Activation of catalyst by friction

Masanobu Kubota, I2CNER, Kyushu University
Yuki Nakamura, Graduate School of Mechanical Engineering, Kyushu University

We study mitigation of hydrogen embrittlement (HE, Degradation of material strength due to hydrogen) by the addition of impurities to hydrogen gas. Established technology that achieves hydrogen compatibility of the steels and alloys is basically microstructure control by the addition of a lot of amount of rare metals and lowering material strength. Our study can provide a great benefit in terms of cost of hydrogen infrastructures. For instance, existing natural gas pipelines, which are made of steels vulnerable to hydrogen, can be used for hydrogen transportation. Basic strategy is deactivation of catalytic metal surfaces created by crack propagation. Hydrogen molecule dissociates into hydrogen atoms by the help of the catalytic metal surface. And then, HE occurs following hydrogen uptake into steel. Impurities having higher affinity to metal surface poisons this catalytic surface. It results no HE in consequence of no hydrogen uptake. The effects of oxygen, carbon monoxide (CO) and ammonia were studied in crack growth test and fracture toughness test.

We carried out a fretting fatigue test of SUS304 austenitic stainless steel in CO added hydrogen (**Fig. 1**). Fretting fatigue is fatigue under friction. We successfully obtained mitigation of HE (**Fig. 2**). However, the mechanism is different from what we expected. During the fretting fatigue test, the friction coefficient between contacting surfaces was significantly reduced by carbon deposition (**Figs. 3 and 4**). This is the reason for the increased fretting fatigue strength. Originally, we considered block of hydrogen entry by the deactivation of catalyst for hydrogen dissociation. However, the phenomena actually took place was activation of catalyst for CO decomposition.

In the crack growth test and fracture toughness test in CO mixed hydrogen gas, there is no carbon deposition. Therefore, friction may affect catalytic action of the metal surface. We thought this chemomechanical effect was interesting. Therefore, we carried out a fretting fatigue test in carbon dioxide (CO_2) and methane. As a result, we obtained decomposition of both gases. The temperature and gas pressure at which the decomposition occurred were room temperature and atmospheric pressure. These experiments are preliminary, but may have a great possibility to add another option to CO_2 utilization. Also, this idea may lead new science entitled chemomechnical catalyst tribology.

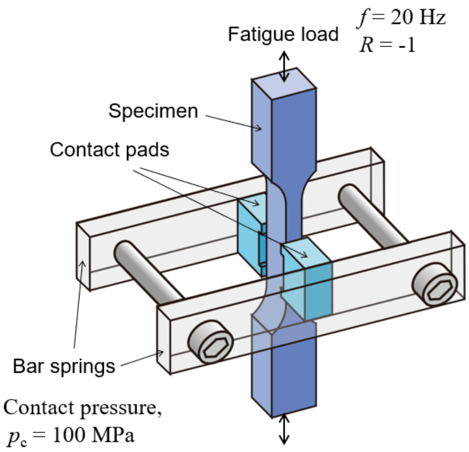

Fig. 1 Freting fatigue test

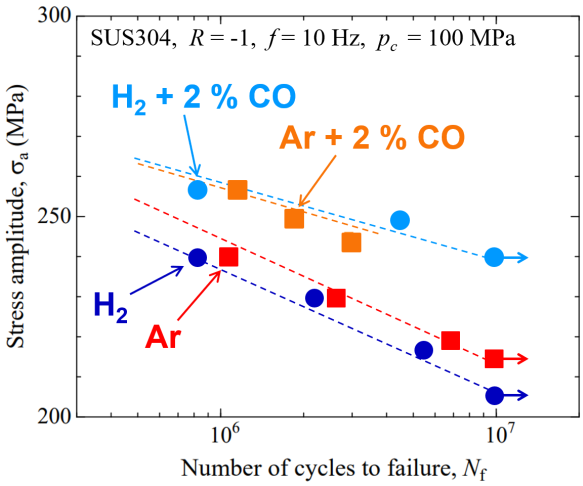

Fig. 2 Results of fretting fatigue test

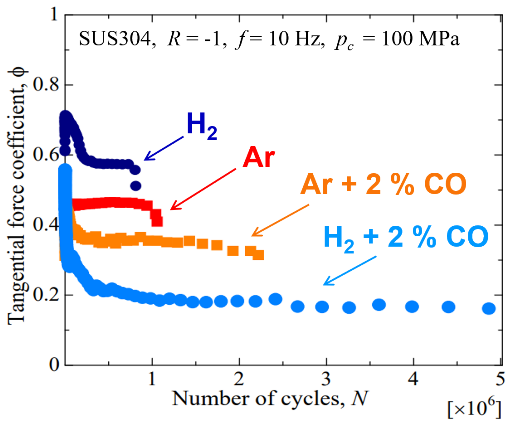

Fig. 3 Friction coefficient

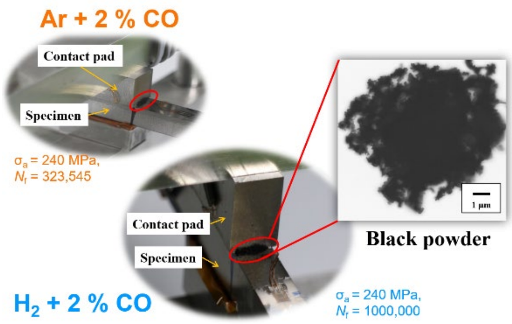

Fig. 4 Reason for the reduced friction coefficient in CO mixed gases