Second Row 60% Seat Cushion Optimization

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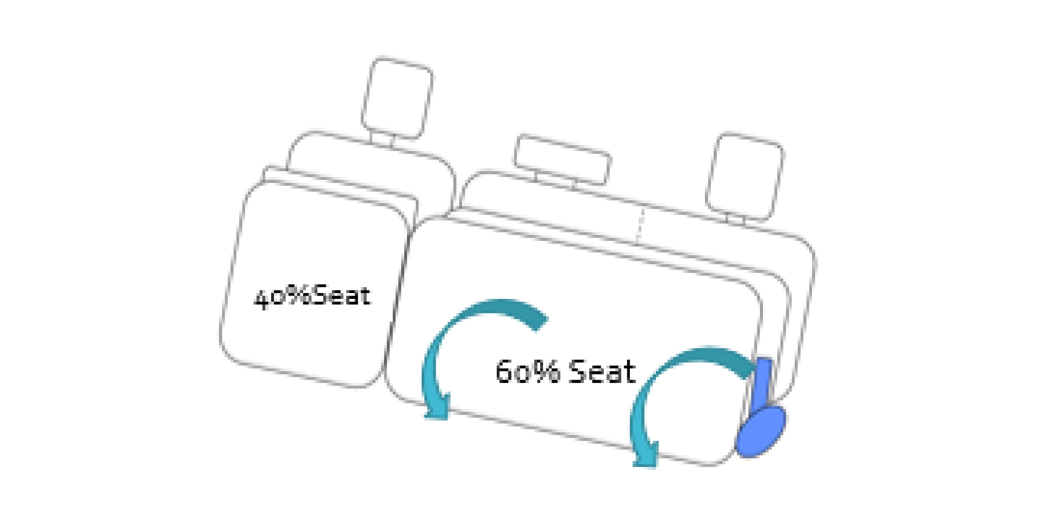
Abstract

This project discusses changes in a seat mechanism design to address an issue found as part of automotive validation. For an automotive manufacturer, prototype vehicles were found to have insufficient retention of the second row 60% seat in stowed position. Through root causing, it was found that the current mechanism design specification did not consider variation in seat trim outline, vehicle mounting floor and seat type. Five designs were proposed where the mechanism output was increased to account for that variation. Three designs were tested in vehicle to determine the winning design solution. All three were determined to have the desired performance, two of the designs were discarded after finding that they rattled, which would pose as a potential customer dissatisfier.

Introduction

Employees of an automotive manufacturer identified vehicles where the second row 60% seat cushion did not remain in stowed position while going over rough roads. Having the second row 60% seat cushion fall unexpectedly while the customer is driving can cause inconveniences that result in warranty claims and customer complaints. As part of the vehicle development and validation process, this issue will be addressed by modifying the second row 60% seat cushion mechanism. Delivering a mechanism design solution that will resist the loads while traveling under rough roads while maintaining lift and fold down efforts that meet customer satisfaction.



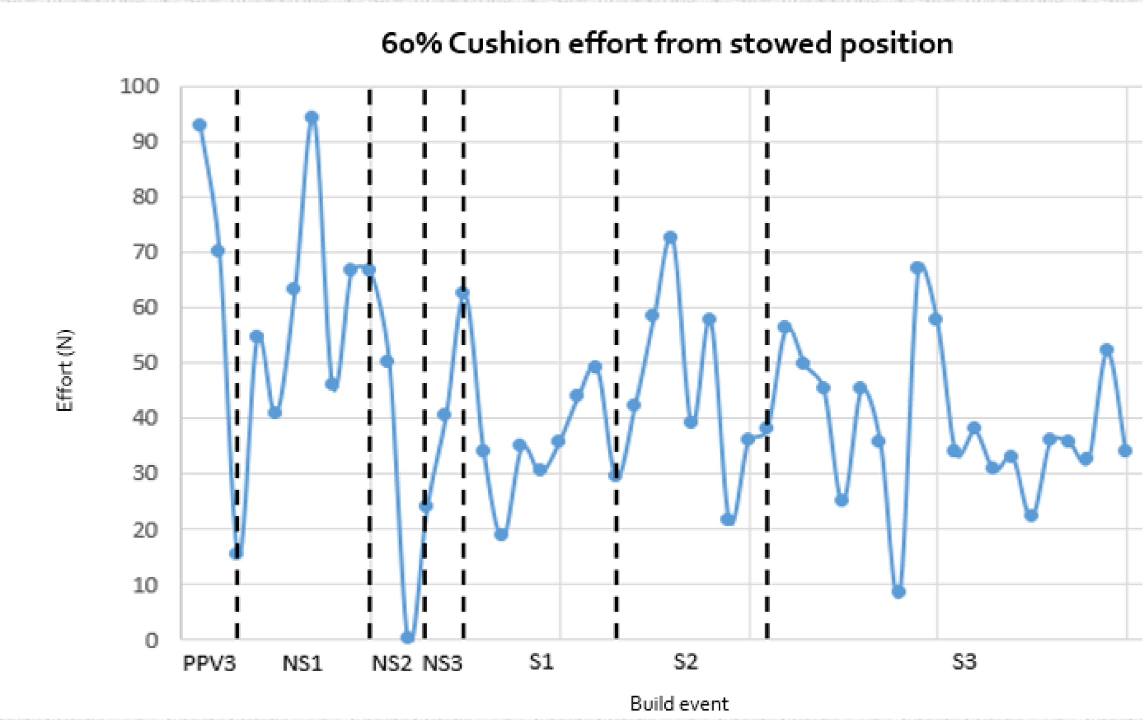
Second Row Bench Seat in stowed position (representation)

