Seat Design of Buses according to seat comfort survey for Improved Ergonomics

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Abstract: Driving a bus in Indian condition cannot be compared with developed countries because of the external factors like road condition etc. Driving a bus throughout the day in such conditions leads to various health problems for the drivers. The present investigation addresses to drivers' seat comfort. Comfort is a vital attribute that today's drivers are demanding the most. To design and develop a comfortable driver's seat, cheaper in cost and adds value to the customer is an important issue in an automotive industry. It is tough to design such a bus driver's seat. However, taking account all these things many researchers have put effort to design and developed a bus driver's seat considering various aspects (e.g. Biomechanical, materials, vibration absorption, safety etc.) which provides more comfortable value to driver with safety and operational durability, but still having a chance to do improvement in design and material to get an ideal designed bus driver's seat. This work aims to design and develop optimum bus driver's seat which is ergonomically satisfied have less weight and cheaper in cost. In a new design, driver car seat lever system is replaced by a press button mechanism and an automatic seat adjusting lock system used to restrict the movement.

Keywords – Anthropometry, CAD, Comfort, Ergonomic Study of Driver Seat, FEM.

1. Introduction

Many bus manufacturers putting effort to be competitive in the global market and to capture more market they are offering variety of new product to customers satisfying their requirements. This is important to frequently release new products. Most of the research findings concerning industrial and office chair design can be applied to automobile seat design. However, there are several important considerations unique to the mobile environment that should influence design recommendations. In particular, the control locations and sight line requirements serve to constrain postures to a greater extent than in most other seated environments. Safety concerns dictate that the driver be alert and continually responding to changing road conditions, and be positioned in such a way that the occupant restraint systems offer maximal protection in a crash. Automotive seats, which are in contact with vehicle occupants, play an important role in improving the comfort and work environment of a driver and passengers. The improvement of automotive seating systems, particularly for the driver, has been the subject of intense interest for many years, since a driver may feel more fatigue than passengers. Seat is one of the important features of vehicle and there is the place where the bus driver spends most of their time. Long route buses are unique in that they are specifically designed to carry passengers over long distances. The bus driver's seat, which is in contact with the driver, plays an important role to position the driver to perform the task of driving, meet the safety requirements, and be acceptable to the driver's comfort needs. The seat comfort is typically used to define short term effect of seat to the human body. Comfort is generic and subjective feeling that is difficult to measure, interpret and related to individual. The automotive industry strongly encourages research in the field of objective comfort assessment, especially dedicated to the seat and the related postures. Driver posture is one of the most important issues to be considered in the vehicle design process regarding not only the car and the user but also the experimental conditions. A simulation is the execution of a model, represented by a computer program that gives information about the system being investigated. The simulation approach of analyzing a model is opposed to the analytical approach, where the method of analyzing the system is purely theoretical. A simulation approach may be more reliable, depending on the quality of the model. Chang et al. [1] developed a practical method for measuring seat pan and seat back contours and a graphical presentation for visual evaluation. Seat designers can use this method for evaluating seat comfort such as support, fitness and accommodation. Cho and Yoon [2] developed a biomechanical model of humans on a seat with a backrest for evaluating the vehicular ride quality. Rakheja et al. [3] developed a model to study the seated occupant interactions with seat backrest and pan, and biodynamic response under vertical vibration. Wang et al. [4] studied the role of seat geometry and posture on the mechanical energy absorption characteristics of seated occupants under vertical vibration. The results show that the absorbed power quantity increases approximately quadratically with the exposure level by the person. The results also reveal that the absorbed power is strongly dependent upon the individual anthropometry variables such as body mass, fat, and mass index. But there is no real proof of the variables given. Computer-aided engineering (CAE) methods such as finite element analysis and simulation techniques have also been used to study and to develop vehicle seats. Some research used the seated man model, anthropometrics and low back pain problems to study the driver's ergonomics. In this paper, the design and suggestion of new improved design of driver's seat on Indian roads have been given.

2. Procedure

2.1 Old Car Driver Seat

In an old model of bus driver's seat, the seat movement is controlled by lever system. The liver system design is complex. The old bus driver's seat is shown in figure 1.

