TABLE XXXII. EXPERIMENTAL DATA FOR HYDRAW OF Ti-6Al-4V WIRE AT 80 AND 500 F

Die angle - 45 degrees (included)
Fluid - Castor oil
Lubrication - Coating-C3
Lubricant-L17
Draw speed - 34 fpm
Starting-wire diameter - 0.045 inch
Temperature - 80 F, except[a]
Wire payed out from free vertical coil

Trial	Reduction Ratio	Area Reduction, percent	Pressure (P), 1000 psi		Draw, Stress, 1000 psi		P+D, 1000 psi (minimum)	Length of Wire, feet	Comments
			Stem	Fluid	Break through	Runout (D)			
513	1.35	26	43	55.5	60.0	35.0	90.5	7	
512	2.0	50	235	203.0	69.0	--	271.0	--	P_b not achieved
521	2.0	50	158	132.0	61.5	30.5	162.5	10	
534[a]	2.0	50	154	--[b]	61.2	--	--	2	Wire broke during extrusion-drawing
522, 523, 525	4.0	75	260	220.0	115.0	--	335.0	--	P_b not achieved
535[a]	4.0	75	210	--[b]	49.0	--	--	--	P_b not achieved

(a) Extrusion-drawing at 500 F; fluid - Acidless stearine; lubricant - L33.
(b) High-temperature high-pressure gage and draw-load transducer out of order.

wire were about 19.0 percent higher than the runout pressures required to hydrostatically extrude solid rounds. These higher stress or energy requirements may be due to:

(1) The so-called "size effect" in which, at smaller "billet" sizes, there is a greater area of die/billet contact per unit volume of material being deformed. Therefore, the proportion of frictional losses is higher.

(2) Differences in the ratio of die bearing length/orifice diameter which will influence the amount of frictional losses expended. This ratio tends to be larger for wire dies than for extrusion dies.

(3) Differences in the condition of the starting material.

On the basis of the results at the two lower ratios, a projection of the P + D requirements for a ratio of 4:1 gives a value of 275,000 psi. In three attempts to reduce wire at this ratio a P + D up to 335,000 psi was achieved without breakthrough occurring. In a single trial (Trial 512) at 2:1, a P + D of 271,000 psi was achieved without breakthrough, yet Trial 521 shows that, in fact, 163,000 psi is all that should be required to effect extrusion-drawing at this ratio. Thus it appears that, in these trials where breakthrough was not achieved, lubrication breakdown may have occurred.

Trial 534 was conducted at 500 F and, comparing the results with those obtained at room temperature (Trial 521), it would appear that the higher temperature does not markedly affect P + D requirements (here comparison of stem pressure and breakthrough draw-stress data only is possible because of an instrument failure). This disagrees somewhat with the findings obtained in the hydrostatic extrusion of solid rounds, where pressures were reduced by about 12 percent when working at 500 F. More trials would be required to determine the contribution of temperature with more certainty.

In two tensile tests on the wire from Trial 521, the ultimate tensile strength was 166,000 psi and its elongation was 7 percent. The properties of the starting wire were 140,000 psi and 6 percent, respectively. The apparent increase in ductility achieved in reducing the wire is probably due to the 4-inch gage length which was used whereas the gage length for the as-received wire tensile tests was reported to be for 10 inches. A shorter gage length increases the effect of the necked area on the percent elongation. The data show, however, that the 50 percent single-pass reduction strengthened the wire without a sacrifice in ductility.

HYDRAW of Beryllium Wire

The aim of this portion of the program was to determine the technical feasiblity of producing beryllium wire down to a target diameter of 0.001 inch by hydrostatic extrusion-drawing. While time did not permit the target diameter to be attempted, the feasibility of producing sound beryllium wire of relatively high-strength was demonstrated.

After some exploratory trials under a variety of conditions including temperatures of 80 and 500 F, beryllium wire having a nominal diameter of 0.020 inch was reduced in one step by a 60 percent in area down to 0.0126 inch. The temperature required to achieve this reduction was 500 F. Table XXXIII gives the data obtained. The pressure