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Design And Finite Element Analysis On Car Seat Height Screw Adjuster Using Autodesk Inventor

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Abstract: This research works investigate the structural stress analysis of car seat height screw adjuster in the driver's side to investigate design failure and to determine the optimum life and necessary factor of safety measures of the chair. In this analysis, parameter and dimension were adjusted during Dynamic simulation and static stress analysis in order to confirm the seat reliability, durability and average weight it can withstand during the use phase. Finite element analysis was carried out on the carriage seat part using Autodesk Inventor^{TM}. The von mises stress and factor of safety produced during the use phase of the chair were documented. It was discovered that the acceptable High values of Von Mises stresses of 49.5903MPa at relatively low displacement of 0.0491955mm and factor of safety of 4.1742 is at mass of 0.094867 kg of 18 mm diameter and 49 mm long of the screw adjuster for the three region analyze. This research illustrates an advanced modeling and analysis which help to know the actual parameter needed for the construction of seat adjusting screw. This will aid quality design concept for resource efficiency within the automobile industries.

Keyword: Finite element analysis, Factor of safety, Von mises stress, Chair, Autodesk inventor.

I. INTRODUCTION

In 2008, about 70 million motor vehicles (i.e cars and commercial vehicles) were produced globally [1]. A motor car can be classified based on opera- tions and performance characteristics. These classi- fycations include the engine, drive train, suspension / steering / wheel and tire, axle/brake/ body control, body and exterior, interior, climate control, driving support and security, electronics/electric parts and small/general parts. Figure 1 show the various classification of a motor car system

Interior			
	Seat		
		Seat Cushion/Seat Back	
			Side Bolster
		Seat Fabric	
		Headrest	
		Seat Frame	
		Seat Adjustor	
			Seat Slide
			Seat Reclining Device
			Lumber Adjustor
		Seat Plastic Parts	
		Seat Metal Parts	
		Seat Parts	

Table 1: Extract of Parts Classification Table of a car [2]

The driver's chair (seat) is an important component of the vehicle. It enhances the posture of the driver when driving a vehicle, [3, 4, 5].. Most car seats are made from inexpensive but durable materials. For example, Volvo, Mercedes Benz, Chrysler (DCX), Ford, GM, Honda, Nissan, etc cars adopted the use of Natural Fiber Composites (NFC) since they have demonstrated a greater benefits in terms of their mechanical and environmental properties and economic objectives Mueller et al. 2001; Mitschang & Hildebrandt 2012, [6, 7, 8,].The NFC's are new material substitutes that reduce dependence on petroleum and fossil fuels, Faruk et al. 2012; Al-Oqla & Sapuan 2014, [9, 10]. The most commonly used of the NFC material is the polyester. There are generally two types of car seat viz: the car bucket seat and the bench seat, [11]. The Car Bucket seat is a type of seat having a contoured platform and designed to accommodate one person at a time. The bench seat has a flat platform and it is designed to accommodate up to three people at once [12]. Individual bucket seats typically have circular backs and offer varieties of adjustments incorporated for passenger's comfort. Few car seat and mirrors systems have automatic power control system to adjust and fix them at a suitable position [13]. In these cases, the car seats and mirrors are adjusted by using an electric control system. Some cars can also allow the driver to save into memory the seat adjustment, and this could be recalled at a later time and/or date for better placement, through a dedicated push button [14]. The ergonomics concept (i.e. the design for comfort and /or to minimize fatigue) is an important consideration during the analysis of a car seat design. The ergonomics study considers the lumbar (an area of the spine between the diaphragm and the pelvis) of the human body. It supports most of the body weight due to its flexibility,[15].The lumbar mechanisms allow the user to adjust the seat in order to manipulate the shape and position of the car seat. This allows the lumbar to experience the cushion effect and ensure comfortability during adjustment. Some car seats are long enough to support the thigh (of human) and designed in such a way as to follow the back curves, [15, 16]. The National Traffic and Motor Vehicle Safety Act enacted by the U.S. in 1966 established standards of strength for automobile seats. It include requirements for proper anchorage and construction of automobile vehicle seat assemblies,[17]. It is stated that the automobile seat frame, the adjuster and its attachment shall be constructed in way that they are joined to the car structure which give support for the forward and backward static load equal to minimum weight of the seat, [18].

