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Evaluation of the Mechanical Properties and Simulation of Sisal/Jute Hybrid Polymer Composite Failure in Automobile Chassis Panel.

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Abstract: *Present in this research work is the evaluation of the mechanical properties and the simulation of sisal/jute hybrid polymer composite properties in comparison to a model metal steel automobile chassis panel. Mechanical behavior of composite material depends on many factors such as fibre content, orientation, types, length etc. A hybrid composite is a combination of two or more different types of fibre balance the deficiency of another fibre. An effort made by this work is to evaluate the behavior of sisal/jute fibre reinforced in polyester based hybrid composites compared to mild steel material. Stress/strain and displacement analysis using solidworks explorer software carried out for structural simulation of the hybrid composite. Sisal/Jute Polymer composite analyzed using solid work explorer software attained maximum Von Mises stress of 207698N/m^2, mass density of 1400Kg/m^3, maximum displacement of 0.0215421mm, Tensile strength of 31.7MPa, and compressive strength of 93.7MPa compare to Mild steel with maximum von Mises stress of 168859N/m^2, mass density of 7858Kg/m^3, maximum displacement of 0.00303525mm and Tensile strength of 425MPa.The simulated results on these properties are significantly not different from those obtained in the experiment.*

Keywords*: Sisal, Jute, Hybrid, Stress, deformation, Unsaturated Polyester*

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I. INTRODUCTION

In recent years, the natural fibre reinforced composites have attracted substantial importance as a potential structural material. The attractive features of the natural fibres jute, sisal, coir and banana have been their low cost, light weight, high specific modulus, renewability and biodegradability. Non-conventional fibres such as jute, sisal, coir, banana, palm fibres etc. are extracted from stem/leaf/fruit of plants. Among all these fibres, jute and sisal have an advantage over other fibres. Today, a major challenge relating to automotive composite design is the unavailability of simulation tools and a general lack of composite material characterization. Another issue is the computational time required to model composite structures and components. Current composite material models within commercial design software require very long solution times. These times are usually too long for the first phase of vehicle development, in which many different options have to be analyzed over a period of just a few months. For composites to be properly evaluated at these early stages, the automotive industry needs a factor of ten reductions in solution times. The commercial software developers have not yet solved this problem, so some of the more advanced research and design centres are developing in-house methodologies, which usually remain confidential (Ciaraldi *et al*., 1992).

Figure 1. Picture of Sisal Plant.

Figure 2: Jute plant.

Table: 1. Properties of Jute and Sisal Fibre

Fibre	Density ($10^3 Kg/m^3$)	Elongation (%)	Tensile Strength (MPa)	Young's Modulus (GPa)	Diameter (µm)
Jute	1.3	1.5-1.8	393-773	26.5	17-20
Sisal	1.5	4-6	511-635	9.4-22	205-230

[Reference: Cook J.G., Handbook of Textile Fibre and Natural Fires, 4th Ed. Morrow Publishing, England, 1968]

Table 2: Mechanical Properties of Mild steel

Mechanical Properties	Metric	Imperial
Tensile Strength, Ultimate	400 - 550 MPa	58000 - 79800 psi
Tensile Strength, Yield	250 MPa	36300 psi
Elongation at Break (in 200 mm)	20.0 %	20.0 %
Elongation at Break (in 50 mm)	23.0 %	23.0 %
Modulus of Elasticity	200 GPa	29000 ksi
Bulk Modulus (typical for steel)	140 GPa	20300 ksi
Poissons Ratio	0.260	0.260
Shear Modulus	79.3 GPa	11500 ksi

(Source : http://www.azom.com/article.aspx?ArticleID=6117, accessed 17/05/2017)

Table 3: Further Summary on mechanical Properties of Mild steel

Mechanical Properties	Mild Steel
Max. Tensile Strength	400 - 550 MPa
Max. Flexural Strength (Bending strength) or Modulus of rupture	300 MPa -
Max. Compression Strength	300 MPa -
Brinell Hardness Number Value.	126 -