Problem Definition & Significance

This mechanism currently has insufficient retention that prevents the seat cushion from maintaining stowed position and addressing this problem earlier on, will prevent issues to the customer. Customer complaints can have an impact in consumer reports as well as warranty costs. It is also of savings to the company to make the design changes while in the prototype stage of the vehicle, as once production tooling is kicked off changes in tooling result in higher costs. Ultimately, the intent is to provide a product of excellence to the customer, therefore it is essential these issues are addressed.

Analysis

Several cases we reported as well as vehicles where the seat cushion would not reach and maintain stowed position at all. Therefore, efforts for the 60% seat cushion coming out of stowed position were taken for all 50 test fleet vehicles. Efforts ranged from 0N to 94N throughout build events, the issue could not be attributed to one of these specifically nor to one specific seat type. Therefore, a vehicle with the worst condition of the complaint (WOW), and one with good retention (BOB) were studied further to understand the issue. As part of the study the seat cushion, back & complete seat assembly were swapped between these vehicles. Low efforts were obtained in the vehicle with the worst condition independent of the seat placed in it.



Measurements for Worst Condition Vehicle		
VIN 1GCXXXXXXXXXXX41 (Identified as WOW)		
Seat Configuration	Condition	Efforts Down (N)
A	As received	23
B	157 Seat Back	19.6
C	157 Seat Assembly	12.8

Measurements for Best Condition Vehicle		
VIN 1GCXXXXXXXXXXX157 (Identified as BOB)		
Seat Configuration	Condition	Efforts Down (N)
A	As received	43
B	41 Seat Back	42
C	41 Seat Assembly	41

It was found that the current performance of the mechanism at component level design 56N (+/-14N) is not robust to variation in vehicle environment. When it comes to vehicle environment, the factors affecting are the variation in seat type, seat trim outline and seat to body mounting area. The floor mounting area was found to have the greatest range in tolerance. A floor scan was performed to understand the variation in the seat mounting area. For the worst condition vehicle X and Z coordinates where on the higher range of the tolerance. This condition creates high interference between seat back and cushion overcoming detent force. Due to these factors, the mechanism output must be increased.

Design Requirements

To account for the variation in seat type, seat trim outline and seat mounting floor, an increase of 50N was targeted. Requirements were reviewed to ensure the magnitude of this increase would not potentially cause problems. As part of this, the seat subsystem technical requirements, operational efforts, customer clinics available (Cushion Lift Customer Loss Function), consumer reports, warranty and current production data were considered. For the current production vehicles, seatback lift efforts were measured.

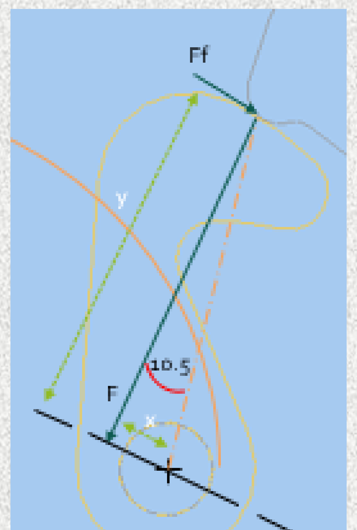
2018 Production Vehicles Effort Measurements			
Description	Average (N)	Min (N)	Max (N)
60% Lift from Design	92.21	72.80	107.60
60% Drop from Stow	93.77	81.80	105.40
40% Lift from Design	85.45	65.40	98.00
40% Drop from Stow	104.33	87.00	121.40

