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DESIGN AND ANALYSIS OF BIKE SADDLE

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ABSTRACT: *Cushioning material increases the comfort of seating. In this research bio-based cushioning material is developed. Bio-based cushioning material comprises of the naturally available material along with appropriate strengthening agent. Cylindrical luffa along with natural rubber latex as strengthening agent is used for the bike saddle application. Study of impact test and temperature resistance comparison of Polyurethane foam and Cylindrical luffa with natural rubber latex as strengthening agent is carried out. 3D model of seat is prepared in SolidWorks and theoretical design of cushioning material is prepared.*

KEY WORDS: Cylindrical Luffa, Bike Saddle, Bio-based Cushioning Material, Unique Cushioning Structure, Testing Standards

INTRODUCTON

Nature has always been affected by human activities resulting to adverse effects. Climate changes, Global warming are some of its results which are matter of concern among scientists and intellectuals which are affecting planet at large. Processes developed by humans for attaining better life are exploiting the nature which is adversely affecting humans and flora and fauna on Earth. To retain nature and to reduce impact of exploiting nature work is done in different fields. Synthetic products, plastic products are now replaced by bio-based products.

In the field of cushioning material synthetic polymer-based products are developed for varied applications. Currently Polyurethane foam is used as cushioning material in Furnitures, Automobile seats. Noise reduction systems and many other applications utilize Polyurethane foam as a primary component.

Production of Polyurethane foams utilizes diisocynates which causes asthma therefore it is listed in regulatory listings of dangerous chemicals. Polyols required in production of Polyurethane foam are obtained from petroleum feedstocks which has higher carbon impact and non-recyclable. Glycolysis is the method for recycling Polyurethane foam which has high energy demand and long reaction time. Polyurethane foam waste is disposed in landfills resulting into soil pollution for decades. Incineration of Polyurethane foam waste which releases toxic gases resulting into polluted atmosphere. [1]

Seats are one of the important parts for any category of automobile. It increases the ride quality and reduces stress levels for passengers by diminishing vibrations. Motorbikes have moulded seats supported by baseplate of bike. Types of seats available for motorbikes are continuous seats and parted seats. Commonly available motorbike seats are continuous seats with sheets of polyurethane foam as cushioning material.

Thickness of seats depend on the design of motorbikes, generally thickness of seats is around 200 to 250mm and length of seat is almost half the length of bike. General length of bike seat is around 625 to 675mm and width of seat is around 220 to 240mm. For conventional bikes width of seat for rider is around 150 to 160mm.

In this research work attempt has been made to develop bio-based cushioning material for application of bike saddle. Cylindrical luffa is used as base material for the application along with natural rubber latex as strengthening agent.

LITERATURE REVIEW

- Material based literature review:

    1) David NV and Mohd Azlam, "Moisture Absorption properties and shock cushioning characteristics of bio-based Polyurethane foam composites", Journal of Mechanical Engineering, Vol SI 5(2), pp 157-168. [19]

In this research work authors have studied about the shock cushioning properties and water absorption properties of Polyurethane foam composites filled with kenaf fibres and saw dust. Outcomes of experiments indicate that moisture gain increased with increase in fibre content. It is also shown that kenaf fibres have the potential to be used as reinforcing agent in polyurethane foam composite. It has also been concluded that kenaf fibre based polyurethane foam composite can be used as cushioning for packaging material.

2) Shamala Ramasamy, Hanafi Ismail, Yamuna Munusamy, "Effect of rice husk powder on compression behaviour and thermal stability of natural rubber latex foam", Bioresources, Vol 8(3), pp 4258-4269.[8]

In this research work authors have studied about the effect of rice husk powder on natural rubber latex foam. The study shows that compression set increased with increase in rice husk powder loading and the recovery rate decreased. Hardness and thermal stability increased with increase in rice husk powder loading.

3) Wit Witkiewicz, Andrzej Zielinski, "Properties of Polyurethane light foams", Advances in material science, Vol. 6, No. 2(10). [20]

In this research work authors have studied about the mechanical properties of polyurethane foams for two different densities 16kg/cubic metre and 62kg/cubic metre. Compression test was carried out on both the samples of foam and tensile shear test was carried out on foam sample with 62kg/cubic metre density. It has been stated in the result that foam sample with 62kg/cubic metre density is appropriate for application of light weight barges.

4) Yuxia Chen, Kaiting Zhang, Tingting Zhang, Fangcheng Yuan, Na Su, Beibei Weng, Shanshan Wu, Yong Guo, "Effect of softening treatments on the properties of high-density cylindrical luffa as potential mattress cushioning material", Springer Publication [2]

In this research work authors have studied about the appropriate softening treatment of cylindrical luffa for application of mattresses. Softening treatment studied includes:

i. 5%NaOH and 5%H_2O

ii. 10%NaOH and 20%CH_3COOH

iii. 18%NaOH and 1.6%CO $(NH_2)_2$

The effect of softening treatment on chemical properties, microstructures, physical and mechanical properties and water absorption and desorption properties were observed and study showed that softening treatment of cylindrical luffa with 10%NaOH and 20%CH_3COOH is most appropriate.

5) Nandkishor Sharma, "Investigation of mechanical properties of luffa cylindrica reinforced epoxy composite for different environmental conditions" [21]

In this research work author has studied about the polymer composite with cylindrical luffa as reinforcing agent bonded with epoxy resin and its moisture absorption behaviour and mechanical properties was studied by considering different volume fraction (layers) of cylindrical luffa. The result showed that double layered composite was the preferred combination of fibre content that increased strength, modulus and work of fracture.

