PREMIER SEALS (INDIA) PVT LTD.

CASE STUDY

DESIGN AND OPTIMIZATION OF RUBBER BUMP STOP USING FINITE ELEMENT METHOD

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1. Abstract

This paper describes the application of the shape optimization process of a bump stop for a new vehicle. Design optimization has emerged from the adoption of the interplay of finite element analysis in automotive component manufacture with the best optimization methods. The rubber bumps top was designed and developed with the initial design. After the test it was observed that the part was not achieving the required load at the desired displacement. The initial component design has remained an outlier to this trend due to poor material models inadequately portraying hyper-elastic behavior. A new design was developed and incorporated through the complete design study from CAD to CAE. From the results of the CAE the part was manufactured and tested. The developed part showed the similar load versus deflection curve as shown in the CAE

2. Objective

The goal of this approach is to optimize the stiffness curve of the bumper such that its behaviour is aligned with the expected stiffness curve of dynamic simulation. . To determine the best material model for the bump stop, this paper compares the results from stiffness tests on the bump stop design both initial and new, with finite element analysis employing various material models.

3. Over View of Bump Stop

Bump stops may be seen as limiting springs as they have elastic qualities in compression similar to other forms of spring materials. Solid and hollow spring stops are molded without reinforcement from a natural rubber compound containing additives to boost the ozone resistance.

The defection characteristics for a given size of rubber bump stop are regulated by the hardness of the rubber, this being controlled to a significant amount by the proportion of sulphur and carbon black, which is added into the rubber compound.

The most typical rubber compound hardness used for a rubber spring stop is quoted as a shore hardness of 65; different hardness ranging from 45 to 75 may be utilized to satisfy a particular operating need. A solid cylindrical rubber block enables only 20 percent deviation when loaded in compression, whereas hollow rubber spring stops have a maximum deflection of 50-75 percent of their free height. The actual amount of deflection for a given spring stop height and response to load will rely upon various factors such as the rubber spring stop size, outer profile, wall thickness, shape of interior chambers, hardness of rubber compound, and the number of convolution folds.

The actual profile of the rubber bump stop selected will depend upon the following:

1 How early in the suspension's deflection or load operating range; the rubber begins to compress and become active.

2 Over what movement and weight change the bump stop is intended to contribute to the sudden or progressive stiffening of the suspension so that it responds to any excessive payload, impact load, and body roll.

4. Existing Design Analysis

The part was initially created using the profile given by the customer. The fig. 1 shows the cross-section of the portion. This design was tested on actual and simulation-based values. The Test was conducted using a UTM. The testing results are presented in the graph using the same hardness.

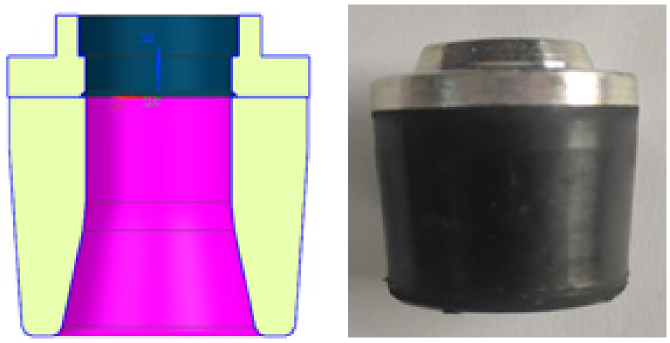

Fig. 1. Initial Design

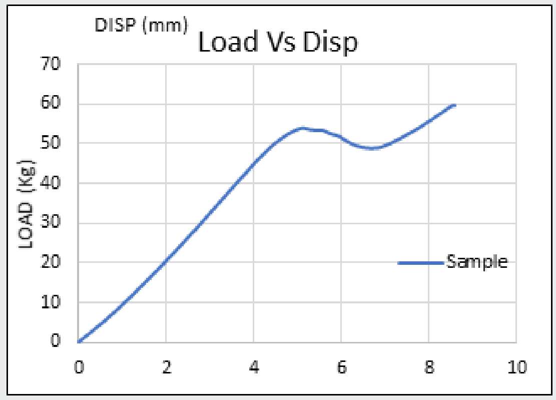

Fig. 2. Result of the initial design.

From the results, it can be inferred that the bump stop shows a slipping behavior after the deflection of 5 mm, due to which the stiffness dips down and quickly rises after the slipping becomes prevented to displace further. The fig. no. 4 depicts the slipping behavior of the part when load is applied.