Apart from this old bus driver's seat produce jerk when the driver applied brake. The excessive jerk causes discomfort to driver. The driver move forward when brake applied but seat remains in his own position and time when driver again take place his original position he suffered from shock and jerk as shown in figure 2. In figure 2 red dotted lines indicates the initial condition of seat and blue dotted line indicates the driver position. When driver applied break the driver move forward and reach in new position which shown by line and again when driver reach original position, he suffered from shock and jerk which is shown by a red spot. This uncomfortness is reducing by design and optimization of the driver seat.

Fig. 1 Old bus driver's Seat Model

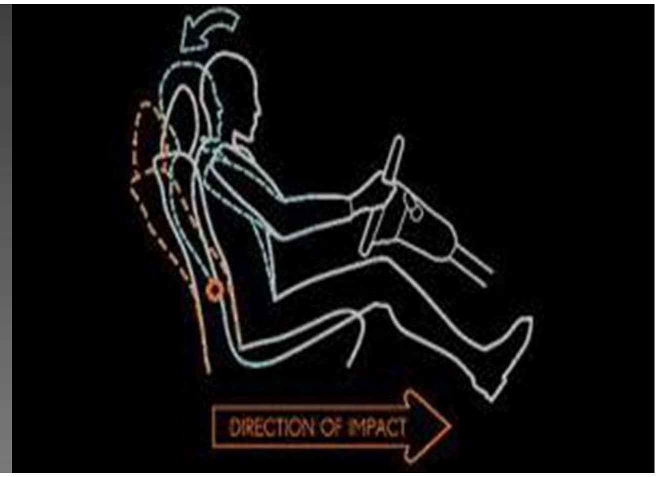

Fig. 2 Shock Impact While Applying Brakes

2.2 Design of New Driver Seat

The new bus driver's seat model postural angles in maximum and minimum position are shown in figure 3. All these postural angles are fulfilling the all ergonomically condition. In a new design, driver bus seat lever system is replaced by a press button mechanism and an automatic seat adjusting lock system used to restrict the movement.

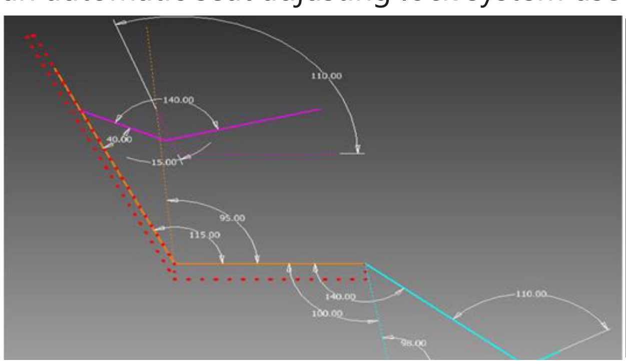

Fig. 3 Posture Angle of New Driver Seat

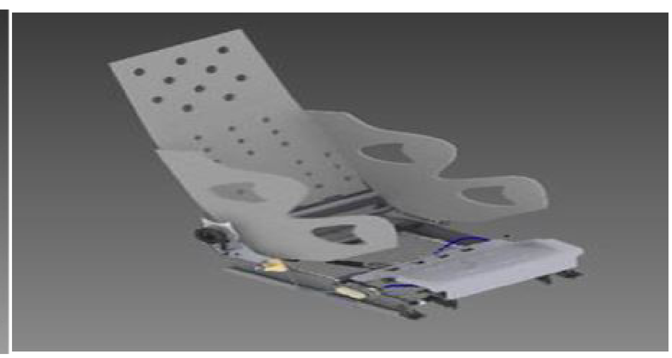

Fig. 4 New Model of Bus driver's Seat

The seat model has been established from three bodies, i.e., seat cushion, seat back and head restraint. These bodies have been connected to each other by three joints: one for the connection between seat cushion and its surroundings, one for the connection between seat cushion and seat back, and one for the connection between seat back and head restraint. These joints allow adjustment in the seat back angle and head restraint angle, but, in addition, re present the stiffness of the connections between seat cushion–seat back and seat back–head restraint. The joint choice for the connection between seat cushion and its surroundings depends on the application of the seat model and, therefore, in this paper it has been arbitrarily set to a translational joint. The seat back and seat cushion have been

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connected to each other by a revolute joint to allow rotations around the y-axis. A similar connection is implemented between the seat back and the head restraint. In this seat model the height of the head rest cannot be adapted. For seats that have an adaptive head restraint, this aspect can be included in the model by the definition of an extra-translational joint.

