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Design Of Test Rig For Motorcycle Seat For Human Comfort

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Abstract: *Today, a rebellious race is taking place among the automobile industry so as to produce highly developed models and the automobile industry has seen a market shift towards sport-utility vehicles. In order to maintain the level of comfort that customers expect from vehicles and still maintain the high safety standards of automobiles, attempts are made to develop an ideal vehicle (motorcycle) which is aesthetically pleasing, ergonomically running and most important is safety. This work solves the problems of human discomfort procured from riding the motorcycle. Seat of motorcycle is one of most important component of vehicle and which are in direct contact with the drivers. From last few decades the majority of Indian population depends upon two wheeler motorcycle and mopeds. Due to improper design and bad road condition riders subjected to extreme vibration. In this project new modified seat developed and compare with existing seat of two wheeler with different weight condition.*

Keywords*: Lumber support, lower back pain, seat design and analysis, FEA*

I. INTRODUCTION

In the overall Asia zone and especially in India two wheelers (motorcycles and mopeds) are an important transportations tool of people for daily activities. Motorcycle are preferred as they are compact, less fuel consumption, pass easily through congested areas as in cities as well as villages, it is quite cheaper to buy and require less maintenance as compared to cars. Instead of these advantages motorcycle riding is a relatively complex and risky process as compare to cars. Motorcycle riders exposed to a variety of hazards in their surroundings especially on bad condition roads.

Apart from that, the motorcycle seat has complicated challenges for design adjustments to engineers about seat comfort and safety aspects. The majority of the motorcycles seat design is not equipped with a backrest support. Therefore, the motorcyclists tend to adopt a variety of postures during their riding process in order to balance the equilibrium of stresses in their body (Karmegamkaruppiah, et al, 2008). The mechanical vibrations of motor cycle are most hazardous to the health (WBV)(Adam M A, et al, 2006)[2]. There only few studies that has specifically examined the effect of exposure by developing models.

Under this paper, the Critical Survey carried out in Nagpur city (Maharashtra State, India) for problem identification of lower backbone pain in two wheeler operators (motorcyclist) due to drawback in recent seat designs. In this survey, more than 500 motorcyclists or two wheeler riders (subjects) interrogated for lower backbone pain study by questionnaire. Based on survey, it has found that in an average 45% - 62% motorcyclist facing the musculoskeletal problem i.e. lower backbone pain (LBBP) in whole body vibrations (WBV) especially between ages of 30-65 years. Which demanding the better design of seat for seating comfort or it is a need of thousand and lacks of two wheeler riders that is motorcyclists to redesign recent seat with lumbar support. Hence, this paper has objectives of redesign of seat with the help of different type of study.

II. LITERATURE REVIEW

1. Literature: - A finite element model of seat cushion indentation with a soft tissue human occupant model.

This paper presents a finite-element study simulating the deflection of seat cushion foam and supportive seat structures, as well as human buttock, thigh and lower back soft tissue when seated. A 6mm neoprene layer was offset from the shell to account for the compression of body tissue expected through sitting in a seat. The thigh-buttock model is therefore made of two layers, covering thin to moderate thigh and buttock proportions, but not more fleshy sizes. To replicate the effects of skin and fat, the neoprene rubber layer was modeled as a hyper elastic material with viscoelastic behavior in a Neo-Hookean material model

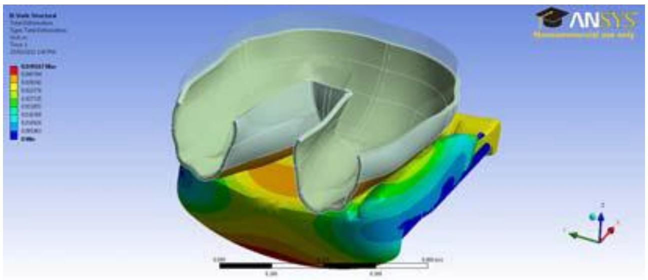


Figure 2.1. Two-layer, rigid steel and flexible skin (neoprene) indenter model in ANSYS V13

2. Literature: - Lumbar support using motorcyclist anthropometric characteristics.

This research shows that motorcyclists in Malaysia experience during the riding process symptoms of discomfort on various parts of their bodies, particularly the lower part of the back (lumbar) area. Similarly, other researchers have also found that sitting for a prolonged duration of time in a vehicle can cause great intradiscal pressure in the lumbar region and consequent low back pain. The lumbar region is also the most vulnerable part of the spine as this part is suspended between the upper heavy part of the body including the rib cage and the lower and lighter part starting from the hip-bone.

Therefore, this lumbar region should be supported by a backrest. However, in Malaysia the current design of motorcycles does not incorporate this feature. Consequently, motorcyclists assume a variety of postures as figure 8 during their riding to balance the intradiscal pressure in their lumbar region. However, the developed design was lacking in some important ergonomic characteristics, i.e. anthropometric dimensions, owing to the unavailability of this information during the study period.

