rake angle of the cutting face, which is measured from the normal to the workpiece surface, influences the shear angle and the amount of chip compression. The clearance angle is necessary to reduce friction between the tool and the machined surface.

The geometry of a single point cutting tool has a major influence in determining the efficiency of a cutting operation. Increasing the rake angle has the effect of reducing both tool forces and friction and giving a less deformed and cooler chip. However, the provision of a large rake angle gives a smaller tool section, thus reducing the strength of the tool. The most effective rake angle for any cutting operation will be determined by the nature of both the workpiece and cutting tool material. The rake angles used in tools for cutting the softer materials, such as aluminium and its alloys, can be larger than those employed in the machining of steels. Carbide and ceramic cutting
tools, although extremely hard, are also brittle. Consequently, the rake angles used in connection with this type of tool are usually either zero or negative to provide added tool strength. The same principle of rake and clearance angles applies to all multipoint tools, such as broaches, milling cutters and saws, in fact, any tool in which the cutting action is one of presenting a wedge-shaped point to the work.

In many practical instances, oblique cutting, rather than orthogonal cutting, is adopted. In this, the cutting edge of the tool is inclined at some angle other than 90° to the cutting direction (Figure 25.2). This offers significant advantages. This chip leaves the workpiece at an angle, equal