Production Rate Capabilities

One of the most important advantages of the Hydrafilm extrusion process is the potential ability to achieve production rates comparable to those obtained in conventional extrusion in either hydraulic or mechanical presses.

Production hydraulic presses currently offered to industry for hydrostatic extrusion are designed for production rates ranging from about 20-35 billets/hour, depending on press and billet size. This is appreciably below the usual production rate of 60 billets/hour and more achieved in conventional hot extrusion. The difference in rate is due mainly to "dead" cycle time lost to hydrostatic-fluid handling which is presently a sequential, "on-stream" part of the total billet extrusion cycle. The Hydrafilm process eliminates this problem by allowing the billet to be precoated with the hydrostatic medium, independent of the sequential steps of the extrusion cycle. Thus, it is quite reasonable to expect that precoated billets can be loaded and extruded at about the same rate now achieved in conventional extrusion. This capability will undoubtedly have considerable impact on the potential economic savings that will be possible by hydrostatic extrusion.

Conventional extrusion presses currently in existence should require minimal modification to gain the advantages of the Hydrafilm process. For example, existing presses could be modified to improve considerably the efficiency of present operations for the billet sizes currently used. It may also be economically advantageous to increase billet length-to-diameter ratios to the maximum possible within the existing "daylight" (distance between the die-support and ram crossheads). This could be done by "muzzle-loading" the billet at the die-end of the container rather than "breech-loading" at the ram-end. This approach alone could result in approximately a 50 percent increase in the billet weight/push. As mentioned earlier, the conversion cost/lb of extrusion potentially can be reduced roughly by a factor proportional to the increase in billet length.

Of course, should a company be in need of a new hydraulic extrusion press, it could be designed to utilize the Hydrafilm and/or the pure hydrostatic process at maximum efficiency, i.e., allowing for billets of maximum length-to-diameter ratio as well as including other special features.

Another very significant fall-out of the Hydrafilm process is that it now becomes possible to achieve the benefits of hydrostatic extrusion in a mechanical press and potentially at the same production rates currently being achieved in conventional cold extrusion, i.e., 40 to 60 billets per minute or more for relatively short billets. Billet length is somewhat limited in mechanical presses, of course, because of the relatively short ram stroke compared to that of a hydraulic press. However, it is well to keep in mind that, even for a billet with an l/d of 2 or 3:1, the pressure required can be roughly 50 to 100 percent greater, respectively, than that needed by hydrostatic extrusion. Thus, the potential gains are indeed appreciable.

Prior to the Hydrafilm concept, there was never any hope of using hydrostatic extrusion techniques in a mechanical press economically because the competitive production rates were simply too fast. Precoating the billets with the hydrostatic medium, however, should allow one to obtain comparable production rates and yet enjoy the advantages of hydrostatic extrusion.

Conventional vertical hydraulic presses are occasionally used for conventional cold extrusion operations when the billet length required to make a given part exceeds the typical ram stroke for a mechanical press. In such instances, the Hydrafilm process could be used quite effectively, yet with little or no sacrifice in production rate. This would be in the order of 10 to 20 billets/minute, depending on the hydraulic press characteristics and product to be extruded.

Additional Advantages

In addition to improved production capabilities, the Hydrafilm process extends the capabilities of hydrostatic extrusion in several other areas. Already mentioned is the minimization of the occasional problem with stick-slip, billet motion control, and sudden energy release. Also, less fluid-handling problems can lead to lower-cost equipment and less maintenance problems. In addition, for a container of given fluid-pressure capability, somewhat higher extrusion ratios are possible. This is because the billet-end pressure developed by the stem can be higher than the fluid pressure by an amount approximately equal to the compressive yield stress of the billet. The amount of billet-pressure augmentation can be quite significant for high-strength materials. For example, many materials have yield strengths greater than 50,000 psi at room temperature. In these cases, with a 250,000 psi container, the billet-end pressure could go to 300,000 psi or somewhat above. Stem pressures of this range are readily withstood by many tool steels currently available. Thus, the extrusion ratio capability can potentially be increased by the Hydrafilm process. Alternatively, a given extrusion ratio could be achieved at a lower fluid-pressure level, thus offering the prospects of better fatigue life in containers.

Another important factor that should not be overlooked is the problem of billet bulging. If there is too much radial clearance between the billet and container in billet-augmented hydrostatic extrusion, the billet tends to bulge just ahead of the die entry point. This was found to be a serious problem by Alexander and Thiruvarudchelvan(3). Higher extrusion pressures were obtained by billet-augmented extrusion and this was associated, in part, with higher die friction. Bulging was suspected of contributing to the higher die friction. In addition, of course, bulging increases the extrusion ratio as well as the amount of redundant deformation which, in turn, would contribute to the higher extrusion pressure. In the Hydrafilm process, however, bulging can be minimized or avoided by keeping the radial clearance to the absolute minimum. In fact, in Hydrafilm extrusion of 7075 aluminum billets, we actually obtained the typical "sinking in" profile on the billets.