EFFECT OF DIE DESIGN, EXTRUSION RATIO AND LUBRICANTS ON STRESS-RELIEVED TZM

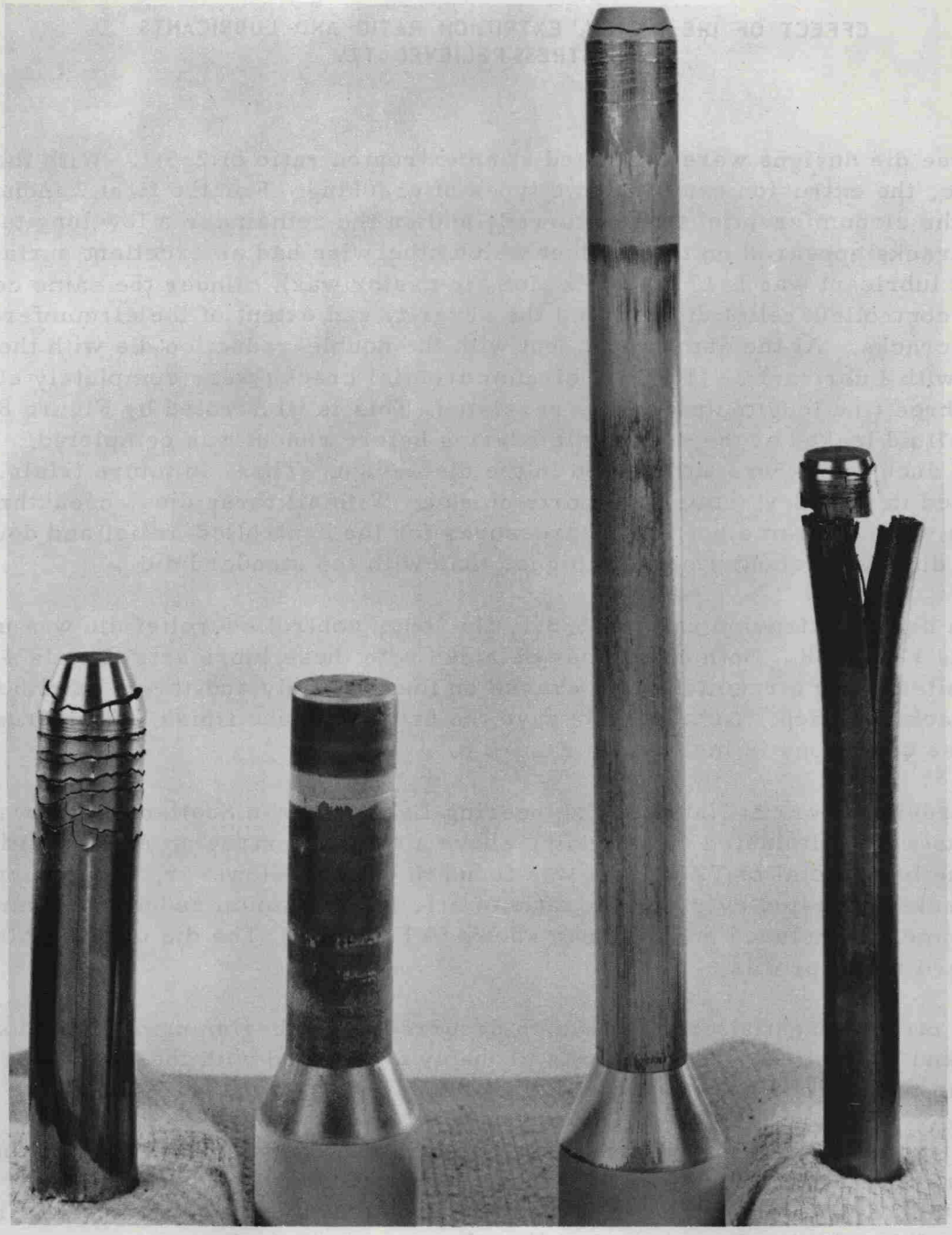
Three die designs were evaluated at an extrusion ratio of 2.5:1. With the standard profile die, the extrusion exhibited two types of cracking. For the first 2 inches of extrusion, the circumferential type occurred, and on the remainder a few longitudinal hairline cracks appeared on the product which otherwise had an excellent surface finish. The billet lubricant was L 17 (20 wt % MoS_2 in castor wax). Under the same conditions, the short controlled-relief die reduced the severity and extent of the circumferential and axial cracks. At the same ratio, but with the double-reduction die with the ports open and with Lubricant 38 (PTFE), circumferential cracks were completely eliminated although three fine longitudinal cracks persisted. This is illustrated by Figure 8. However, the fluid leaked at the second die bearing before runout was completed. The possibility of such a leak was anticipated in the die design. Thus, in future trials, the die will be used in the "dry" state with ports closed. With all three dies, breakthrough pressures were the same but runout pressures for the controlled-relief and double-reduction dies were about 4 percent higher than with the standard die.

At a higher extrusion ratio of 3.3:1, the long, controlled-relief die was used with Lubricants 17 and 38. Both extrusions obtained with these lubricants (Trials 452 and 455) exhibited a few circumferential cracks on the nose only and three hairline longitudinal cracks on each. Lubricant 38 gave the better surface finish. An extrusion made under these conditions is included in Figure 8.

In previous work at National Engineering Laboratory in Scotland[8], it was reported that cracks were eliminated by extruding above a critical extrusion ratio. With molybdenum, the base metal of TZM, this was found to be 3:1. However, in the current program, cracks persisted even up to a ratio of 5:1, the maximum reduction attempted. This specimen is included among those shown in Figure 8. The die used in this case had the standard relief profile.

The circumferential cracking which occurred at the beginning of extrusion with the standard and controlled-relief dies was probably associated with the lower extrusion ratio achieved in the tapered nose of the billet.

The extrusion pressure data obtained so far with the wrought TZM molybdenum alloy is presented in Figure 9. Even though conditions were varied somewhat, an approximate and tentative relationship can be drawn between extrusion ratio and fluid runout pressure. It is of interest to point out that the pressure requirements appear to be roughly the same as those for cold hydrostatic extrusion of AISI 4340 steel.



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Trial	441	469	455	443
Extrusion Ratio	2.5	2.5	3.3	5
Billet Lubricant	L17	L38	L38	L17
Die	Standard	Double reduction	Long controlled-relief	Standard

FIGURE 8. INFLUENCE OF DIE DESIGN AND EXTRUSION RATIO ON CRACKING OF HYDROSTATIC EXTRUSIONS OF WROUGHT TZM MOLYBDENUM ALLOY

Specimens from Trials 455 and 469 are shown as extruded without the lubricant removed.