Fluids and Billet Lubrication at 80 F

Several fluids and billet lubricants were investigated at room temperature with the aims of minimizing breakthrough and runout pressures and obtaining good finishes on the extruded product. In addition, it was hoped that lubricants would be developed which would negate the need for billet conversion coatings. The main billet conversion coating involved in this study was a zinc phosphate coating (C1) which was used extensively with success in the previous program(1). Zinc phosphate coatings on steel are commonly used in conventional cold extrusion to assist in lubrication. Billet surface finish, which affects the performance of lubricants at the die billet interface, was also investigated to a limited extent.

Further study of lubrication systems for AISI 4340 was also necessary because, in the past program(1), it was found that the effectiveness of some fluids and billet lubricants diminished as the fluid pressure level was increased. This was believed to be due possibly to (1) excessive viscosity of the fluid and (2) incompatibility of the fluid and billet lubricant.

The conditions under which the study of lubricants was made were essentially constant (see Table IX). Most of the trials were conducted at an extrusion ratio of 5:1 where the pressure level required to effect extrusion was sufficiently high (215,000 psi approximately) to permit judgement of the effectiveness of the lubrication systems. Some trials were conducted at an extrusion ratio of 4:1. For ease of reporting, the components of the lubrication system will be dealt with separately in the following discussion.

The repeatability of data from Tables IX and X were checked to determine the significance of the comparisons made later in the discussion. Three examples are given below where the data from three or more trials were obtained under nominally identical extrusion conditions.

Trials	Standard Deviation, psi		Coefficient of Variation, percent	
	P_b	P_r	P_b	P_r
209 through 212	1,120	435	0.52	0.2
238 through 241	810	810	0.31	0.31
257, 277, 280	3,500	2,160	1.65	1.0

It is seen that except for the third example, the repeatability of the data is very good. In the several cases where trials were repeated only once, the agreement in results is excellent; differences in the order of about 1000 psi are recorded. On this basis it is felt that reliable conclusions can be made on the results obtained in a single trial.

Billet Lubricant and Coatings

The effects of the individual billet lubricants in conjunction with castor oil as the fluid medium, on fluid pressures and an assessment of billet finish are identified in Table XII. The table condenses the data presented in Table IX for direct comparison. A measure of the effectiveness of the lubricants is given by comparison of breakthrough and runout pressures. The reference lubricant chosen was L17 (20 wt percent MoS_2 in castor wax) without a billet coating. This lubricant resulted in a low breakthrough pressure peak, smooth runout conditions, and an excellent surface finish on the extrusion.

The remaining lubricants used without a billet coating generally resulted in higher pressure levels than those obtained with L17 and with two of the systems some lubrication breakdown occurred on runout, which caused a poor finish. Stick-slip and scoring was encountered with L11 (castor wax). This result suggests that the solid film additive (MoS_2) to the castor wax, which comprises L17 was responsible for the prevention of lubrication breakdown obtained in the reference conditions. Lubrication breakdown did not occur on runout with Lubricants L31 and L38. Here the runout pressure levels were very close to that obtained with L17 though the breakthrough pressures were somewhat higher.

When billet coating Cl was used in conjunction with billet lubricants (Items 6 through 11), it invariably produced extrusions which had excellent finishes and which required lower pressure levels than those required for the reference lubrication system. Except for two lubricants, the pressure curves were of the Al type which exhibited no breakthrough pressure peak. Three lubricants, L19, L20, and L21 used with coating Cl gave the lowest runout pressure level achieved at 5:1. This pressure level, 208,000 psi, was nearly 4 percent lower than the runout pressure for the reference system.

The relative effectiveness of Lubricants L18, L19, L20 and L21 in comparison with Lubricants L11 and L17 appears to be associated with the melting points of the constitient waxes. The lowest melting point lubricant (L20) required the least P_b to effect extrusion whereas the highest melting point lubricant (L21) required the highest. The lubricants with similar melting points (L18, L19, L11 and L17) required about the same P_b.

Coating Cl without a separate billet lubricant (Item 12) performed satisfactorily. Even though the breakthrough pressure peak was high and small amplitude stick-slip occurred, smooth runout conditions were achieved and an extrusion having an excellent finish was produced. Apparently, the lubrication provided by the castor oil, the hydrostatic fluid, was fairly adequate. However, castor oil without both a billet coating and lubricant could not prevent momentary seizure at the die billet interface and the product was scored. Pressures were increasing rapidly during runout and complete seizure might have occurred had the extrusion stroke continued further.

Two other coatings were evaluated. Coating C3 (metal-free phthalocyanine) was not as effective as Cl. However, experimental data from friction tests on C3 suggests that its effectiveness may be better at elevated temperatures. Coating C4 (lead) was not effective by itself, but in conjunction with Lubricant L11 it provided extremely low friction conditions at breakthrough. However, the pressures rose continually on runout. The lead coating apparently broke down by melting as the extrusion temperatures rose. Consequently, the extruded surface was discontinuous and spotty. The surface temperature of the product, as measured by a contact pyrometer about 30 seconds after extrusion, was found to be around 600 F.