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DESIGN OF TWO-WHEELER SEAT: A REVIEW

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Abstract: From last few decades the majority of Indian population depends upon two wheeler motorcycle and mopeds. The two wheeler riders are subjected to extreme vibrations due to the vibrations of its engine, improper structural design of the two wheeler and bad road conditions. These vibrations are most hazardous to the health for musculoskeletal symptom in the lower back bone pain (LBBP), degeneration of the spine and whole body vibration (WBV). It is found that the survey of 550 motorcyclists on identification of lower back bone pain, it is observed that an average 55% - 62% motorcyclists facing the musculoskeletal problem i.e.Lower Back Bone Pain(LBBP) especially between ages of 30-65 years in the survey of 550 motorcyclists by questionnaire.Effective digital human model (DHM) simulation of automotive driver packaging ergonomics, safety and comfort depends on accurate modeling of occupant posture which is strongly related to the mechanical interaction between human body soft tissue and flexible seat components. This paper presents a finite-element study simulating the deflection of seat cushion foam and supportive seat structures, as well as human buttock and thigh soft tissue when seated. Various studies carried out by other researchers may help in redesigning, evaluation and analysis of seats of two wheelers riders for better comfort during riding.

Keywords: Lower back bone pain, lumbar support, Seat Design and analysis, FEA

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INTRODUCTION

In India motorcycles are an important transportations tool of people for daily activities. Motorcycle riders are exposed to a variety of hazards in their surroundings specially on bad condition roads. Apart from that the motorcycle seat as complicated challenges for design adjustments to engineers about seat comfort or safety aspects (Karmegam karuppiah, et al, 2008). 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. Hence there is a need to explore motorcyclist discomfort due to fatigue (Karmegam karuppiah, et al, 2008). However the study reveals that there is very little direct research evidence or information concerning motorcyclists' fatigue (discomfort) (Horberry et al. 2008, Haworth and Rowden 2006).An effective digital human model (DHM) simulation of automotive driver packaging ergonomics, safety and comfort depends on accurate modeling of occupant posture, which is strongly related to the mechanical interaction between human body soft tissue and flexible seat components (Gunther Paul, 2013). Both seat safety functions and seat comfort are key attributes for designing a seat. As a physical seat design validation method, SAE J826 (Society of Automotive Engineers, 2008) is the widely accepted standard in the automotive industry. The method has proven to validly measure seat deflection and consequently the human H-Point for modern seats; however it lacks the capability to predict seat pressure with reasonable precision and confidence (Reed et al, 1999)Pressure mapping is the standard method for investigating static comfort (Andreoni et al, 2002; Siefert et al, 2008)at the seat body interface. The method however has not always proven practical in the past. While Kyung and Nussbaum (2008)reported correlations between aggregated driver–seat interface pressure factors and overall comfort ratings, Gyi and Porter (1999)and Porter et al (2003)found no consistent association between interface pressure and driving discomfort. This was partially supported by Paul etal (2012a)who found that seat interface pressure measurements face reliability issues. While a FE model with a rigid, human shaped indenter developed by Paul et al (2012b)was able to predict pressure distribution reasonably well, it showed a 12% error when simulating seat deflection in a spring suspended seat.

2. SUGGESTEDSEAT DESIGN

2.1 The Model of Study

This is a cross-sectional study with the objective of evaluating the severity of the motorcyclist's discomfort during a prolonged riding process with and without a lumbar supports (Karmegam et al. 2008).

a) Sampling Unit

Students who fulfill the inclusive criteria, both male and female with age range of 18 to 24 years, participated in this study. All students voluntarily participated in this study and signed an informed consent prior to participation. Students were selected by the following criteria:

i) Respondents are motorcyclists for a motorcycle of 150cc and below.

ii) Respondents have more than one year riding experience.

iii) Normal Body Mass Index (BMI) of 18.5 - 24.5.

iv) Respondents have no history of accident or injury in the past one year.

v) Respondents have no immediate complaint of musculoskeletal disorders at the neck, head, shoulder, upper back, arms, hands, low back, buttocks, thighs, knees, calf, ankles or feet.

