

The Effect of Suspension Types and Tuning on Vehicle Durability

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ABSTRACT

As a new vehicle is based on common vehicle platform, the durability problems of chassis components in development stage are decreasing. However a vehicle body structure is changed by exterior design and a chassis and a suspension are tuned by vehicle performance targets. The main issue on developing a new vehicle is to satisfy the durability target of a body structure and tuned suspension components. The accuracy of durability Computer Aided Engineering analysis is mainly depending on the accuracy of input loads and boundary conditions on suspension system. The input loads should be estimated accurately. These could be changed by vehicle specifications such as vehicle weight, wheel base and so on. It is also affected by the change of suspension types and tuning parameters.

This paper presents the experimental parametric study results using road load data analysis techniques. The previous research presents the effect of vehicle parameters such as vehicle weight, wheel base, wheel tread, vehicle center of gravity, tire size, tire air pressure and so on. In this research suspension types and tuning parameters such as cross member mounting are investigated. The main factors affecting on input loads and behavior of suspension components are explained.

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INTRODUCTION

Recently a new vehicle based on a common vehicle platform is made using the common underbody structure. However the vehicle upper body would be changed by vehicle types such as sedan, Sports Utility Vehicle and Crossover Utility Vehicle. Moreover, suspension system is tuned by vehicle performance targets. For example, the A1 vehicle is hatch back and the A2 vehicle would be Crossover Utility Vehicle based on the same platform. The suspension would be changed by target region and customers. The B1 vehicle is mid-sized sedan and the B2 vehicle would be full-sized sedan based on the same platform. The ride, handling and Noise, Vibration and Harshness of B2 vehicle would be leveled up by suspension tuning.

The developing time of a new vehicle based on a common vehicle platform is reducing by a half. The durability target of the vehicle could be achieved by increasing the level of design quality of prototype vehicle. It is very important to increase the accuracy of Computer Aided Engineering analyses and durability prediction techniques [1]. In this research, the procedure for durability estimation is described. The durability of vehicle body structure is influenced by suspension types. Moreover, it is also influenced by some

suspension tuning [2]. The effects of those kinds of variation were analyzed by road load data of suspensions.

Firstly, the effect of suspension tuning parameters was analyzed. In this case the cross member mounting types were chosen for this study. There are two types of mountings. The one is solid mounting and the other is rubber bushing mounting. The fatigue life of the cross member with bushing mounting is shorter than that of solid mounting. The cause of this phenomenon was investigated by comparing input loads and deformation of cross members. The vehicle installed each cross member by turns. The quasi-static approach was used for comparison. The full vehicle road simulator was used for this quasi-static analysis.

Secondly, the effect of suspension types was analyzed. In this case, rear suspension types were considered. The one is coupled torsion beam axle suspension and the other is multi-link suspension. The same vehicle bodies with those two types of rear suspensions were manufactured. The fatigue life of body structure with multi-link rear suspension is shorter than that of Coupled Torsion Beam Axle rear suspension. The main cause was investigated and explained by road load data analysis. In this analysis, the dynamic characteristics of each

suspension were compared. The differences of each suspension types could be explained by this approach.

METHODOLOGY

Durability Prediction

Because a new vehicle developed upon common vehicle platform has no prototype stage, it is important that the durability targets of the vehicle should be achieved in early stage. The durability prediction procedure has an important role in this development process. This procedure is described in Figure 1.

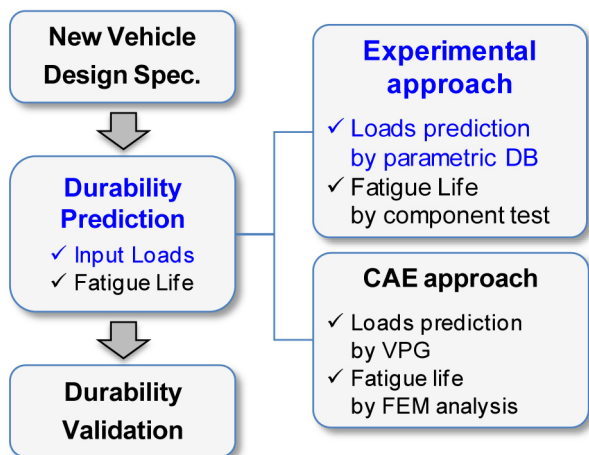


Figure 1. Durability prediction procedure in early development stage

Firstly, a new vehicle design specifications should be reviewed in early stage. There are two kinds of prediction techniques. The one is using experimental approach and the other is Computer Aided Engineering approach. The data base of durability parametric studies could be used for estimating the effect of suspension types and tuning on the vehicle durability.

Also the Computer Aided Engineering analyses could be used for estimation of road loads of suspension components. The changes of load inputs could be predicted by Virtual Test Laboratory analysis techniques [3]. The weak point of this method is that it is needed to have the wheel forces of the similar vehicle. The error could be much larger as the variation of vehicle and suspension types. The research of Virtual Proving Ground analysis technique has been carried out for increasing the accuracy of load estimation in design stage in many automotive companies.

After estimating how much input loads are changed and which boundary conditions would be changed, it is possible to determine whether the suspension components and body structure are reinforced or not. Before prototype stage, the durability of suspension components could be validated by component tests [4,5,6]. For these component tests, the load estimation results from the above load prediction procedure should be applied

Suspension Parameters Influencing Vehicle Durability

Suspension tuning

It is normal procedure that vehicle Ride and Handling performance target is achieved by suspension tuning. For example, the B1 vehicle is mid-sized sedan and the B2 vehicle would be full-sized sedan. The Ride and Handling performance of B2 vehicle should be leveled up by suspension tuning. In this project, front and rear cross member mounting types were tuned. The original is solid mounting type. For B2 vehicle, a rubber bushing is attached on body mounting location of cross member. The same prototype vehicle with those two types of cross-member was manufactured.

