51,200 psi ultimate strength
36,900 psi yield strength (0.2 percent offset)
2.5 percent elongation

Lubricants and Coatings

Billet lubricants and coatings used during this report period are listed in Table 1. In addition to lubricants applied directly to the billet surface, some billets were first pretreated with special coatings before the lubricants were applied. One coating, C2, is a fluoride-phosphate chemical-conversion coating and was previously described(1). Coating C3 is a special anodized coating developed at the Watervliet Arsenal(5). Coating C4 is a diffused nickel plating produced at Battelle by using conventional plating procedures followed by vacuum annealing to diffuse the nickel into the billet material.

Fluids

Most of the trials were made with castor oil as the fluid media. However, water, polyethylene glycol, and a polyphenyl ether were used in a few trials. Both castor oil and polyethylene glycol were previously used(3). The polyphenyl ether (a mixed, isomeric, five-ring type) is a commercial product developed for use in high-temperature hydraulic, heat-transfer, and lubricant applications, and is one of the fluids which will be evaluated for use at elevated temperatures. However, the fluid was used at room temperature for extrusion of Ti-6Al-4V for reasons discussed later. The kinematic viscosity of the fluid is 363 cs at 100 F.

COLD HYDROSTATIC EXTRUSION OF 7075.0 ALUMINUM ROUNDS

7075-0 aluminum alloy is known for its tendency to crack during conventional hot extrusion when excessive extruded surface temperatures are encountered. To prevent cracking, the exit extrusion speeds are kept as low as one or several feet per minute. However, as mentioned in the fifth interim report(4), sound extrusions can be produced at exit speeds of about 3000 ipm by hydrostatic extrusion.

An area which requires additional improvement in hydrostatic extrusion, however, is billet lubrication. Stick-slip occurs during momentary lubrication breakdown. This causes high breakthrough pressure peaks and sometimes causes surface cracking of the extrusion during the "slip" portion of stick-slip.

Lubrication Systems

The experimental data developed in the evaluation of several new lubrication systems (hydrostatic fluid + billet lubricant) are given in Table 2. Since castor oil and L17 billet lubricant was the most effective system found in the previous studies, Trial 347

TABLE 1. BILLET LUBRICANTS AND COATINGS EVALUATED IN CURRENT HYDROSTATIC EXTRUSION PROGRAM

Lubricant	Coating	Source	Description	Billet Material Treated
L8	--	Battelle	10 w/o graphite in commercial self-drying, semihydrogenated gum resin	7075Al and Ti-6Al-4V
L17	--	Battelle	20 w/o MoS_2 in castor wax	7075Al, AISI 4340, Ti-6Al-4V, Be
L22	--	Battelle	20 w/o MoS_2 in polyethylene glycol, m w 1000	7075Al
L26	--	Battelle	20 w/o I_2 in a chlorinated terphenyl (42% chlorine)	Ti-6Al-4V
L31	--	Commercial	Fluorocarbon telomer	Ti-6Al-4V
L34	--	Battelle	50 w/o MoS_2 in castor wax	Ti-6Al-4V
L35	--	Battelle	20 w/o graphite in castor wax	Ti-6Al-4V
L39	--	Battelle	20 w/o I_2 and 20 w/o MoS_2 in chlorinated terphenyl (42% chlorine)	Ti-6Al-4V
L45	--	Commercial	Microfine low-density polyethylene resin	Ti-6Al-4V
L46	--	Battelle	50 w/o MoS_2 in low melting castor wax	7075Al
L47	--	Battelle	50 w/o MoS_2 in carbowax	
L48	--	Battelle	20 w/o MoS_2 in castor wax plus metallic lead, copper flake, and graphite	AISI 4340
L49	--	Battelle	20 w/o graphite in fluorocarbon telomer	Ti-6Al-4V
L50	--	Battelle	20 w/o graphite in microfined low-density polyethylene resin	Ti-6Al-4V
L51	--	Commercial	Metallic lead, copper flake, and graphite	7075Al
--	C2	Battelle	Fluoride-phosphate coating	Ti-6Al-4V
--	C3	Watervliet Arsenal	Anodized coating	Ti-6Al-4V
--	C4	Battelle	Diffused nickel-plating	Ti-6Al-4V