A. THE STRUCTURE OF FINITE ELEMENT METHODS

Finite Element Methods (FEM) are numerical methods for approximating the solutions of mathematical problems that are usually calculated so as to accurately state an idea of some aspect of physical properties of the material [19]. FEM is best known from the practical application of it, commonly known as Finite Element Analysis (FEA) [20]. FEA as used in engineering is an analytical tool used to performing engineering analysis (i.e. stress, strain, factor of safety, displacement, e.t.c) that involve the use of mesh generation method for dividing a complex component to smaller elements [21]. FEA provides precise solutions for complex component which is commonly used for structural analysis of material. It involves 1) decentralization of the structure, 2) application of loads, 3) solution with an appropriate solver and 4) the post processing. The commercially available FEA software includes Solidworks, Pro-engineer, Catia, Autodesk inventor ANSYS, NASTRAN, etc [22].

II. AIM AND OBJECTIVES

The aim of this work is to evaluate the possible design failure of a car seat with the aid of FEA. The specific objectives are to:

- ✓ Evaluate the average human body weight
- ✓ Geometrically model the driver's seat
- ✓ Simulate the car seat design with Autodesk Inventor
- ✓ Analyze and determine the optimum design using the various factors of safety in order to optimize the design concept.

III. RESEARCH METHOD

The Auto desk inventor software was adopted for the design, dynamic simulation and FEA of the driver's seat for three different regions i.e. Africa, Oceania and North America. The parameters simulated were based on values from Figures 1 and 2 and Tables 1 and 2. For the mesh, the average element size is set to 0.1 of a grading factor of 1.5 at an angle of 60^o.

Materials	Steel, Mild
Mass	12.7928 kg
Area	1584400 mm^2
Volume	1844560 mm^3
Center of Gravity	x=221.412 mm y=-3.63618 mm z=54.2096 mm
Mass Density	7.85 g/cm^3
Yield Strength	207 MPa
Ultimate Tensile Strength	345 MPa
Young's Modulus	220 GPa
Poisson's Ratio	0.275
Shear Modulus	86.2745 GPa

Table 1: Mechanical and Physical of the Material

Component Name	**Parameter Name**	**Values (mm)**	**Current Value**
Screw Adjuster	d0	18,19,20	20
Screw Adjuster	d8	49,54,59, 64	59

Table 2: Parameter definition of the Part

The original diameter, d0 of the screw adjuster is assumed to be 20 mm while the adjustment screw length, d8 is 59 mm for all categories of cars. These parameters are stated in Table 2. For the simulation, d0 and d8 were varied at different combinations of the screw adjustment length. For example, at d0 of 18 mm, the adjustment screw length was varied between 49 mm to 64 mm.

A. AVERAGE HUMAN BODY WEIGHT

The average human body weight is adopted to be the measurement of the body mass and the expected gadgets that the body carries at each specific time. For example cloth, shoes, mobile phones and wallets e.t.c. All these items were considered as addition to the total body mass. [23, 24]. These were estimated and loaded on the anchor that carry the body during the process of dynamic simulation [25]. Figure 2 shows the variations of the average body mass around the World. These are assumed to be the average driving age.

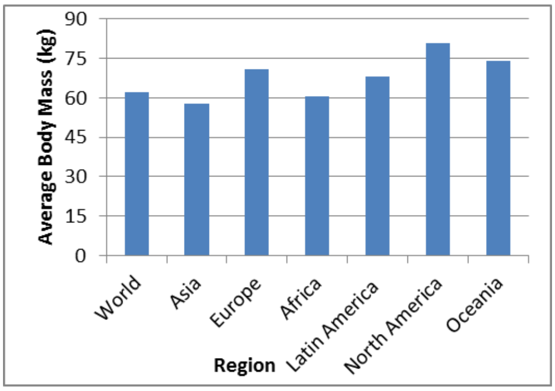

Figure 2: A chart of average weight around the world by region

B. CALCULATION OF FORCES APPLIED

The vector sum of the external forces (F_1 *and* F_2) *F* on an object is equal to the mass *m* of that object multiplied by the acceleration vector *a* of the object. Therefore,

F = ma. and weight *F=mg*

where, m represent the mass in *kg*, *g* is the acceleration due to gravity (9.81 m/s^2). Since this work is specifically to determine the impact of the body mass of the inhabitant in the African continent on the driver's car seat, the estimated average human body mass in Africa according to Figure 2 is 60.7kg. It therefore follows that the applied force, F can be estimated as in Equation 1.

F=60.7 *9.81= 595.467N (1)

C. DESIGN IMPLEMENTATION

a. THE OPERATING CONDITIONS OF BODY LOADS

Fig. 3 shows the assembly of a car seat height screw adjuster that were loaded and simulated. During the simulation, the developed driver seat was loaded with a magnitude of linear acceleration of 14069.016 mm/s^2. The body was also subjected to a 11571.497 mm/s^2 of acceleration along the x-axis vector that was located at 140.484 mm. Furthermore, the body was subjected to an angular acceleration of 2245.725 deg/s^2 and 2245.725 deg/s^2 along the y-axis vector. At the end of the loading, reactional forces were generated based on the constraints moments as shown in Fig. 4.

