Second Row 60% Seat Cushion Optimization

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Abstract *— This paper 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. Root causing was performed for these vehicles. It was concluded 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 variation of these factors. Three designs were tested in vehicle to determine which would be the winning design solution. All three were determined to have the desired performance, however two of the designs were discarded after finding that they rattled, which would pose as a potential customer dissatisfier*

Key Terms *— design, seat, mechanisms, Computer Aided Engineering (CAE), Buzz Squeak and Rattle (BSR)*

INTRODUCTION

As part of the vehicle development and validation process, an automotive manufacturer provides prototype fleet vehicles to the employees for them to test and report issues based on their everyday use as if it were from a customer standpoint. For this company, fleet vehicles were identified 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.

Therefore, the focus will be on modifying the second row 60% seat cushion mechanism highlighted in Figure 1. 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.

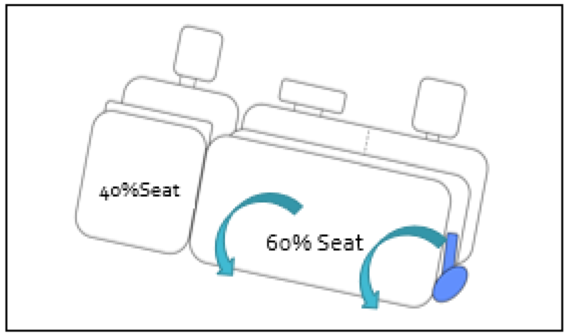

Figure 1
Second Row Bench Seat in stowed position (representation)

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.

LITERATURE REVIEW

Vehicle design involves large part assemblies that account for very different functions. Seats are one of the most significant vehicle components [1]. As it holds the occupant, a seat must meet comfort, ergonomic and safety criteria. Currently, seats contain a lot of technology such as thermal control, haptic system, massaging, airbags, airbag suppression, and even entertainment. Computer Aided Engineering (CAE) is used to assess specifics of the different components that go in them. Seats must accommodate a variety of occupant sizes, which is one of the most challenging but critical design considerations [2]. To fit various occupants, they are made adjustable. Adjustments enabled are typically for the seat back, track, height, and cushion tilt. They are also functioned (typically folded or brought down) to create storage space or what is called a “load floor”. Seat functionality is enabled by mechanisms and electrical components.

Latching mechanisms are available for many applications, but they are essential for the seat assembly. To develop robust mechanism independent of its application, a system model, performance requirements and representation of uncertainty must be considered [3]. Validating these components virtually can be challenging as it has been noted that for car-seat manufacturers to use them in their full potential, models need to be further developed to show more realistically the seated human, the seat and the seated-human/seat interactions. In addition, objective seating-comfort quantifying parameters must be established [4]. CAE then provides a basis to move along the vehicle development process, but its tools are subject to assumptions. This can pose limitations by not fully representing actual use or environment conditions, therefore unprecedented design issues typically arise with hardware validation.

ANALYSIS

As part of the design correction process, the issue was first root caused in the automotive manufacturers on campus garage to establish what conditions needed to be met for improvement. Once identified, design concepts were developed and tested to confirm desired results. Following, this process will be discussed.

Root causing

To perform issue root causing, the BOB (Best of the Best) and WOW (Worst of Worst) approach was used. 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.

A vehicle identified with the worst condition of the complaint and one with good retention 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 WOW vehicle independent of the seat placed in it. This showed the mechanism was sensitive to the vehicle environment. To confirm, data was requested from the seat supplier. This data shows the effort on a component level and is measured with the seat in a nominal fixture.

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. The data is summarized in Table 1.

Table 1
Summary for Current Production Vehicle Effort Measurements

2018 Production Vehicles	*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. These are discussed in Table 2.

Table 2
Seat Mechanism Design Alternatives

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

Design Selection

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 as shown in Figure 2, 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 as shown Figure 3 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.

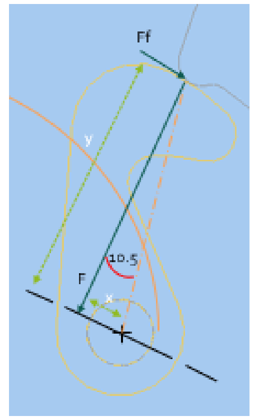

Figure 2
Mechanism Cam Angle

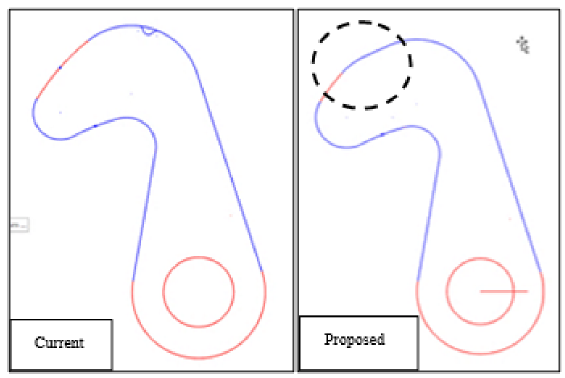

Figure 3
Changes to Cam Profile

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 and summarized in Table 3. 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.

Table 3
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 change that included changes to the cam angle and profile will be implemented into production. As there is still a small period before the start of regular production, additional mechanisms were manufactured and replaced in all 50 test fleet vehicles. Although some of the vehicles did not present the issue, all were replaced to serve as further validation. This presents the opportunity to monitor for issues. The employee issues reported will then be reviewed to ensure the issue is no longer present.

CONCLUSION

The object 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 found to be due to insufficient output in the current mechanism spec as it was found to 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 ultimately 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.

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