

Development of Axial Force Testing System for Wheel Bearing

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ABSTRACT

The actual installed conditions of 1st, 2nd and 3rd generation of wheel bearing were introduced. The theoretical factors of the axial fastening force for the axle (or CVJ bolts) and nuts were analyzed and the requirements for building up a precise axial force test system were given out. Four testing plans were discussed for the requirements. Based on the cases, the axial force test system was built up, and the axial force test was successfully carried out for the front wheel bearing of a car.

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INTRODUCTION

The clearance of a wheel bearing is a key factor that affects the fatigue life. Either oversized or undersized clearance of a wheel bearing can cause low fatigue life. The clearance of a wheel bearing can be considered under two different states, the clearance of the bearing before and after installation into a vehicle. The clearance of bearing before installed to a vehicle is assembling clearance. When installed to a vehicle, the bearing is fastened by axle nuts and thus is subjected to axial force F_a , which results in the deformation δa of the raceway. As a result, the clearance is changed after the bearing is installed, which is known as the working clearance, as [figure 1](#) shows below. To obtain the working clearance of a wheel bearing, the fastening axial force caused by the axle (or CVJ bolt) at a specific torque should be measured.

There are disadvantages in the current methods of measuring the axial force. The wheel bolt factories normally take the fastener (axle nuts, shown in [figure 2](#), [3](#), [4](#)) as the major test object, and replace the fastened object with the tooling. This method will lead to the deviation of the friction coefficient of the matching surfaces and thus affects the accuracy of the results.

The sensing element which contains strain gauge is used for measuring the force. There are two methods of installing sensing element. One method is embedding the sensing element in the machined hole on the axle (or CVJ bolt). The other method is

adhering the sensing element to the processed surface of the axle (or CVJ bolt). However, it is difficult to implement these two methods due to the particularity of the structure of axle shaft [[1](#), [2](#), [3](#)].

This study aims to establish a system to test the axial fastening force of hub bearing, which provides a criterion to guarantee a clearance of wheel bearing which has high fatigue life.

1. THE STUDY OF TEST METHODS

1.1. The Fastening Features of Wheel Bearing and the Test Requirements

The hub bearing tends to be integrated in the development process due to the high rigidity and reliability requirements. The widely-used hub bearings include 1st, 2nd and 3rd generations, their assembling features are displayed in [figure 2](#), [3](#) and [4](#) respectively, where bearings are shown in the blue areas.

The 1st generation of wheel bearing is the double-row angular contact ball bearings. The outer ring is matched with the knuckle, the inner ring is matched with the flange, and the flange is connected to the hub.

The 2nd generation is based on 1st generation, the outer ring is designed as flange structure and is directly connected to the hub and the inner ring is matched with axle. Thus, the rigidity is strengthened.

Based on the 2nd generation, both the outer ring and the outboard inner ring of the 3rd generation have flanges. The flanged inner ring is connected to the hub and flanged outer ring is connected to the chassis suspension. The rigidity is further strengthened.