b) Sampling Size

The sample size calculator (Naing et al. 2006 and Karmegam et al. 2008) was used in this study to estimate the adequate sample size. The following formula (Daniel 1999) is used in the calculator for the sample size determination process:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

Where,

n = sample size

Z = statistic for a level of confidence

P = expected prevalence / proportion

d = precision

Thus, the following require values are used in the sample size calculator:-

i)Level of confidence = 95% (Z=1.96)

ii) Expected prevalence or proportion= 0.5 (Karmegam et al. 2008)

The following information was produced by the sample size calculator based on the provided values:-

i)Sample size, n = 90 (with a finite population correction and normal approximation assumption)

ii)Precision, d = ± 0.10 (due to the limitation of resources (Naing et al. 2006)

c) Study variables

A motorcycle (less than 150cc) was considered for the study. The independent variables in this study were motorcycle with and without the lumbar support (Fig.1) and the dependent variables were the motorcyclists discomfort in lower back bone i.e. Lumbar disc.

Fig.1 Motorcyclist's sitting a) without & b) with prototype (lumbar support)(Karmegam et al. 2008)

3.1 Seat and shell FE Analytical Models

The study of G. Paul, et al, explained that seats physical indentation for validation of analytical models were measured according to Ford specification CETP 01.10-L-401. Both protocol and results of these measurements as well as the physical seat specification were reported in (Paul et al 2012b). An optimized analytical seat model was derived from the CAD assembly of a FORD

Territory seat representing seat frame, suspension and foam pad. The FE mesh of the seat CAD model was generated in ANSYS V13 WB (Canonsburg, USA).

Figure 2: Seat cushion of motorcycle

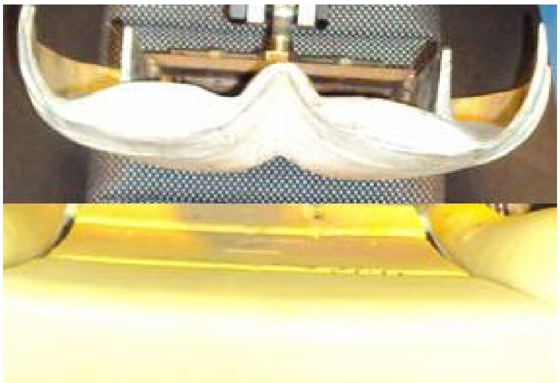


Figure 3: Seat indentation test on an untrimmed seat cushion following FORD CETP 01.10-L-401

The three-dimensional indenter shell model of thighs and buttocks was generated from the scan of a 95th percentile male subject (Paul et al, 2012b).A 6mm flexible material layer was offset from the rigid model to simulate a neoprene wrapping of the shell. This approach was to represent human soft tissue compression in the human-seat system, and the unknown non-rigid behavior of a composite material SAE J826 shell (Society of Automotive Engineers, 2008) in the physical model. Hence the thigh-buttock indenter model was made of two layers, a rigid steel and flexible neoprene layer representing lean proportions (Fig 4)(Paul et al, 2013)

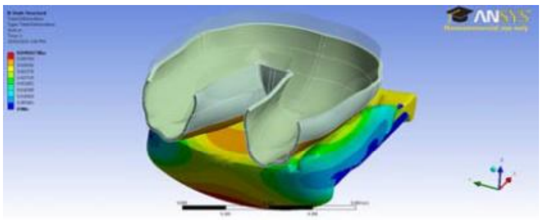


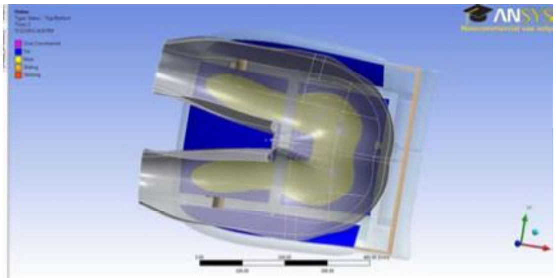
Figure 4: Two-layer, rigid steel and flexible skin (neoprene) indenter model in ANSYS V13

3.2 Methods

To imitate the properties of skin and fat, the neoprene rubber layer was modeled as a hyper elastic material with visco elastic behavior in a Neo-Hookean material model. The visco elastic shear modulus of the material was 8.45 MPa. Finite element (FE) analysis was performed in ANSYSV13 WB (Paul et al, 2013).The new indenter shell was modeled using 1683 nodes and 1227elements, while the neoprene wrapping of the shell was modeled with 1227 nodes and 1154 elements. Contact force was calculated using the penalty method (0.94 mm penetration) for a defined indenter stroke of 41mm.

