CMSE2022
September 16-19, 2022
Shenzhen, China

CMSE4647

Research on fretting fatigue of tungsten carbide coating based on strain energy density methods

X. Zeng[a, b], X. X. Wang[a, b], X. C. Ping[a, b, *], R J Wang[a, b] and T. Hu[c]

a. School of Mechanical Engineering, Tianjin University of Science and Technology, Tianjin, China
b. Tianjin Key Laboratory of Integrated Design and Online Monitoring of Light Industry and Food Engineering Machinery and Equipment, Tianjin University of Science and Technology, Tianjin 300222, China
c. Shanghai Xifa Business Consulting Co., Ltd., Shanghai 200232, China

Introduction

Coating technology has the ability to improve the wear resistance of parts surface or repair the surface of damaged parts without affecting the basic mechanical properties of matrix materials. Therefore, it is favored by aerospace, metallurgical engineering, mechanical engineering, packaging and printing, etc. Among them, Tungsten Carbide (WC) coating is widely used in aviation field instead of hard chromium electroplating as a surface strengthening method because of its mechanical, physical and chemical properties such as high hardness, high strength, high temperature resistance, wear resistance and corrosion resistance.

In this paper, the fretting fatigue life of WC-12Co coatings will be predicted based on the multiaxial fatigue theory of strain energy density method. First, the damage parameters of Smith-Watson-Topper (SWT), Nita-Ogatta-Kuwabara (NOK) and Chen (CHEN) are determined according to the stress and strain components in the critical plane, and the fretting fatigue life prediction formula is established. Then, the material parameters in the fatigue life prediction formula are determined through the fretting fatigue experiment of WC-12Co coating. Finally, the effects of cyclic load, normal contact load and friction coefficient on the location and life of fretting fatigue damage are investigated. This will provide a feasible method for predicting the fretting fatigue behavior of WC coating, greatly reducing the maintenance cost of mechanical components.

Materials and Methods

The geometric dimensions of the specimen in this study are shown in Fig. 1. The WC-12Co powder was sprayed by high velocity oxygen-fuel (HVOF) with a coating thickness of 0.5 mm. The tensile fretting fatigue experiment was carried out on an electro-hydraulic servo fatigue testing machine. As shown in Fig. 2, the normal fretting contact load is applied through the contact pad. The pad is made of Gr12MoV bearing steel, which clamp the specimen from two opposite sides. Experiments were performed at room temperature, the test tensile loading frequency is fixed at 20 Hz, the stress ratio R is equal to 0, and five levels of stresses are taken from high to low for fatigue test. The test specimen and a bridge foot form a rectangular contact area, and the normal contact pressure P on the two pads is changed by adjusting the bolt on the loading ring.

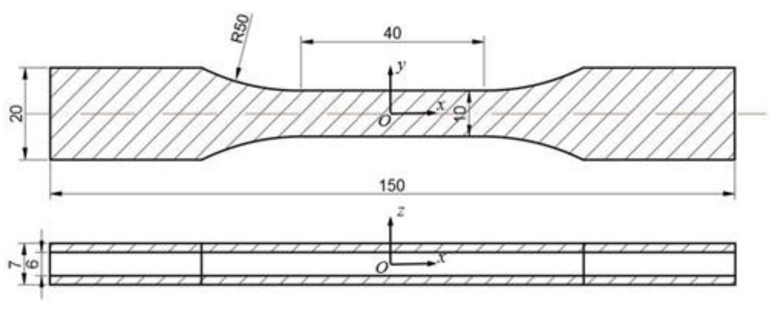

Fig. 1. Diagram of WC-Co coated specimen size.

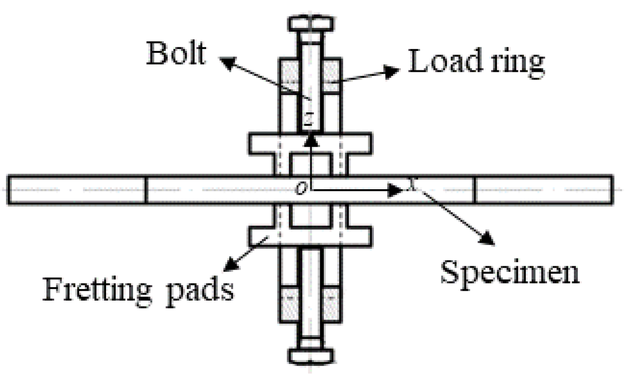

Fig. 2. Experimental setup: preloading fixture.