Design Alternatives

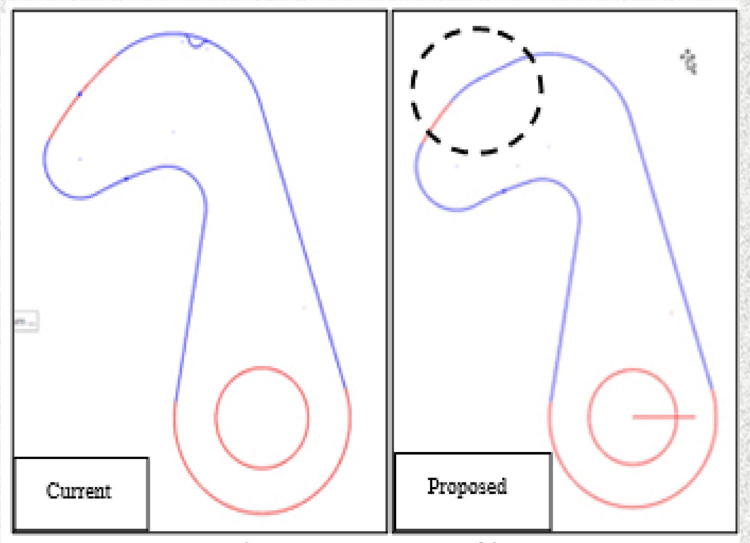
Five design alternatives were developed were developed regarding changes to cam angle, cam profile and spring.

50% Seat cushion Mechanism Design Concepts	
Concept	Description
1	Increase detent effort in stow position by 35N – Changes cam angle to 10.05
2	Increase detent effort in stow position by 35N & Modify upper Cam Profile – Changes to Cam Profile & Angle
3	Increase detent effort in stow position by 50N – Changes cam angle to 9.07
4	Modified cam spring free position – Increase detent effort up to 30N
5	Square Wire cam spring – increase detent effort in stow up to 70 N

A SWOT (Strength, Weaknesses, Opportunity, Threats) decision matrix was used to establish the pros and cons of each alternative and determine which designs to be mocked up. Concepts 1 and 3 Included changes to the cam angle in order to increase the detent force 35 and 50 N. These design concepts were very attractive due to no other component changes being required, therefore could be integrated quickly. Concept 2 , is a change to the cam profile, it shares the same strengths as design Concepts 1 and 2. Because of the implementation ease, these 3 concepts were selected. A threat for all three was that production tooled parts on the long run, may have slightly lesser efforts than prototypes because of tool wear during continuous mass production.



Mechanism Cam Angle



Changes to Cam Profile

Concept 4 was a modification to the cam spring free position; this design was rejected due to the current equipment not supporting the installation of this spring the seat assembly. Concept 5 was also disregarded as the available production equipment does not support installation as well. Both concepts also involved modifying other components in the assembly for these to fit.

Results

The three selected design concepts were implemented in vehicle and data was collected. In terms of performance, all the concepts resulted higher than the minimum at which the cushion has been reported to fall (40N) for out of stow effort. The out of design effort was in a similar range for all concepts, reducing weight on this as a deciding factor.

Summary for Current Production Vehicle Effort Measurements				
Measurement	Original Mechanism	Concept 1	Concept 2	Concept 3
60% Out of Stow	74	96	80	92
40% Out of Stow	24	60	63	54
60% Out of Design	77	71	71	74
40% Out of Design	52	55	59	55

The 50N and 35N increase samples showed overall higher results for the effort going out of stow but concerns arose with these mechanisms rattling under certain conditions. This risk was further studied by BSR (Buzz, squeak & rattle) experts. All three concepts were evaluated in the on campus BSR lab. In this on campus lab, a variety of road conditions are replicated in the efforts to identify any potential issues. Sounds identified in the interior of the vehicle are one of the strongest customers dissatisfiers. Upon evaluation rattle was present for Concepts 1 & 3. Concept 2 was also tested, and no rattle was identified. Due to this factor, despite efforts being lower than Concept 1, Concept 2 was chosen to eliminate any BSR risk.

Final Design Solution

The mechanism design including changes to the cam angle and profile will be implemented into production. Additional mechanisms were manufactured and replaced in all 50 test fleet vehicles. Although not all presented, they were all replaced to serve as further validation. After one week the employee issues reported were reviewed and the issue was not found reported.

Conclusion

The objective of this project was to make changes to the second-row seat cushion mechanism due to insufficient retention in stowed position while traveling on rough roads. This issue was due to insufficient output in the current mechanism spec as it did not account for variation in seat trim outline, seat type and seat mounting floor. To address this issue, five design alternatives were explored. The ultimate design solution included changes to the mechanism's cam angle and profile. This concept was selected to be implemented due to no other component changes required and no rattle issues when compared to the other alternatives. Correcting this issue earlier on enables the company to provide a better quality in product initially to the customer. It also saves costs as making changes once production is kicked off is much more expensive.

References

Tan, C.F., et al. "Vehicle Seat Design : State of the Art and Recent Development." NARCIS > Home, Federation of Engineering Institutions of Islamic Countries, 1 Jan. 1970, www.narcis.nl/publication/RecordID/oai:pure.tue.nl:publications/436adac7-fded-40d9-9c66-fb0edb34cc39.

Buss, Dale. Creating the Perfect Fit: New Car Seat Design. 30 Apr. 2009, www.edmunds.com/car-buying/creating-the-perfect-fit-new-car-seat-design.html..