II. MATERIALS AND METHOD

Sisal/Jute Hybrid Polymer composite at 1:1, 1:2, 2:1 mixture ratio, 0.25, 0.35 and 0.45 volume fraction mixture using unsaturated polyester resin, Methylethylketone (Catalyst) ,Cobalt (accelerator), Vaseline (releasing agent) bought from Pascal Scientific Laboratory, Akure, Ondo State, Nigeria. Sisal plant was purchased from Ineni , Anambra State, Nigeria while Jute plant was purchased from Owode, Ogun State, Nigeria. Sisal and Jute plant were retted to obtain fibres. Fibres strands were reinforced with unsaturated polyester resin. The unsaturated polyester low temperature curing resin and corresponding harder Methylethylketone hardener and Cobalt accelerator at a ratio of 10:1:0.5 by weight as recommended. The different composites are fabricated for tensile, flexural, compression and Hardness test. Each composites are loaded in 0.25, 0.35 and 0.45 fibre loading - resin fraction, arranged in the orientation of (90, 45, -45, 90,), (0, -45, 45, 0), (30, 60, -60, 30) and in fibres combination ratio, sisal to jute of 1:1, 2:1, 1:2, sisal alone, jute alone with reference to a control sample of nil fibre (resin alone). The casting of each composite was consolidated with a roller load weight of 50g, and cured under room temperature, at 4hrs before sample is removed from the mould. Then, specimens are cured in the air for another 12hrs after removing from the mould. Test specimens were subjected to various mechanical test as per ASTM standards using Instron 3369 Universal testing machine located at Obafemi Awolowo University, Ife, Center for Energy and Research- The tensile test – ASTM D638, ASTM D790 three-point flexural tests, ASTM C790 compression test and Tensometer (Type 'W'), S/N: 18655 by Monsanto Tensometer for the Brinell Hardness Number Value Test. Flexural sample dimensions: Length =120mm, Width =35mm, Thickness =4mm. Tensile sample dimensions: Gauge Length =50mm, Thickness =5mm, Width =12mm, Grip Length =17mm. Compression sample dimensions: Cube (20X20X20)mm. Hardness sample dimensions: Length =40mm, Width =35mm, Thickness=4mm.

Fig. 5. Samples prepared with unsaturated polyester resin

fig.6. Isron Universal testing machine

Fig. 7. Tensometer (Type ‘W’), S/N: 18655 by Monsanto Tensometer for BHN Test.

Table 4. Experimental Result of Sisal/ Jute/Polyester Composite Maximum Mechanical Properties obtained

Mechanical Properties	**Sisal/Jute /Unsaturated Polyester Composite**
Max. Tensile Strength	31.65459MPa
Max. Flexural Strength (Bending strength) or Modulus of rupture	78.89411 MPa
Max. Compression Strength	93.74326 MPa
Brinell Hardness Number Value.	198.2

ASSUMPTIONS ON THE SIMULATION OF THE SISAL/JUTE POLYMER COMPOSITE

Some of the assumptions used for the analysis work are.

(1)Fibers are not porous.

(2)The material property for all the constituents are attributed as isotropic material for both volumes.

(3)Fibers are uniform in properties with diameter.

(4)Inter-phase bonding is maintained between fibers and matrix.

(5)Perfect bond between fiber and matrix and no slippage.

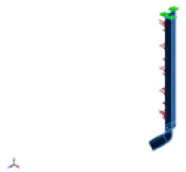
(6)Fibers are perfectly aligned and arranged.

(7)Composite material is free of voids.

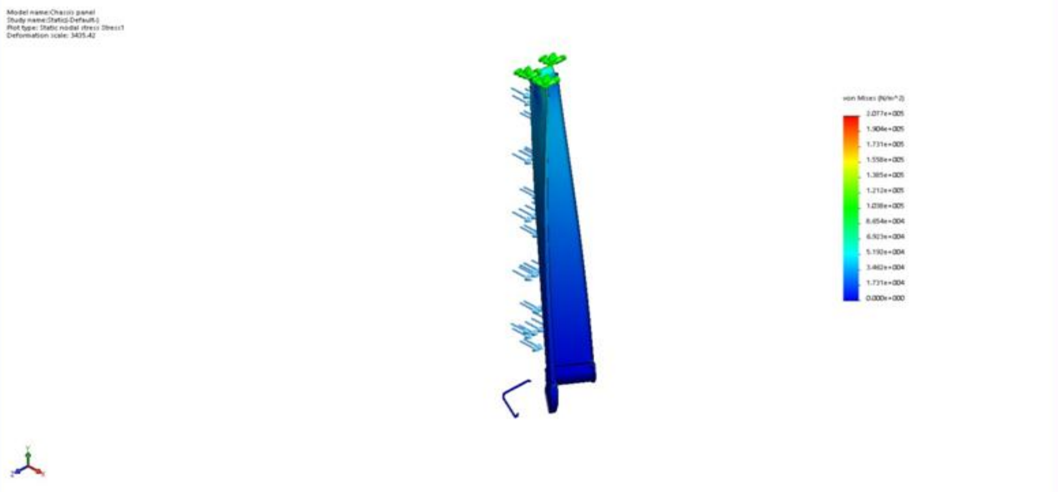
(8) Poisson’s ratio of sisal/jute polymer composite = 0.1