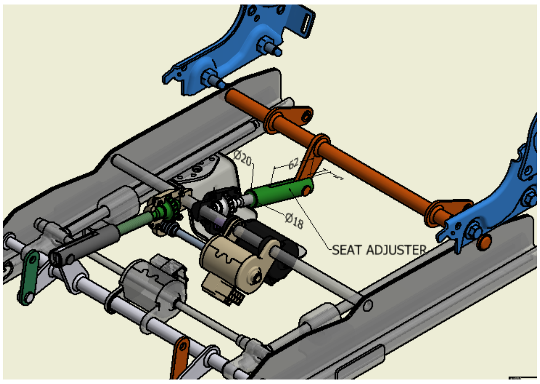

Figure 1: Diagram of car seat height screw adjuster

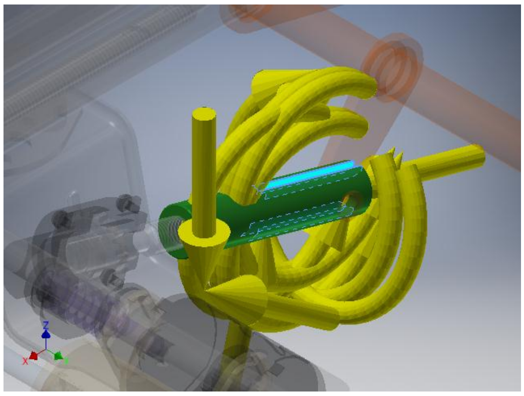

Figure 2: Diagram of loading conditions on car seat height screw adjuster showing the reaction Force and Moment on Constraints

IV. RESULTS AND DISCUSSION

A. ANALYSIS CAR SEAT ADJUSTER

The average body weight from each region was apply to the car seat and a comparison was made to evaluate the behavior of the selected mild steel material and the yield strength of the car seat adjuster.

Based on the mesh parameters, the body was dynamically simulated. Figures 3, 4 and 5 shows the results of the analysis based on different regions.

