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Strength Analysis Modeling for Lightweight Front Axle Beams for Medium-duty Commercial Vehicles

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Abstract. In recent years, improving fuel economy for greenhouse gas (GHG) reduction has emerged as an important issue in the automotive industry. Consequently, the complex forming method for weight reduction has been applied to front axle beams for medium-duty commercial vehicles. For the strength analysis of lightweight front axle beams, the present study developed, tested, and verified a precise strength analysis model to which the dynamic technique had been applied. It will be possible to utilize these results usefully for strength analysis of lightweight front axle beams.

Keywords: Medium-duty commercial vehicles, front axle beams, strength analysis, modeling,

1 Introduction

In the case of recently developed automobiles, efforts have been made to improve fuel economy with the goal of reducing greenhouse gases (GHG). Consequently, in the case of chassis parts, new materials and methods have been applied for high functions and weight reduction [1]. Because of this, front axle beams for medium-duty commercial vehicles continue to be produced using the forging method. This is because these beams are important chassis parts that must withstand the vehicle weight and the load. However, to satisfy demands for weight reduction, a complex forming method that combines hot press forming (HPF) and welding technology was attempted [2][3]. Previous studies applied this complex forming method for the strength analysis of front axle beams for medium-duty commercial vehicles, which simplified boundary conditions and elastic properties. This application led to the problem of disparity between analysis results and tests [4].

The present study developed a model similar to previous tests by applying both precise boundary conditions using the dynamic technique and the material properties of the plastic region to lightweight front axle beams for medium-duty commercial vehicles. By using the developed model, the study performed structural strength analysis based on the spring seat position.

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2 Strength Analysis Modeling

Programs that can analyze dynamic characteristics include software such as finite element method (FEM)-based ABAQUS, MARC, and LS-DYNA and multibody dynamics-based ADAMS and DAFUL. To perform structural dynamics analysis based on an analysis model whose validity had been verified, DAFUL, a program that specializes in the process, was used [5]. As shown in Fig. 1, for the strength test evaluation environment, the left spindle of the axle beam was fixed with a jig and the right spindle was pressed down with a normal load of 6,000 kg. Under the axle beam were two supporting parts that buttressed the spring seat part. The left part, which was capable of one revolution, and the right part, which was capable of two revolutions, were structurally connected. Strength analysis boundary conditions were modeled so that the test environment could be simulated in its entirety, as shown in Fig. 2. The fixed parts and the load input parts were modeled in the same position, and the spring seat supporting parts were modeled so that kinematic movements would occur, as in the tests, by using revolution joint elements on parts that were capable of revolutions. For strength analysis, the axle beam and spring seat were finite elements modeled using a tetra 10 mesh. As for the remaining spindle and king pin, because they are not affected by stress, rigid bodies were applied. Because axle beams and spring seats are connected through welding in actual products, they were hypothesized as inseparable through the use of tie contact elements in the analysis model.

