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

Super-lubrication of DLC coatings for green tribology technology

Makoto Kano[1)*] ,Kentaro Yoshida[2)] ,Yoshiharu Utsumi[3)], Kazuhiro Oda[4)] and ,Shunsuke Monjiya[4)]

[1)]Laboratory for Future Interdisciplinary Research of Science and Technology, Tokyo Institute of Technology, Japan
[2)]Kanagawa Institute of Industrial Science and Technology, Japan
[3)]Nippon ITF Co., Japan
[4)]NOF Corporation, Japan
*Corresponding author: mkano@cronos.ocn.ne.jp

DLC coatings, especially ta-C coatings have been applied to actual automotive engine components commonly such as valve lifter and piston ring to improve the fuel economy by reducing friction under the mixed lubrication region mainly. Additionally, the super lubricity of ta-C coating under glycerol and oleic acid lubrication was widely observed in mixed lubrication and EHL region. Several ultra, super-low friction properties by DLC coating under the human friendly lubrication such as the xylitol aqueous solution are introduced and the future technology for the automotive engine component using this green tribology technology is discussed.

Keywords: Diamond-like carbon, ultra-low friction, engine component, EHL, green tribology

1. Introduction

The ultra-low friction property of ta-C coating with the gasoline engine oil contained GMO(Glycerol mono-oleate) was applied to the actual mass-produced engine component, valve lifter to improve the fuel economy first in the world in 2006. The application has been enlarged as the production volume and the different kinds of component such as the piston ring.

On the research aspect, the trigger of the mechanism of reducing friction was found that hydroxyl group derived from GMO was adsorbed on ta-C sliding surface by tribo-chemical reaction. Furthermore, it was found that the super-low friction was created by ta-C with glycerol and oleic acid under mixed lubrication and EHL.

After a few results of ultra and super-low friction properties with the human friendly lubricants are shown, the possibility of the applied technology with the green tribology to the engine component is discussed.

2. Result and discussion

The sliding tests in which the pure alcohol, ethanol was dropped on the sliding interface directly after sliding in ambient air for a few minutes were conducted to evaluate the effect of alcohol on the friction property of ta-C and a-C:H as a trial test by the ball on disc. Figure 1 shows amazing result which displayed the contrary effect between ta-C and a-C:H. For ta-C coating, the friction coefficient reduced sharply after supplying ethanol and this phenomenon was observed repeatedly. On the contrary, a-C:H displayed to increase the friction coefficient after adding ethanol. Therefore, it suggests that ta-C only exhibits to reduce friction markedly by combining alcohol due to tribo-chemical reaction.

Furthermore, the friction property of DLC coatings under the water contained with 30% xylitol which has the hydroxyl group by the pin on disc test was evaluated. As shown in Fig.2, the friction coefficient of the steel-steel pair displayed much higher value around 0.2 and the fluctuation was also very large.Judging from this result, the sliding condition was very severe to belong to the boundary lubrication regime. The friction coefficient of the ta-C pair decreased from 0.1 to 0.01 in 10 minutes.

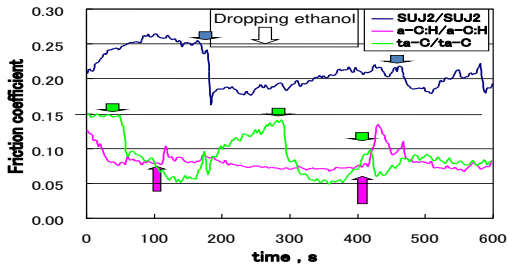

Fig.1 Reducing friction of ta-C by supplying ethanol

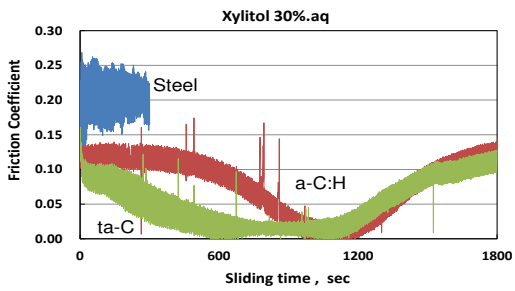

Fig.2 Super-low friction of DLC under xylitol aqua

Surprisingly, that of the a-C:H pair also decreased to 0.01 level in 15 minutes. It is demonstrable that the super-low friction property is able to be created easily using only with the perfectly human-friendly material of DLC and xylitol aqueous solution.

The super-low friction properties of ta-C coating under glycerol and oleic acid lubrication was observed in EHL regime [1][2]. Judging from these results, the applied technology of DLC coatings with definitely human-friendly lubricant to the engine component, such as the crank journal is expected to realize in near future.

3.References

[1] M I De Barros Bouchet, et.al., ”Diamond-like carbon coating under oleic acid lubrication”, Sci.Rep.,7,46394(2017)

[2] M.Kano, et. Al., “Super-low friction of ta-C coating in presence of oleic acid”, Friction2(2):156 (2014)