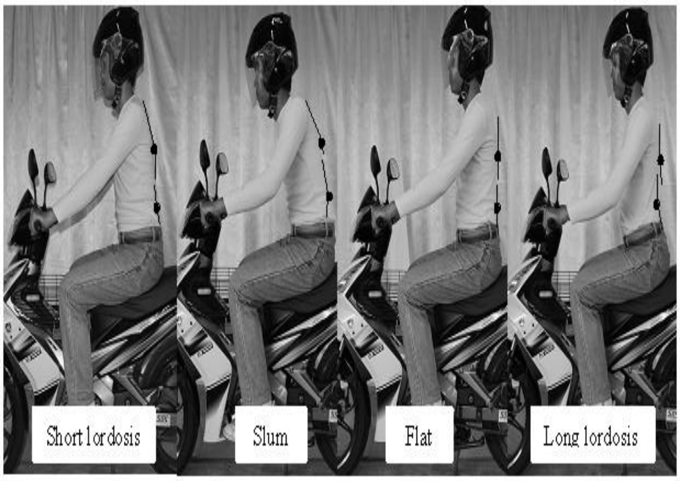


Figure 2.2 Variety of riding postures

3. Literature:- Evaluation of motorcyclist's discomfort during prolonged riding process with and without lumbar support.

In Malaysia, motorcycles and cars are rated as two important transportations for people's daily activities. However, motorcycles are preferred as they are economical for purchase, less consumption of fuel, easy for driving from congested areas, and less maintenance compared to cars. Despite these advantages, motorcycle riding is a relatively complex and risky process. Motorcyclists are exposed and vulnerable to a variety of hazards in their surroundings. Hence, study was conducted in a controlled room, in the Department of Mechanical Engineering, Polytechnic of Sultan Azlan Shah, and Perak, Malaysia. The study population consists of 100 motorcyclists from same Polytechnic. The independent variables in this study were are motorcycle with and without the lumbar support figure.2.3 and the dependent variables were the motorcyclists discomfort in body parts.

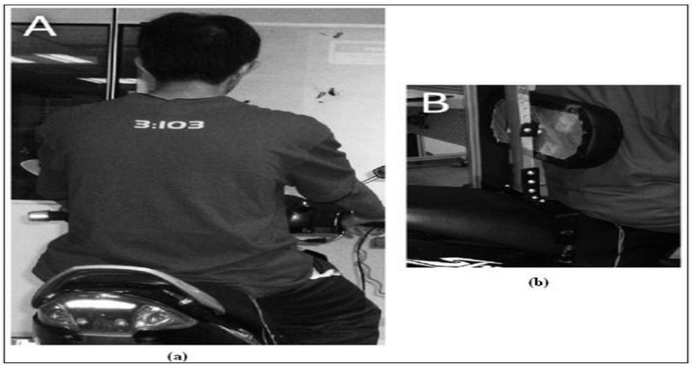


Figure 2.3 Motorcyclists sitting a) without & b) with prototype (lumbar support)

The participants were required to sit on the static motorcycle in a controlled room environment. The duration of the testing was 2 hours. At 15-minute intervals, participants were required to evaluate their discomfort level on the Borg's CR-10 questionnaire. There were two sessions for the testing, the first without the lumbar support and the second with the lumbar support .

The Borg Scale Rating ($\geq$ 5) is considered as the 'break point' or, in other words, as the point where the participants rated their discomfort as strong. Thus, in this study, this point was considered as the point where the participants started to feel the discomfort in their relevant body parts. The results of this discomfort 'break point' with and without the lumbar support prototype shown in Table 1.

Table 1
Discomfort 'Break Point' data distribution (Borg Scale Rating≥5)[15]

		Borg Scale Rating (≥ 5) at end time period (minutes)			
		Male(n=50)		Female (n=50)	
Body Part	Condition	Time Period (minutes)	% of comfort changes (±)	% of comfort changes (±)	% of comfort changes (±)
Neck Or Head	W/O	75	+20.0	90	+16.7
	W	90		105	
Shoulder	W/O	75	+20.0	90	+16.7
	W	90		105	
Upper Back	W/O	60	+100.0	75	+60.0
	W	120		120	
Arms & Hands	W/O	90	+16.7	75	+40.0
	W	105		105	
Low Back	W/O	60	+100.0	75	+60.0
	W	120		120	
Buttocks	W/O	75	+40.0	90	+16.7
	W	105		105	
Thighs	W/O	105	+14.3	105	+14.3
	W	120		120	
Knees	W/O	105	0	105	+14.3
	W	105		120	
Calf	W/O	120	0	105	+14.3
	W	120		120	
Ankles & Feet	W/O	105	+14.3	105	+14.3
	W	120		120	

Note: - W/O = assessment without 'Lumbar Support Prototype'; W= assessment with 'Lumbar Support Prototype'

The results indicated that there is a positive effect on the body part's comfort with the usage of the lumbar support prototype. The highest comfort changes in male participants were seen in the low back and upper back, both recorded +100% changes with the usage of the lumbar support prototype. Similarly, the female participants also recorded the highest comfort changes in low back and upper back with +60.0% changes, respectively.

