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Contact analysis of Type17 coupler based on finite element method

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ABSTRACT

Fatigue cracks of the hook tongue components in Type17 coupler usually occur on its S-surface under improper working conditions. Stress of S-surface mainly consists of tensile stress, bending stress and contact mechanics on the contact surface in stretch conditions. Finite element method with pure penalty algorithm, which discovers the details of stress distribution on S-surface contact regions in contact analysis, is proposed. Stress interpolation curves illustrated the effect of contact to stress concentration on S-surface by extracting the surface stress data. Several peaks value of stress caused by surface contact in contact areas coincide with Hertz stress. According to the comparative analysis, an improved design, which avoids line contact under stress condition, made the four main peak value of stress in the original design decreased by 18.1%, 18.2%, 10.0% and 14.0% respectively. The results conduct that the proposed approach is feasible and the improved design is one way for improving stress condition of hook tongue components.

1. Introduction

Type17 coupler is the latest model of heavy freight trains in China. As a main part of the equipment for connecting rolling stock, the hook tongue components often generated shocks and collisions with surrounding parts when transmitted pulling force and braking force. Researchers had found that fatigue cracks easily occurred on the S-surface under this improper working condition. The loads of hook tongue components mainly applied on its S-surface i.e. the inside surface of the bend and the loads passed through a small contact area under stretch conditions. Stress of S-surface mainly consists of three parts: the longitudinal tensile stress of the coupler, the bending stress generated by the bending moment of the hook tongue and the contact stress caused by collisions between two hook tongues [1].

Hook tongue, as a core component for both automatic coupling and rapid off in coupler assembly, is not only a movement mechanism, but also needs to bear the vehicle load at the same time. The strength properties of the hook tongue are unavoidable to make compromise to take into account its mechanism structure. It is the cause of the cracks damage in hook tongue component on the other hand.

In order to reduce the crack damage, it is necessary to analyze the contact mechanism and to find out the resolution of solving the problem. Finite element method with pure penalty algorithm, which estimates the details of stress distribution on S-surface contact regions in contact analysis, is proposed. According to the comparative analysis, an improved design, which avoids line contact under stress condition, decreases the peaks value of stress in the original design of the hook tongue components.

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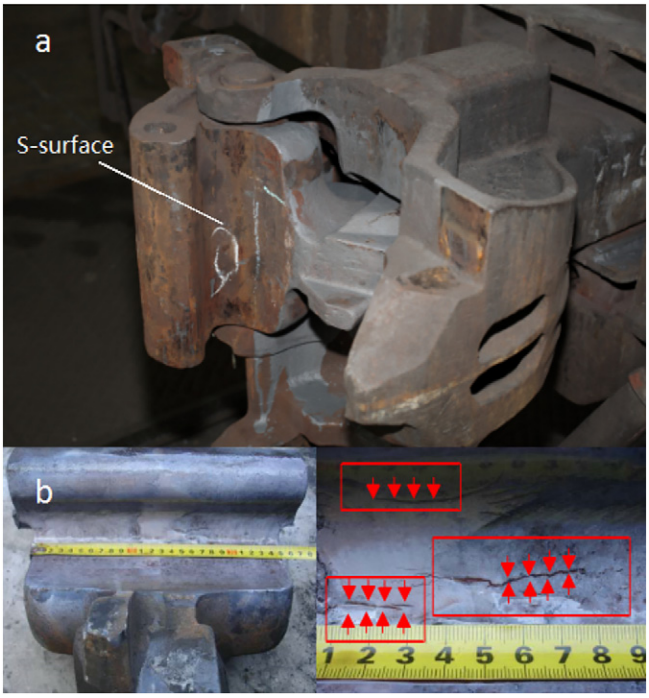

Fig. 1. Type17 coupler and fatigue crack on its S-surface.

2. Cracks & contact analysis

When contact pressing happens, there must be some areas of local tensile stress concentration [2]. These tensile stress concentrations increase the amplitude of the fatigue cycle, which plays an active role in generation and propagation of fatigue cracks to some extent. In order to measure how much the contact factor to crack damage had impact, an analysis based on Hertz contact is quite necessary.

Fig.1a shows a Type17 coupler. There are several polished metallic luster areas on the hook tongues. The area of metallic luster represented large amount of contact in services. These areas reflect the positions of contact under working status, they were mostly long strip and distributed in the vertical direction through observation. Fig.1b shows the fatigue cracks on the S-surface [3]. It is obvious that a large amount of extrusions with line contact took place on the S-surface. In order to explain and solve such engineering issues, Hertz contact mechanics is chosen to describe this phenomenon.

The theory of Hertz mainly focuses on non-adhesive contact without tension force occurred within the contact area [4]. For the contact between two cylinders with parallel axes, there are different radii ρ_1, ρ_2 on its contact surface. When two bodies pressed each other with load F increases, the contact area changed to an ellipse [5,6].

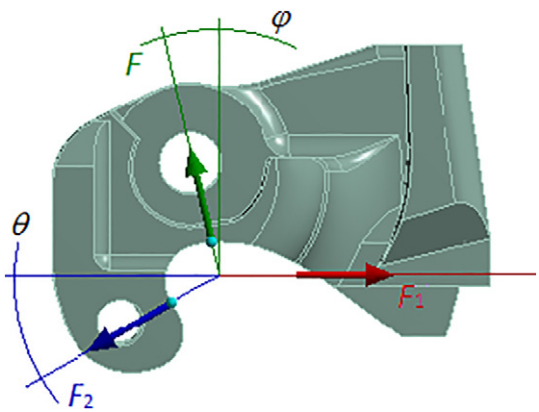

Fig. 2. The load conditions of hook tongue component.