Introduction

The selection and application of cutting fluids in industry have not always been accomplished in an optimal manner. This chapter will strive to present, on a brief overview basis, useful background information regarding the evolution of modern fluids, their compositions, and simple methodologies to match products to applications. These discussions will be presented from the perspective of the user with the intent to provide a matrix of information to aid potential users in the formulation of effective in-house fluid programs.

Background

In this section, the evolution of cutting fluid technology will be highlighted from early uses of plain water through complex modern formulations available to the manufacturing industry. This development closely followed advances in the metal-removal industry. Early machining operations were conducted at relatively low speeds with carbon steel tools. Improvements in technology, such as tools of high-speed steel or more powerful and faster machines, tended to stimulate developments in other elements of the machining process. Hence, a synergism evolved in which overall progress was made by a series of incremental developments in each of the necessary technological elements. This
discussion will focus on the evolution of cutting fluid technology and the characteristics of the resulting cutting fluid industry.

Cutting fluid formulation technology for the manufacturing industry had its more serious beginnings soon after Fredrick Taylor reported improvements in tool life when water was applied to the cut. Early experimenters surmised that water reduced thermal damage to carbon tool steels in use at the time. As a result, the term coolant has since become firmly entrenched as the descriptor of all fluids applied to the tool–chip interface. This term has largely persisted to this day regardless of the functions provided by contemporary cutting fluid formulations.

It was quickly recognized by the manufacturing community that plain water was not a completely satisfactory solution to the question of tool life improvement. The rapid rusting of both ferrous workpieces and machine tool components was of major concern. In addition, observations of used cutters indicated that water had been effective in reducing tool damage through thermal effects but had little effect on reducing mechanical wear. Attempts to use oils instead of water to provide the perceived need for lubricity resolved the rust problem but resulted in smoke, messy shops, rancidity, and inadequate heat abstraction at all but the slowest machining speeds of the day.

The above findings suggested to many experimenters of the time that perhaps combinations of water and oils would be effective by simultaneously providing cooling and lubrication. Since oil and water do not mix, efforts to produce emulsions stable in the shop environment spawned the cutting fluid industry. A fiercely competitive industry emerged following discoveries that additives to an oil–water emulsion provided further performance improvements. In addition to better emulsifiers, the more notable additives were those containing sulfur, chlorine, phosphorus, and fatty acids. The variety of such compounds available to fluid chemists permitted formulation of an essentially infinite series of product compositions, each claimed by its manufacturer to offer advantages over another product for general and specific applications. More recently, synthetic (oil-free solutions) and semisynthetic products have appeared on the market to compete with the older oil–water emulsions and straight oil-base products.

This diversity of products and manufacturers has created a difficult situation for those charged with fluid selection within a production facility. Aggressive marketing practices reminiscent of the old “snake oil” pitchmen did little to aid the selection process. Production engineers became exceedingly skeptical of sales claims for products. Logically, a “prove it to me” attitude developed which resulted in a new set of problems. It soon became an impossible proposition to conduct in-shop tests for products suggested by every salesman without disruption of production or to obtain meaningful data at acceptable costs. Similarly, fluid manufacturers also could not afford the costs associated with laboratory testing of their products under every conceivable combination