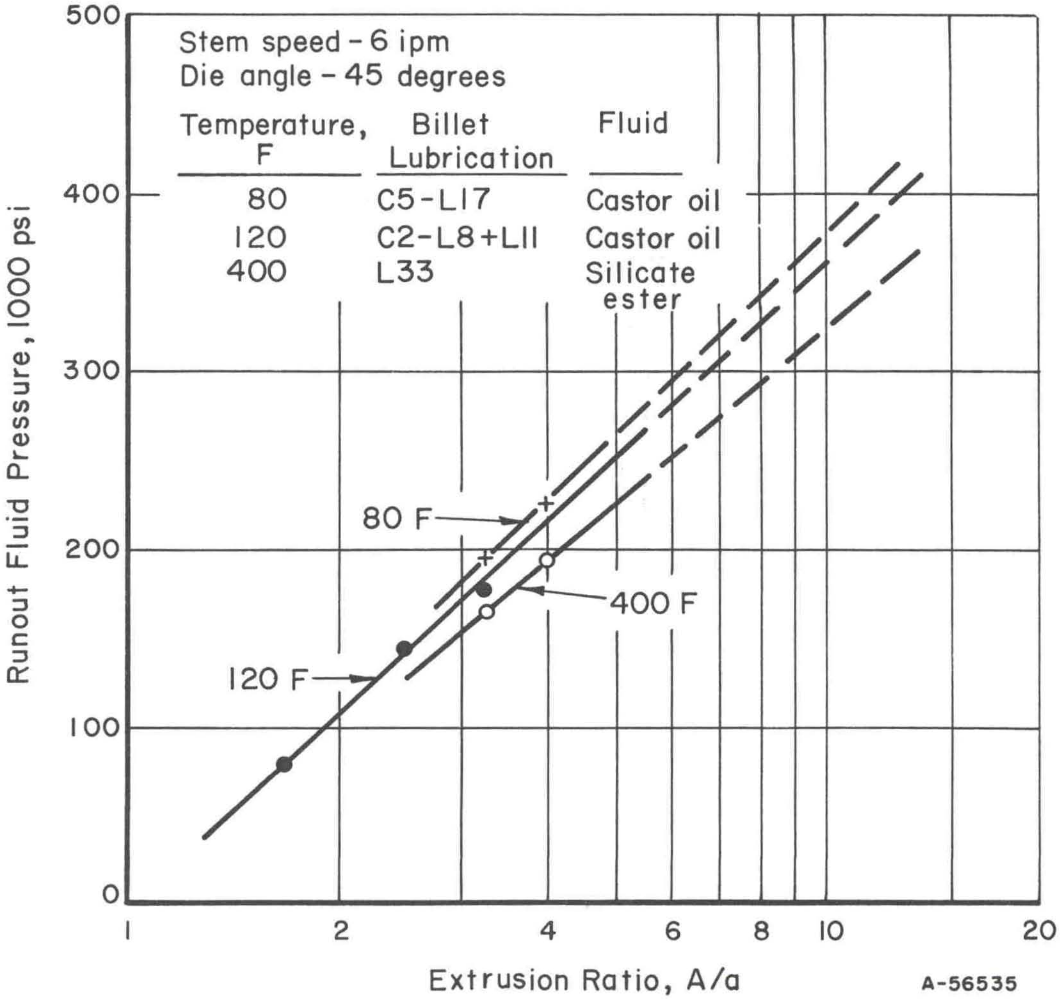

FIGURE 19. EFFECT OF EXTRUSION RATIO ON RUNOUT-FLUID PRESSURES FOR Ti-6Al-4V ROUNDS

20 wt percent MoS_2 in addition to the iodine, breakthrough did not occur despite the high pressure reached.

A single trial (Trial 375) was conducted to evaluate a grit-blast billet finish. Although this technique did not assist in eliminating stick-slip, breakthrough pressures were marginally reduced as compared with those of Trials 278 and 279 which were conducted under otherwise similar conditions.

During these trials without billet coatings, die wear was considerable. In removing the wear scars from the die-entry angle and die bearing by grinding, the opening of some of the dies was altered. This resulted in some slight reductions in extrusion ratio below the nominal ratio of 3.33:1. These reductions, however, were not sufficiently large to affect the lubrication-evaluation program.

Evaluation of Billet Lubricants with Billet Coatings

Sections II, III, and IV of Table XIX give the data obtained with several billet lubricants applied with billet coatings C2, C5 and C6, respectively. In these trials, extrusion ratios of 3.3 and 4:1 and stem speeds of 6 and 20 ipm were evaluated also.

Several lubrication systems based on coatings C2 and C5 produced extrusions without stick-slip occurring. However, the system that produced extrusion with the most satisfactory surface finish was Coating C5 in conjunction with Lubricant 17 and castor oil as the fluid medium. Coating C5 was an anodized coating developed by Watervliet Arsenal primarily to improve wear resistance of titanium and has been designated as "titanium hardcoat" by the developers[13].

In two trials with this system at a ratio of 3.3:1 and 6-ipm stem speed (Trials 368 and 374), little or no stick-slip occurred during runout and excellent extruded surfaces were obtained. One of these is shown in Figure 20 in comparison with an extrusion obtained without the C5 coating. The surface finish obtained with C5 was in the order of 20 to 40 microinches in the transverse direction. Without the C5 coating, the surface was in the range of 120-150 microinches. At a ratio of 4:1 and stem speed of 6 ipm (Trial 376), stick-slip occurred on exit. While the product surface finish was excellent, small transverse cracks were observed at periodic points along the extruded surface. It is believed that the cracks were associated with the stick-slip cycles. In Trial 487, also conducted at a ratio of 4:1 but at a faster stem speed of 20 ipm and with a compound-angle billet nose, stick-slip was completely eliminated. An excellent surface finish without cracks was obtained. This improvement is attributed partly to increasing the stem speed and partly to using a compound-angle nose on the billet, but the extent of contribution of each variable is not known. One or both of these factors apparently also contributed to a 6-7 percent lowering of breakthrough and runout pressures.

In Trial 372, the C5 coating was used in conjunction with Lubricant L45. The extrusion pressure and the shape of the extrusion curve were similar to that obtained with C2 coating and L45 (Trial 360). However, the extruded surface quality was considerably better with C5 than it was with the C2 coating. Appreciable die wear occurred with C2, whereas no wear was noted with C5.