III. DESIGN & REDESIGN OF TWO WHEELER SEAT

The dimensions of the present seat of two-wheeler are taken by its physical (manual) measurement. The most popular two wheelers seat dimensions are nearly same. Present seat of two wheeler given name as SEAT A and redesigning of present seat of two-wheeler is name as SEAT B.

The dimensions of SEAT B for redesign are calculated from the study of anthropometric characteristics data available in review papers and dimensions of seat choose from costly two wheelers which are available in market. These are some costly two wheeler having comfort seats, but cannot affordable to common people. Hence under this project, it is sincere effort to redesign the present defective seat (Seat A) to avoid and minimize the Lower Body Back Pain (Lumbar Pain) and provide better comfort seat for short as well as daily long drive in same regular economical two wheelers which are choice of common people.

3.1Two Dimensional Design

3.1.1 DRAWING OF PRESENT SEAT (Seat A)

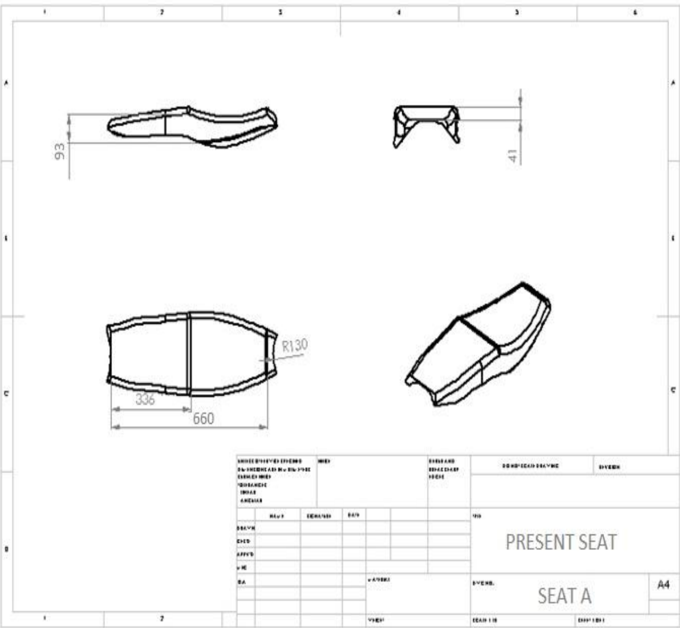


Figure 3.1 Two dimensional design of seat A

3.1.2 DRAWING OF REDESIGN SEAT (Seat B)

The dimensions of the redesign seat (SEAT B) is calculating and final as on base of anthropometric characteristics data and from study of Royal Enfield Bullet- 350 two wheeler. In the study of dimensions for seats, it is found that the area of seat particularly area under motorcyclists buttock-cushion is quit less. Also front (rider's) seat surface is somewhat round in shape and there are mostly bad conditions of Indian roads. Thus riders receive mechanical vibrations through seat. Because of these reasons mechanical vibration are transfers to vertebra (back side) of riders through seat and especially due to small area of buttock cushion of seat it is directly transfer to lumbar of riders. These mechanical vibrations are most hazardous to the health for musculoskeletal symptom in the lower backbone pain, degeneration of the spine, rupture and compression of lumbar and whole body vibration (WBV).

Hence to overcome these problems, the buttock cushion area of seat is increases which is inversely proportional to weight (force) of riders. By increasing surface area of buttock seat, whatever the vibrations transfer to lower back and vertebra will may be reduce and hence stress and fatigue in lower back (lumbar) will be reduce. This will make comfort and safety seat for two wheeler riders.