6) Hamilton, Thomsen, Madaleno, Rosgaard Jensen, Rauhe, J. C. M., and Pyrz, "Evaluation of anisotropic mechanical properties of reinforced polyurethane foam", Composites science and Technology, vol. 87, pp 210-217. [22]

In this research work authors have studied about polyurethane foam with relative density less than 0.2 mixed with milled glass fibres and its effect on tensile, compressive and shear properties. It has been shown that normalized moduli increased by 4.26% in foam rise direction and it decreased by 40% in transverse direction.

7) Joseph Miltz, Gad Greunbaum, "Evaluation of cushioning properties of plastic foams from compressive measurements", Polymer Engineering and Science, vol. 21, no. 15. [23]

In this research work authors have studied about the cushioning properties of 2 flexible polyurethane foam and 2 semi-rigid bonded foams. From the compressive tests and shock impact test shows that polyurethane chip foams are preferred for packaging application.

8) Fabrice Saint-Michel, Laurent Chazeau, Jean-Yves Cavaille, Emanuelle Chabert, "Mechanical properties of high-density polyurethane foams: (i)Effect of density", Composites Science and Technology, Elsevier, vol.66, pp 2700-2708. [24]

In this research work authors have studied about the mechanical properties of high-density polyurethane foam with density as a parameter and compared the results with two theoretical models:

i. Gibson and Ashby approach used for foam description

ii. 2+1 phase model by Christensen and Lo used for description of particulate composite materials

The result shows that second approach is more appropriate.

9) U Stirna, I Beverte, V Yakushin, U Cabulis, "Mechanical properties of rigid polyurethane foams at room and cryogenic temperature", Journal of Cellular Plastics, Vol. 47(4), pp 337-355. [25]

In this research work authors have studied the effect of wide range of temperature on mechanical properties of rigid polyurethane foams. The temperature for which samples were studied was of range 296K to 77K. From the test results obtained it is shown that tensile strength perpendicular to foam rise direction increases and modulus in same direction decreases.

10) Nuno Gama, Artur Ferreira, Ana Barros-Timmons, "Polyurethane Foams: Past, Present and Future", Materials, Vol. 11, pp 1841 [1]

In this research work authors have studied regarding blending, processing, production and recycling processes of Polyurethane foams. It is indicated that production of polyurethane foams is based on petroleum-based products. Glycolysis process which is the industrially accepted recycling process of polyurethane foam has huge power demand and produces toxic gases. Degraded foams are incinerated or buried in soil, both these process results into pollution of air or soil. Study also showed increment in demand of bio-based composites of polyurethane foams.

11) Joo Seong Sohn, Hyun Keun Kim, Sung Woon Cha, "Bio-based Foamed Cushioning Materials using Polypropylene and Wheat Bran", Sustainability, Vol. 11, pp 1670. [6]

In this research work authors have studied about the process for production of polypropylene and wheat bran-based foam. Effect of foam properties is observed by differing the proportion of wheat bran by 20% to 70% in mixture. Optimum mixing ratio obtained from tests was PP50/WB50. Dynamic cushioning characteristics were compared with polystyrene bead-based foam and test results showed that the properties were comparable.

- Design based Literature Review:

1) Swapnil Mathurkar, "Design of Test Rig for Motorcycle seat for human comfort", International Research Journal of Engineering and Technology, Vol. 3(9). [26]

In this research work author has studied about stresses developed on human body by conventional design of seat and has redesigned seat by including lumbar support and measured stresses developed on human body and comparable results were obtained.

2) Hideo Isoda, Mitsuhiro Sakuda, Yoshihiro Amagi, Kenji Tanaka, Kunio Kimura, Michio Kobayashi, Tadaaki Hamaguchi, Seiji Swahara, "Recyclable Vehicular Cushioning Material and Seat", United States Patent US005298321A, 1994. [27]

In this patent authors have studied about polyester based cushioning material which has 3D web structure with fineness level lower than 45 denier per filament and initial tensile strength higher than 30g/d. It has also been stated that material has good air permeability and does not release toxic gases while combustion.

3) Heinrich Fromme, "Cushioning assembly having plastic springs for supporting a pad", United States Patent US005588165A, 1996. [18]

In this patent author has prepared an array of plastic springs with pad on each spring mounted on fixed column and the array of springs is placed under the foam for better cushioning experience. Loading in direction perpendicular to the direction of plane formed by pads on springs is better supported.

4) Matthew Pyzik, John Pacella, “Structural foam and Urethane composite for use in a Motorcycle seat and method of Manufacturing the same”, United States Patent US007032967B2, 2006. [17]

In this patent authors have invented motorcycle seat which does not require mould base for supporting foam sheets and mounting seat to baseplate of motorcycle. It includes 3D shaped insert with foam at front and structural foam at back for support brackets at back for mounting.

5) Niels Mossbeck, “Slow Acting Pocketed Spring Core Having Cushioning Material”, United States Patent US008474078B2, 2013. [16]

In this patent author has prepared an array of springs distributed over the length of loading area. Springs are pocketed individually with a fabric material and cushioning foam is placed adjacent to the springs for lower noise. Air flow through each embodiment is at slower rate resulting into recovery after unloading.

6) Tomohisa Chiba, Katsuhiro Kiya, Yoshinori Ueyama, “Cushioning Material Structure for Vehicle Seat”, United States Patent US009821868B2, 2017. [14]

In this patent authors have modified the cushioning material structure for decreasing weight and maintaining cushioning effect. Concave voids on lower surface of cushioning material are prepared facing baseplate of vehicle which underloading maintains strength of seat.

