International Journal of Automobile Engineering (IJAUE)
Volume 1, Issue 2, July–December 2019, pp. 15–24, Article ID: IJAUE_01_02_002
Available online at
https://www.iaeme.com/ijaue/issues.asp?JType=IJAUE&VType=1&IType=2
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ROVER WHEEL

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ABSTRACT

This paper focuses on the concept of developing a gyroscopic 2 wheeler vehicle. This paper focuses on the concept in which a normal two wheeler can be balanced with a gyro-wheel attachment without making many changes to the two wheeler design, geometry and structure so that it can be easily adopted in different type of two wheelers. This paper contains detailed description of design and analysis of Gyro wheel used for the stabilization of the bicycle. The Gyro wheel is a special kind of wheel which is designed as an alternative to the training wheels used in bicycle for people with Balance disorders, especially for aged people and new learners. The Gyro wheel works on the principle of Gyroscopic effect caused by the rotating wheel. The Gyro wheel consists of a solid disk/wheel (Depending upon size of the bi-cycle) inside the tire which is spinning independently. The wheel rotates at a high speed and creates a gyroscopic effect known as gyroscopic precession. The Gyro wheel detects the direction of fall and precision the direction of fall and re-stabilizes the wheel. It is designed as a special type of wheel working on mechanical aspects that would be able to balance itself i.e. it would maintain vertical position because the rotating flywheel nullified all the forces acting upon the wheel. For designing of the Gyro wheel, 3d modelling software namely SOLID WORKS 2017 is used. Structural analysis is done to find the stress distribution and the deformation on the model. For structural analysis, ANSYS software is used.

Index Terms: Bi-Cycle; Gyro Wheel; Gyroscope; Gyroscopic Effect; Self-Stabilize; Two Wheeler.

1. INTRODUCTION

The composites that form heterogeneous structures, which meet the requirements of specific design and function, embedded with desired properties. However there is new horizon as the fact new types of composites are being innovated all the time, each with their own specific purpose like the filled, flake, particulate and laminar composites.

Fibers or particles embedded in matrix of another material would be the best example of modern-day composite materials, which are mostly structural.

Further, though composite types are often distinguishable from one another, no clear determination can be really made. To facilitate definition, the accent is often shifted to the levels at which differentiation take place viz., microscopic or macroscopic.

In matrix-based structural composites, the matrix serves two paramount purposes viz., binding the reinforcement phases in Place and deforming to distribute the stresses among the Constituent reinforcement materials under an applied force.

Polymers make ideal materials as they can be processed easily, possess lightweight, and desirable mechanical properties. It follows, therefore, that high temperature resins are extensively used in aeronautical applications.

Metal matrix composites, at present though generating a wide interest in research fraternity, are not as widely in use as their plastic counterparts. High strength, fracture, toughness and stiffness are offered by metal matrices than those offered by their polymer counterparts.

Ceramics can be described as solid materials which exhibit very strong ionic bonding in general and in few cases covalent bonding. High melting points, good corrosion resistance, stability at elevated temperatures and high compressive strength, render ceramic-based matrix materials a favourite for applications requiring a structural material that doesn't give way at temperatures above 1500ºC. Naturally, ceramic matrices are the obvious choice for high temperature applications.

Carbon and graphite have a special place in composite materials options, both being highly superior, high temperature materials with strengths and rigidity that are not affected by temperature up to 2300ºC.

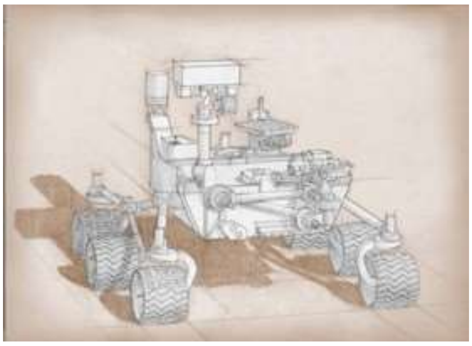

Figure 1 A six wheel rover

The figure above shows a six wheel rover, as you can see the body portion of the rover consists of the instruments such as cameras, sensors, solar panels etc. The total mass of this six wheel rover is about 25kg.