(8) Poisson’s ratio of mild steel = 0.29

Material Properties

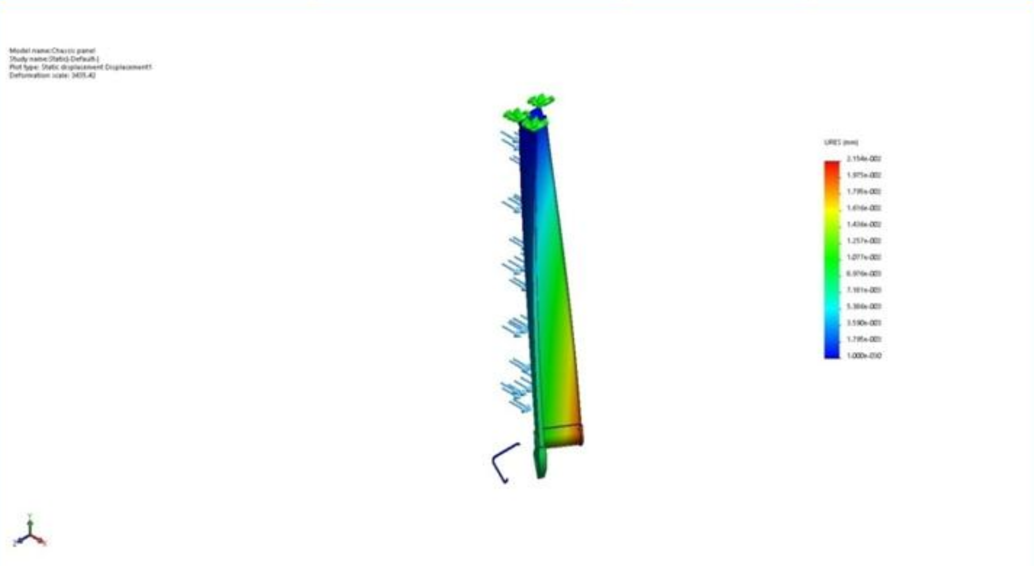
Model Reference	Properties	Components
	Name: **Sisal/Jute polymer composite** Model type: **Linear Elastic Isotropic** Default failure criterion: **Unknown** Tensile strength: **3.16546e+007 N/m^2** Compressive strength: **9.37433e+007 N/m^2** Elastic modulus: **2.65e+010 N/m^2** Poisson's ratio: **0.1** Mass density: **1400 kg/m^3**	**SolidBody 1(Base-Flange2)(Chassis panel), SolidBody 2(Cut-Extrude1)(Chassis panel), SolidBody 3(Sweep1)(Chassis panel)**
Curve Data:N/A		

Name	**Type**	**Min**	**Max**
Stress1	VON: von Mises Stress	0 N/m^2 Node: 2628	207698 N/m^2 Node: 3787