We have,

Stress = Force / Area

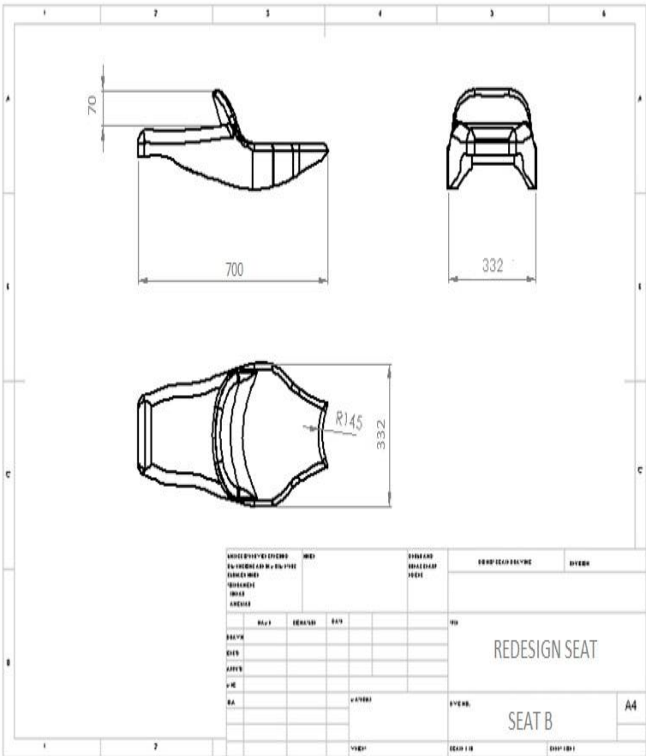


Figure 3.2 Two dimensional design of seat B

3.2 Three Dimensional Design

Three dimensional designs of seat models are developed in Solid Works CAD software. Both models of seat A and seat B are shown in

3.2.1 Design of Seat (Seat A)

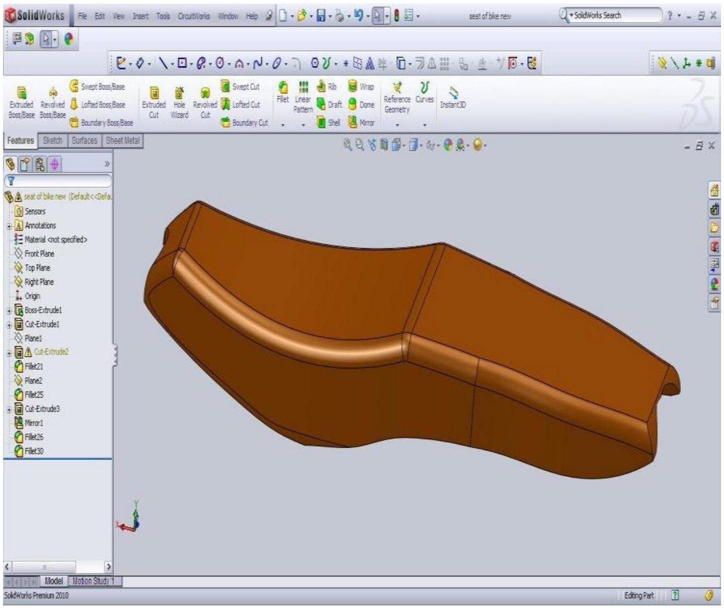


Figure5.3Three dimensional design of seat A

3.2.2 Design of New Seat (Redesign - Seat B)

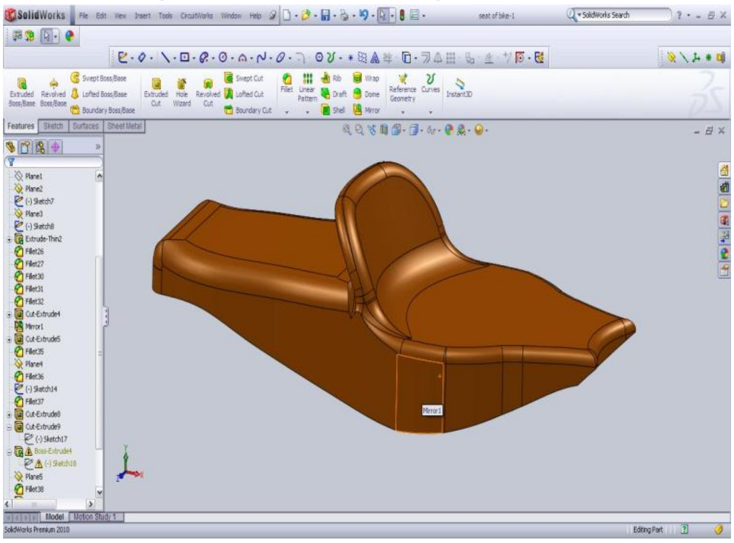


Figure 3.4Three dimensional design of seat B

IV. SELECTION OF MATERIAL OF SEAT

Material of seat is one of the major part of seat comfortless. The most popular and preferable material of seat is 'CARBON FIBER'. After the study of seat materials it is found that carbon fiber is used in large number of applications due its versatility, strength and durability which make it valuable in seat manufacturing.

