Reduction of weight in seating systems using a modular system for power seat actuations

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Abstract

The automotive industry as a whole is striving to breakthrough new grounds in producing environment-friendly vehicles without compromising on performance. The stringent constraints in relation to CO2 emissions from different governments all around the world have encouraged OEM's to adopt different solutions. Due to which in recent years a trend of cutting out weights of different sub-systems in the vehicles has been observed to be one among them. In this paper, the possibility of reducing the weight of the seating systems through a modular actuator system is discussed. On observing the seating systems as a whole it could be noted that the seating system as a whole has not changed much. On comparing the weights of an entry level manually actuated seating system with a high-end luxury motorized seating system, the difference in weight could be almost 100% in certain cases. The demand for luxury in seating systems gave way for motor powered seating systems. The OEM's kept on adding more and more actuators, wiring harnesses and control systems for every manually operated actuation rather than redesigning the seating structure owing to time and cost effects. This trend resulted in the seating systems to be one of the most complicated systems in a vehicle. Thus this paper will discuss a possible solution towards cutting down the weight of the seating system as a whole by introducing a modular actuator design.

Keywords: Automotive seat; weight reduction; emission; seating system

1. INTRODUCION

The automobile industry has become more complex with constant improvements to old systems. Interiors of an automobile have seen a major shift towards luxury in the last three decades. The luxury to have automatic systems over mechanical systems enticed people and the companies alike. All the mechanical systems were fully or partially automated to satisfy a perceived demand for luxury and comfort. Automated seats and other automated systems in the interior of an automobile became a major marketing strategy for these companies. As a result, the current interior systems are a cluster of complicated subsystems with all the different actuators and a network of wiring harnesses. Hence a requirement of optimization of the subsystems arose owing to companies wanting to shave off the weights from their offering wherever possible. There are adequate measures for software, sensor and electronic optimization. Mechanical improvements of these systems could be perceived to be saturated in the current industry but still, there are possibilities of innovative methods to optimize. This paper will discuss the strategy and the possible improvements to the redundancy of actuators in seating systems

2. REASONS FOR REDUCDANCY IN THE SEATING SYSTEMS

Historically the developments in any automotive systems have come in the form of improvements over the existing systems rather than a complete redesign of that system. The strategy the manufactures relied on was to carry over designs with slight improvements made to them. Carryover design strategy implies using parts from a predecessor vehicle program to a successor program. This strategy reduced the burden of high cost of creation for new prototypes owing to testing, complying with safety standards and the lead time to bring a new design to the market as a finished design to the market. But it was a tradeoff to the best possible design. Though focus towards the optimization of sensors and other electronics have increased in recent years, the actuators used and the other mechanical systems still conform to the traditional trends of the industry.

Also, consumer perception of premium feature(s) can be held accountable for a rise in automated features. Looking into the timeline of feature demand over the years its evident demand and race grew parallel & non-linearly. Manufactures had to meet the demand by maximizing the carry over to keep the lead time short and business profitable.

Introduction of comfort ratings such as 'JD power rating' stating and perceiving the standards of comfort has also played a role in the trend of packaging the seats with all the features imaginable such as motorized actuators, seat heating system, massagers, ventilators, memory seats, biometrics etc. The addition of subsystems into the base frame of a seating system kept on increasing. These numbers are most likely to increase in the years to come with the introduction of autonomous driving automobiles. The industry is more than ever in a need of a quantifiable solution to address the rise in the redundancy with every new actuator.

3. NEED OF OPTIMIZATION

Critical assessment of actuator's percentage utilization vs. the load, both weight and electrical suggests a steep increase in terms of CO2 emissions. With the emission target of 95g/km of CO2 by 2020 [1], it evident that automotive industry has to explore beyond conventional strategies of achieving a reduction in weight. With

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increased automated features and subsequent increase in the number of actuators, there is a significant contribution of the actuator's weight to the total weight of the vehicle. Every actuator could bring an additional weight of up to ~20% of its own weight, in the form of connectors and wiring harness. It inherently increases level of complexity.

