In-situ wear behaviors of various rubbers in low-pressure hydrogen environment

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Hydrogen is being actively researched as a future eco-friendly energy source. In particular, studies on the hydrogen embrittlement of metallic materials used in hydrogen environments have been ongoing for a long time. Recently, non-metallic materials such as rubber O-rings are used in hydrogen cars and hydrogen stations, research on evaluating their hydrogen compatibility is becoming more active. In this study, we conducted research to find out how the tribological characteristics vary depending on the type of filler and the rubber matrix in ambient air, 5 bar hydrogen, and 5 bar helium atmospheres. The final objective of the study is establishing the wear testing standards for polymers used in high-pressure hydrogen environments and evaluating the hydrogen compatibility of polymers by mechanical, chemical, thermal and tribological property testing. This research was supported by Development of Reliability Measurement Technology for Hydrogen Refueling Station funded by Korea Research Institute of Standards and Science (KRISS).

**RESULTS AND DISCUSSIONS**

- **Black carbon filled NBR:**
  - Initial rapid increase in coefficient of friction (CoF).
  - CoF in hydrogen and helium become stable and showed minimal difference with CoF in ambient air.
  - Roll forming wear mechanism developed well in air and showed less deformation in hydrogen and helium.

- **Silica filled NBR:**
  - SC filled NBR has a lower CoF than CB filled NBR in air.
  - CoF increased consistent and stabilized in hydrogen and helium atmospheres.
  - CoF was lower in hydrogen and higher in helium.
  - Dusty-like wear particles were observed.

- **Silica filled EPDM:**
  - SC filled EPDM showed similar CoF with SC filled NBR in air.
  - CoF increased rapidly in hydrogen with broad scatter and showed similar CoF in helium when they are stabilized.
  - CoF in hydrogen and helium were higher than CoF in air.
  - Wear particles were remained in wear track.

**CONCLUSIONS**

- The wear amount of CB filled NBR in air is almost 2 times higher than in hydrogen and helium, but SC filled NBR and EPDM showed negligible change of wear amount in 3 gas atmosphere.
- Friction coefficient of CB filled NBR increased rapidly up to approximately 2.5 at the early stage, then stabilized to 1.6 in ambient air; hydrogen and helium.
- SC filled NBR and EPDM have a lower and gradually increasing friction coefficient in ambient air compared to CB filled NBR. They also have minor deformation in wear track than CB filled NBR.
- SC filled NBR has lower CoF in hydrogen and higher CoF in helium than CoF in air; however, EPDM showed both higher CoF from the early cycles under hydrogen and helium than ambient air.
- The minimal surface deformation and presence of wear particles or deformed asperities on the wear track suggest a stronger interaction between the EPDM rubber matrix and silica.