7) Anthony Sprouse, “Motorcycle Seat”, United States Patent US20050121953A1, 2005. [13]

In this patent author has prepared a motorcycle seat in which air cell cushions are provided at the ischial areas of rider and passenger. The air cells are filled with air by separate pump or built-in pump. The air cells are supported by layers of foam based cushioning material which is further supported by mould of seat and baseplate of motorcycle.

8) Daniel Kim, “Composite Cushioning material with Multiple Strata”, United States Patent US20130303041A1, 2013. [12]

In this patent author has prepared composite cushioning material by arranging sheet like structures by bonding layers with Hot Melt Adhesive (HMA).

EXPERIMENTAL

MATERIAL:

Cylindrical luffa is the dried form of sponge gourd it has a tough fibrous structure with seeds filled inside it over the length. It is available in different lengths and diameters. Untreated luffa has high strength but lacks elasticity. The natural layer over cylindrical luffa can be easily removed by soaking it in water for certain period of time. Drying time of cylindrical luffa is about 4 to5 hours in open sunlight.

Figure 1 (Cylindrical Luffa)

It has high strength due to fibrous network and can withstand shear and compressive loads. In dried form it is light weight but tough. For a cushioning application material should be elastic in nature.

AVAILABILITY: Cylindrical luffa is available in abundance all over India, in Gujarat wild cylindrical luffa is available. It is available over the year. Wild cylindrical luffa is not a desired crop and therefore left unattended as waste and thrown after it dries.

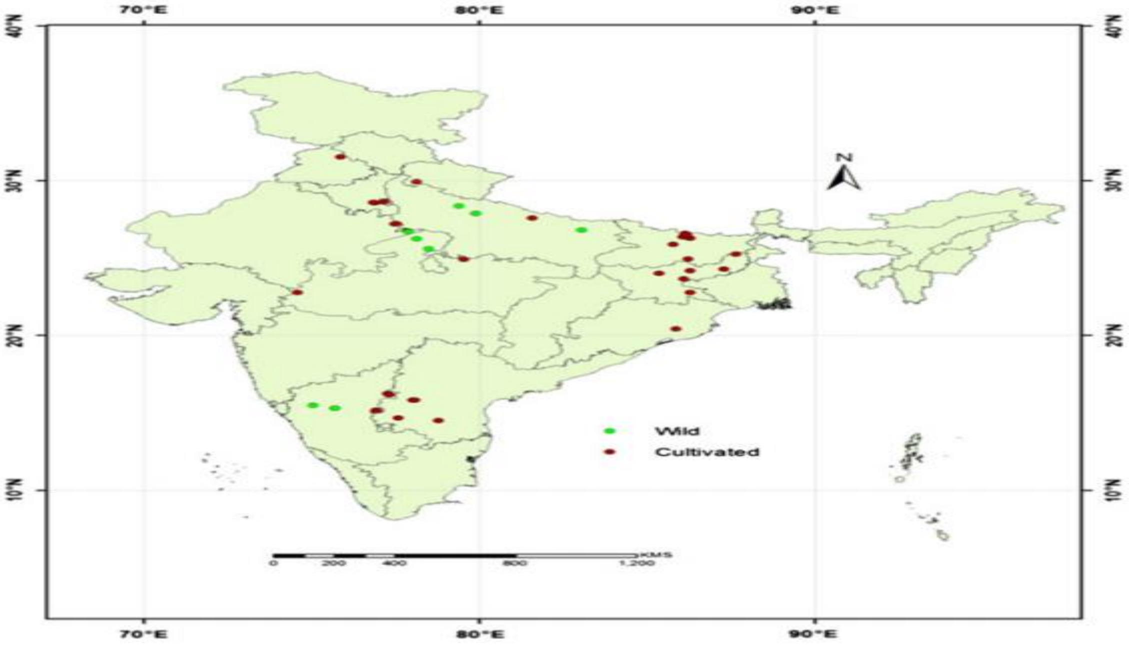


Figure 2 (Cultivation of Cylindrical Luffa) [7]

CHEMICAL TREATMENT:

Cylindrical luffa undergoes chemical treatment for attaining required properties for a cushioning material. Chemical treatment follows: [2]

- Frequent cleaning of cylindrical luffa with boiled water after removal of seeds.
- Treatment of cylindrical luffa with 10% NaOH (sodium hydroxide) for thirty minutes at 40 degree Celsius.
- Treatment of cylindrical luffa with 20% acetic acid for thirty minutes at 40 degree Celsius
- Humidifying cylindrical luffa at 65% relative humidity for 24 hours at 21 degree Celsius.

For efficient treatment of cylindrical luffa, it is cut into sheet form prior to treatment.

