Other Trials

T-Sections

An attempt was made to extrude a 7075 aluminum T-section from a solid round billet at a ratio of 14.5:1 but the pressures required apparently were beyond the capacity of the tooling. The T-section die had the same configuration and overall dimensions as that used in previous trials except that the width of the arms and web of the T were reduced from 1/4 inch to 1/8 inch. This die was also used in an attempt to re-extrude T-sections obtained previously with the 1/4-inch-thick T-die but a seal was not achieved. The extrusion conditions used for the above (Trials 445 and 459) are given below:

Billet lubricant	L53
Fluid	Castor oil
Stem speed	6 ipm
Die angle	45 degrees (included)

A die specially designed for the re-extrusion of the 1/4-inch T-sections is being machined. Here, sealing of the billet is not expected to be a problem.

Low Extrusion Ratios

All previous work to date with 7075-0 aluminum solid rounds has been at ratios of 20, 40, and 60:1. The ratios at which tubing were extruded were much lower, ranging from about 4 to 12:1. Therefore, extrusions of solid rounds were made at ratios of 2.5 and 7:1 (Trials 456 and 457, Table 2) to provide data for comparison at the lower ratios. The results will be presented graphically in a later report.

Flame-Plated Dies

A die to be used at extrusion ratios of 20:1 with 7075 aluminum was "Flame-Plated"* on the billet contact surfaces with a 0.005-inch-thick coat of tungsten carbide containing 15-17 percent cobalt. The base material of the die was AISI M50 with a hardness of $55R_C$. The purpose of Flame-Plating was to provide a hard ($72R_C$), wear-resistant surface which reportedly reduces friction in some applications.

Table 2 provides the data for comparison with unplated dies for two lubricants. With Lubricant 53, Trials 453 and 454 indicate that the Flame-Plated die only marginally reduced the fluid breakthrough pressure (by 3 percent) and runout pressure was unaffected. However with L31, a relatively poorer lubricant than L53, the pressures with the Flame-Plated die (Trial 449) were marginally higher (compare with Trial 447). Thus, the Flame-Plated die does not appear to reduce friction, but may be useful for minimizing die wear in a commercial extrusion operation.

*Flame-Plate is a proprietary process of the Union Carbide Corporation.

COLD HYDROSTATIC EXTRUSION OF AISI 4340 STEEL ROUNDS

Additional lubrication systems were evaluated for hydrostatic extrusion of AISI 4340 at a ratio of 5:1. Table 3 gives the extrusion data obtained with these systems along with that obtained with the previous "best" system to date, L17 (20 wt % MoS_2 in castor wax) and castor oil.

The three lubricants evaluated (L31, L38, and L53), gave low P_b peaks, and runout pressures were uniform at about 220,000 psi. These pressures are of the same order as those obtained with L17. Using L17 again but with silicate ester in place of castor oil, the P_b peak was eliminated completely.

A number of good lubrication systems are now available for AISI 4340. The choice of lubricant and fluid is clearly dependent upon their cost and availability.

In a single trial at an extrusion ratio of 6:1 with L17 as the billet lubricant, breakthrough was not achieved at a pressure of 246,000 psi. The purpose of this trial was to determine the feasibility of extruding at this ratio without a zinc phosphate coating (C1) which had been used previously[1]. With this coating, extrusion at a ratio of 6:1 was achieved at about 245,000 psi. However, more trials would be necessary to substantiate the necessity of the C1 coating at 6:1.

COLD HYDROSTATIC EXTRUSION OF Ti-6Al-4V TITANIUM ALLOY ROUNDS AND TUBING

The experimental data given in Table 4 describe the evaluation of several billet lubricants on both solid rounds and thin-walled tubing of Ti-6Al-4V titanium alloy.

The most notable result obtained was the production of a 4-1/2 inch length of high-quality tubing 0.663-inch OD x 0.030-inch wall (Trial 437). The tubing "billet", initially 0.069-inch wall, was extruded at a ratio of 2.4:1. The initial tube stock was produced by Wolverine Tube Company under Air Force Contract No. AF 33(615)-3089.

The lubrication used in the extrusion of the tube in this case was L17 (20 wt % MoS_2 in castor wax) on an anodized coating C3, a combination which was found to be the most successful with solid rounds[5].

During runout, increasing friction between the mandrel and the extruding tube prevented further extrusion and a continued increase in fluid pressure caused the billet to upset. It was shown in Interim Report VI[5] that the floating mandrel arrangement used here could cause billet upsetting when the billet end pressure exceeded the fluid pressure by roughly the billet's yield strength. In Trial 437, the fluid runout pressure was 77,000 psi which gave a billet end pressure of 234,000 psi. Thus, the unbalanced axial pressure on the billet end was 157,000 psi, 25,000 psi in excess of the compressive yield strength of the billet material.

With another billet Lubricant 33 (55 wt % MoS_2 and 6 wt % graphite in sodium silicate), tubing was not extruded at the same ratio and billet upsetting occurred.