4.4.1 Some of its major benefits including: -

- 70% lighter than steel, 40% lighter than aluminum
- High strength to weight ration
- High corrosion resistance
- Application flexibility
- Low mass

4.4.2 Characteristics and properties of carbon fiber: -

Table 4.1 Characteristics and Properties of Carbon fiber

Carbon Fiber	
Structural	Add/Remove Properties
Young's Modulus	70000 MPa
Poisson's Ratio	0.33
Density	1.7e-006 kg/mm³
Thermal Expansion	2.3e-005 1/°C
Alternating Stress	
Tensile Yield Strength	4800. MPa
Compressive Yield Strength	4800. MPa
Tensile Ultimate Strength	6.e+005 MPa
Compressive Ultimate Strength	6.e+005 MPa
Thermal	Add/Remove Properties
Thermal Conductivity	
Specific Heat	154. J/kg·°C

V. FINITE ELEMENT ANALYSIS OF SEAT A & SEAT B

5.1 MODELING DATA

For generation of 3D model of seats various geometrical features and dimensions are selected from observation and critical study of recent seats of two wheelers.
SOLIDWORKS is used for creating solid model of both seats (Seat A& Seat B) which is imported IGES file to ANSYS V11, as shown in figure 5.1,

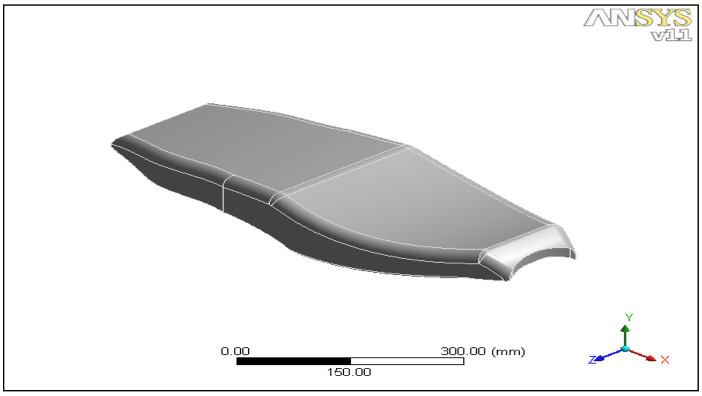


Figure 5.1 Model of Seat A (without lumbar support)

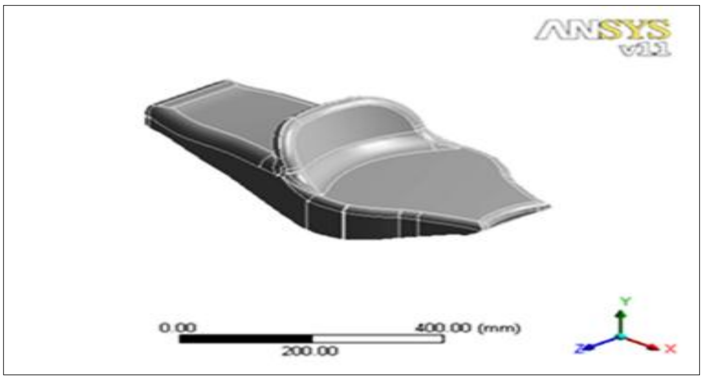


Figure 5.2 Model of Seat B (with lumbar support)

5.2 Meshing of Seat

A model prepared in workbench is used for static analysis. A structure Tetrahedral Solid element is used for creating FE model of two different seats and a fine meshing is carried out. The meshing model created is shown in figure as,

SEAT A

Statistic analysis takes place on seat A so that its number of nodes and elements are given as follows,

Statistics	
Nodes	9861
Elements	5075

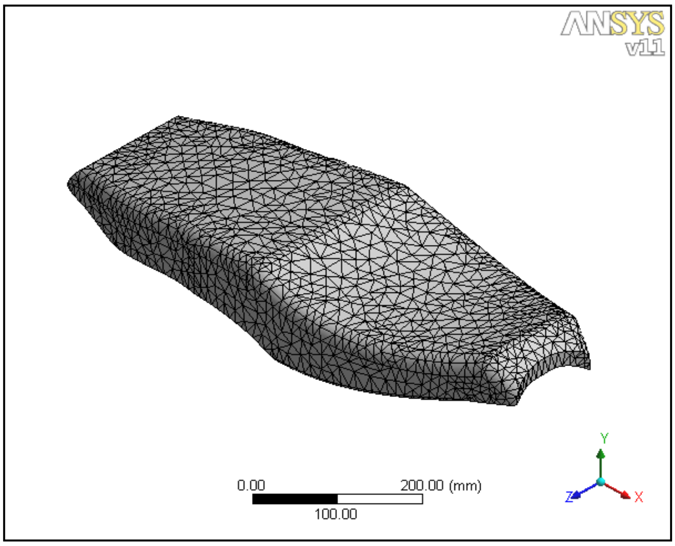


Figure 5.3 Tetrahedron Type of Regular Meshing of Seat A

SEAT B

Advanced	
Relevance Center	Fine
Element Size	Default
Statistics	
Nodes	17282
Elements	9462