Results

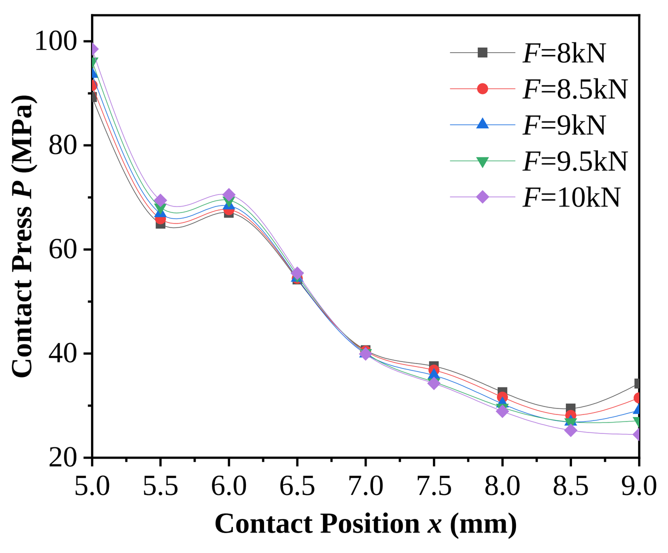

Fig. 3. Contact pressure under tension load F.

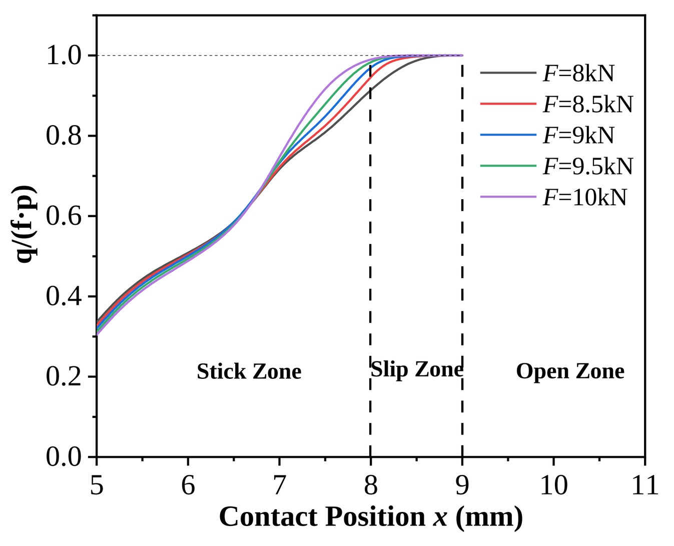

Fig. 4. Contact status under tension load F.

