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Robust Design of a Ball Joint Considering Uncertainties

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Abstract : An automobile ball joint is a pivoting element used to allow rotational motion between the parts of the steering and suspension system. And it plays a role in smooth transmission of steering movement, also reduction in impact from the road surface. A ball joint is under various repeated loadings that may cause cracks and abrasion. This damages lead to safety problems of a car, as well as reducing the comfort of the driver's ride, and raise questions about the ball joint procedure and the whole durability of the suspension system. Accordingly, it is necessary to ensure the high durability and reliability of a ball joint. The structural responses of stiffness and pull-out strength were then calculated to check if the design satisfies the related requirements. The analysis was sequentially performed, following the caulking process. In this process, the deformation and stress results obtained from the analysis were saved. Sequential analysis has a strong advantage, in that it can be analyzed by considering the deformed shape and residual stress. The pull-out strength means the required force to pull the ball stud out from the ball joint assembly. The low pull-out strength can deteriorate the structural stability and safety performances. In this study, two design variables and two noise factors were set up. Two design variables were the diameter of a stud and the angle of a socket. And two noise factors were defined as the uncertainties of Young's modulus and yield stress of a seat. The DOE comprises 81 cases using these conditions. Robust design of a ball joint was performed using the DOE. The pull-out strength was generated from the uncertainties in the design variables and the design parameters. The purpose of robust design is to find the design with target response and smallest variation.

Keywords : ball joint, pull-out strength, robust design, design of experiments
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