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FATIGUE ANALYSIS OF WELD REGION IN TORSION BEAM REAR SUSPENSION SYSTEM

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ABSTRACT−Torsion beam rear suspension systems have been widely used in small passenger vehicles. However, welding can lead to local stress concentrations, residual stresses and other various defects, which affects the fatigue life of this system. In this paper, 3D digital image correlation (DIC) technique was used to measure the weld region deformation of a torsion beam rear suspension system in the bench test. The test results show that the obvious strain concentration occurred at the welding seam under the cyclic loading. The numerical simulation work by finite element analysis (FEA) has been done to predict the fatigue damage of the torsion beam rear suspension system. The simulation results show that the location of the fatigue crack was at the strain concentration region in the test work. The enhancement test was performed on a proving ground. The fatigure crack location of the torsion beam rear suspension system in the test automobile was coincident with the results by DIC and FEA. If the load conditions of bench tests are close to the road test, DIC is a useful method to predict the fatigue damage by the strain concentration. As a in lab test it would reduce the cost of fatigue analysis.

KEY WORDS : Weld region, Fatigue crack, Digital Image Correlation (DIC), Finite Element Analysis (FEA)

1. INTRODUCTION

The torsion beam rear suspension system has been widely used in small passenger vehicles owing to its compactness, cost efficiency, and light weight (Lee and Yang, 2013). The system consists of two trailing arms interconnected by a flexible beam. Figure 1 shows the fundamental structure of the system and its install location in a typical vehicle.

The torsion beam should bear the large torsional displacement over its length without failure of the material in the service stage. Moreover, it must have enough stiffness to support lateral forces during cornering and possess enough flexibility to allow each wheel to displace independently over a bump. The desgin process and durability evaluation of the torsion beam rear suspension system are crucial issues in the automotive industry (Choi *et al*., 2009; Lee and Yang, 2013; Zhao *et al*., 2014a). Typically, the components of the torsion beam rear suspension system are the steel plate weld structures. The weld process usually leads to local stress concentrations, residual stresses and various types of defects (Finch and Burdekin, 1992), which may induce the fatigue crack formation and propagation under the cyclic loading. This fatigue failure would prevent the components from functioning properly, and cause the critical problems in vehicle safety (Barsoum *et al*., 2012).

Recently, durability evaluation of weld joints is one of the major concerns in the design stage for vehicle (Blacha *et al*., 2013; Dong, 2001; Mahadevan and Ni, 2003). Prototype field test is a conventional method to evaluate the durability (Kong *et al*., 2014). However, the proving ground experimental assessment is time-consuming and expensive. Laboratory test can accelerate the design process due to the advantages of time savings, economy and visibility. The strain gauge is commonly used to measure the strain state of the weld joints both in the prototype field test and the laboratory test (Niemi, 1995). But the strain gauge technology is a non full-field and contact measurement method. Digital image correlation (DIC) method can cover the shortages of the strain gauge technology (Pan *et al*., 2009; Sutton *et al*., 2017). It is widely used in the deformation measurement of weld region with the advantages of sufficient sensitivity, simple experimental setup, multi-scale view, non-destructive and full-field deformation measurement (Fernandez *et al*., 2016; Li *et al*., 2014). In the automotive industry, DIC has been applied to investigate the mechanical behavior of materials for the automobile (Lim and Huh, 2017; Park *et al*., 2015). Nevertheless, the applications of DIC on the

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