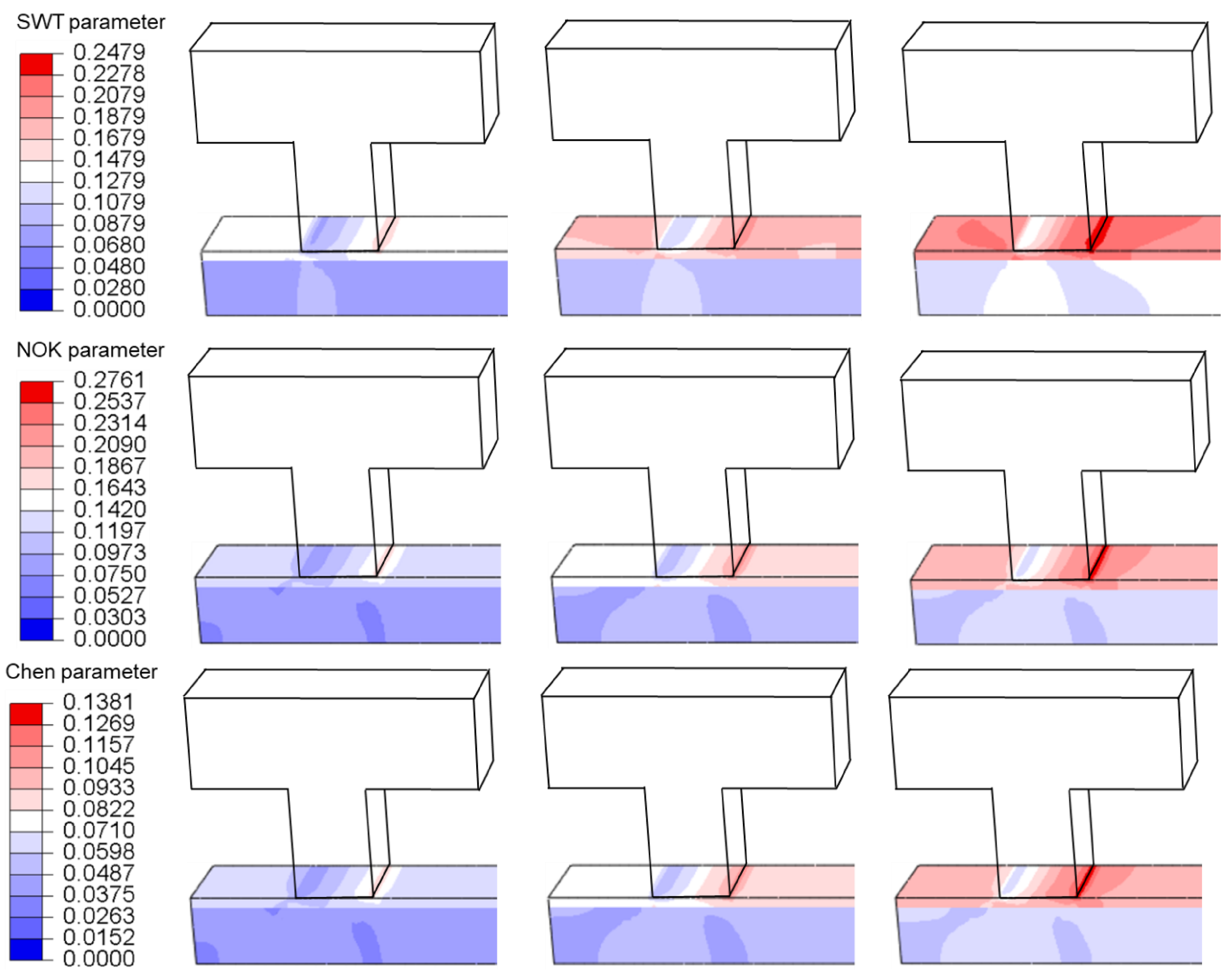

Fig. 5. Contour of the fretting fatigue parameters under cyclic loading F.

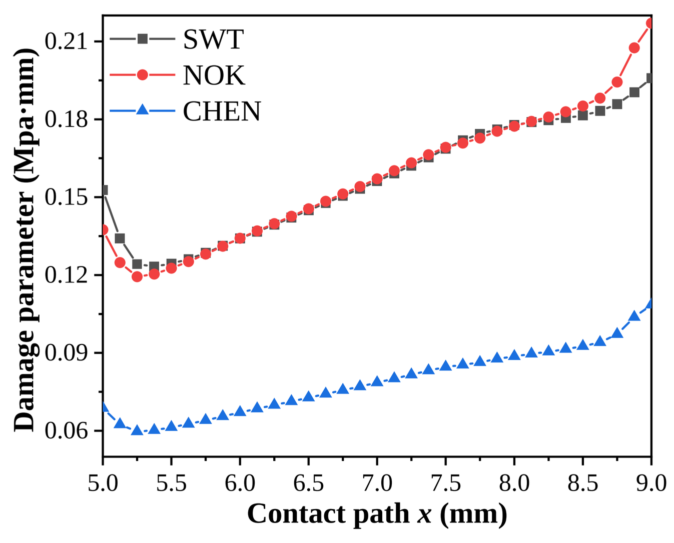

Fig. 6. Different damage parameters of WC-12Co coated specimens along contact path.

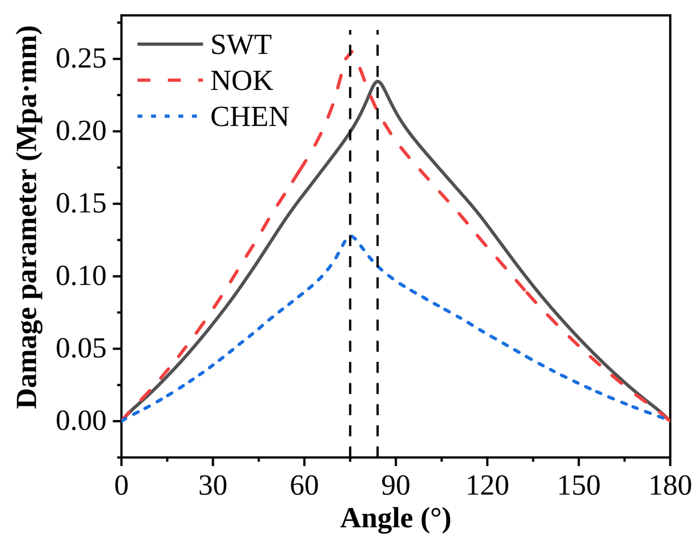

Fig. 7. Damage parameters of WC-12Co coated specimens versus inclination angle.