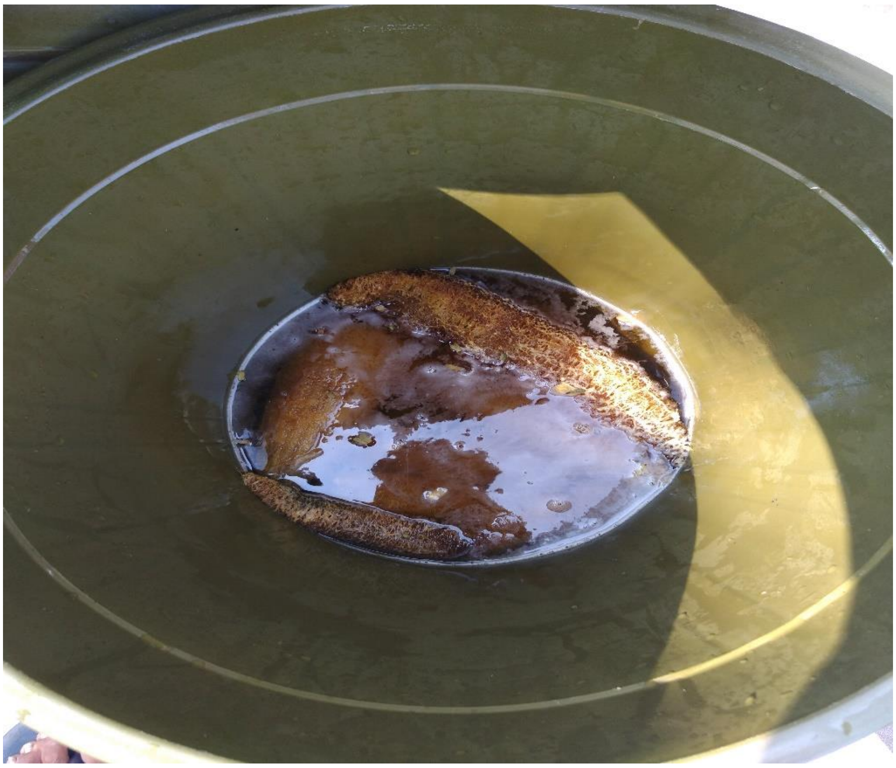


Figure 3 (Treatment of Luffa)

Cylindrical luffa is further dried at room temperature up to a stage with zero moisture content.

Sheets of luffa after treatment become softer and elastic.

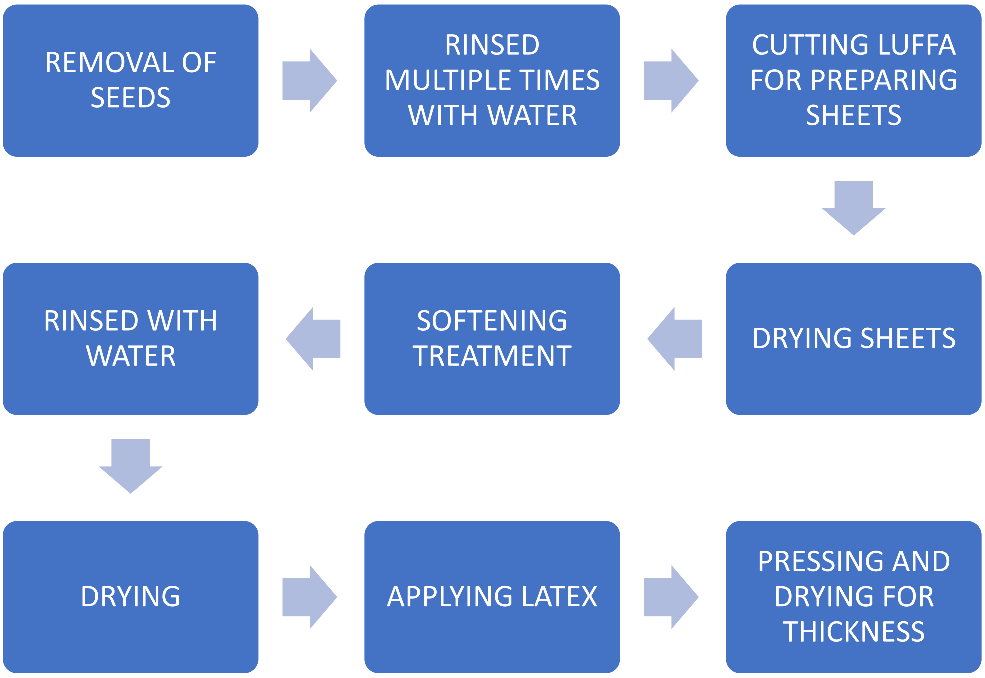
Figure 4 (Sheets of Luffa after Treatment)

Sheets of cylindrical luffa after treatment are cut by dimensions of specimen size for different tests.

Figure 5 (Sheets of Luffa brushed with Natural Rubber Latex)

Pre-cut sheets of luffa are brushed with natural rubber latex and arranged according to specimen size and pressed with suitable force to achieve desired thickness. About 2 to 3 hours is required for drying of brushed sheets of luffa.

MANUFACTURING PROCESS OF RUBBERIZED LUFFA



DENSITY OF CYLINDRICAL LUFFA:

Density of cylindrical luffa can be measured from the equation given below: [2]

$$\rho = \frac{2m}{(S_1 + S_2) \times H}$$

Where,

m = mass of cylindrical luffa (kg)

$$S_1 = area\ of\ upper\ surface\ (m^2)$$

$$S_2 = area\ of\ lower\ surface\ (m^2)$$

$$H = height\ of\ cylindrical\ luffa\ (m)$$

This equation yields density of luffa according to the height of luffa considered. For the motorbike application sheets of luffa are required therefore density of each luffa can be calculated by carefully cutting the ends and forming plain surface.

Table 1 (Density of Luffa)

Sr no.	m(kg)	$S_1(m^2)$	$S_2(m^2)$	H(m)	$\rho(kg/m^3)$
1	0.015	12.56×10^{-4}	13.195×10^{-4}	0.13	89.6
2	0.018	14.17×10^{-4}	14.51×10^{-4}	0.2	62.75
3	0.014	11.93×10^{-4}	12.56×10^{-4}	0.15	76.22
4	0.01	10.17×10^{-4}	10.74×10^{-4}	0.11	86.95
5	0.012	10.74×10^{-4}	11.33×10^{-4}	0.13	83.64
6	0.013	12.56×10^{-4}	13.84×10^{-4}	0.14	70.34

TESTING PROCEDURE:

Prior to testing sheets of luffa are carefully cut according to the dimensions of the specimen for different tests and brushed with natural rubber latex to further increase elasticity and act as strengthening agent. The sheets are further left for drying with load acting on them depending upon the thickness required according to specimen size.

