Study of Human Fingertip Friction with Controlled Relative Humidity

CATEGORY OR KEYWORD

Biotribology, Contact Mechanics

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INTRODUCTION

Understanding the friction mechanisms between human fingertips and contacting surfaces is important for the design and optimization of haptic (touch-based) devices. The presence of condensed water, secreted sweat and sebum can significantly affect the friction between fingertips and contacting surfaces. Some previous studies controlled the moist conditions of fingertips and the contacting surfaces and with limited relative humidity variation [1-2]. However, the moisture of fingertips can only qualitatively describe the phenomenon. Some experiments had relative humidity control, but tested volar forearms instead of fingertips [3]. Therefore, relative humidity was designed to be controlled in this paper to better quantify the moist condition of fingertip and to simulate real-life touching situation.

EXPERIMENTAL RESULTS AND DISCUSSION

Series of experiments with varying relative humidity and temperatures were conducted. One of the tests was conducted with a male subject's middle finger on an etched glass sample with 0.5N normal load applied under 25°C. The friction force measurements were performed with RH at 40%, 50%, 60% and 70% (Fig. 1). At 40% RH, the coefficient of friction (COF) appeared to be relatively constant at about 0.35 for the first 40 seconds, then it increased gradually over the next 80 seconds and stabilized finally at around 1.0. At higher relative humidity, however, the friction behavior was slightly different: the COF started to increase immediately and reached a constant value. The normal force, friction force and calculated COF are plotted in Fig. 2 for 50% RH as a typical experimental result. For 50%, 60% and 70% RH, the final stable COF were 1.3, 1.5 and 1.7 respectively. In general, an increasing relative humidity ranging from 40% to 70% leads to an increase of the COF. This observation is consistent with our hypothesis that capillary force contributes in friction and needs to be accounted for in haptic device design.

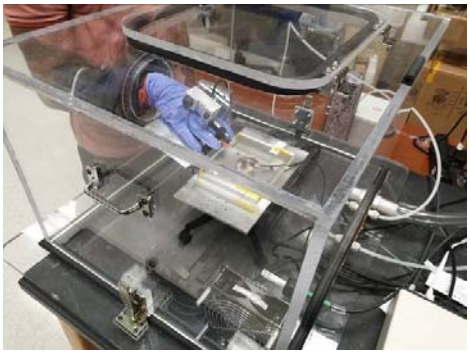

Fig1. Experiment setup

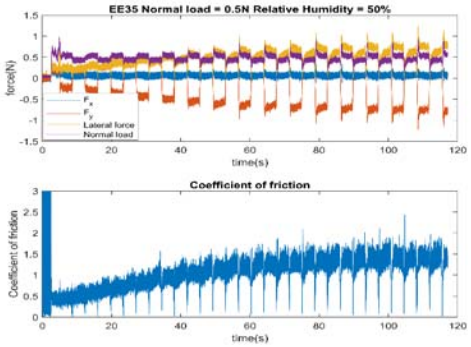

Fig2. Experiment result at 50% RH

REFERENCES

[1] Tomlinson, S. E., Lewis, R., Liu, X., Texier, C., & Carré, M. J. (2011). Understanding the friction mechanisms between the human finger and flat contacting surfaces in moist conditions. *Tribology letters*, *41*(1), 283-294.

[2] André, T., Lefèvre, P., & Thonnard, J. L. (2009). A continuous measure of fingertip friction during precision grip. *Journal of neuroscience methods*, *179*(2), 224-229.

[3] Klaassen, M., Schipper, D. J., & Masen, M. A. (2016). Influence of the relative humidity and the temperature on the in-vivo friction behaviour of human skin. *Biotribology*, *6*, 21-28.