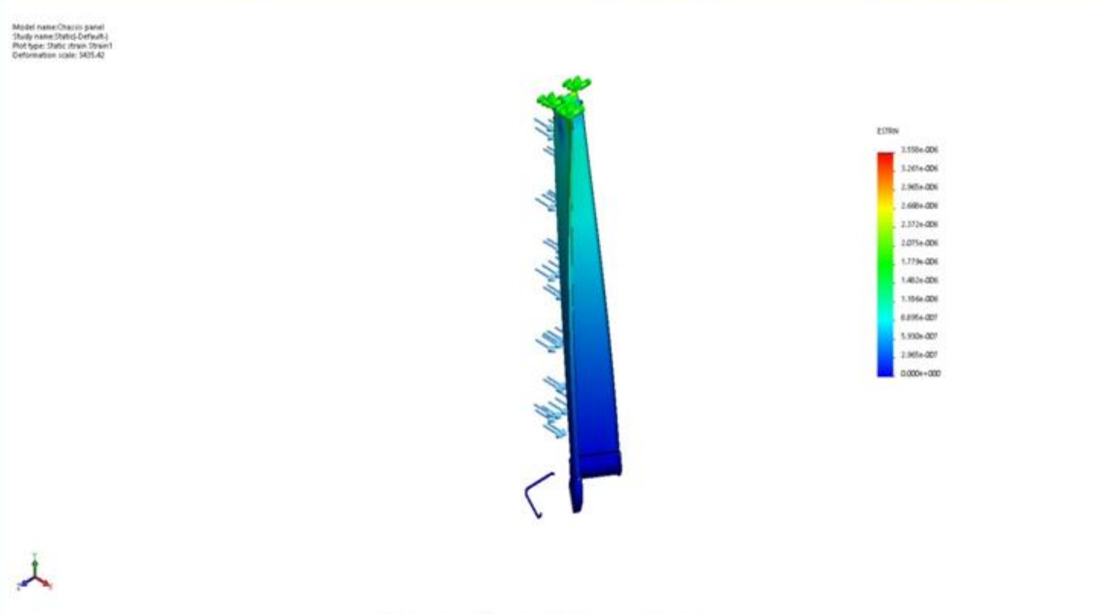
Chassis panel-Static-Stress-Stress1

Name	**Type**	**Min**	**Max**
Displacement1	URES: Resultant Displacement	0 mm Node: 2628	0.0215421 mm Node: 45



Chassis panel-Static-Displacement-Displacement1

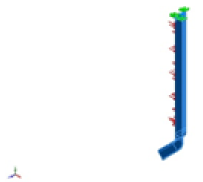
Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	0 Element: 1234	3.55799e-006 Element: 3166



Chassis panel-Static-Strain-Strain1

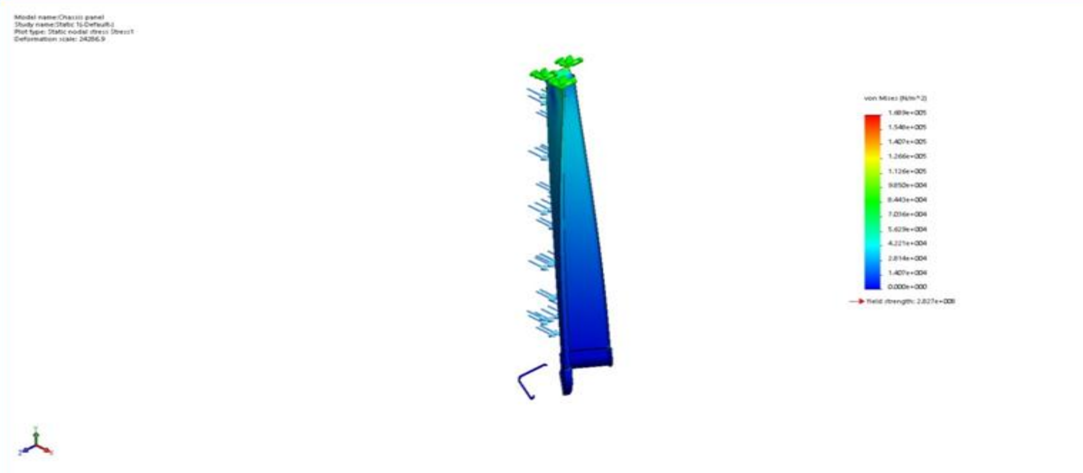
Mild steel

Material Properties

Model Reference	Properties	Components
	Name: **1023 Carbon Steel Sheet (SS)** Model type: **Linear Elastic Isotropic** Default failure criterion: **Max von Mises Stress** Yield strength: **2.82685e+008 N/m^2** Tensile strength: **4.25e+008 N/m^2** Elastic modulus: **2.05e+011 N/m^2** Poisson's ratio: **0.29** Mass density: **7858 kg/m^3** Shear modulus: **8e+010 N/m^2** Thermal expansion coefficient: **1.2e-005 /Kelvin**	**SolidBody 1(Base-Flange2)(Chassis panel), SolidBody 2(Cut-Extrude1)(Chassis panel), SolidBody 3(Sweep1)(Chassis panel)**
Curve Data:N/A		

