Different Mode Shapes of Indian Human Body in Sitting Posture

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Abstract— Predicting the responses of the combined human body-seat structure to vibration excitation is still a challenging task. This is mainly due to the complex dynamics behavior of the seated human body in response to the vibration. Nevertheless, several applications, such as optimizing the vehicle seat structure or reducing the transmission of the vibration to the seat occupant, do not necessarily require complex modeling of the human body. It is however essential to characterize and predict the critical frequencies and the corresponding vibration patterns of the combined seat with human occupant. This study aims to predict the resonant frequencies and corresponding vibration mode shapes of the vehicle seat with occupant 76Kg Indian male. In the present study, have founded mode shapes of the human body at the different frequencies and theses mode shapes shows the deformation of the body on different parts.
Keywords: FEM, 76 Kg Indian Human Male, ANSYS, SOLIDWORKS, Mode Shapes

I. INTRODUCTION

The choice of a passenger automobile depends on factors, such as the vehicle type, brand, trend, security, its performance, interior space, interior design, additional equipment offered, etc. The seat comfort is a very important issue for the users. Long time driving usually results in manifestation of low back pain or other musculoskeletal disorders, caused by the discomfort of the seats. Accordingly, the expectations of customers regarding the seat comfort are continuously increasing. The manufacturers of seats for passenger automobiles have to respond to market requirements fast and appropriately and offer seats with higher quality and comfort. The manufacturers of automobile seats usually make prototypes for testing the comfort in order to achieve the desired results. Testing with prototypes is costly and time consuming process. Application of contemporary software products for virtual modeling of vehicle structure, as well as software products for simulation of processes and system behavior, reduces the time for testing of the new vehicle. Contemporary testing of new vehicles starts with virtual testing of virtual models, using virtual humans. The errors and inconveniences are reduced in the early phase. As a consequence, time and price for testing of new or improved vehicles are reduced. The final tests are applied on real models - prototypes. The basic components of the automobile's user comfort were determined: angles for placement of the human body and the necessary space for the foot controls, as well as the ranges of adjustments of the driver's seat and the steering wheel. Then we determined what influence of the parameters like variation of the spatial mechanical properties of the polyurethane foam, such as thickness and density, as well as the shape of the contact surface between user and seat, have upon the seating comfort of the automobile.

II. LITERATURE REVIEW

Dahil et al. [10] described the amplitude levels are low in certain frequencies; they reach very high amplitudes (peak points) at certain frequencies. The force implemented at these special frequency points, where the amplitudes peak, transforms more into vibration within the structure. The special frequency values, where the structure exhibit higher reactions against the implemented force, correspond to natural frequencies of the structure. Considering the lower frequencies, it is seen in the graphics that the casting leg would work better, while it is seen that the original leg would work better while considering the higher frequencies. Particularly considering the damping rates obtained, it can be concluded that casting leg showed better damping in first 2 modes in proportion to original leg, and that it would offer more comfortable and healthier journey by decreasing the vibration coming to passenger seat.

G. Tan et al. [21] presented that the blast loading on the human surface was generated from the simulated C4 blast explosions, via a novel combination of 1-D and 3-D numerical formulations. We used the explicit finite element solver in the multi-physics code Cobi for the human body biomechanics. This is capable of solving the resulting large system containing millions of unknowns in an extremely scalable fashion. The meshes generated for these simulations are of good quality. This enables us to employ relatively large time step sizes, without resorting to the artificial time scaling treatment. In order to study the human body dynamic response under the blast loading, we also developed an interface to apply the blast pressure loading on the external human body surface. These newly developed models were used to conduct parametric simulations to find out the brain biomechanical response when the blasts impact the human body. Under the same blast loading we also show the differences of brain response when having different material properties for the skeleton, the existence of other body parts such as torso.

Shiva Kumar et al. [13] conducting simulation test and design of experiments for comfort car seat design, it was found that the combination of 5 KPa foam hardness, 6 mm wire diameter, 3 wires and lower position of the wire was found to be optimum which in turn has resulted in better stiffness of back and cushion foam. This combination has resulted in achieving the target H-point specified by original equipment manufacturers. Foam hardness, wire diameter and wire position are contributing significantly, and there is also interaction among these factors, whereas number of wires is not playing a significant role.

U. More et al. [18] study was done in static condition. The analysis was done based on different criteria like fit parameters related to anthropometric measurements, feel parameters and support parameters defined with respect to seated posture. Particularly attention is given to appropriate lumbar support where five seats were quantified and compared to the survey information. Based on above analysis it is observed that seat A has less lumbar support than other seats.

Uttam Y. et al. [19] described a model of new seating system for vibration response is developed and it analyzed by simulation for purpose of minimizes human body responses. In this analysis, finite element advance is used to analyze the vibration feature of seating system by determining the natural frequency for steel and cast iron material. The analysis result shows that individual steel and cast iron material are showing resonant frequency in hand rest of seat so we change the material of the arm rest. On the basis of FE analysis result, we can conclude that both steel and cast iron material combination would be a better choice for seat assembly to avoid the resonance phenomenon so the natural frequency of seat component must be separated from frequency of the human body parts.

