HIGH FRICTION OF RUBBER CAUSED BY NEGATIVE FLUID PRESSURE UNDER GLYCEROL LUBRICATION AND ITS UNDERLYING MECHANISM

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KEYWORDS
Friction; Mixed lubrication; Fluid lubrication, Fluid pressure

ABSTRACT
High-friction soles are desired to prevent slips and falls on floor contaminated with water or oil. Previous studies have examined the effect of shoe sole design on friction under lubrication. Ishizako et al. [1] has reported that the friction coefficient of rubber block increased with an increase in the negative fluid pressure generated under glycerol lubrication. The aim of this study was to investigate the effect of fluid pressure on the friction of tread blocks with different orientations under glycerol lubrication and its underlying tribological mechanisms.

Three rubber tread specimens with different hardness (shore hardness HS(A/15) = 40, 59, and 74) were prepared. Friction coefficients were determined between a rubber tread specimen and a glass plate at various sliding velocities (v = 0.01–0.20 m/s) and constant normal force (W = 87.2 N) under glycerol lubrication. Sliding direction was set to two conditions: parallel ($\theta = 0°$) and perpendicular ($\theta = 90°$) to the longitudinal direction of the tread blocks, as shown in Fig. 1. The friction coefficient, tread block cross-sectional shape, and fluid pressure were measured using a load cell, a displacement sensor, and a piezoelectric pressure sensor, respectively.

Regardless of the specimen hardness, the kinetic friction coefficient μ_k for $\theta = 0°$ was greater than that for $\theta = 90°$ (Fig. 2). The fluid pressure measurements showed that negative fluid pressure was generated under all conditions. Comparing the adsorption force F_{fluid} calculated by integrating the negative fluid pressure, F_{fluid} of $\theta = 0°$ was larger than that of $\theta = 90°$.

Fig. 3 shows the effect of the estimated normal force F_e ($F_e = W + F_{fluid}$) on the minimum gap h_{min} between the specimen and glass. Regardless of the specimen hardness, F_e tended to be larger and h_{min} got smaller for $\theta = 0°$ than for $\theta = 90°$.

Fig. 4 shows the effect of h_{min} on μ_k. There was a negative correlation between h_{min} and μ_k, suggesting that μ_k increased as the viscous resistance of glycerol increased and/or real contact area increased when h_{min} decreased.

Our results indicated that the negative fluid pressure caused high friction under glycerol lubrication due to the decrease in the film thickness and/or increase in the real contact area caused by the adsorption force. This finding provides new insight into the control of the friction of the soft material under lubrication.

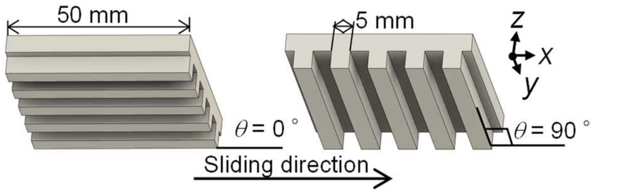
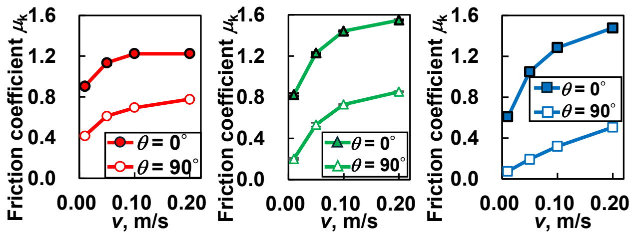


Fig.1 Orientation of tread block relative to sliding direction



(a) HS = 40 (b) HS = 59 (c) HS = 74

Fig. 2 Friction coefficient

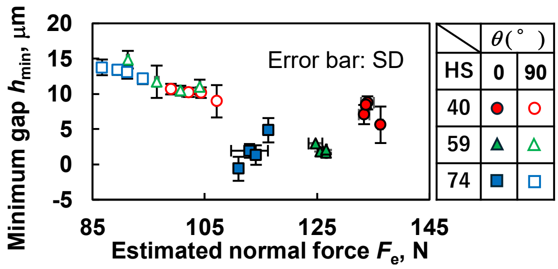


Fig. 3 Effect of F_e on h_{min}

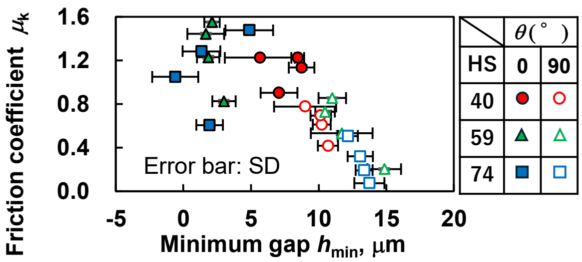


Fig. 4 Effect of h_{min} on μ_k

REFERENCE
[1] Ishizako, A., Nishi, T. and Yamaguchi, T., “High friction of rubber caused by negative fluid pressure under glycerol lubrication,” Tribol Int, 192, 2024, 109213.