4. Findings of study

The presented revised FE simulation (model-2)delivered outcomes which are compared to the standardized physical test and previous simulation results using the rigid shell indentation BOB model (model -1)(Paul et al, 2012b).The standardized physical test is considered a valid reproduction of the real phenomenon of human-seat indentation(Reed et al, 1999).Converging results with the least computational effort were achieved for a bonded connection between cushion and seat base as well as cushion and suspension, no separation between neoprene and indenter shell and a frictional connection between cushion pad and neoprene. Results are compared with the previous simulation, using the anthropometrically equal BOB model (Paul et al,2012b)and the physical indentation, which is approached with very high fidelity (Tab 1) (Paul et al, 2013). Young's modulus at contact was determined as0.032 N/mm2 (Fig 3), cushion elastic strain was42% and maximum equivalent stress 1.41 MPa.



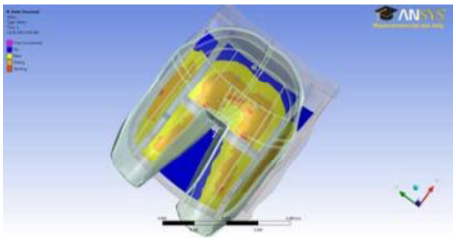


Figure 5: Simulated contact status at full indentation with model 1 (rigid top) vs. model2(flexible, bottom)

Indentation in the simulation was performed in one second, while the physical experiment extended over 16.7 seconds.

Table 1: Physical vs. analytical parameters for 41 mm stroke at SgRP. All values reported are maximum values. Model 2: two layer shell indenter model.

	Physical untrimmed test	Model 2 simulation
Force [N]	922	957
Cushion mass [kg]	0.89	19.1*
Shell mass [kg]	8.6	8 (incl. Neoprene)
BOB in CAD		9.5
SAE J826	<10	

*This physical property was incorrectly reported by

ANSYS V13 WB

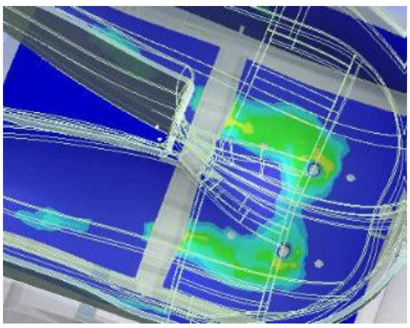


Figure 6: Simulated seat interface pressure when indented with model 2 (flexible surface)

Compared to the forces for indentation (Tab 1), themass of human thigh and upper body would be96.5% of the mass of a 95thpercentile (stature) Australian male (People size, Open Ergonomics Ltd, UK), which equates to 73.3kg (5th percentile)-111kg (95th percentile). As a consequence of a soft surface, the simulated contact pressure distribution is significantly more realistic in model 2 than in model 1.

CONCLUSION

In prototype model, this study has provided new insights into the effects of lumbar support on motorcyclists during the process of prolonged riding. The use of lumbar support (prototype) has provided a protective mechanism (provides postural stability and integrity) for the motorcyclist's musculoskeletal system, particularly the spinal column. Motorcyclist riding posture is also related to both comfort and discomfort during the riding process. Therefore, this prototype (lumbar support) is capable of providing an ideal posture and enhances the comfort ability of motorcyclists during the riding process. And in FE Analysis, SAE composite buttock form indentation of a suspended seat cushion can be validly simulated in a FE model of merely similar geometry, but using a two-layer rigid and softskin structure. Human-seat indentation of a suspended seat cushion can be validly simulated with a simplified human buttock-thigh model for a selected anthropomorphism.

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