SPECIAL FEATURE

Industrial performance of a new lubricant for manufacturing PM gears

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Admixed lubricants used in Powder Metallurgy (PM) have been effective at meeting the needs of the industry to manufacture traditional PM parts. With increasing demand to improve upon part tolerances, surface finish, density distribution, weight consistency, and reduced environmental impact; parts makers desire to replace traditional lubricants such as Acrawax and Kenolube. In an effort to do so, AncorLube has been developed as an engineered lubricant system to enable robust part manufacturing. This work compares the production characteristics, based on lubricant type, for a water pump gear pressed to a density of 6.80 g/cm^3. The weight consistency was evaluated during serial production of more than 5000 gears, each weighing approximately 191 grams. A standard deviation of 0.6 grams was measured, indicating that a stable process was achieved with a premix containing AncorLube. Metallographic inspection of surface quality and density distribution was evaluated and compared against parts made with Kenolube. In addition, laboratory studies show improved ejection characteristics are obtained at typical press operating temperatures approaching 60°C (140°F).

Introduction

Traditional PM lubricants typically consist of metallic stearates, synthetic amide waxes, and composite hybrids of stearates and waxes admixed into premixes at 0.5–1.5 mass percent [1–4]. Lubricants have a strong influence on powder behaviors such as apparent density and flow and are critical for providing an even distribution of forces for uniform green density during compaction. Furthermore, lubricants are necessary to reduce ejection forces to improve tool life and permit production of high precision components with good surface finish. Ideally, a single lubricant would provide these advantages while maintaining high compressibility of the powder premix, providing excellent green strength of the powder compact, and burning out cleanly during sintering. Currently, there is no single lubricant that can meet all these demands in one package, whereby selection of a lubricant over others could possibly lead to a sacrifice in one property in order to improve another for a specific processing requirement or application need. Consequently, a need exists to develop a lubricant that can better support all the demands needed to enable robust part manufacturing and reduce environmental impact.

This paper will focus on comparing traditional admixed lubricants with a recently developed lubricant system, AncorLube, in a manufacturing setting. Additionally, laboratory test samples were compacted at room temperature and using a warm die at a temperature of 60°C. When using lubricants designed for warm die compaction, this approach can effectively lower the necessary ejection forces and increase the achievable green density, often resulting in improved properties overall [5].

Experimental procedure

Laboratory premixes of similar composition were prepared using commercially available Ancorsteel 1000 base iron powder from

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TABLE 1

Nominal compositions and identifications of lubricants studied (mass%).

Mix	Acrawax	Kenolube	AncorLube
A1000	Balance	Balance	Balance
Cu	2.0	2.0	2.0
Graphite	0.6	0.6	0.6
Lubricant	0.8	0.8	0.8

Hoeganaes Corporation. All premixes contained 2.0 mass % Royal Cu 155 powder, 0.6 mass % Asbury type 3203H graphite, and 0.8 mass % lubricant content. The nominal compositions for each premix are shown in Table 1. Commonly used lubricants, Acrawax C and Kenolube, were used as a reference for evaluation against AncorLube from Hoeganaes.

Laboratory procedures were carried out in accordance with the appropriate MPIF standards [6]. The green density was determined using rectangular bars with dimensions of 32 × 12.7 × 12.7 mm according to MPIF Standard 15. Bars were compacted at 414, 552, and 690 MPa (30, 40, and 50 Tsi) at room temperature and with a heated die at 60°C. Cylindrical slugs with dimensions of 14 × 25 mm (diameter × height) were compacted at 600 MPa (43.5 Tsi) using an instrumented hydraulic compaction press to study ejection characteristics. Effect of lubricant type was evaluated by comparing the initial ejection pressure (strip) and pressure applied as the sample exits the die (slide) over time.

Results and discussion

Laboratory evaluation of lubricants

The green properties of samples compacted at room temperature are listed in Table 2. The green density of AncorLube premixes were found to be similar to Acrawax, though slightly less than Kenolube. The green strength, however, of the AncorLube premix was found to be more comparable with Kenolube containing premixes under room temperature compaction conditions, with a range of 13–17 MPa. The springback behavior of the AncorLube premixes was found to be slightly higher than both Acrawax and Kenolube at most compaction pressures.

The green properties of samples compacted at 60°C are listed in Table 3. The green density of AncorLube premixes were found to be similar to both Acrawax and Kenolube containing premixes, though the green springback was higher with AncorLube. With the elevated die temperature, green densities were increased by 0.05–0.10 g/cm^3 for all premixes as compared with the densities achieved using a room temperature die. The green strength of the AncorLube premix was equivalent to Kenolube (19–22 MPa). Both AncorLube and Kenolube are superior to the Acrawax premix (14–18 MPa).

To further assess the influence of the different lubricants, the ejection characteristics are compared in Fig. 1. The initial peak of

TABLE 2

Green properties from compaction at room temperature.

Mix	Information			Green			
	Compaction	Die temp	Density	Springback		Strength	
	Tsi	MPa	°C	g/cm^3	%	psi	MPa
Acrawax	30	414	Room	6.71	0.18	1637	11
	40	552	(∼22)	6.98	0.22	2084	14
	50	690		7.11	0.28	2195	15
Kenolube	30	414		6.75	0.16	1978	14
	40	552		7.00	0.21	2387	16
	50	690		7.12	0.25	2470	17
AncorLube	30	414		6.72	0.19	1852	13
	40	552		6.96	0.24	2241	15
	50	690		7.09	0.28	2425	17

TABLE 3

Green properties from compaction at 60°C.

Mix	Information			Green			
	Compaction		Die Temp	Density	Springback	Strength	
	Tsi	MPa	°C	g/cm^3	%	psi	MPa
Acrawax	30	414	60	6.82	0.12	2006	14
	40	552		7.06	0.18	2525	17
	50	689		7.17	0.24	2621	18
Kenolube	30	414		6.83	0.14	2553	18
	40	552		7.10	0.20	3160	22
	50	689		7.17	0.26	3070	21
AncorLube	30	414		6.83	0.17	2696	19
	40	552		7.05	0.23	3172	22
	50	689		7.16	0.29	3223	22