SECTION 2

PRODUCTION ASPECTS OF HYDROSTATIC EXTRUSION

XIV

SUMMARY OF SECTION 2

The aim of this portion of the program was to apply the technology of hydrostatic extrusion to products other than round bars and to consider some of the problems involved in high rates of production using the hydrostatic extrusion process. Products selected for study were tubing, T-sections, and round wire.

High-quality thin-walled tubing was produced from 7075-O Al, AISI 4340, and Ti-6Al-4V alloy. In the case of the 7075-O Al and steel, two sequential reductions with in-process anneals were required to achieve 98 and 91 percent reductions, respectively. A single pass reduction of 60 percent was achieved with the Ti-6Al-4V alloy tubing. It reduced the wall thickness of the tubing from 0.069 to 0.030 inch.

T-sections were produced from round billets of 7075-O Al and AISI 4340 and from previously extruded T-sections of 7075-O Al, Ti-6Al-4V, and Cb 752 alloy. The die designs used for those operations are considered significant developments.

The HYDRAW operation, which is described in detail, was used for extruding T-shaped billets of the 7075-O aluminum alloy.

The HYDRAW process was applied to the reduction of wire from beryllium, Ti-6Al-4V, and TZM alloy with which single-pass area reductions of up to 60 percent were achieved.

Consideration was given to tandem hydrostatic extrusion (extrusion of two billets in sequence). A successful joint design for use with this technique is described.

The economics of hydrostatic extrusion were analyzed on the basis of producing rounds from or variety of materials and tubing from Ti-6Al-4V alloy. The results of the analysis show that the hydrostatic extrustion process can be very competitive with conventional techniques.

XV

HYDROSTATIC EXTRUSION OF TUBING

Tooling

The arrangement of the mandrel tooling used for extruding tubular billets to reduce their wall thickness is shown in Figure 27. A floating rather than fixed-type mandrel was used. It was anchored at the top end by a guide which rested on the top of the billet and had a sliding fit in the container bore. The fluid was free to flow past the mandrel guide to surround the billet but the flat interface between the billet and the mandrel guide acted as a seal to prevent fluid leaking past the mandrel. As the billet extruded, the mandrel and guide moved with it. The mandrel was slightly tapered to reduce frictional drag on the tubing as it was extruded over the mandrel.

Effect of Floating-Mandrel Arrangement

It can be seen in Figure 27 that in addition to the effect of fluid pressure, the billet also supports the fluid pressure acting on the mandrel so that the pressure on the billet-end exceeds the fluid pressure, P, by

$$\frac{PA_m}{A} ,$$

where

A_m = mandrel cross-sectional area

A = billet cross-sectional area.

It is the magnitude of the billet-end pressure, $P + \frac{PA_m}{A}$, that effects extrusion and consequently, this value is presented with the experimental data for evaluation purposes. Table XXIX gives the data obtained in the extrusion of tubes of 7075-O aluminum, AISI 4340 steel, and Ti-6Al-4V alloy. With each of these alloys, good quality thin-walled tubing was obtained at ratios close to the maximum ratios reported in Section 1 for solid rounds of the same materials. If the mandrel friction coefficient is high, then the billet end pressure may be further increased. The frictional drag of the extruded tube over the mandrel will exert an axial force on the mandrel which is borne by the tube billet.

It is difficult to predict the maximum extrusion ratios achievable in the hydrostatic extrusion of tubing using the floating-mandrel arrangement because of the possibility of billet upsetting due to the effect of the additional or "unbalanced" billet-end-pressure. The magnitude of this pressure, $\frac{PA_m}{A}$, is clearly dependent on the dimensions of the tube blank to be extruded. However, the extra billet-end-pressure produced by the mandrel enables extrusion to take place at a lower fluid pressure level than would be required for a solid billet at a given ratio. This is particularly significant for thin-walled tubing where the end pressure might be several times higher than the fluid