It uses a six wheel drive mechanism where each individual wheel is powered by a motor torque of 5N-m and the total torque of the rover is 20N-m. Since the velocity of the rover is very small (i.e) about 10cm/sec the calculations were performed for static condition.

2. SOFTWARE BACKGROUND

Modelling - PTC Creo

Modelling of wheel was carried out using PTC Creo software.

Creo is a family or suite of design software supporting product design for discrete manufacturers and is developed by PTC. The suite consists of apps, each delivering a distinct set of capabilities for a user role within product development.

Creo runs on Microsoft Windows and provides apps for 2D design, 3D CAD parametric feature solid modelling, 3D direct modelling, Finite Element Analysis and simulation, schematic design, technical illustrations, and viewing and visualization.

The Creo suite of apps replace and supersede PTC's products formerly known as Pro/ENGINEER, Co-Create, and Product View.

PTC began developing Creo in 2009, and announced it using the code name Project Lightning at Planet PTC Live, in Las Vegas, in June 2010. In October 2010, PTC unveiled the product name for Project Lightning to be Creo. PTC released Creo 1.0 in June 2011.

Figure 2 3D Models of Rover Wheel

Modelling - Solid Edge

Solid Edge is a 3D CAD history based, parametric feature and synchronous technology solid modeling software. It runs on Microsoft and provides solid modeling, assembly modeling and drafting functionality for mechanical engineers, designers and drafters. Through third party applications it has links to many other Product Lifecycle Management (PLM) technologies.

Originally developed and released by Intergraph in 1996 using the ACIS geometric modeling kernel it later changed to using the Para solid kernel. In 1998 it was purchased and further developed by UGS Corp (the purchase date corresponds to the kernel swap).

In 2007, UGS was acquired by the Automation & Drives Division of Siemens AG. UGS company was renamed Siemens PLM Software on October 1, 2007. Since Sep 2006 Siemens also offers a free 2D version called Solid Edge 2D Drafting. Solid Edge is a direct competitor to Solid Works and Autodesk Inventor.

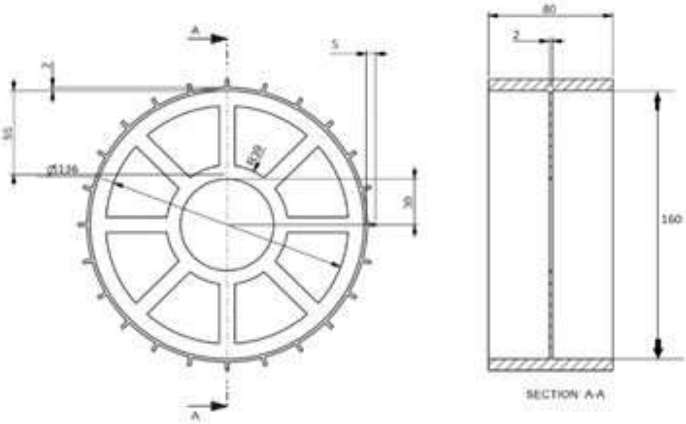

Figure 3 2D Drawing of Rover Wheel

3. ANALYSIS OF ROVER WHEEL

Initially solid model is imported from modeling software package, then the wheel was meshed using mesh tool command, after meshing the material properties were entered to the software, then boundary conditions were applied to the wheel for different loading conditions, after this step analysis of wheel is done using analysis command.

MPC: In case of boundary conditions the MPC (multi point constrain) is created at the centre of the wheel, it acts as medium of transferring boundary conditions when boundary conditions are applied to it.

Equivalence and verify: In order to get proper meshed model equivalence and verify command used, in equivalence overlapping surfaces are removed then model is verified.

Figure 3 FE Models

4. DESIGN SPECIFICATION AND CALCULATION

Terra-Mechanics Based Load on the Wheel Calculation For Draw Pull:

In order to design an effective wheel, it is imperative to understand the interactions that occur between a wheel and the ground it is in contact with. This field of study is called terra-mechanics.

