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Sliding Characteristics of Rubber O-ring Coated by Diamond-like Carbon (DLC) in Medium Vacuum

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Abstract

The sliding behavior of a rubber O-ring coated by diamond-like carbon in the medium-vacuum deposition method was evaluated. The superiority of rubber members has been pursued for the valve structure of pneumatic control equipment in the automation field. It has been considered that a DLC-coated rubber member which has low friction with superior wear resistance could be applicable to improve the performance of the sliding members. For cost reduction of the DLC film formation, the medium-vacuum method was adopted for the rubber coating. The oil-less sliding friction and the wear characteristics of the DLC on the rubbers were examined over a 2,000 m slide distance, which is the practical requirement in industry. As a result, it was confirmed that the oil-less sliding friction when coated with DLC for more than 10 min deposition time was sufficient for practical use.

Keywords: Rubber, Medium-Vacuum, PCVD, DLC, Friction

1. Introduction

In recent years, resource and energy saving have become requirements for making environmentally friendly products, while the technology has rapidly advanced [1-3]. Among the new technologies, oil-less sliding is receiving a lot of attention. DLC film is used as a clean sliding member in semiconductor manufacturing equipment, food processing, medical fields and so on, due to its superior tribological properties such as the small friction and superior wear resistance [4]. DLC technology has been developed for the tribological enhancement of the metal, ceramics materials and so on. Most of the papers regarding DLC study have been concerned with rigid materials [5]. There are few DLC applications reported for an elastic medium such as rubber [6-8]. Nitrile rubber (NBR) is one of the most important artificial materials for industrial use. NBR is used for the sliding members in the valve structure of pneumatic control equipment. Lower friction properties are required for the joint members to feed the oxygen or anesthetic gas in medical equipment because the wear of the plug is non-negligible, which might cause risks to the patient. Because clean and highly durable use is needed in the medical field, ethylene propylene rubber (EPDM) based components with an atoxic 10-year life-time on the condition of 5 time-connections (10 mm per one sliding) is required. DLC is also regarded as a human friendly material and the good sliding performance of rubber members in the medical and semiconductor industries. However, only a film deposition method equipped with a high-vacuum pump (0.1 to 0.001 Pa) has so far been used for the DLC formation. On the other hand, medium-vacuum (1 to 10 Pa) plasma chemical vapor deposition (MV-PCVD) equipment is desired to make the DLC film formation feasible at reduced cost.

In this study, DLC derived from the MV-PCVD method was coated on NBR and EPDM flat substrates and the tribological properties were investigated by the ball-on-disk test. Furthermore,

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