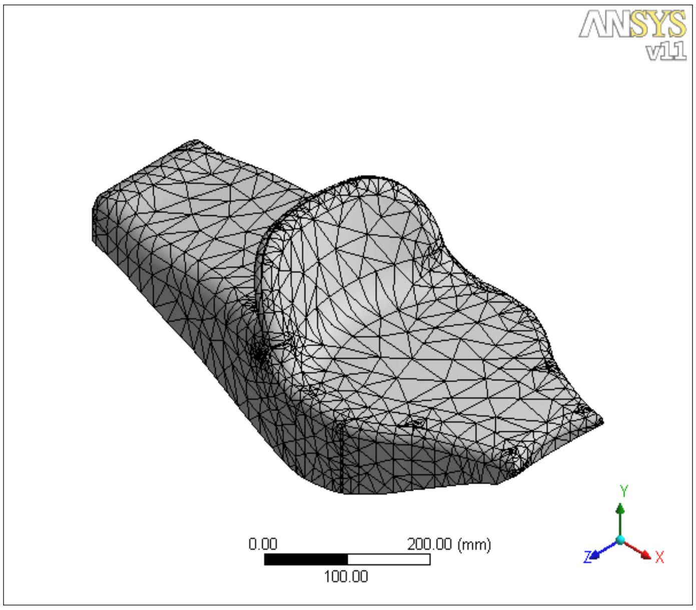
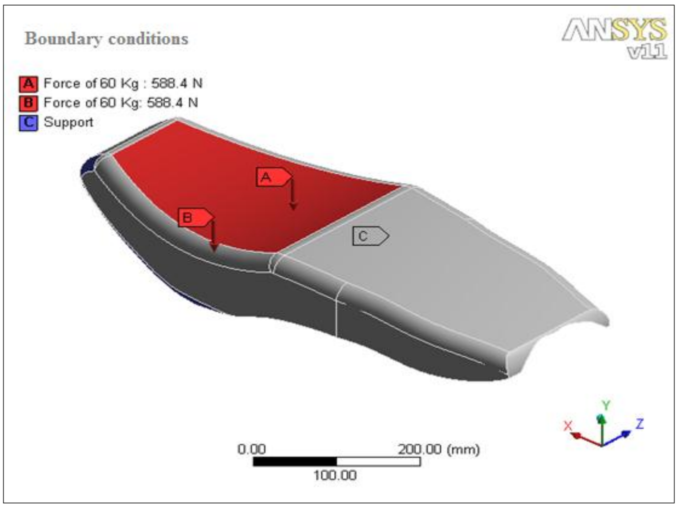


Figure 5.4 Tetrahedron Type of Regular Meshing of Seat B

5.3 Boundary conditions

Two wheeler seats are fixed and various forces and conditions are applied on bunch of nodes of the upper surface of seat (buttock area of rider) force (load) in downward direction.

In this project as the FE analysis consider various weights in terms of forces acting on the seat, considering different general weight of the wheeler riders are 60kg, 70kg, 75kg and 80kg respectively. All loads (weights) which will be acting along the vertical Y- axis on the seats (Seat-A and Seat-B).



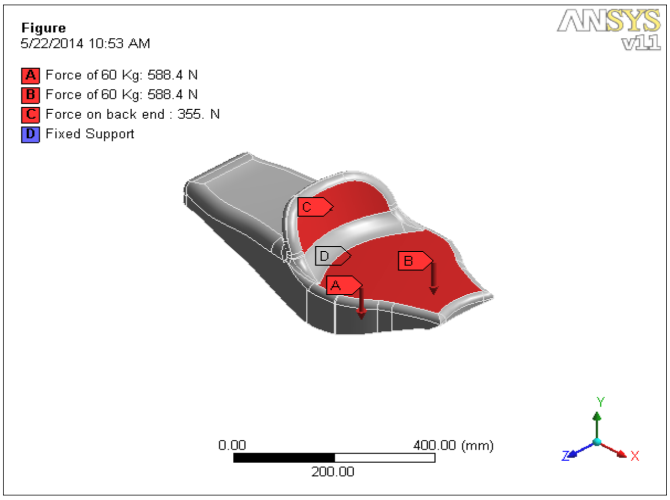


Figure 5.5 & 5.6 Boundary conditions on seat A & seat B

5.4 Different loads applied on seats (Seat A & Seat B)

1 kilogram = 9.80665002864 N

Table 5.1 loads applied on seats

Case No.	Seat A	Seat B
1	60 kg	60 kg
2	70 kg	70 kg
3	75 kg	75 kg
4	80 kg	80 kg

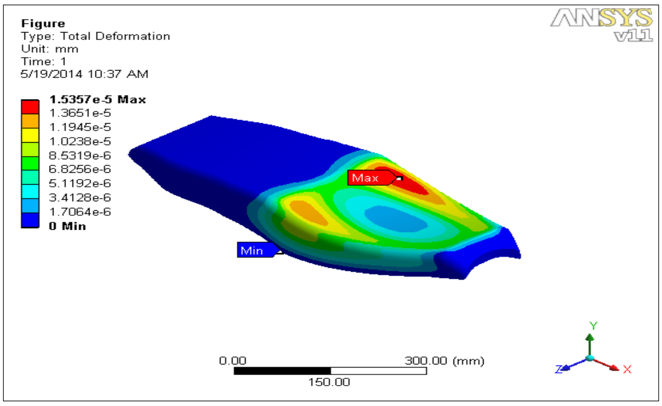
5.5 Different types of properties of force analysis on seat