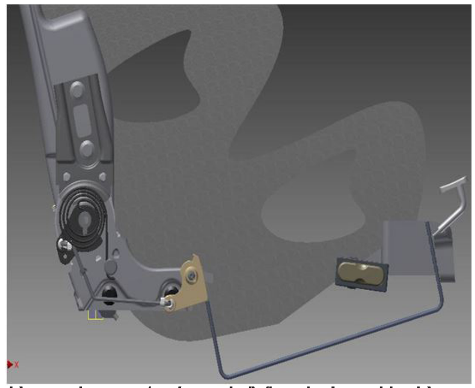


Fig. 5 New Bus driver's Seat Model with Press Button

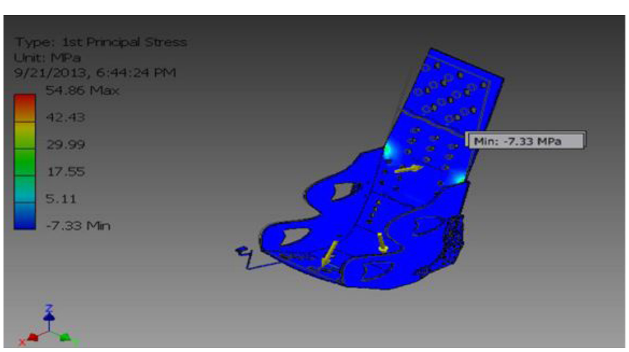
3. Simulation & Results

3.1 Simulation of New Driver Car Seat

Auto Desk Inventor software is selected for part simulation. The calculation of various properties of materials is done by Auto Desk Inventor design software. The properties which are taken as inputs for a multi-body seat model in Auto Desk Inventor are given below. For mass of head rest, seat back and seat cushion are-

- Moments of inertia of head rest, seat back and seat cushion.
- Location of the centre of gravity of the head rest, seat cushion and seat back.
- The lumped frame–foam stiffness's (loading and unloading) of the different parts in the seat cushion, seat back and head restraint.
- The lumped damping properties of the frame and foam.
- The joint properties (loading and unloading).
- Friction coefficient of the seat cushion and seat back.

The stress distribution in various parts of car seat is given in Figure 6.



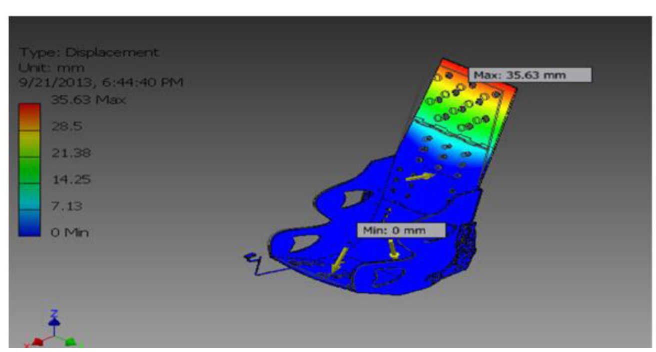


Fig. 6 Stress Distributions In Parts Of the Seat. Fig. 7 Displacements in Seat Parts

The figure 7 shows the maximum and minimum displacement of the seat due to factor of pressure force. Maximum displacement occurs at the upper part of the seat due to unsupported part of the seat. This figure 8 describe in about the safety factor in various zone.

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Figure 9 shows the pressure distribution in the various parts of seat where human body comes in contact with seat.