After changed into bushing mounting, the cross-member had been cracked in vehicle durability test. It was not considered that the fatigue life is shorter than that of solid mounting. The cause of this phenomenon was investigated by comparing the behavior and deformation of cross members between two types of cross members.

Case 1 - Front cross member

The first case is front cross member. Figure 2 shows solid mounting and bushing mounting cross members. By using bushing mounting cross member, Noise, Vibration and Harshness got better than that of solid mounting. Especially road noise level is decreased by about 2 dB. However cracks were occurred in bushing mounting cross member in vehicle durability test.

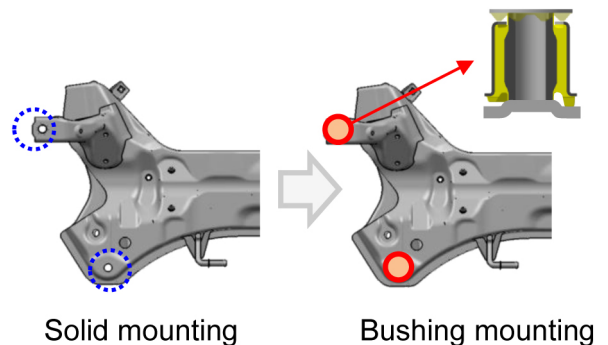


Figure 2. Front cross member mounting types

Figure 3 illustrates the location of cracks. The cause was investigated by Road Load Data Analyses. The strains of crack location, wheel forces and lower control arm forces were measured in durability test track such as Belgian Blocks.



Figure 3. Strain Gage at crack location on bushing mounting front cross member

The relative severity values are compared between two types as illustrated in [Figure 4](#). The relative severity is calculated by calculating fatigue damage of each time signal. The wheel input forces of bushing mounting type are decreased by 2 to 4 % compared to solid type. The ball joint axial forces of lower control arm are decreased by 18 %. However the strain of crack location is increased to 218 %.

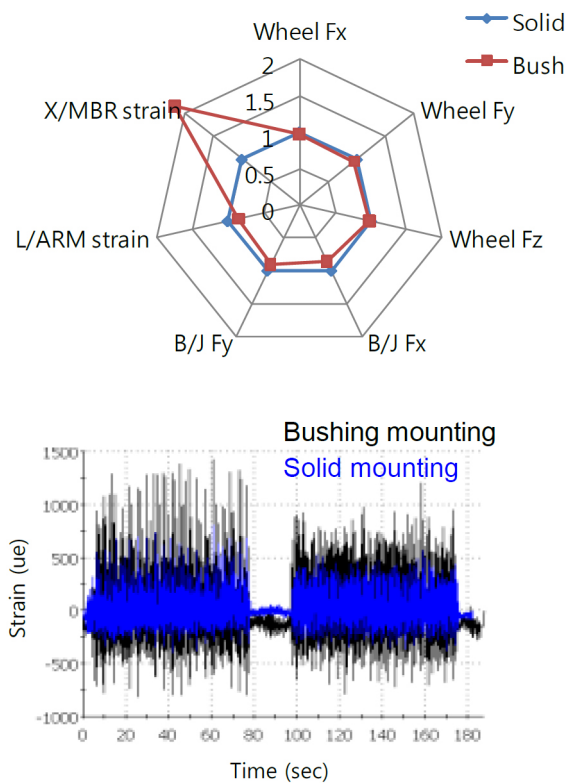


Figure 4. Wheel forces, lower control arm ball joint forces and strain of crack point on bushing mounting cross member

The damping property of bushing can decrease the wheel dynamic behavior. Therefore it decreases wheel forces and lower control arm axial forces. However, bushing releases the restraints of cross member from body structure. This makes larger deformation of cross member than that of solid mounting. The cross member should be much stiffer or

reinforced than solid mounting cross member. After next discussion, this phenomenon will be explained in detail by feasibility tests.

Case 2 - Rear cross member

The next case is rear cross member. [Figure 5](#) illustrates solid mounting and bushing mounting rear cross members.

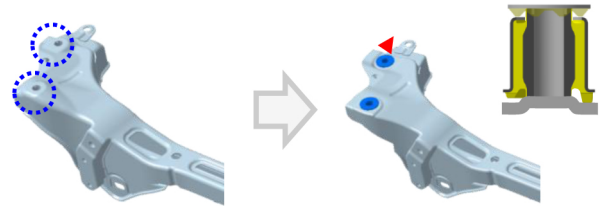


Figure 5. Rear cross member mounting types

The crack was occurred in center region of bush mounting cross member in vehicle durability test as shown in [Figure 6](#). The strains of crack location, wheel forces and axial forces of lower control arm, upper control arm and trailing arm were measured in durability test track.



Figure 6. Cracks on bushing mounting rear cross member

These results are illustrated in [Figure 7](#). The wheel lateral input force of bushing mounting type is decreased by 5 % comparing to solid type. The longitudinal and vertical forces are similar. The axial forces of lower and upper control arms are decreased by 10 to 12 %. The force of trailing arm is similar. However the strain of crack location is increased to 200 %. The similar phenomenon as front cross member case is observed.