Friction temperature sensitivity of solid lubricants for brake friction materials

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This work aims to evaluate the friction behavior of graphite- and sulfide-type solid lubricants under sliding reciprocating sliding test with progressively increased temperature. Model formulations containing phenolic resin and different solids lubricants were analyzed in terms of the onset temperature of friction decreasing and the friction decrement. Two types of graphite with coarse particle size showed more friction stability while the manganese and iron sulfide with fine particle size exhibited the worse friction behavior. Besides particle size, thermal decomposition and wear rate influence the friction of solids lubricant as a function of temperature.

Keywords: solid lubricants, friction, temperature

1. Introduction

Solid lubricants play important roles in friction materials for brake systems, forming and maintaining the transfer film at the friction interface. The loss of braking effectiveness in the range of 300-400 °C is accompanied by a reduction in the kinetic friction coefficient (μ). This response depends on the types and relative amounts of ingredients used in commercial brake friction materials, especially on the synergistic effect from multiple solids lubricants and abrasives [1,2]. This work aims to evaluate the μ-temperature sensitivity of graphite- and sulfides-type solid lubricants through high-temperature tests.

2. Methods

Model materials were fabricated, keeping the phenolic resin composition constant (25 wt%) and varying the type of solid lubricant (75 wt%). These materials were manufactured following mixing, pre-forming, hot pressing, and post-curing conventional rote. The raw materials were analyzed in terms of their particle size (D90) and thermal (TGA) properties, as well as their morphological features. Reciprocating tests with a ball-on-plate geometry were used to evaluate the friction change of model materials as a function of temperature. The tests were conducted with 10 N, 0.5 Hz, and progressively increasing the temperature from 25 to 400 ºC at 3 ºC/min. Plots of μ differential *versus* temperature were used to obtain the onset temperature of friction decreasing (T_{onset}) and the percentage of friction decrement with respect to the highest μ, $\%\Delta\mu = (\mu_{máx}-\mu_{min})/\mu_{max})\times 100$. Wear response of the samples was analyzed by scanning electron microscopy and 3D optical profilometry. Further reciprocating sliding tests were conducted with a load range from 5 to 30 N to estimate the shear strength (τ) of interfacial films [3].

2.1. Results

The graphite types differed in their particle size but exhibited similar thermal stability up to 700 ºC (Table 1). Model materials with coarse synthetic graphite (GS-grs) and natural flaky graphite (GN-flk) exhibited less sensitivity to temperature change (T_{onset} = 282 ºC - GS-grs) and a low %Δμ (6.2 % - GS-grs) (Figure 1b). Sb_2S_3 showed a higher T_{onset} (235 ºC) and a lower %Δμ (0.7) than MoS_2 (196 ºC; 17,9%). (Mn,Fe)S exhibited the worst behavior in terms of thermal decomposition temperature (150 ºC), T_{onset} (156 ºC) and %Δμ (49%).

Table 1: Particle size and thermal properties of raw materials

	Sb_2S_3	MoS_2	(Mn,Fe)S	GN-flk	GN-fin	GS-grs	GS-mol
D90 (μm)	16	50	28	239	46	409	397
TGA (ºC)	350	450	150	770	710	715	750

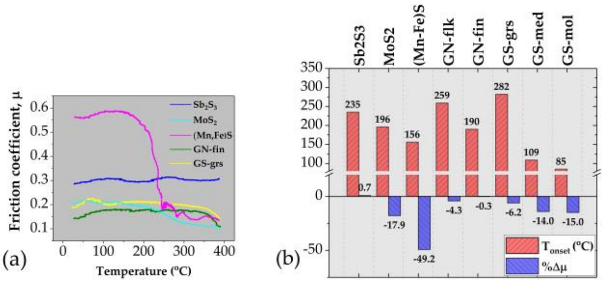

Figure 1: (a) Friction coefficient vs. temperature. (b) Friction decreasing temperature (T_{onset}) and friction variation (%Δμ)

3. Discussion

The friction-temperature sensibility approach allowed to distinguish the friction behavior of different graphite and sulfides used as solid lubricants in brake friction materials. Besides resin decomposition, oxidation of graphite, and decomposition into oxide of solid lubricants influence this friction response [1,2]. Although its good friction stability and higher shear strength (τ = 0.74 MPa), associated with a good brake performance, Sb_2S_3 showed the highest wear loss ($k = 5.16\times10^{-3}$ mm^3/N.m), that may provide a friction material with a low lifespan. In contrast, GS-grs exhibited the lower values of τ (0.13 MPa) and $k = 0.39\times10^{-3}$ mm^3/N.m) that supports its use in brake friction materials.

4. References

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