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

Billet Surface Finish: 60-100 μin. rms

Extrusion Pressure C, 1000 psi				Length of Extrusion, in.	Comments
Breakthrough		Runout			
Stem	Fluid	Stem	Fluid		
205	210	--	--	2-1/8	P_b not reached; stopped at indicated pressure
201	199	189	184	2-3/4	High P_b peak followed by severe stick-slip
190	196	185	188	10-1/2	Slight P_b peak; uniform P_r with decreasing pressure toward end
181	192	177	187	11-1/8	Slight P_b peak; uniform P_r with decreasing pressure toward end
225	195	206	180		Moderate P_b peak followed by moderate stick-slip
210	184	201	181		Slight P_b followed by slight stick-slip
175	185	170	182	8-1/2	Slight P_b peak; uniform P_r increasing toward end
211	213	--	--	2-7/16	P_b not reached; stopped at indicated pressure
191	182	188	181	2	Slight P_b peak followed by severe stick-slip
226	216	--	--	2-1/4	P_b not reached; stopped at indicated pressure
178	170	177	168	8	P_b peak; uniform P_r decreasing toward end
212	198	206	194	8-1/4	Slight P_b peak; uniform P_r decreasing toward end

Effect of Fluid

PPE and SE fluids were evaluated in the warm extrusion of Ti-6Al-4V titanium rounds at ratios of 3.3:1 and 4:1 with Lubricant L33. Comparison of the pressure data in Table 9 indicates that at 3.3:1 the SE fluid reduces stem pressures on the order of 5 percent. However, at 4:1 there is no appreciable difference in pressure requirements between the fluids. These are similar to the results obtained with AISI 4340 at ratios of 4:1 and 5:1, respectively. It appears that the SE fluid is more effective than PPE in reducing pressure at the lower pressure levels (about 170,000 psi for the lower ratios) than at the higher levels (about 195,000 psi for the higher ratios). This may be due to some appreciable loss in lubricity resulting from the higher pressures and temperature developed at the billet-die interface during extrusion at the higher ratios.

Effect of Lubricant

The results obtained in studies with several lubricants, which are described in detail in Table 1, are given in Table 9. No special billet coatings were applied before lubrication.

One of the most significant findings is that Lubricant L33 (55 w/o MoS_2 and 6 w/o graphite in sodium silicate) was effective in completely eliminating stick-slip dur-during both breakthrough and runout at extrusion ratios of 3.3:1 and 4:1. Of particular importance is the fact that this was possible without any of the special coatings found essential for hydrostatic extrusion of this alloy at room temperature. In fact, even the most satisfactory coating (anodized coating C3), gave rise to high breakthrough peaks, although it did eliminate stick-slip during runout. The elimination of such billet coatings simplifies the lubrication process, and thus would effect appreciable cost savings in a production operation. Furthermore, the surface finish of all extrusions made with L33 could be rated as "very good" to "excellent". Machining marks carried through from billet to extrusion give additional evidence of the effectiveness of L33 lubricant.

PTFE lacquer (L38) also yielded a good extruded surface finish and a low breakthrough-pressure peak. However, continuous increase in the runout pressure after breakthrough indicated some lubrication breakdown.

Other lubricants investigated (L30, L40, L43, and L44) either did not permit breakthrough at relatively high pressures or, if breakthrough was achieved, broke down to the extent that severe stick-slip occurred during runout.

Effect of Temperature

Pressures for hydrostatic extrusion of Ti-6Al-4V at two temperatures are plotted against extrusion ratio in Figure 6. Curves A and B represent the pressure-extrusion ratio relationships at room temperature for two lubrication systems. (The lower pressures shown in Curve B are a result of improved lubrication developed recently.) From Curve C, it is seen that the pressures were reduced by 12 to 15 percent when extruding at 400 F. It is recognized, however, that a portion of this reduction may be attributable to other process conditions, including lubricants and fluids.