4. SEAT ACTUATOR CLUSTER

Figure 1 – Exploded view-Volvo XC90 driver seat

In a seating system, the mechanical adjustments were automated. This resulted in seats with 2 way to up to 16-way adjustment seats that are currently available. In the whole process, however, the seat structure had been carried with minimal or no change.

For the research of seat optimization, Volvo XC90 driver seat was chosen for evaluation. The study focuses on five major actuations including track movement, height adjustment, recline, thigh cushion and cushion length adjustment. Figure 1, shows the 10- way seat that houses at least five individual motors. Also, each motor brings along its own wiring harness and set of connectors. The system was reverse engineered to establish the architecture as shown in table 1. The parameters are primarily identified in terms of weight.

Table-1 –Seat parameters [2]

Existing Seat Adjustment Motors and Wiring Harness	
Total weight of the seat	29 (kg)
seat cushion	7 (kg)
seat back	8 (kg)
Weight of Seat power adjusters	9 (kg)
heat/cooling systems	0.75 (kg)
Wiring harness	4.25 (kg)

Approximating the utilization factor of actuators working compared to the overall drive cycle the utilization factor of actuators in seating system is less than 5 % (assumption based on driver seat); Table 1 quantifies the burden on onboard power due to the distributed actuator system. Any additional weight on the vehicle which is not serving functionality is a liability on the system. In this case, actuators are non-functional for more than 95% of the time. These losses/ weights are directly proportional to the emissions and footprint.

5. PROPOSED SYSTEM DESIGN

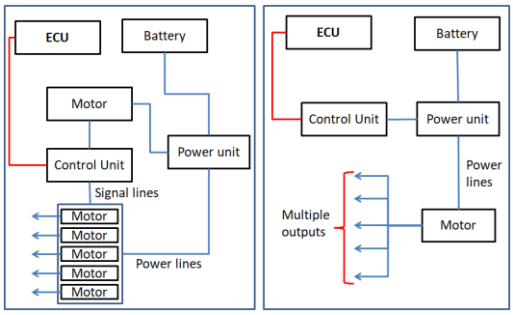

Figure 2 – (a) Actual system, (b) Proposed system

Figure 2a shows the current layout of the actuator's control in the seating system. This approach allows the addition of actuators depending upon the number of features. However, the noticeable adverse effect is that every additional actuator implies an additional weight of actuator, weight of wire harness, weight of connectors and power losses due to internal resistance.

Figure 2b shows the proposed design of optimized actuator arrangement such that all the functional attributes are performed by a single motor. There are several ways of achieving multiple outputs from a single motor with individual output control [3]. Experimental setup comprising a mechanical power train connected to electromagnetic clutches or using a direction changing mechanism would be key. Arrangements in terms of either positive linkage or flexible cable could be made to transfer motion from one central unit to respective physical location. The clutch based system would be capable of performing unidirectional sequential operations and the direction changing mechanism could be capable of performing bidirectional operations both parallel & sequential. An illustration of how the mechanism could potentially look like and how it could be mounted on to the existing seat structure as shown in figure 3

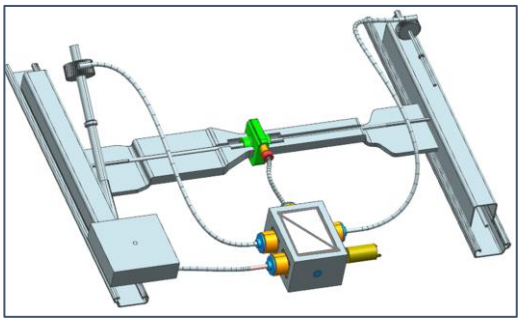

Figure 3 – Potential setup of the new system

The goal behind this system is to reduce the weight of the seating system without making major changes to the existing seat structure.