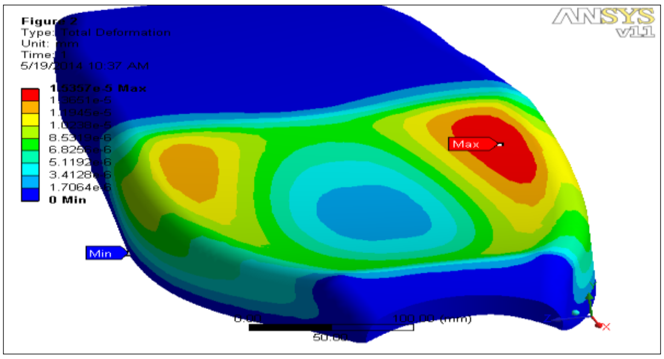
1) Total Deformation Results
2) Equivalent / Resultant Stress Induced
3) Maximum Shear Stress
4) Normal Stress

VI. RESULT OF FEA IN ANSYS RESULT OF SEAT A

6.1A Case 1A- Applied Weight of 60 Kg

6.1.1 Total Deformation Results

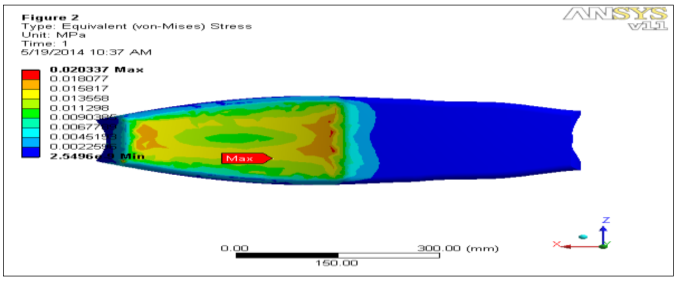




6.1.1 Total Deformation Results

(Maximum Deformation occurs in seat is 1.535 X 10-5 mm)

6.1.2 Equivalent / Resultant Stress Induced



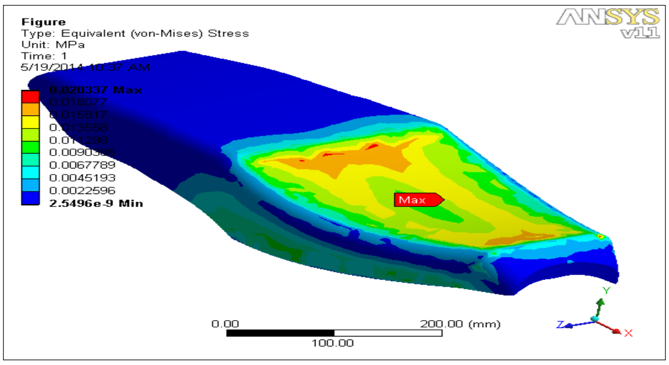
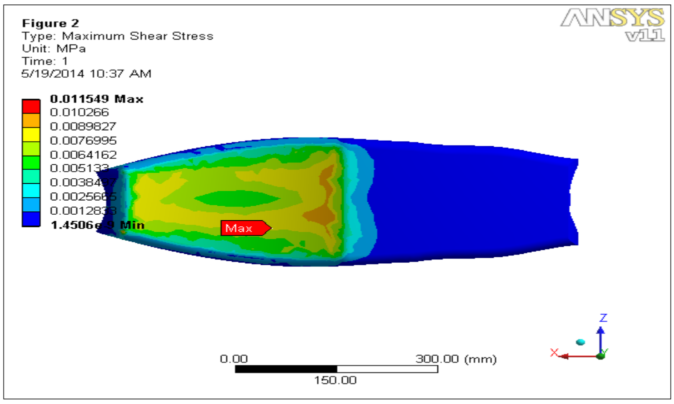