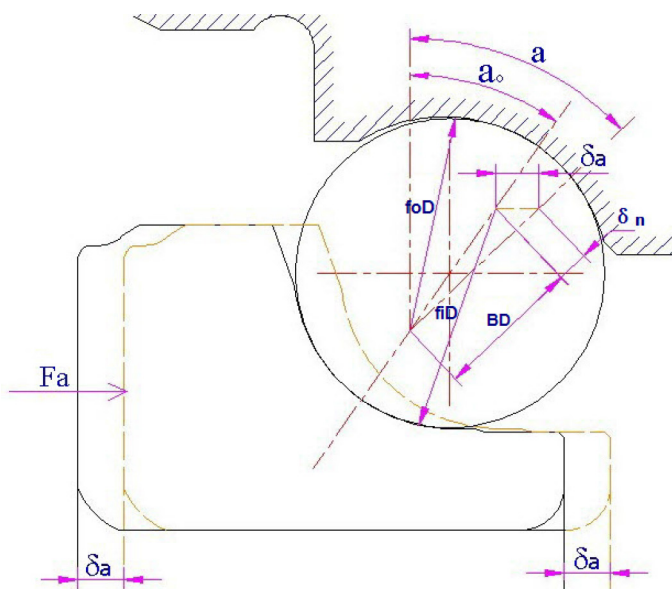


Figure 1. Schematic diagram of working clearance of a wheel bearing

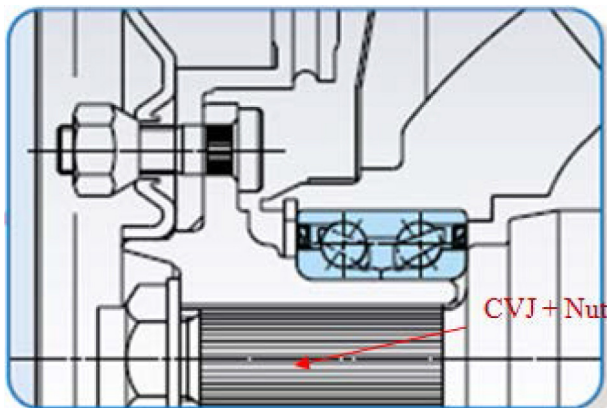


Figure 2. Schematic diagram of 1st generation of wheel bearing

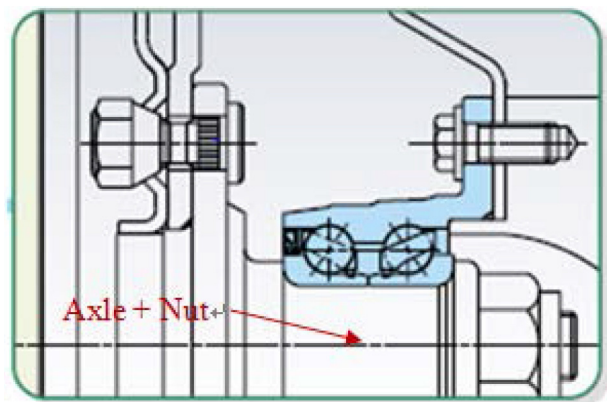


Figure 3. Schematic diagram of 2nd generation of wheel bearing

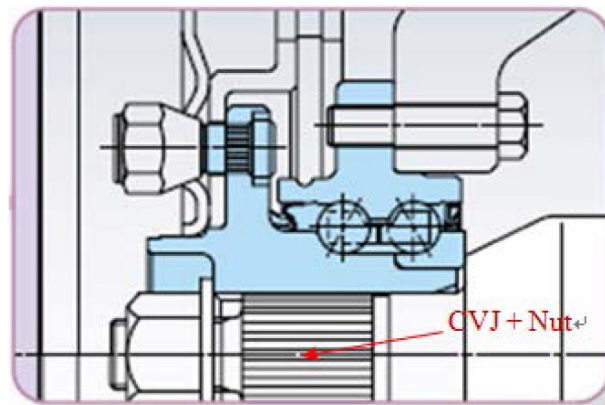


Figure 4. Schematic diagram of 3rd generation of wheel bearing

Using a nut to fasten the wheel bearing to an axle is still very common. Two effects can be achieved by this: the prevention of looseness of wheel bearing and the preload of raceway. The fastening force produced by the axle (or CVJ) and nuts directly influences the working clearance. Thus, it is necessary to accurately obtain the axial force. Theoretically, the axial force of fastener can be calculated as equation 1 shown [4].

$$F_o = \frac{M}{Kd} \quad (1)$$

Where M is the fastening torque, K is the torque coefficient, d is the nominal diameter of screw thread. The torque coefficient K is determined by equation 2:

$$K = \frac{d_2}{2d} \tan(\varphi + \rho_v) + \frac{f_v(D_w^3 - d_o^3)}{3d(D_w^2 - d_o^2)} \quad (2)$$

Where d_2 is the pitch diameter of thread, φ is the thread angle, ρ_v is the equivalent friction angle of the thread, f_v is the equivalent friction coefficient, and D_w and d_o are displayed in Figure 5.

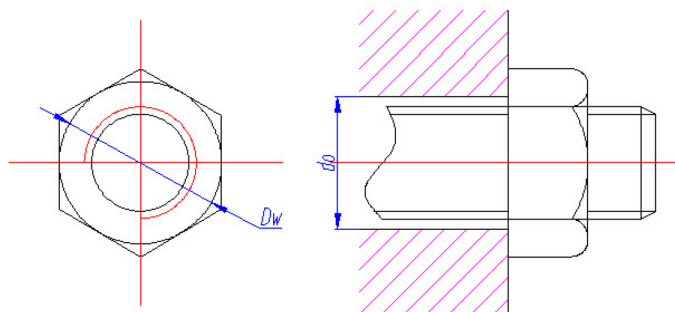


Figure 5. Schematic diagram of D_w and d_o

Based on the actual installed conditions and the theory, the establishment of the test system for the axial force of the wheel bearing should meet four requirements to get accurate axial fastening force:

1. The original CVJ (or axle) and nuts should be used to carry out the test to assure the accuracy of the friction coefficient between