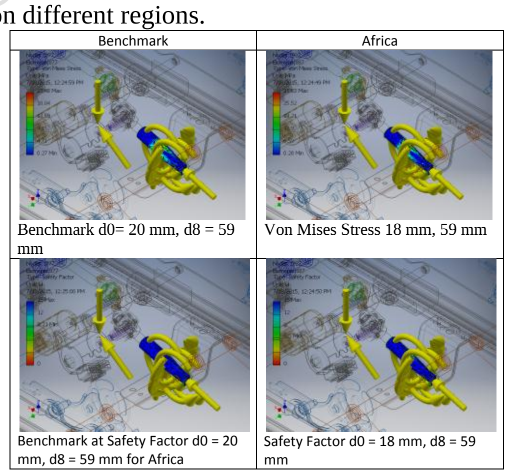

Figure 3: VMIS and SF for Africa body weight

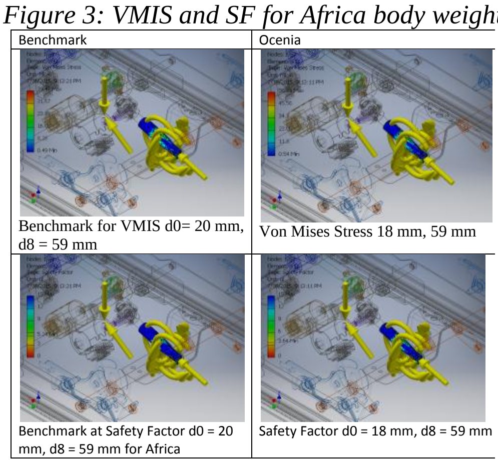

Figure 4: VMIS and SF for Oceania body weight

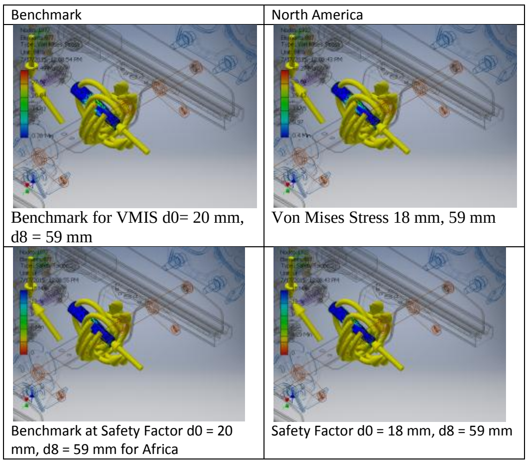

Figure 5: VMIS and SF for North America body weight

The FEA result in design from the first region one was compared with the Ultimate Tensile Strength 345 MPa which was in line with design principle that says Von Mises Stress (VMIS) of a design must be less than the ultimate yielding stress of the material. Als as the mass of the material is being reduce by parametric dimensional principle in Statics Stress analysis the displacement of the material increases for the three region weight apply to the system. This show radical deformation of the material as the mass was reducing, but There was increase in VMIS. This shown a good behavior of the material towered the ultimate tensile stress of the mild steel used. There was reduction in the factor of safety towered 2ul. For the three regional weights apply to the system. After the dimension d0, d8, had being varied as shown in fig. 4, 5, and 6 and from the three graph below it was gathered that a low displacement of high VMIS of relatively low factor of safety with a light weight of d0, d8 for 18, 49 for the diameter and length of the screw respectively for the three region was recommended for better design.

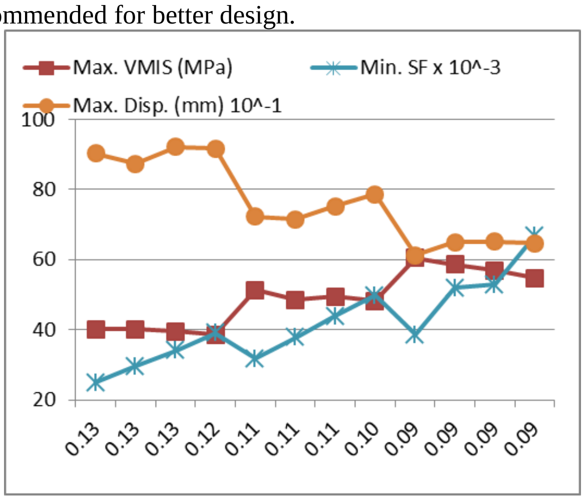

Figure 6: Graph Represents of Result for Africa weight on the car seat of 595.467N

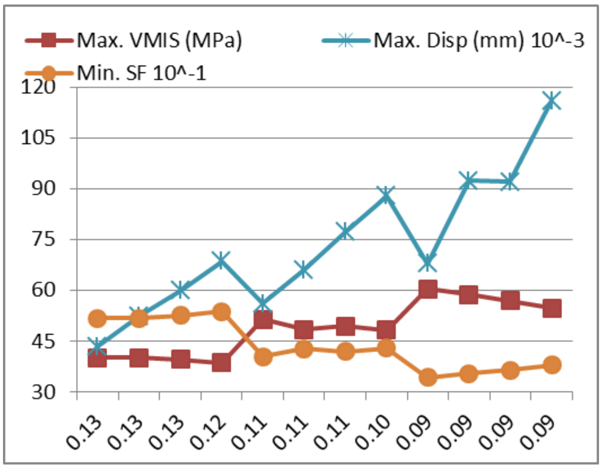

Figure 7: Graph Represents of Result for Oceania weight on the car seat of 726.961N

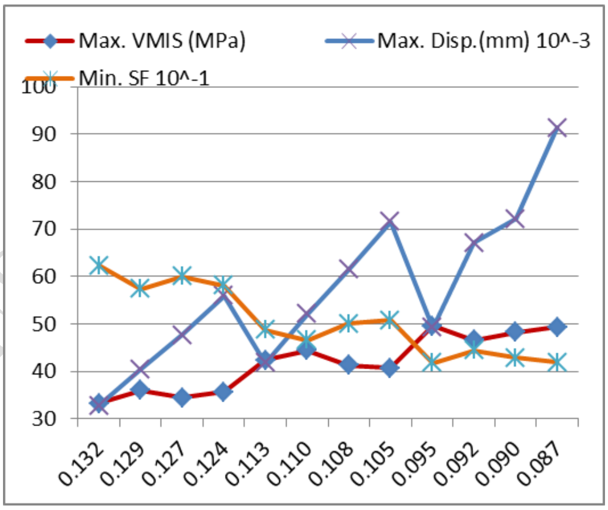

Figure 8: Graph Represents of Result for North America weight on the car seat of 791.667N

V. CONCLUSION

It is a common knowledge in design and FEA that the VMIS should be comparably lower than the yield strength of the material. This is important during the design for safety 'DfS' of mechanical moving components. In this work, the screw adjuster for car seat assembly was simulated and analyzed for optimum design performance. The following conclusions were derived from the study:

- ✓ From Figures 17, 18, and 19 , it can be observed that the acceptable values of Von Mises stresses at relatively low displacement and factor of safety occurred at a mass of 0.094867kg, d0 of 18mm and d8 of 49mm of the screw adjuster for the three region analyzed above. This values represents the optimum parameters for the car seat design for Africa, Oceania and North America.
- ✓ The values obtained also shows that irrespective of the region investigated the optimum parameters are consistent in values and body mass of the car seat adjuster.