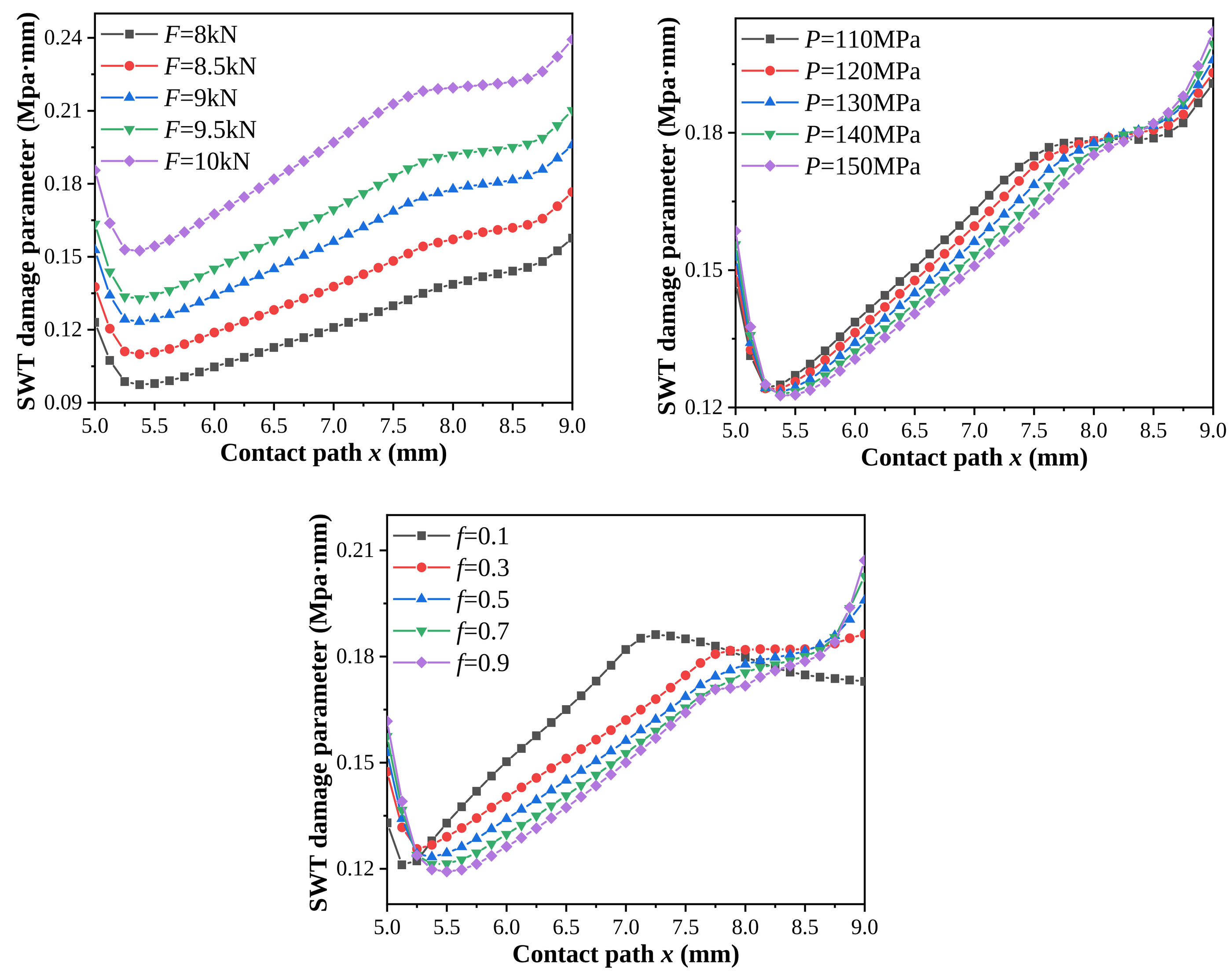

Fig. 8. Variation of SWT damage parameters versus x coordinate corresponding to different cyclic loading F, normal loading P and friction coefficient f

Conclusions

・The predicted locations of crack initiation predicted by the Smith-Watson-Topper, Nita-Ogatta-Kuwabara and Chen parameters are similar. Although the absolute amplitudes of each parameter are different, it does not affect the judgment of crack initiation location.

・ For the prediction of the cracking angle, the predicted results of Smith-Watson-Topper damage parameters are in complete agreement with the experimental results, which indicates that this parameter is more suitable for judging the crack initiation orientation than Nita-Ogatta-Kuwabara and Chen parameters.

・ The axial cyclic load F has little effect on the crack location, but the Smith-Watson-Topper damage parameters decreases with the increase of the cyclic load; An increase in the normal load P make the Smith-Watson-Topper damage parameters more concentrated at the outer edge of the contact surface; A reducing in the friction coefficient f will increase the Smith-Watson-Topper damage parameters in the middle area of the contact surface.