6. PROPSED REDUCTION IN WEIGHT OF THE SEATING SYSTEM

The proposed new architecture could be implemented to actuate different actuation using one motor. By replacing at least 5 actuators with one and a gearbox setup made with fiber filled silicon and flexible shafts, the weight of the new system could be ~4 kg + 1/5th of the weight of actuators and the wiring harness of the original system, which is 6.65 kg. Thereby the potential weight reduction of the seat could be 22.7% in total weight, 80 % in terms of weight of motor and 80 % drop in the weight of wire harness. Time-saving on the assembly line is an added advantage.
This establishes the due benefits of adopting the proposed actuator optimization strategy could potentially have.

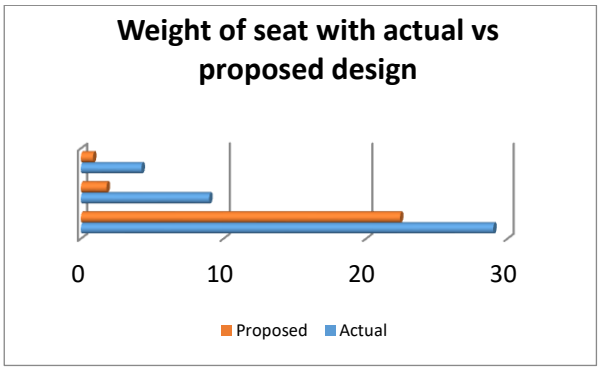

Figure 4 - Weight of seat with actual vs. proposed design

7. STRATEGY OF IMPLEMENTATION INTO MARKET

Stage 1: Subsystem level
Considering the complexity of actuators in the current vehicle system, it is recommended to implement the optimization strategy locally in stage 1. This should include driving the change at outsourcing stage, i.e. with a tier1 supplier for eg. Seating system, steering system etc. This would ensure an optimized system for OEM's.

Stage 2: System level
It would be the final stage of implementation for optimization. This could eliminate any redundancy of the actuators at the boundary of two subsystems. Evaluations can be made to allow the sharing of actuators across subsystem depending on complexity. This could allow for further reduction in the number of sensors.

8. REDUCTION IN EMISSIONS THAT COULD BE ACHIEVED

Figure 5 shows the percentage drops in weight of the overall seat. Considering an average consumer car of ~1300 kg with an average CO2 emission of 110g/km, [4], the percentage reduction in weight just by optimizing the seat is 1.73%. Furthermore, reduction in power losses due to lesser wires will contribute to power saving, resulting to further reductions in emission.

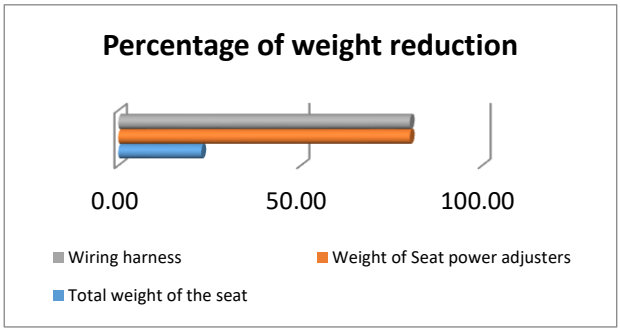

Figure 5 - Percentage of weight reduction

As per EU directive [4], [5] The CO2 saving per vehicle due to the reduction of weight by 100kg is equivalent to 6 g/km of CO2 per vehicle. Considering a percentage reduction of 1.73% implies a cost saving of ~€ 21 per vehicle, i.e. € 21 million per million units.

8. CONCLUSON

This paper provides compelling insight into actuator optimization of an automotive seat by presenting a modular approach. The experimental validation of this strategy could suggest a monumental potential in terms of weight and emission reduction by adopting modular best engineering practices. This learning could also be extrapolated to anticipate the behavior of the strategy at a broader level.

9. REFERENCES

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