CHAPTER

V

General Aspects of Tool Design

Tooling design is the key to electrochemical machining. Machining facilities, cost analysis and planning, good management, and a host of good intentions are worthless if a company does not possess the competence to design ECM tooling. This has been called an "art", since much information has evolved by empirical development of tooling; "tricks" of tool design do work but are not always supported by logical explanation. An "art" implies skills acquired by tedious trial and error, as such it is hardly compatible with the pace of modern industry. Fortunately, however, the various practices developed in tooling design do have logical explanations that relate well to theoretical analysis of the process. The main purpose of this book, by setting out the principles of electrochemical tool design, is to present a tangible technology rather than an elusive art.

There are many aspects of the process that should be understood and taken into account in the design of tooling. The corresponding design concepts, although simple in themselves, are numerous, and thus, at first, present a confusing picture. It is imperative that each of these concepts be considered carefully and included in tooling designs where applicable. Each concept must be considered and applied if there is to be no risk to the successful operation of the tools. In fact, guessing is never permissible, since because of the many factors involved, the chance of tool failure will otherwise be high.

There are two broad areas in which the concepts of tool design may be considered. First, there are basic ones that generally apply to all tooling. Second, there is a series of concepts that should be reviewed,

one by one, as a procedure in designing tooling for a particular component. The two areas are summarized in the next paragraphs and treated in detail in the following two chapters.

5.1 BASIC TOOLING CONCEPTS

Fixtures and tools must operate for long periods in a corrosive environment of electrolyte and stray electric currents. The choice of material for each part of the tooling is, therefore, most important, so that rapid corrosion is avoided. Generally, stainless steel, copper, bronze, brass, monel, and reinforced plastics are suitable materials. Parts having an anodic potential rapidly corrode so that it is wise to limit the number of parts in electrical contact with the workpiece. Nonmetallic materials are useful, since they are electrically nonconductive and chemically corrosion resistant, but are not suitable for highly stressed parts.

Since it is essential to the operation of the process that no particles of corrosion enter the electrolyte flow to the tool, all electrolyte ducts are of copper, stainless steel, monel, or plastic, which do not corrode. Copper is the usual choice of material for tools because of its resistance to corrosion, high electrical conductivity, ease of manufacture, and ease of repair by electroplating. Subjected to the corrosive conditions within the work enclosure, high current carrying joints require special design attention, and their number should be reduced to a minimum.

In order to prevent overheating, current carrying parts need a section of 1 $in.^2$/1000 A for copper, 4 $in.^2$ for bronze and brass, and 40 $in.^2$ for stainless steel. For metal surfaces cooled by rapidly flowing electrolyte, much smaller areas may be used. Alignment between tool and work holding fixture is best achieved with removable setting pieces. Other systems, for example, the use of the "die set" principle, are to be avoided; these give rise to rapid corrosion when metallic parts are used, or lack of accuracy when nonmetallic parts are used.

Fixtures and tools are substantially constructed to avoid deflection or vibration, under the high hydraulic forces to which they are subjected. A typical work enclosure with tool platen and work table is shown in Figure 5.1.

5.2 PROCEDURE FOR TOOL DESIGN

Following an initial appraisal of a component to be electrochemically machined, it is usually possible to arrange minor component design

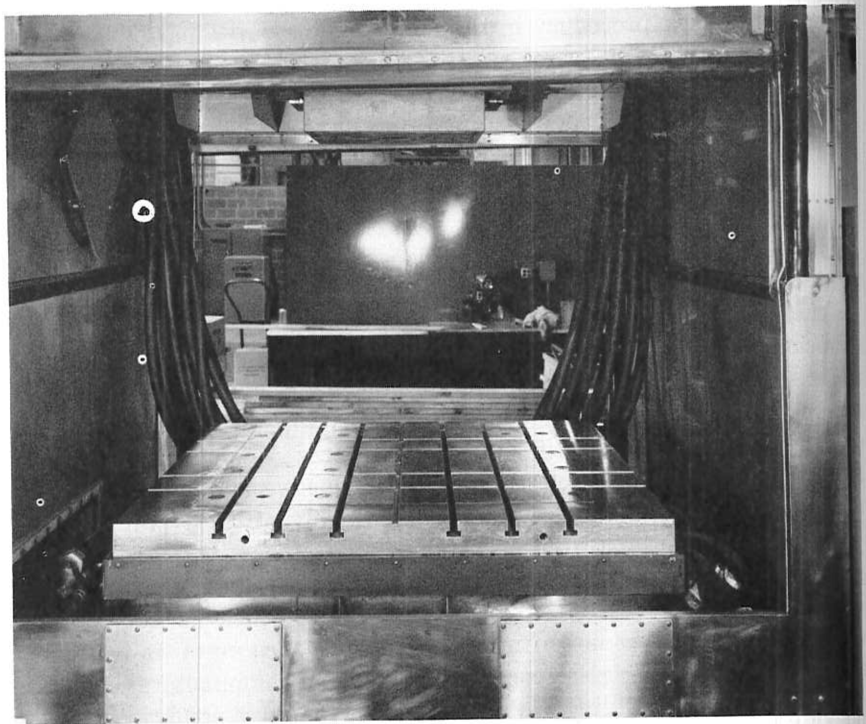

Figure 5.1 The work enclosure of a vertical electrochemical machine. (Courtesy of the Anocut Engineering Company.)

changes, and choose forging or casting shapes that simplify the ECM tooling. If a number of separate operations are to be performed on the component, the area to be machined by each tool is selected for the simplest electrolyte flow arrangement and current densities exceeding 100 A/in.^{2} on all surfaces. In designing each tool, the method of providing adequate electrolyte flow over its working surface is first decided. Where bosses or similar features are to be machined, electrolyte can be supplied through a port in the tool corresponding to the boss form. Narrow supply slots in the tool or dams that direct the flow across the operative areas of the tool are alternative methods.

Sometimes the initial shape of the work piece is incompatible with the tool shape. A good flow, at points where the tool first engages the work, is achieved using specially shaped inlet slots in the tool, or "flow restrictors," which regulate the flow from the periphery of the tool. If possible, the use of flow restrictors or dams should be avoided because of increased tooling costs and work corrosion problems. Work corrosion

occurs if electrolyte impinges on adjacent finished work surfaces; this can be avoided by ensuring that a thin "ridge" of material is left between adjacent operations, which deflects the stream of electrolyte away from the work.

If a tool is required to machine features of the work that are parallel to its direction of feed, corresponding tool surfaces are insulated. There are insulations that can be applied in a liquid form, but solid pieces of insulating material secured to the surface are preferred, because of the proved reliability of this method on production work.

Finally, corrections to the tool shape are made so that the work will be produced within drawing tolerance.