TESTING DETAILS:

- Compression based tests:[4]

3. Indentation force deflection (IFD) – force required to produce 25% and 65% deflection is measured.

Specimen size = 380mmx380mmx100mm

2. Compression force deflection (CFD) – force required to produce 50% compression over entire top area of specimen is measured.

Specimen size = 50mmx50mmx25mm

3. Tensile strength and elongation – effect of tensile force is determined. Tensile strength, tensile stress and ultimate elongation is measured.

Specimen size = dog bone specimen with 12.5mm thickness

4. Tear resistance strength – (ISO8067)

Tear propagation resistance is determined.

Specimen size = 152mm long with width and depth as same as material pad thickness.

5. Dynamic fatigue test by constant force pounding – (ISO3385)

Determines the loss of force support at 40% IFD, loss in thickness, structural breakdown.

Specimen size = 380mmx380mmx50mm

Conditions of test: time period – 12 hours

Temperature – 23 degree Celsius

Relative humidity – 50%

- To perform tests ASTM D3574 foam test machines are required.

Machine type: electromechanical

Force capability: 1.1KN,2.2KN,5KN

- Measurement of physiological properties:[3]

1. Thermal resistance: (ISO11092)

Test conditions: Air temperature = 20 degree Celsius

Relative humidity = 65%

Air velocity = 1m/s

2. Water vapour resistance:

Test conditions: Air temperature = 35 degree Celsius

Relative humidity = 40%

Air velocity = 1m/s

3. Air permeability: (EN 9237:1995)

STRESS ANALYSIS OF CUSHIONING MATERIAL

A foam for which strain increases at constant value of stress is called ideal foam.

$$\sigma = \frac{F}{A}$$

$$\sigma = \epsilon \times E$$

$$\epsilon \times E = \frac{F}{A}$$

Here,

E = Young’s modulus of elasticity

A = surface area of foam

Surface area of foam and modulus of elasticity are constant

$$F \propto \epsilon$$

Force acting on foam is directly proportional to stain of foam, therefore as force increases strain increases.

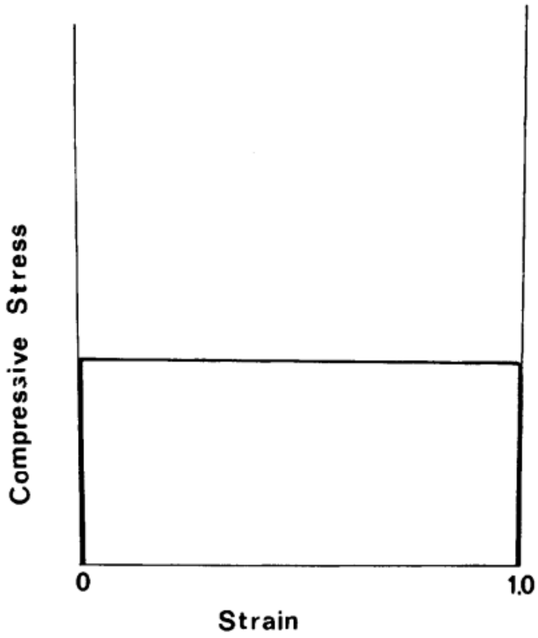


Figure 6 (Stress-Strain Curve of Ideal Foam) [23]

- Polyurethane foam which is used as cushioning material in bike saddle shows similar behaviour for certain range of strain value after that stress also increases as strain increases.

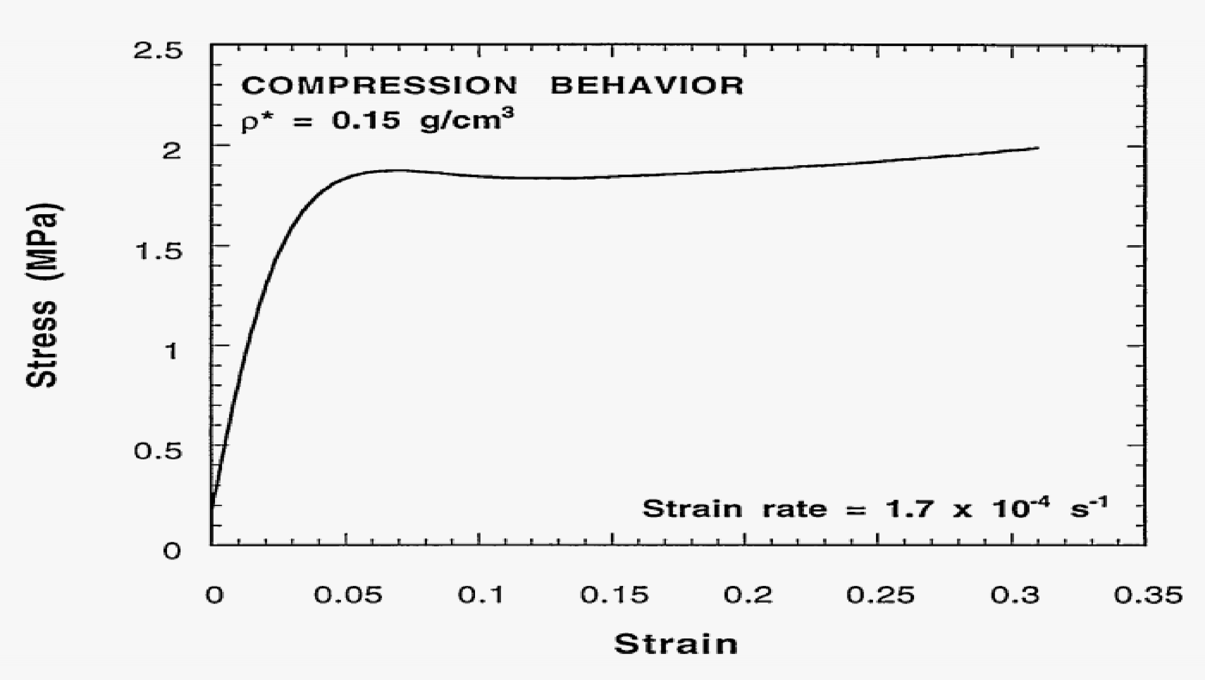


Figure 7 (Stress-Strain Curve of Polyurethane Foam) [28]

