7th World Tribology Congress, WTC 2022
July 10-15, 2022, Lyon, France

Ultrasonic sensor for the real-time measurement of pressurized gas absorption in ionic liquids

Michele Schirru*, Michael Adler, Daniela Posselt, Markus Varga

AC2T research GmbH, Wiener Neustadt, Austria
*Corresponding author: michele.schirru@ac2t.at

In this study, an ultrasonic sensor acting as a rheometer was integrated in a gas absorption reactor to measure viscosity changes in ionic liquids caused by absorption of hydrogen and nitrogen gas. The sensor was designed to resist corrosion and to allow long-term observations. The results show that under operating pressure and temperatures ionic liquids will absorb gas which changes the rheological properties and consequently the lubrication conditions.

Keywords: ionic liquids, viscosity, ultrasonic sensor.

1. Introduction

Although excellent lubricating properties are reported for ionic liquids, attempts to assess their performance under operating or close-to-reality conditions are rare [1]. This research work presents a new way to measure transient events to detect gas absorption in lubricants, in detail ionic liquids, via an ultrasonic reflectance sensor.

2. Methods

The construction of such sensor followed a wholistic approach, taking into consideration aspects of electrical, mechanical, and acoustics engineering. In particular, the piezoelectric element was selected after evaluating all possible commercially available piezoelectric material structures via 6 different candidate materials. The optimum piezoelectric material was chosen by establishing performance parameters including bandwidth, signal-to-noise ratio, amplitude, response linearity, response repeatability, and stability to thermal hysteresis under thermal gradient.

3. Results

The ultrasonic viscometer was designed in accordance to [2]. The reference protocol followed a strict procedure that included blinding, repetitions of thermal cycling referencing, and calibration using air interface, hexadecane, and Canon standard oils. Once long-term stability was proven, the sensor was mounted on a gas absorption test rig designed at AC²T [3]. Selected ionic liquids were saturated with nitrogen gas at pressures of up to 100 bar and at varying temperature between ambient temperature and 80°C. Figure 1 shows an example of a measurement conducted at 50°C and 100 bar. The measurement was conducted over a period of 17 hours, and ultrasonic measurements were acquired every second.

4. Discussion

The results show that once temperature and pressure are stabilised, the viscosity increases due to gas absorption. This effect was measured in literature for a series of hydrocarbons [4], but not yet reported for ionic liquids. Rheological measurement due to the combined effects of temperature, pressure, time, and gas saturation in lubricants will contribute to the design of more efficient tribological contacts occurring in components operating in an environment of pressurized gases.

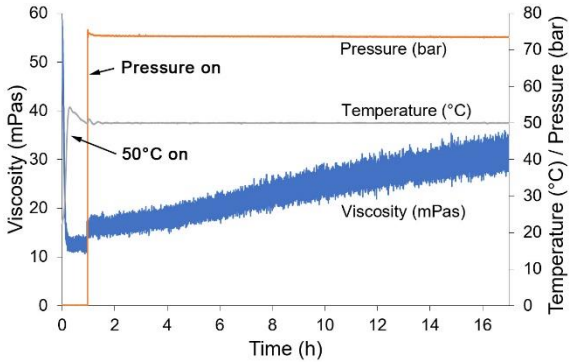

Figure 1: Example of ionic liquid viscosity changes due to gas absorption.

5. Acknowledgments

This work was funded by the Austrian COMET-Program (project K2 InTribology1, no. 872176) and has been carried out within the “Excellence Centre of Tribology” (AC2T research GmbH).

6. References

[1] Dörr, N., et al., “Five-stage selection procedure of ionic liquids for lubrication of steel-steel contacts in space mechanisms,” Tribol. Lett., 67, 73, 2019.
[2] Schirru, M., “Development of an ultrasonic sensing technique to measure lubricant viscosity in engine journal bearing in-situ,” Springer, 2017.
[3] Posselt, D., et al., “Gas solubility in base oils,” Proceedings of the ÖTG Symposium, Dornbirn, Austria, 2019.
[4] Kariznovi, M., et al., “Solubility of carbon dioxide, methane, and ethane in 1-butanol and saturated liquid densities and viscosities,” The Journal of Chemical Thermodynamics, 67, 227-233, 2013.