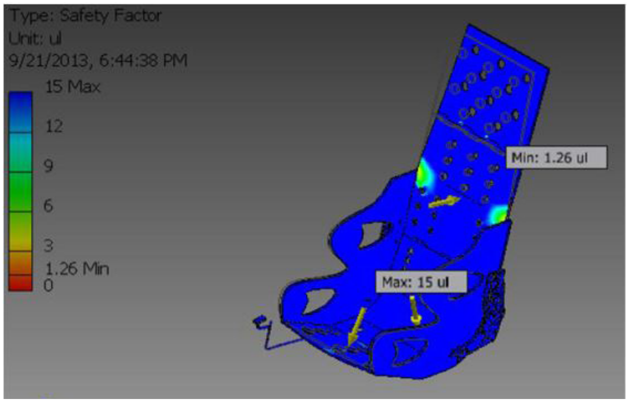

Fig. 8 Factor of Safety in Parts Of bus driver's Seat

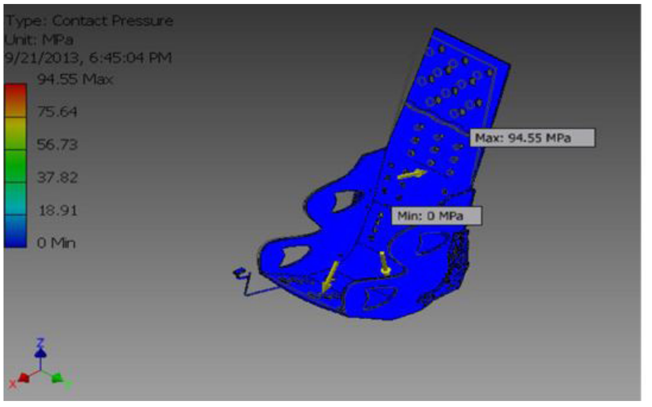

Fig. 9 Contact Pressure Distribution In Car Seat

3.2 Results

With the help of simulation we found out various properties and factors related to new car seat model. All these properties and factors like stress, strain, factor of safety, contact pressure and displacement of all the parts of the car driver seat are shown in the following table I

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Table 1 Simulation Results of Car Driver Seat

Name	Minimum	Maximum
volume	6220160mm³	
Mass	9.404 kg	
Von mises stress	0 MPa	65.7282MPa
1st principal stress	-7.32789 MPa	54.8644MPa
3rd principal stress	-57.8842MPa	4.54135MPa
Displacement	0 mm	35.6264mm
Stress XX	-29.041 MPa	21.1085MPa
Stress XY	-9.09781MPa	6.73652 MPa
Stress XZ	-30.8444 MPa	34.1474MPa
Stress YY	-37.0047MPa	20.1611 MPa
Stress YZ	-17.5148MPa	20.547MPa
Stress ZZ	-377234MPa	31.4927MPa
X Displacement	-34.3753 mm	4.52457 mm
Y Displacement	-4.98736mm	4.93369mm
z Displacement	-9.86774mm	0.0533656mm
Contact pressure	0 MPa	94.5498 MPa
Contact pressure X	-52.7266 MPa	79.1514 MPa
Contact pressure Y	-28.4631 MPa	24.8802 MPa
Contact pressure Z	-38.3764 MPa	50.8811 MPa

4. Conclusion

This paper presents different tools and methods used for optimization of structural properties of seats to reduce shocks while applying brake and the future perspective of making suitable changes in design to obtain better results. It will also serve an important guidance to the users for the selection of required cross-sectional properties at different positions and the most important load-carrying structural components of the bus driver seat. The work presented in this paper reports optimal design of the bus driver seat, taking into account various aspects (e.g. Biomechanical, materials, vibration, absorption, safety etc.) which provides more comfortable value to driver with safety and operational durability. Previously for adjustment of seat the lever system was used. In our work the lever system will be replaced by press button mechanism. Spring and plunger damping system is used to reduce shock during brakes applied by the driver. It will reduce unbalancing and help the driver to auto adjust himself. The designing and modeling and simulation of car driver seat are done on AUTODESK INVENTOR software model under different operating conditions.

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