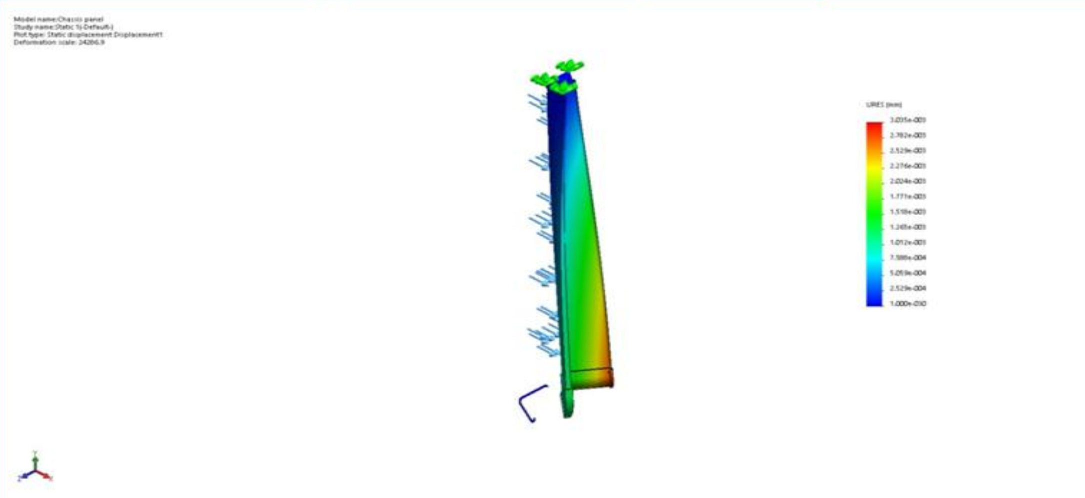
Study Results

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/m^2 Node: 2628	168859 N/m^2 Node: 3787



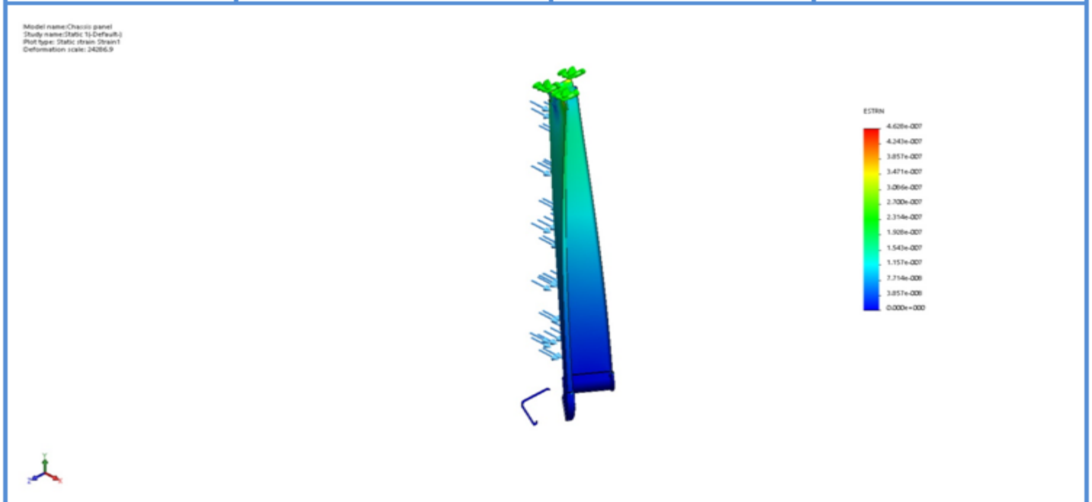
Chassis panel-Static 1-Stress-Stress1

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 2628	0.00303528 mm Node: 45



Chassis panel-Static 1-Displacement-Displacement1

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	0 Element: 1234	4.62826e-007 Element: 3122



Chassis panel-Static 1-Strain-Strain1

III. DISCUSSION OF RESULTS.

Sisal/Jute Polymer composite analyzed using solid work explorer attained maximum Von Mises stress of 207698N/m^2, mass density of 1400Kg/m^3, maximum displacement of 0.0215421mm, Tensile strength of 31.7MPa, and compressive strength of 93.7MPa compare to Mild steel with maximum von Mises stress of 168859N/m^2, mass density of 7858Kg/m^3, maximum displacement of 0.00303525mm and Tensile strength of 425MPa. On experimental result, Sisal/Jute hybrid fires reinforced in unsaturated polyester resin, demonstrated a highest tensile strength of 31.7MPa on sample SJ/T3/75/2:1 laid at $90^0/45^0$ orientation, highest flexural strength of 78.9MPa on sample SJ/F1/45/55/2:1 laid at $90^0/45^0$ orientation, highest compression strength of 93.7MPa on sample SJ/C1/45/55/2:1 at $90^0/45^0$ orientation and a highest Brinell Hardness Number (BHN) value of 198.2 on sample SJ/I1/45/55/1:1 at $90^0/45^0$ orientation.

IV. CONCLUSION

The properties of Sisal/Jute Polymer composite analyzed using solid work could help to predict the behavior of sisal/jute hybrid polymer under stress and deformation failure analysis. The simulate results on tensile strength, compressive strength is close to that obtained from experiment. The sisal jute composite has a mass density of 1400kg/m^3 compared to 7858kg/m^3 of mild steel which a major advantage of light weight that aid their application in automobile body.

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