

Effect of Lubricants

A good measure of the effectiveness of the lubricants is given by:

- (1) The difference between fluid breakthrough pressure and the corresponding runout pressure for individual trials
- (2) The occurrence of stick-slip evident from the pressure curve
- (3) Surface finish of the extruded product.

An evaluation of several lubricants on this basis is contained in Table 8.

With the exception of L33, all of the lubricants used at 500 F with AISI 4340 and PPE as the fluid can be rated as good to excellent. Three of the lubricants, L31, L34, and L38, gave outstanding results. For these lubricants, low breakthrough-pressure peaks and uniform or decreasing runout pressures were achieved. In addition, the extruded surface finish was exceptionally good in all three cases. However, the other lubricants are considered satisfactory except where criteria such as surface finish are unusually demanding.

Apparently good lubrication of AISI 4340 for hydrostatic extrusion at 500 F is readily accomplished. Choice of the lubrication system for a production operation appears to be dependent on economic factors or availability.

Effect of Temperature

The effect of temperature on the stem breakthrough pressures required to extrude AISI 4340 is shown in Figure 5. Of necessity, the fluids, lubricants, and stem seals used at room temperature are different from those at 400 F. While these differences in conditions may obscure the precise effect of temperature, it is believed that temperature is mainly responsible for the pressure reductions obtained.

Figure 5 shows that the stem breakthrough pressure at room temperature is reduced by 8 to 10 percent at 400 F. The same reduction is achieved in fluid pressure at a ratio of 5:1, but at 4:1 the reduction was only marginal. This is inexplicable, and further trials will be necessary to clarify this finding.

WARM HYDROSTATIC EXTRUSION OF Ti-6Al-4V TITANITUM-ALLOY ROUNDS

Experimental data for warm hydrostatic extrusion of Ti-6Al-4V alloy rounds are given in Table 9. Variables investigated included fluids, lubricants, stem speed, and extrusion ratio.

TABLE 8. EVALUATION OF LUBRICANTS USED IN EXTRUDING AISI 4340 STEEL AT 500 F

Extrusion ratio = 4:1 Fluid: Polyphenyl ether

Trial	Lubricant	Difference Between Breakthrough and Runout Pressures ^(a) , 1000 psi		Extruded Surface Finish Rating	Type of Extrusion Curve
		Stem	Fluid		
394	L31	1.0	2.5	Excellent	P_f decreasing and then becoming uniform
393	L33	--	--	--	Breakthrough not reached
397	L34	2.0	1.5	Very good	P_f decreasing slightly
409	L35	4.0	4.0	Good; some lubrication breakdown	Uniform P_f
399	L38	2.0	1.5	Excellent	Uniform P_f
401	L38	3.5	3.0	Excellent	Slightly decreasing P_f
407	L40	9.0	5.5	Good; some lubrication breakdown	Slight stick-slip followed by uniform P_f
406	L43	3.0	4.0	Good; some lubrication breakdown	Mostly uniform P_f
408	L44	1.0	1.5	Good; small amount of lubrication breakdown	Very slight stick-slip

(a) The runout pressure level for the above trials was on the order of 180,000 to 200,000 psi.