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Mechanical Behavior of Hollow Shaft and Sleeve with Interference Fit and Axial Tensile Load in Textile Machinery

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Abstract

Interference fit is one of the most common assembly methods in textile machinery, this paper focuses on the interference assembly of hollow shaft and sleeve. The mechanical behaviors of hollow shaft and sleeve were investigated by using the finite element method under interference fit and axial tension load. The effects of interference, hollow degree, axial load, friction coefficient, sleeve thickness on the mechanical property were studied. The results show that there is still an "end effect" of the contact stress and equivalent stress of the sleeve under axial load. Maximum equivalent stress of hollow shaft appears on the inside cylindrical surface under tensile loading. Under axial tensile load, contact stress and the equivalent stress of sleeve increases with the increasing of interference, sleeve thickness, and decreases with the increasing of hollow degree and load. The equivalent stress of hollow shaft increases with the increasing of the four parameters. The friction coefficient has a very small effect on the mechanical property.

Keywords: Textile Machinery; Hollow Shaft; Sleeve; Interference Fit; Axial Tensile Load; Mechanical Behavior; Finite Element Method

1 Introduction

Textile machinery covers all processing equipment from fiber preparation to clothing molding process, such as chemical fiber machinery, spinning machinery, weaving machinery, knitting machinery, dyeing and finishing machinery, non-woven machinery, garment machinery and textile equipment [1]. Interference fit is one of the most common assembly methods in textile machinery, such as the fit of gear and shaft, assembly of the roller bearing, connection of wheel and wheel cone, etc. Interference fit is a semi permanent assembly method for mechanical parts, which is achieved by the interference after the tolerance part (hole) cooperate with the contained part (shaft). Assemblies can transmit torque and load bearing after interference fit. There are many advantages for the assembly method, such as good neutrality, strong carrying capacity, and its ability to withstand impact load. Under external load, if the local stress of parts or the surface

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contact stress is too large, fretting damage [2] and strength failure will be caused, which will affect the bearing strength of the assembly structure. Interference assembly structures of most parts in textile machinery can be simplified as the interference assembly of hollow shaft and sleeve. The research on mechanical behavior of interference fit structure is very important.

There has been extensive research regarding the interference fit for cylindrical. For example, Baldanzini [3] established a kind of interference fit model, which has a higher accuracy. Croccol [4] studied the static and dynamic strength of interference fit, and did experimental verification. Oswald [5] analyzed the effect of interference assembly on the bearing life. The numerical simulation of fretting contact for wheel-set was done with ANSYS by Zeng [6]. Yang [7] studied the fretting damage of the shaft and sleeve under interference fit, and analyzed the effects of sleeve length, sleeve thickness, friction coefficient, interference on the contact stress and shear stress. Teng [8] established the BP neural network model of maximum stress of cylindrical contact edge under interference fit. Li [9] analyzed the elastic-plastic problem of interference fit shaft hub. Liao [10] studied the three dimensional multi-body contact problem of interference assembly in turbocharger, which contains the impeller, sleeve and shaft. However, although these studies are very important for the engineering practice, the objects of which mostly are solid shaft structure, or only analyzed the elastic-plastic problem of hollow shaft without considering the actual working load. In this paper, the mechanical behavior of hollow shaft and sleeve were studied considering axial tensile load, and effects of key parameters on the mechanical behavior were analyzed.

This paper established the mechanical model of the hollow shaft and sleeve with interference fit and axial load, and established the finite element model of interference assembly, studied the effects of interference, hollow degree, axial load, friction coefficient and sleeve thickness on their mechanical properties. It will have important practical value and significance for the design, optimization and safety evaluation of inference parts of textile machinery.

2 Interference Contact Model of Hollow Shaft

As shown in Fig. 1, the inner radius of hollow shaft is a, the outer radius is $b+\delta_1$, the inner radius of sleeve is $b-\delta_2$, the outer radius is c, the interference is δ.

$$\delta = \delta_1 + \delta_2 \tag{1}$$

where, δ_1 is radial displacement of hollow shaft's outer surface, δ_2 is radial displacement of sleeve's inner surface.

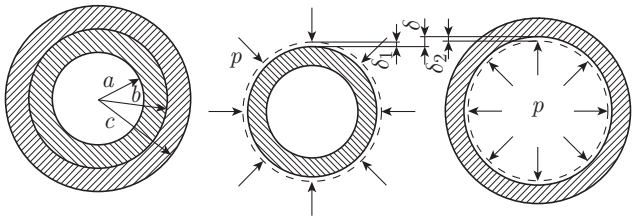

Fig. 1: Assembly diagram of hollow shaft and sleeve

Theory of thick wall cylinder was used in this paper, it is assumed that materials are elastic deformation. Hollow shaft and sleeve were assembled by using the temperature difference method,