Zhang et al. [22] study has quantified the transmission of forehand- aft vibration from the base of a car seat to the seat pan surface, to the backrest, to the headrest and to the corresponding positions on the seat frame. There are large differences between the fore-and-aft transmissibility of a seat when measured with a manikin and when measured with human subjects, consistent with the human body having dynamics very different from those of a rigid mass. There are non-linearity's in seat transmissibility's measured both with a manikin and with human subjects, which may be explained by nonlinearity in the biodynamic of the human body and non-linearity's in the responses of the seat and the manikin.

III. Objective of the Study

1) To make 3-D CAD model of 76 kg Indian male human subject and seat of the car.
2) To perform modal analysis of the 3-D CAD model of Indian male human subject of mass 76 kg in sitting posture on a car seat and find out the mode shapes.

IV. Methodology

Modal analysis of 76 kg model of a human subject in sitting posture assembled with seat has been performed using FEM in ANSYS 16.0 workbench. The part file generated in SOLIDWORKS software and then saves in STEP file format converted into ANSYS software, and while performing modal analysis, the mesh has been created utilizing automatic elements since automatic elements are stiffer and give better outcomes in complex structures contrasted with different elements. Amid investigation, limit conditions were taken by considering feet and seat base to be fixed and physical properties of a human subject have been viewed as homogeneous and isotropic in nature.

V. Geometric Modeling and Finite Element Analysis

A. Sketcher:

Sketching is valuable for making unpredictable limits or for following with a digitizer. Determine the article type (line, polyline, or spline), augmentation, and resilience before sketching.

B. Modeling:

SOLIDWORKS software is utilized to make 76Kg human body and car seat assembly. SOLIDWORKS is an intuitive PC supported structuring and assembling framework. The miscreant capacities robotize the typical building, plan and drafting abilities found in the present assembling organizations. Formation of a 3-D model in SOLIDWORKS can be performed utilizing three workbenches for example sketcher, displaying and assembly.

C. Finite Element Analysis:

The finite element method (FEM), is a numerical method for taking care of issues of designing and mathematical material science. Common issue zones of intrigue incorporate basic examination, heat exchange, liquid stream, mass transport, and electromagnetic potential. The investigative arrangement of these issues for the most part requires the answer for limit esteem issues for halfway differential conditions. The finite element method definition of the issue results in an arrangement of logarithmic conditions. The method approximates the obscure capacity over the domain.[1] To tackle the issue, it subdivides an extensive framework into littler, less complex parts that are called finite elements. The basic conditions that model these finite elements are then collected into a bigger arrangement of conditions that models the whole issue. FEM then uses variation methods from the analytics of varieties to estimate an answer by limiting a related mistake work.

D. Mesh Generation and Boundary Conditions:

ANSYS Meshing is a broadly useful, canny, mechanized elite item. It creates the most proper work for precise, productive multiphasic arrangements. A work appropriate for a particular investigation can be created with a solitary mouse click for all parts in a model. Full powers over the alternatives used to create the work are accessible for the master client who needs to calibrate it. The intensity of parallel handling is consequently used to lessen the time you need to sit tight for work age. ANSYS Meshing knows about the sort of arrangements that will be utilized in the task and has the proper criteria to make the most appropriate work. ANSYS Meshing is consequently incorporated with every solver inside the ANSYS Workbench condition. For a snappy examination or for the new and rare client, a usable work can be made with a single tick of the mouse. ANSYS Meshing picks the most fitting choices dependent on the examination type and the geometry of the model. The feet of the human body and base of the car seat are kept fixed.

VI. RESULTS AND DISCUSSIONS

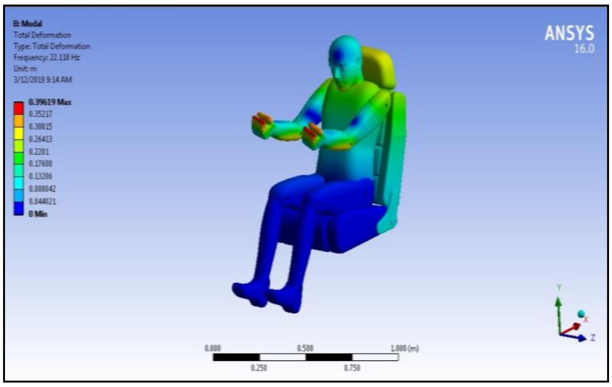

Fig. 1: Mode shape of 76 kg human subject at natural frequency 22.118 Hz

At first mode, at the natural frequency of 22.118 Hz as shown in Figure 1, the motion of upper body segments i.e. head, neck, both arms, and hands has been observed in the lateral direction. Also, maximum deformation is located at hands and no deformation is obtained at feet and base of the seat. It might be due to reason that feet and seat base are fixed to the ground. The maximum deformation occurs on the both hands. Feet and seat base are fixed therefore no deformation occur on the lower body.

