Running-in Control for Super-Low Friction of Carbon Nitride Coatings

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Carbon Nitride (CN₃) coatings exhibit a wide range of attractive properties such as low friction and wear, good thermal and chemical stability which make them very suitable for demanding mechanical applications. In sliding of CN₃ coatings in inert gas atmosphere and/or high temperature in the air, it provides super low friction. The beneficial effect of inert gas on reducing friction of CNx coatings is much more enhanced by selection of counter material, coating condition, surface roughness of the coatings, atmospheric humidity and especially running-in process, which is pre-sliding before introducing inert gas to the sliding interface.

By using a ball-on-disc type friction tester with a gas supply unit, 2-step friction test as shown in Fig. 1 was introduced to clarify the effect of running-in on friction. The first step, “Step-1”, is also called as pre-sliding and is separated from the subsequent “Step-2”. The ball is replaced by a new one between the steps, consequently the effect of pre-sliding on the CNx-coated disk, which affects friction of CNx against itself in inert gas stream, can be investigated. The atmosphere in Step-1 was either N₂, O₂, or none-gas blow in air.

Representative effect of pre-sliding on friction coefficient in N₂ gas stream is shown in Fig. 2. By introducing 500 cycles of pre-sliding to CNx-coated disk by Si₃N₄ ball in ambient air (Step-1), friction coefficient reduces from 0.07 to 0.004 in subsequent CNx / CNx sliding in N₂ gas stream.

Effect of pre-sliding under various conditions in Step-1 (pre-sliding cycles: 0 to 5,000, atmosphere: in air with either N₂, O₂, or none-gas blow in ambient air) on steady state friction coefficient in Step-2 is summarized in Fig. 3. The pre-sliding cycles of 50-to-1,000 range in Step-1 can give the friction coefficient lower than 0.025. The condition of with none-gas blow in Step-1 shows lower friction coefficient than those observed in N₂ or O₂ gas stream. From these results, when 500 cycles of pre-sliding with non-gas blow in ambient air is given in Step-1, minimum friction coefficient of 0.004 is observed in Step-2.

During pre-sliding, micro-asperities on the initial coating surface are removed and formed a flat contact interface, leading to a low inter-locking force at the contact interface. To confirm the effect of micro-asperities, the CNx-coated disk was polished and tested without pre-sliding. The polished disk successfully prevent unstable friction even without pre-sliding, however lower friction observed in rubbed CNx-coating by pre-sliding is not observed. This result gives us the meaning of running-in for reducing friction of CNx coatings.

Based on the results mentioned above and another attractive results, high potential of CNx coatings for future successful tribological usage is discussed from the view point of running-in control.