Density of polyurethane foam for which stress-strain curve is generated is 150kg/m^3 and strain rate is 1.7× 10^{-4} s^{-1}, polyurethane foam shows ideal behaviour in strain range of 0.05 to 0.3 [28]

From the experiment it has been shown that foam shows unique behaviour depending on density and modulus of foam.

$E \propto (\rho)^n$

Modulus of elasticity of foam is directly proportional to density of foam raised to exponent 'n'.

Value of exponent 'n' is range of 1.6 to 2.

- Cylindrical luffa also shows similar behaviour of modulus of elasticity dependence on density of luffa. [2]

$E = A\ (\rho)^B$

E = modulus of elasticity of luffa (MPa)

ρ = density of luffa (kg/m^3)

A and B are constants, value of B is in range of (1.5 to3)

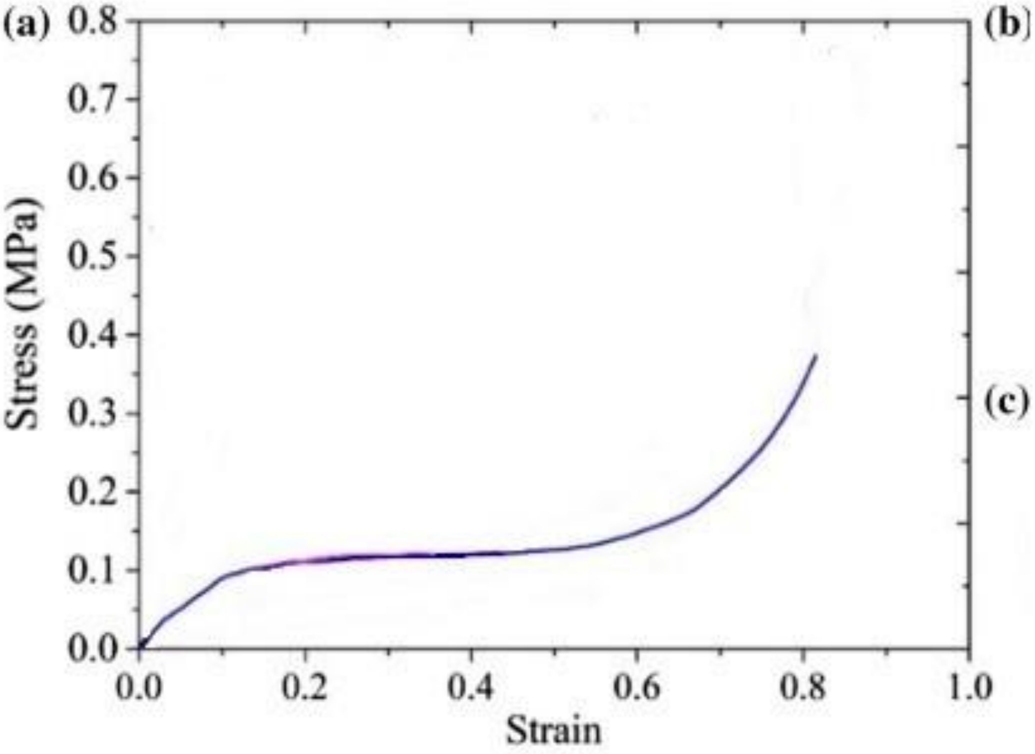


Figure 8 (Stress-Strain Curve of Treated Cylindrical luffa) [2]

Density of cylindrical luffa for which the stress-strain curve is generated is 57.64kg/m^3. Treated cylindrical luffa shows ideal behaviour in strain range of 0.1 to 0.6 which is more than polyurethane foam.

Considering polyurethane foam and treated cylindrical luffa of density 150kg/m^3,

- Cylindrical luffa:

$E = A(\rho)^B$

A = 9.746×10^{-6} and B = 2.318

E = $9.746\times 10^{-6}(150)^{2.318}$

E = 1.0789MPa

$$\sigma = \epsilon \times E$$

6640.61 = $1.0789\times 10^{6} \times \epsilon$

$$\epsilon = 6.155 \times 10^{-3}$$

$$\epsilon = \frac{\delta l}{l}$$

$$\delta l = 6.155 \times 10^{-3} \times 90$$

$$\delta l = 0.55395mm$$

- Polyurethane foam:

E$\propto (\rho)^{n}$

For $\rho = 150kg/m^3$, E = 65MPa

$$\epsilon = \frac{\sigma}{E}$$

$$\epsilon = \frac{6640.61}{65 \times 10^{6}}$$

$$\epsilon = 1.0216 \times 10^{-4}$$

$$\delta l = \epsilon \times l$$

$$\delta l = 9.1945 \times 10^{-3}mm$$

Optimum range of modulus of elasticity of cushioning material for application of bike saddle is 0.15MPa to 0.234MPa. [29]

Considering Young's modulus of elasticity E = 0.234MPa

- Polyurethane foam:

$$\frac{E_1}{E_2} = \frac{(\rho_1)^{1.6}}{(\rho_2)^{1.6}}$$

$$\frac{65}{0.234} = \frac{(150)^{1.6}}{(\rho_2)^{1.6}}$$

$$\rho_2 = 4.45kg/m^3$$

- Cylindrical luffa:

$$E = A(\rho)^{n}$$

0.234 = $9.746\times 10^{-6} \times (\rho)^{2.318}$

$$\rho = 76.48kg/m^3$$

For the application of bike saddle polyurethane foam used has constant density however cushioning performance, strength can be increased and weight can be decreased if cushioning material at base has more density which offers higher load carrying capacity and the upper cushioning material can have lower density for better cushioning performance.