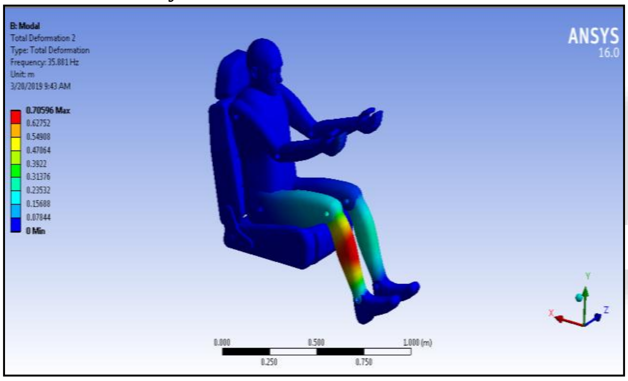

Fig. 2: Mode shape of 76 kg human subject at natural frequency 35.881 Hz

At second mode, with a natural frequency of 35.881 Hz as shown in Figure 2, a motion of all segments of human subject except lower body in the lateral direction is observed with maximum deformation at right leg. The right leg tends to bend in the lateral direction but minimum effect occurs on the left leg. No vibration effect occurs on the upper body i.e. Head, arms, neck etc.

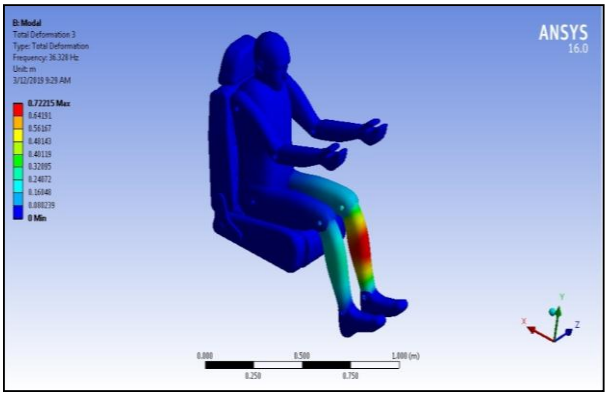

Fig. 3: Mode shape of 76 kg human subject at natural frequency 36.328 Hz

At third mode, from Figure 3, it has been observed that at natural frequency of 36.328 Hz, body segments of human segments i.e. legs are deformed in the lateral direction. No deformation occurs at head and maximum deformation at left leg and minimum deformation occur on the right leg.

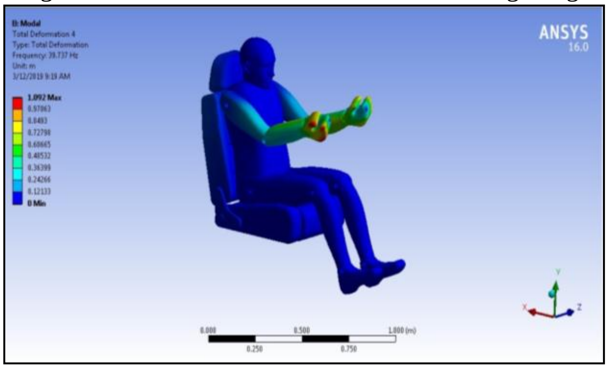

Fig. 4: Mode shape of 76 kg human subject at natural frequency 39.737 Hz

At fourth mode, it is observed from Figure 4, at natural frequency of 39.737 Hz that the maximum deformation occurs at both lower arms of human subject in lateral direction. The maximum effect of vibration occurs at lower arms.

VII. CONCLUSION

The maximum effect of vibration on the body of the human subject is observed on the left leg, right leg and on the both hands. At first mode, at the natural frequency of 22.118 Hz as shown in Figure 2, the motion of upper body segments i.e. head, neck, both arms, and hands has been observed in the lateral direction. Also, maximum deformation is located at hands and no deformation is obtained at feet and base of the seat. It might be due to reason that feet and seat base are fixed to the ground. The maximum deformation occurs on the both hands. Feet and seat base are fixed therefore no deformation occur on the lower body. At third mode, from Figure: 4, it has been observed that at natural frequency of 36.328 Hz, body segments of human segments i.e. legs are deformed in the lateral direction. No deformation occurs at head and maximum deformation at left leg and minimum deformation occur on the right leg. At fourth mode, it is observed from Figure 5, at natural frequency of 39.737 Hz that the maximum deformation occurs at both lower arms of human subject in lateral direction. The maximum effect of vibration occurs at lower arms.

A. *Future Scope*

The present work can be extended in following directions:

1) Experimental study can be performed to validate results obtained in current study for Indian male human subject.

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