- ✓ For sustainable manufacture of the car seat assembly, product designers could adopt the dynamic simulation strategy used in this work.
- ✓ This research illustrates an advanced modeling and analysis which help to know the actual parameter needed for the construction of seat adjusting screw.

REFERENCES

[1] "The First Car – A History of the Automobile". Ausbcomp.com. Archived from the original on 2011-07-16. Retrieved 2011-07-17.
[2] Marklines Automotive industry (2015) http://www.marklines.com/en/supplier_category_list#axlebrakeetc. Accessed on 04/08/2015.
[3] "Recent Developments in Body Design". Horseless Age: The Automobile Trade Magazine 33 (6): 264. 11 February 1914. Retrieved 7 September 2014.
[4] National Traffic and Motor Vehicle Safety Act of 1966. National Highway Traffic Safety Administration, U.S. Dept. of Transportation. 1985. pp. 50–51. Retrieved 7 September 2014.
[5] "Freelander By Land Rover". My Freelander/ Land Rover. Retrieved 7 September 2014.
[6] Mueller, D., Krobjilowski, A. & Muessig, J., 2001. Available at: https://scholar.google.com/scholar?q=Mueller+D%2C+Krobjilowski+A%2C+Muessig&btnG=&hl=en&as_sdt=0%2C22#2 [Accessed July 20, 2015].
[7] Mitschang, P. & Hildebrandt, K., 2012. Advanced Materials in Automotive Engineering, Available at: http://www.sciencedirect.com/science /article/pii/B9781845695613500089.
[8] Faruk, O. et al., 2012. Biocomposites reinforced with natural fibers: 2000-2010. Progress in Polymer Science, 37(11), pp.1552–1596.
[9] Al-Oqla, F.M. & Sapuan, S.M., 2014. Natural fiber reinforced polymer composites in industrial applications: Feasibility of date palm fibers for sustainable automotive industry. Journal of Cleaner Production, 66, pp.347–354.
[10] "Question 'N' Auto". Thehindubusinessline.com. 25 September 2005. Retrieved 7 September 2014.
[11] John A. Jakle, Keith A. Sculle. (2004). Lots of Parking: Land Use in a Car Culture. Charlottesville: Univ. of Virginia Press. ISBN 0-8139-2266-6.
[12] Jeff Rubin (2 March 2009). "Wrong Turn" (PDF). CIBC World Markets [13]. John A. Jakle, Keith A. Sculle. (2004). Lots of Parking: Land Use in a Car Culture. Charlottesville: Univ. of Virginia Press. ISBN 0-8139-2266-6.
[13] Sousanis, John (2011-08-15). "World Vehicle Population Tops 1 Billion Units". Wards Auto. Retrieved 2012-07-17.
[14] "Mary Ward 1827–1869". Universityscience. ie. Archived from the original on 2008-0311. Retrieved 2008-10-27.
[15] Encyclopædia Britannica "Nicolas-Joseph Cugnot"
[16] "Car"(etymology). Online Etymology Dictio- nary. Archived from the original on 2008-05-20
[17] Younger generations shifting to other modes of transport.
[18] Reddy, J.N. (2006). An Introduction to the Finite Element Method (Third ed.). McGraw-Hill. ISBN 9780071267618.
[19] "SAP-IV Software and Manuals". NISEE e-Library, The Earthquake Engineering Online Archive.
[20] P. Solin, K. Segeth, I. Dolezel: Higher-Order Finite Element Methods, Chapman & Hall/CRC Press, 2003.
[21] , K.J. (2006). Finite Element Procedures. Cambridge, MA: Klaus-Jürgen Bathe. ISBN 097900490X.
[22] Data extracted from "The world's fattest countries: how do you compare?". The Daily Telegraph. 21 June 2012. Retrieved 13 June 2013.
[23] Devine, Ben J (1974). "Gentamicin therapy". Drug Intell Clin Pharm 8 (11): 650–5. doi:10.1177/106002807400801104.
[24] Lubitz, Deborah; Seidel, JS; Chameides, L; Luten, RC; Zaritsky, AL; Campbell, FW (1988). Ann Emerg Med 17 (6): 576–81.