From the unique arrangement of sheets of luffa above condition can be achieved by utilizing higher density luffa for base and middle sheets and other boundary sheets to be lower density laid continuously.

TEST PERFORMED:

- IMPACT TEST: Energy absorbed by the material is measured.

Weight of ball = 1.2753N = mg

Drop height = 0.36m = h_1

Thickness of polyurethane foam and cylindrical luffa = 14mm

- For polyurethane foam;

Rebound height = 0.2m

Energy absorbed = $mg(h_1 - h_2)$

E = 1.2753(0.36-0.2)

E = 0.2040J

- For cylindrical luffa:

Rebound height = 0.2m

Energy absorbed = 1.2753(0.36-0.2)

E = 0.2040J

TEMPERATURE COMPARISON:

Polyurethane foam and untreated Cylindrical luffa are kept under direct sunlight for 60 minutes under normal surrounding conditions and temperature is measured;

- For Polyurethane foam;

Mass = 12gm

Thickness = 14mm

Length = 130mm

Width = 106mm

Density = 62.2kg/m^3

Measured Temperature = 46°C/319.15K

- For untreated cylindrical luffa;

Mass = 12gm

Thickness = 14mm

Length = 130mm

Density = 83.64kg/m^3

Measured Temperature = 48°C/321.15K

- For treated cylindrical luffa, strengthened by natural rubber latex;

Mass = 14gm

Thickness = 14mm

Length = 130mm

Density = 76.22kg/m^3

Measured Temperature = 45°C/318.15K

MODELLING OF SEAT

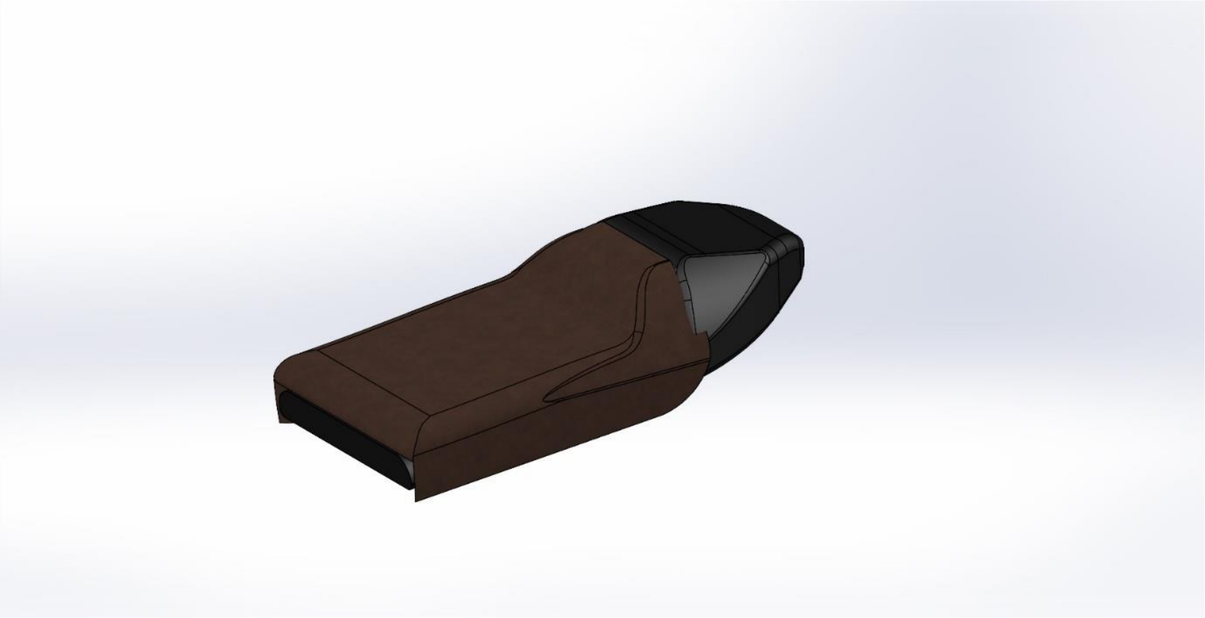


Figure 9 (3D Model of Seat)

3D model of seat has been prepared in SolidWorks 3D modelling software. Dimensions of seat are:

Length of seat = 650mm

Width of seat = 200mm

Thickness of seat = 90mm

Conventional seats have polyurethane foam over the length and width of seat without any unique design of cushioning material. Concave voids can be prepared on lower surface of cushioning material facing baseplate of vehicle. It helps in reducing weight of seat.