Figure6.1.2 Equivalent / Resultant Stress Induced in seat

6.1.3 Maximum Shear Stress due to Impact



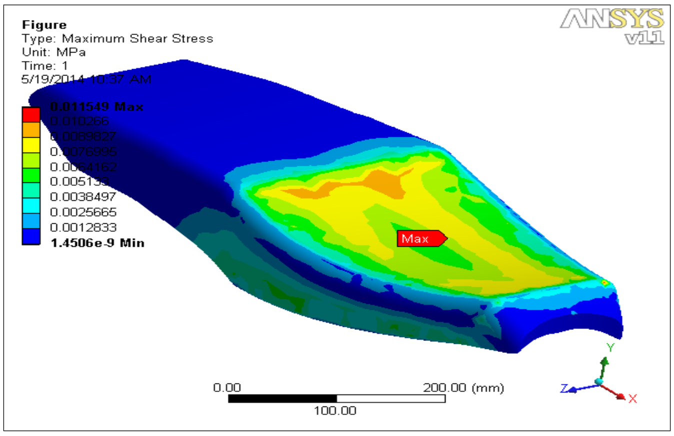


Figure6.1.3 Maximum Shear Stress due to Impact

6.1.4 Normal Stress Developed

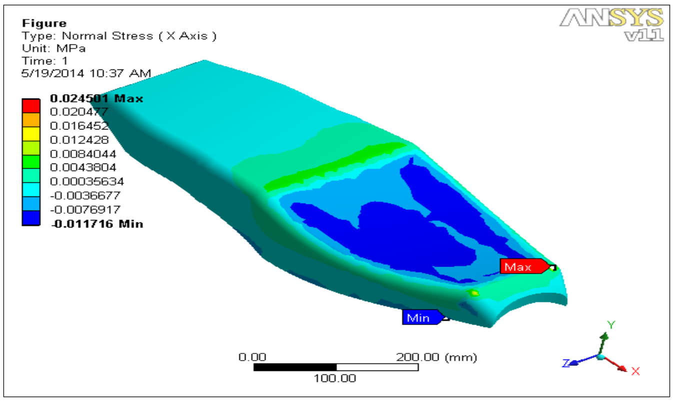


Figure6.1.4 Normal Stress Developed

VII. RESULT OF FINITE ELEMENT ANALYSIS COMPARISON BETWEEN SEAT A & SEAT B

7.1 Applied Load 60 kg

Sr. No.	Properties/Parameters	**SEAT A**	**SEAT B**
1	Total Deformation (mm)	1.5357 e-5	5.7323 e-5
2	Equivalent Stress (MPa)	0.013558	0.01945
3	Maximum Shear Stress (MPa)	0.01157	0.01655
4	Normal Stress (MPa)	0.01645	0.000634

7.2. Applied Load 70 kg

Sr. No.	Properties/Parameters	**SEAT A**	**SEAT B**
1	Total Deformation (mm)	2.0089 e-5	.000603
2	Equivalent Stress (MPa)	0.02667	0.1069
3	Maximum Shear Stress (MPa)	0.09670	0.01508
4	Normal Stress (MPa)	0.03132	0.0132

7.3 Applied Load 75 kg

Sr. No.	Properties/Parameters	**SEAT A**	**SEAT B**
1	Total Deformation (mm)	2.1522 e-5	0.0001437
2	Equivalent Stress (MPa)	0.05371	0.03700
3	Maximum Shear Stress (MPa)	0.031165	0.02075
4	Normal Stress (MPa)	0.00967	0.00187

7.4 Applied Load 80 kg

Sr. No.	Properties/Parameters	**SEAT A**	**SEAT B**
1	Total Deformation (mm)	2.2975 e-5	7.6 e-5s
2	Equivalent Stress (MPa)	0.04622	0.03913
3	Maximum Shear Stress (MPa)	0.01845	0.02112
4	Normal Stress (MPa)	0.01032	0.00249

From the static analysis of seats we got the results of material properties, redesigning capability, stress result as like deformations (deflection), equivalent stress, maximum shear stress and normal stress. There are four average loads are applied on both seats and got the observations as a result of work.

From analysis results and observations it is found that, due to increase in buttock area of current seat and with lumbar support of seat the Equivalent Stress and Normal Stress get reduced on all loading conditions of seat. So that it work that the basic principle of stress theory, that force (load) inversely proportional to the area.

VIII. CONCLUSION & FUTURE SCOPE

The aim of this project is to critical study of present seats design of motorcycle and redesign current seat to protect lower back-bone of two wheeler operator (rider) from mechanical vibrations and impact during riding through seat of two wheelers (motorcycle) by design lumbar support in recent seat and study its outcomes by analysis of these seats. Lumbar support has provided a protective mechanism which provides postural stability and integrity for the motorcyclist's spinal column system, particularly the lower back bone. The intensity of lumbar pain will decreases due to reduction in vibrations of vehicle transfer to lumbar by supporting it. Motorcyclist riding posture is also related to both comfort and discomfort during the riding process. Therefore, this redesign seat with lumbar support may be prove as a capable to providing an ideal posture and enhances the comfort ability of motorcyclist's rider during the riding process.

The Future scope for this work will be, to acquire the advantages of this redesign seat by developing actual prototype model and get test on two wheeler by driving, and feel difference between current seats and redesign seat.

After that if it will give good Comfort and satisfactions then automobile industries can go for the regular production of this redesign seat with concern development. So that, common people can get the benefits of this resign seat and make comfort daily driving on Indian roads with minimum mechanical vibration to lower back bone.

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