ABSTRACT

This paper describes a modification of the pure hydrostatic extrusion method which offers the potential of extending the process capabilities even further for selected applications. This new approach of "thick-film" hydrostatic extrusion offers the possibility of achieving production rates comparable to those obtained by conventional extrusion while still retaining many of the benefits of pure hydrostatic extrusion. In addition, both mechanical and hydraulic presses may be used with a minimum of design modification. Moreover, this technique, called the "Hydrafilm Extrusion Process", renders the hydrostatic process about as operationally routine as conventional cold and hot extrusion.

INTRODUCTION

The numerous advantages of the hydrostatic extrusion process over conventional extrusion as well as other competitive techniques have been amply demonstrated in many laboratories throughout the world. Extensive work has been published in England, Sweden, Russia, Czechoslovakia, Japan, France, and the United States. The process has advanced to the point where several companies are now offering production presses to industry for commercial application.

The purpose of this paper is to describe a modification of the hydrostatic extrusion process which extends its potential capabilities even further for selected applications. This new approach of "thick-film" hydrostatic extrusion* will allow, for example, a considerable improvement in production rate capabilities in hydraulic presses. It will also permit one to obtain the benefits of hydrostatic extrusion in mechanical presses at potentially the same cycle rates of 40 to 60 billets/minute now achieved in conventional cold extrusion. This improved concept, which we have termed the "Hydrafilm Extrusion Process", is based on limiting the effect of the hydrostatic fluid only to those aspects that are actually functional for a given application.

Before describing the Hydrafilm extrusion process, it is important to reexamine the pure hydrostatic extrusion process, how it compares to conventional extrusion, and what are its relative advantages over conventional techniques. Subsequently, the details of the Hydrafilm process will be discussed along with how it extends the capabilities of pure hydrostatic extrusion.

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* A patent application has been filed.

PURE HYDROSTATIC EXTRUSION PROCESS

Figure 1 shows a schematic comparison of the conventional and pure hydrostatic extrusion processes. In pure hydrostatic extrusion, a fluid completely surrounds the billet. A quantity of fluid is always maintained between the stem and the billet, even under pressure. When the fluid reaches the extrusion pressure, the billet extrudes through the die. The billet does not contact the container bore. Thus, container friction is virtually eliminated because of the low shear strength of the fluid layer between the container and billet. Also, the hydrostatic fluid appreciably reduces die friction.

Separate billet lubricants can be used, in addition to fluid, depending on the billet material and extrusion conditions. For relatively low-strength billet materials which do not tend to gall, the hydrostatic fluid generally is sufficient. However, for certain materials which tend to seize or which are extruded under severe conditions (high speed, temperature, ratio, or a complex shape), then a separate billet lubricant may be used.

In conventional extrusion, the billet upsets tightly against the container and very substantial container friction can exist even when the billet is lubricated. This is shown rather dramatically in Figure 2. The plot shows the effect of billet length-to-diameter (l/d) ratio on pressures required for conventional and hydrostatic extrusion of mild steel bar. For conventional cold extrusion(1), the steel billets were coated with zinc phosphate + sodium stearate soap (Bonderlube 235), a commonly used lubrication system for cold extrusion of steel. It is well known also that this lubrication system is extremely effective in that bare metal-to-metal contact is generally prevented and excellent surface finishes are obtained on the extruded product. Yet, by comparison to what would be expected by hydrostatic extrusion, the energy lost to container friction is indeed excessive.

Even for billets in the l/d range of 1 to 3, the common range used in conventional extrusion, the pressures are about 23 to 95 percent greater, respectively, than that expected in hydrostatic extrusion. It is no wonder that billets with l/d ratios much greater than 3 are seldom used. Moreover, just moderate increases in billet l/d ratios to the range of 4 to 6 would result in corresponding pressure increases of about 134 to 203 percent above that for hydrostatic extrusion. These ridiculously high pressure levels are totally unnecessary. By hydrostatic extrusion, commercial extruders can immediately go to billets with l/d ratios of 4 to 6, and without a concern for stem buckling since stems of this slenderness ratio can easily withstand pressures up to 250,000 psi and beyond.

One might ask what are the advantages of going to longer billets? One big advantage is the potential of greater throughputs per unit time and, consequently, a reduction of extrusion conversion cost/lb by very substantial margins. Assuming for the moment the same number of billet pushes/hour at given set of extrusion conditions, the extrusion conversion cost/lb for a billet with an l/d = 2 could be cut roughly to one-half for a billet twice as long (l/d = 4) and to about one-third for a billet three times as long (l/d = 6). This is, of course, a very rough estimate but it does indicate