5. New Design

After the design failure was detected, it was evident that necessary design adjustments must be made. Multiple design iteration was undertaken in order to get the requisite load vs. displacement curve. The design iteration with which the stiffness requirement was achieved is finalized for the manufacture in the single cavity.

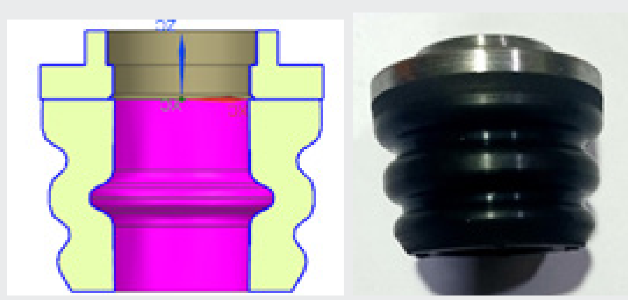

Fig. 3. Final Design

6. New Design Analysis

While testing, the part is seen to display symmetrical loading behavior, and no slippage has occurred. Compared with the previous design for the same hardness of the material, the part achieves the required stiffness without abnormal behavior.

Fig. 4. Compressed behaviour of Initial (Left) and new (Right) design bump stop

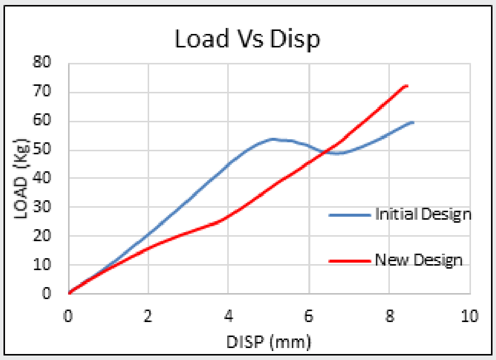

Fig. 5. Initial and New Design Comparison

The production was completed, and based on the testing specifications, the test was done in the single direction fig. 5 shows the results of the part. From the results gained, it is evident that the FEA and the actual results display a similar pattern of loading behavior.

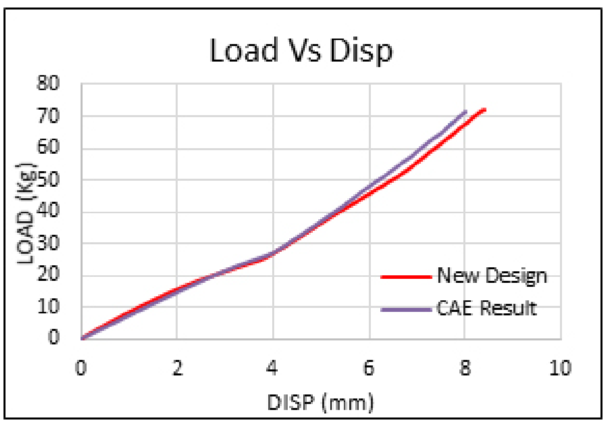

Fig. 6. Actual to CAE comparison of new design

6.1 Details of CAE Analysis.

The CAE study was conducted across the two designs and from this it was discovered that the part was demonstrating buckling behaviour in the initial design. While in the new design the part was having a symmetrical approach while loading until the point of 8 mm.

Also, the level of the stress over the section of new design was observed reduced when compared to the initial design. The difference of the stress and load bearing behaviour can be noted in the fig. 7.

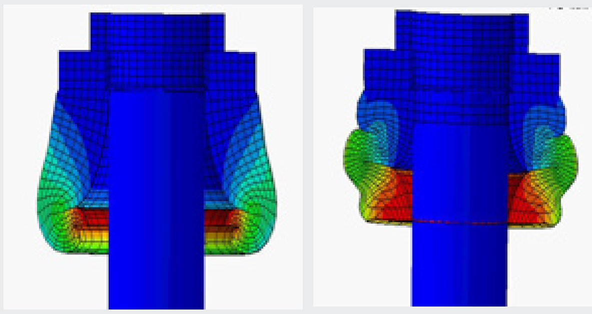

Fig. 4. Compressed behaviour of Initial (Left) and new (Right) design bump stop

From the above image it is clear that the behaviour observed in the CAE and in the actual part is same.

7. Conclusion

Based on the whole project, it is evident that the non-linear analysis employing the finite element method plays a crucial role during the product's development phase. It not only minimizes the effort but also saves the time required for the prototyping of the product. To accomplish the static stiffness, several design iterations were executed. The produced component replicates the CAE data curve in the similar pattern which demonstrates the reliability of the CAE data.