

## COLD HYDROSTATIC EXTRUSION OF AISI 4340 ROUNDS

Extrusion variables investigated for AISI 4340 steel included the following:

- (1) Stem speed
- (2) Lubrication system
- (3) Die angle
- (4) Billet surface finish

Experimental data obtained in each area are given in Table 2.

### Stem Speed

The influence of stem speed on extrusion pressure and surface quality was evaluated for extrusion of AISI 4340 rounds at ratios of 3.33, 4, and 5:1. Stem speeds up to 80 ipm (the maximum speed of the hydraulic press) were investigated. Figure 2 shows the effect of stem speed on the stem breakthrough pressure in extrusion of AISI 4340 at a ratio of 5:1. Increasing the stem speed from 1 to 6 ipm decreased the stem breakthrough pressure by about 8 per cent. The stem pressures were essentially constant over the stem speed range from 6 to 80 ipm. The same general trend was reported previously<sup>(1)</sup> for hydrostatic extrusion of 1100-0 Al at stem speeds up to 20 ipm.

Although stem speeds above 6 ipm did not reduce extrusion pressure further, it is significant that hydrostatic extrusions of AISI 4340 of excellent surface quality can be produced at stem speeds of 80 ipm. Moreover, because the stem-to-billet cross sectional area ratio was 1.85:1, the "billet speed" on the "effective stem speed" was actually 148 ipm. This speed is well within the range used in production processes for conventional hot or cold extrusion. No problems in sealing were encountered. It appears likely that even faster stem speeds could be used without difficulty.

### Lubrication System

Several billet lubricants and fluid media were evaluated at a stem speed of 20 ipm and extrusion ratios of 4 and 5:1. Some of the pertinent data obtained at a ratio of 4:1 are given below:

<u>Trial</u>	<u>Hydrostatic Fluid</u>	<u>Billet Lubricant</u>	<u>Fluid Extrusion Pressure, 1000 psi</u>	
			<u>Breakthrough</u>	<u>Runout</u>
289	Castor oil	L17	185.5	186.0
306	Castor oil	L17	186.0	186.0
294	Water	L17	175.0	183.5
295	Water	L17	187.0	186.0
301	Water	L17	186.5	186.0
302	Water	L17	186.0	185.0
303	Polyethylene glycol	L22	183.5	187.5
293	Polyethylene glycol	L23	185.5	179.0

TABLE 2. EXPERIMENTAL DATA FOR GOLD HYDROSTATIC EXTRUSION OF AISI 4340 ROUNDS

Billet diameter - 1-3/4 inches

Billet surface finish - 60 to 100  $\mu$ -inches, rms, except where noted.

Extrusion Ratio	Stem Speed, ipm	Die Angle, degrees	Hydrostatic Fluid	Billet Lubrication	Extrusion Pressure, 1000 psi				Length of Extrusion, inches	Comments
					Breakthrough		Runout			
					Stem	Fluid	Stem	Fluid		
5.0	20	30	Castor oil	L17	(273.0) <sup>(a)</sup>	(250.0)	--	--	0	Stopped at pressure indicated
5.0	20	45	Castor oil	L17	255.0	215.0	251.0	212.0	17-3/8	Slight P <sub>b</sub> <sup>(b)</sup> peak; P <sub>r</sub> <sup>(c)</sup> uniform
5.0	20	45	Castor oil	L17	(296.0)	(238.0)	--	--	1/16	Stopped at pressure indicated
5.0	20	45	Castor oil	L17	240.0	220.5	240.0	213.0	13-1/2	Slight P <sub>b</sub> peak; P <sub>r</sub> uniform
5.0	20	45	Castor oil	L17	248.0	222.0	248.0	216.0	13	Slight P <sub>b</sub> peak; P <sub>r</sub> uniform
5.0	20	60	Castor oil	L17	256.0	222.0	254.0	220.0	19-1/4	Slight P <sub>b</sub> peak; P <sub>r</sub> uniform
5.0	20	60	Castor oil	L17	259.0	232.0	257.0	230.0	14	No P <sub>b</sub> peak; P <sub>r</sub> uniform
5.0	20	90	Castor oil	L17	267.0	239.0	--	--	1-3/4	Stopped at P <sub>b</sub> peak; no P <sub>r</sub>
5.0	1	45	Castor oil	L17	266.0	242.0	263.0	233.0	6-1/4	Slight P <sub>b</sub> peak followed by stick-
5.0	1	45	Castor oil	L17	260.0	229.0	256.5	222.0	11-1/2	No P <sub>b</sub> peak; slight stick-slip
5.0	6	45	Castor oil	L17	255.0	231.0	256.0	227.0	12-7/8	Slight P <sub>b</sub> peak; P <sub>r</sub> uniform
5.0	20	45	Castor oil	L17	240.0	217.0	241.0	214.0	15	Slight P <sub>b</sub> peak; P <sub>r</sub> mostly uniform
5.0	80	45	Castor oil	L17	240.0	218.0	--	--	3-1/2	Very slight P <sub>b</sub> peak; P <sub>r</sub> not estim
5.0	80	45	Castor oil	L17	240.0	215.0	240.0	213.0	4-3/4	No P <sub>b</sub> peak; P <sub>r</sub> uniform
5.0	80	45	Castor oil	L17	237.0	216.0	243.0	216.0	14-1/4	No P <sub>b</sub> peak; P <sub>r</sub> very uniform
3.33	80	45	Castor oil	L17	--	160.5	--	--	8	Test data other than fluid P <sub>b</sub> inv.
3.33	80	45	Castor oil	L17	176.5	163.0	180.0	165.5	11-1/2	No P <sub>b</sub> peak; P <sub>r</sub> mostly uniform
3.33	80	45	Castor oil	L17	171.0	157.0	168.0	156.0	14	No P <sub>b</sub> peak; P <sub>r</sub> very uniform
4.0	20	45	Castor oil	L17	208.0	186.0	208.0	186.0	11	Very slight P <sub>b</sub> peak; P <sub>r</sub> uniform
4.0	20	45	Castor oil	L17	204.0	186.0	200.0	186.0	13	Very slight P <sub>b</sub> peak; P <sub>r</sub> uniform
4.0	80	45	Castor oil	L17	206.0	187.0	206.0	186.0	17	No P <sub>b</sub> peak; P <sub>r</sub> very uniform
4.0	20	45	Polyethylene glycol	L22	205.0	184.0	208.0	187.5	14	No P <sub>b</sub> peak; P <sub>r</sub> uniform
4.0	20	45	Polyethylene glycol	L23	204.0	186.0	201.0	179.0	14-3/4	Slight P <sub>b</sub> peak; slight stick-slip
4.0	20	45	Water	L17	192.0	175.0	205.0	184.0	9	No P <sub>b</sub> peak; P <sub>r</sub> mostly uniform
4.0	20	45	Water	L17	204.0	187.0	212.0	186.0	13	No P <sub>b</sub> peak; P <sub>r</sub> very uniform
4.0	20	45	Water	L17	206.0	186.5	212.0	186.0	15	No P <sub>b</sub> peak; P <sub>r</sub> very uniform
4.0	20	45	Water	L17	202.0	186.0	204.0	185.0	13	Very slight P <sub>b</sub> peak; P <sub>r</sub> very unif
5.0	20	45	Polyethylene glycol	L22	249.0	229.0	249.0	226.0	15-1/2	No P <sub>b</sub> peak; P <sub>r</sub> uniform