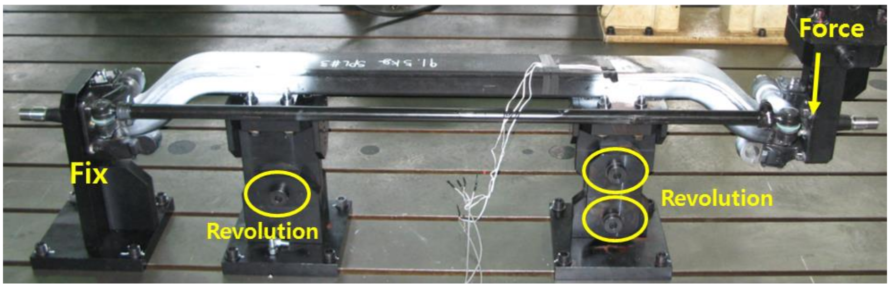

Fig. 1. Strength test evaluation environment

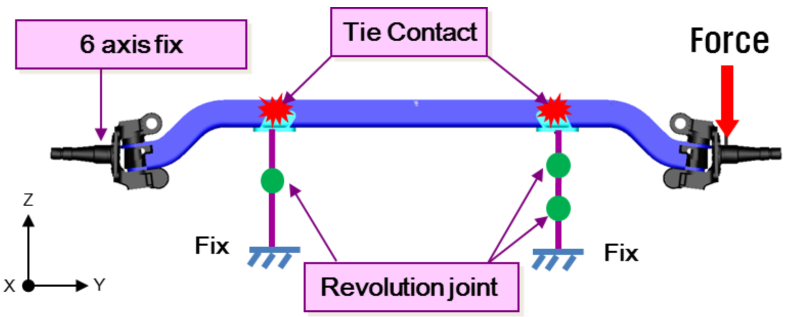

Fig. 2. Strength analysis boundary condition modeling

Material properties were confirmed to exceed yield stress during the initial analysis so that they were applied in consideration of the plastic region. These properties are shown in Table 1:

Table 1. Material properties

Category	Applied Values
Elastic modulus	205,000 MPa
Poisson's ratio	0.29
Yield strength	400 MPa
Allowable strength	310 MPa
Ultimate strength	645 MPa
Elongation at break	35%

3 Verification Tests

Positions where high stress had occurred were confirmed through preliminary strength analysis. Strain gauge attachment positions were also selected. As for the strain gauge, the gauge length was 1 mm, the resistance was 350 Ω, and a 3-line type was used. An axle beam with a strain gauge attached to it was mounted on a strength testing device, and strain verification tests were performed using a data collecting device, as shown in Fig. 3:

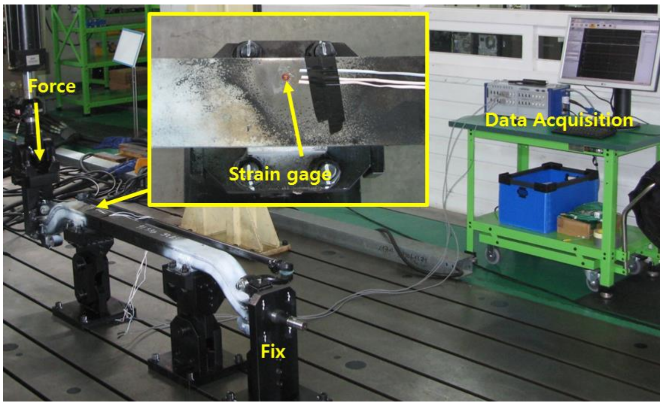

Fig. 3. Strain verification test settings

According to the verification test results, a strain on actual products amounting to approximately 0.004 was generated, as shown in Fig. 4. Also, according to the analysis results, the strain was approximately 0.0039, thus being very similar:

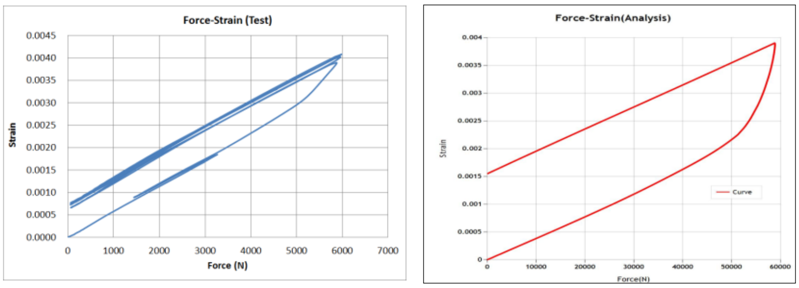

Fig. 4. Strain verification test results

5 Conclusion

The present study constructed precise boundary conditions for lightweight front axle beams for medium-duty commercial vehicles to which the complex forming method was applied by using the dynamics modeling method. A finite element model was developed by applying the material properties of the plastic region. The model developed confirmed similarities to previous tests through strain verification tests. It will be possible to utilize these results in strength analysis of lightweight front axle beams. In the future, the model of the strength analysis obtained in the present study will be used to perform the strength and durability analysis of axle beams.

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