DESIGN OF CUSIIONING MATERIAL

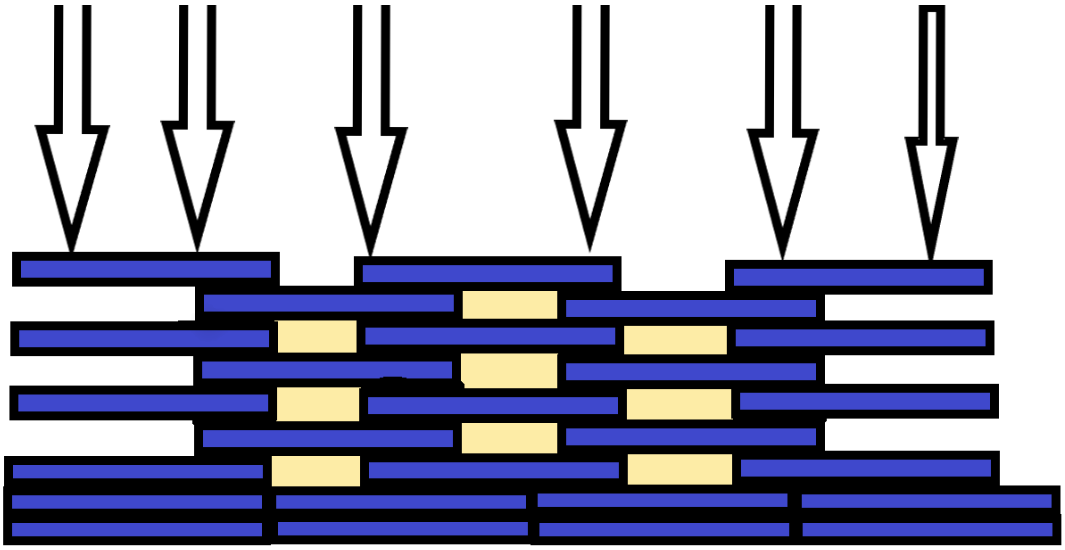


Figure 10 (Theoretical Design of Seat)

In this theoretical design of cushioning material sheets of luffa are arranged in unique order for elasticity and strength.

Strength of seat: Base of seat comprises of double thickness sheets continuously laid over the length of seat for proper weight distribution and strength. Front and rear sheets are single thickened laid along the width of seat for strength. All the boundary sheets are single thickened and laid continuously along the width of seat. Base sheets are layered with natural rubber latex on entire surface for proper bonding of sheets.

Elasticity of seat: All middle luffa sheets are double thickened and arranged in unique order as shown for purpose of elasticity and strength. The voids generated in middle part of seat due to the arrangement of luffa sheets provides elasticity and air permeability in seat.

Considering 160kg of weight supported by seat and transmitted to suspension system and front and rear wheels. From geometrical distribution of load 55% of load acts on rear segment if bike.

Force acting on seat = $0.55\times 160 \times g = 863.28$N

Considering uniform distribution of load, this force acts on upper surface of seat.

Area of upper surface of seat = $l \times b = 0.65\times 0.2 = 0.13 m^2$

Stress acting on seat

$\sigma = \frac{F}{A} = \frac{863.28}{0.13} = 6640.61 \mathrm{N}/m^2$

Deflection of seat can be calculated as;

$$\delta l = \frac{l}{\epsilon}$$

Strain can be calculated by using strain gauges rosettes on seat experimentally.

RESULT AND DISCUSSION:

- Chemical treatment of luffa increases the elasticity and its strength increases by addition of natural rubber latex.
- Treatment of sheet form of luffa gives better effect of treatment as compared to cylindrical form of luffa.
- Impact test shows that energy absorption capacity of cylindrical luffa strengthened with natural rubber latex is similar to polyurethane foam with same thickness.
- Temperature comparison of Polyurethane foam and untreated cylindrical luffa shows that when samples are kept under direct sunlight in natural surroundings with ambient temperature around 40°C/313.5K temperature gained by Polyurethane foam is 46°C/319.15K when kept for 60 minutes and temperature gained by untreated Cylindrical luffa sample is 48°C/321.15K. When treated luffa kept under similar conditions temperature gained is 45°C/318.15K.
- Theoretical design of cushioning material having unique arrangement of treated luffa sheets can be used. Base luffa sheets have double thickness as compared to other boundary luffa sheets. Boundary sheets at front, rear and upper surface are laid continuously without any gaps. Middle sheets have double thickness as that of boundary sheets and are laid in an arrangement generating voids which enhance elasticity and air permeability and maintains strength.

CONCLUSIONS:

- Cylindrical luffa is available in abundance both in wild and cultivated form. Cylindrical luffa is available in different sizes so its density differs as shown in **Table 1.**
- Testing of treated and strengthened cylindrical luffa can performed as per the testing details provided.
- Stress-Strain curves of polyurethane foam and only treated cylindrical luffa shows that when same density (150kg/m^3) is considered for same value of stress (6640.61N/m^2) for similar dimensions of sample, value of deflection for cylindrical luffa is 0.55395mm and that of polyurethane foam is $9.1945\times 10^{-3} mm$. Cylindrical luffa deflects more than polyurethane foam for same value of stress. From the ideal foam curve, it can be said that cushioning material which deflects more at same value of stress should be selected.
- From the impact test for the given value of height (0.36m), weight dropped (1.2753N) and thickness of both the samples (14mm) same value of energy absorbed (0.2040J) is calculated.
- Temperature comparison of both the samples shows that temperature gained by treated and strengthened cylindrical luffa (45°C/318.15K) is lower than polyurethane foam (46°C/319.15K) for same thickness of samples (14mm) and same time period (60 minutes) for similar surrounding conditions.

From the study of Cylindrical luffa as bio-based cushioning material it can be concluded by its abundance, similar energy absorption characteristics, higher resistance to heat and higher deflections for similar value of stress that it has a potential to be used as cushioning material for bike saddle.

FUTURESCOPE

- Detailed testing of samples of treated and strengthened cylindrical luffa can provide physical and physiological properties of material.
- Comparison of Cylindrical luffa and Polyurethane foam can be carried out on finite element analysis software and result can be analysed.
- Fabrication of bike saddle using cylindrical luffa can be done and tests can be performed for exact solutions.

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