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Study on self-loosening of bolted joints excited by dynamic axial load

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Abstract

Loosening tests of bolted joints are carried out under various preloads and excitation amplitudes. Three coatings are utilized to treat bolts, and their effects on the anti-loosening performance are studied. For the MoS_2 coated bolt, a reasonable preload is calculated, and its anti-loosening performance is also examined. It is found that the anti-loosening performance of MoS_2 coating on bolt is better than that of the other two coatings. Under the same equivalent stress as that of the uncoated bolt at the thread root, both the preload and the anti-loosening performance of the MoS_2 coated bolt are significantly greater. Additionally, a FE model is created to simulate the bolted joint, and very good agreement is found between numerical and experimental results.

Key words: Bolted joints; Loosening; Fretting wear; Frictional energy dissipation

1 Introduction

Because of the advantages of simple structure, convenient use and low cost, bolted joints are widely used in many engineering structures. Self-loosening is one of the main failure modes of bolted joints in vibration environment, thus self-loosening mechanisms have been widely studied by many researchers, in view of their importance and complexity. Experimental results indicate that the common causes of self-loosening of bolted joints are plastic deformation of the fastener, slippage and fretting wear between the contact surfaces [1-8]. The FE method has been increasingly used to study the dynamic behaviour of bolted joints in the past two decades. In addition, a number of anti-loosening methods have been reported.

Goodier and Sweeney [1] investigated the loosening mechanism of bolted joints excited by axial load, and suggested that a micro slippage occurred radially between the contact threads because of the change of axial load. Based on static tensile tests, they pointed out that the bolt twisted in the loosening direction during loading and twisted in the opposite direction during unloading, and thus loosening behaviour occurred at last. Hosokawa et al. [9] found that due to the effect of Poisson's ratio, relative radial micro-slip between the contact threads occurred under axial load. The self-loosening mechanism of bolted joints was attributed to a reduction in friction, which led to slip both on the contact threads and on the bearing surfaces [2, 10-19]. Bickford [14] and Jiang et al. [2, 15, 16] described a loosening process of bolted joints: preload reduced first slowly because of some of the relaxation mechanisms, and then quickly. This was because sufficient preload was lost and the friction forces dropped below a critical level, which caused the nut to back off. Ibrahim et al. [17] and Horn and Schmitt [18, 19] showed that fretting wear between contact surfaces, which caused the clamping force to decrease in the early stage, was one of the reasons for self-loosening of bolted joints. Some studies reported that fasteners could twist with or against gravity when threaded fasteners were subjected to axial harmonic excitation [20-24]. Hess and co-workers [21]

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