Draw pull (DP): It is the amount of force required for the free movement of the wheel.

Sinkage (Z): It is the amount by which the wheel sinks into the loose soil.

Compacting resistance (R_c**):** It is the resistance encountered due to compacting of loose soil.

Bulldozing resistance(R_b)**:** It is the resistance encountered due to the bulldozing action of the wheel.

Rolling resistance (R_r**):** It is the resistance encountered due to friction of the soil.

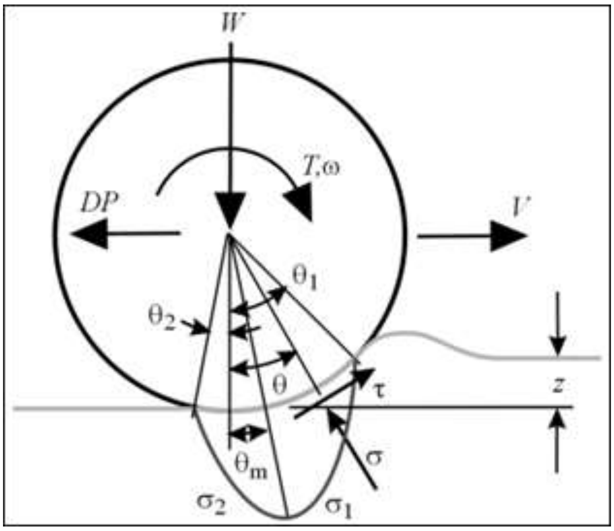

Figure 4 Diagram of Wheel/Soil Interactions

The sinkage of rigid wheel on flat ground:

$$Z = \left(\frac{3W_w}{(3-n)(k_c+b_w k_\phi)(\sqrt{d_w})}\right)^{\left(\frac{2}{2n+1}\right)}$$

$$= \left(\frac{3 \times 42}{(2)(689+0.08 \times 1058600)(\sqrt{0.16})}\right)^{\left(\frac{2}{3}\right)} = 15\text{mm}$$

Compacting resistance:

$$R_c = \frac{\left(\frac{3W_w}{\sqrt{d_w}}\right)^{\frac{2n+2}{2n+1}}}{\{(3-n)^{\frac{2n+2}{2n+1}}\}(n+1)(k_c+bk_b)^{\frac{1}{2n+1}}}$$

$$= \frac{\left(\frac{3 \times 42}{\sqrt{0.16}}\right)^{\frac{4}{3}}}{\{(2)^{\frac{4}{3}}\}(2)(689+0.08 \times 1058600)^{\frac{1}{3}}}$$

= **9.6 N**

Bulldozing resistance:

$R_b = (0.5 \propto b_w z^2 (\tan(45 + \frac{\emptyset}{2}))^2) + 2cb_w z(\tan(45 + \frac{\emptyset}{2}))$

$= (0.5 \text{ x } 1 \text{ x } 0.08 \text{ x} 0.015^2 (\tan(45 + \frac{28}{2}))^2)$

$+2 \text{ x } 180 \text{ x } 0.08 \text{ x } 0.015(\tan(45 + \frac{28}{2}))$ = **0.72 N**

Rolling resistance:

$R_r = f_r W_w$= 0.05 x 42 = **2.1 N**

$R_{tot}=R_c + R_b + R_r$

= 9.6+2.1+0.72 = **12.5 N**

Traction force:

$H = Ac + (\frac{W}{4})\tan \emptyset$

$= (7.44\text{x}10^{-3}$

$\frac{42}{}\tan 28$

= **23.67 N**

x180) + ($_4$)

Length of contact area:

$L=\sqrt{[d^2-(d-2z)^2]}$

$= \sqrt{[0.160^2 - (0.160-2 \text{ x } 0.015)^2]}$

= **0.093 m**

Contact area of the wheel:

A=L x b

= 0.093 x 0.08 = **7.44x**$10^{-3}m^2$

Draw pull:

DP=H-R

=[23.67-12.5]=**11.17N**

5. LOADING CONDITIONS AND ANALYSIS

IMPACT LOAD

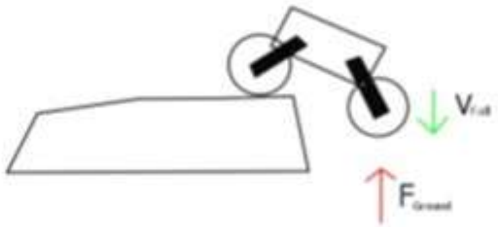

Figure 6 Impact Load design

A common type of structural analysis problem results from An impact load. The impact could be caused by a weight falling on the design object or possibly from the Object falling and striking a hard surface. In both cases, the Loads are not obvious but can be easily derived from our Knowledge of mechanics.

Force Calculation:

Assumed,

Height of drop: H=0.1m,

Distance covered during drop: X=0.01m

Work Done=Potential Energy

FX= mgh

On rearranging above equation, we get

$(4F)x = mgh$

$$F = \left(\frac{25 \times 9.81 \times 0.1)}{4 \times 0.01}\right) = 630\text{ N}$$

Equivalent static force **F=630N**

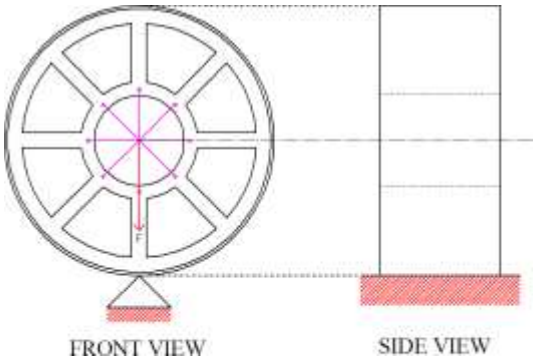

Figure 7 Impact Load Boundary Conditions Plot

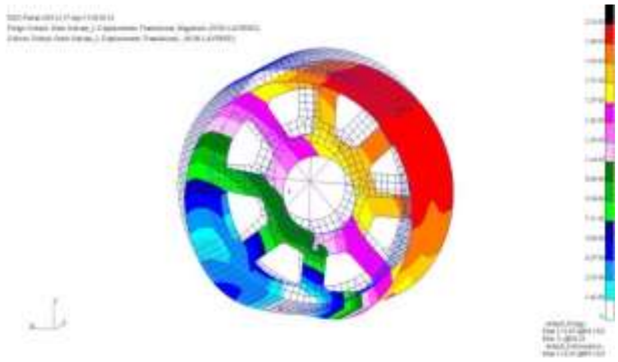

Figure 8 Alumminium Displacement Plot Maximum displacement=0.0213mm

Figure 9 Von Mises Plot – Alumminium Von Mises Maximum stress=26Mpa

Boundary Conditions

Figure 10 Hoffman's Failure Index Plot Hoffman failure index**=0.198**

6. FABRICATION

There are numerous methods for fabricating composite components. Some methods have been borrowed (injection molding, for example), but many were developed to meet specific design or manufacturing challenges. Selection of a method for a particular part, therefore, will depend on the materials, the part design and end-use or application.

Composite fabrication processes involve some form of moulding, to shape the resin and reinforcement. A mould tool is required to give the unformed resin /fiber combination its shape prior to and during cure. For an overview of mold types and materials and methods used to make mold tools.

The most basic fabrication method for thermo set composites is ***hand layup***, which typically consists of laying dry fabric layers, or “plies,” or prepreg plies, by hand onto a tool to form a laminate stack. Resin is applied to the dry plies after layup is complete (e.g., by means of resin infusion).

7. SUMMARY AND CONCLUSION

Mass comparison CFRP wheel with existing Al. wheel

Table 1 Masses of Aluminium and CFRP Wheel

Aluminium wheel (in gm)	CFRP wheel (in gm)
326	153

RESULTS OF DIFFERENT LOADING CONDITIONS

Table 2 Results of Different Loading Conditions

Loading Conditions	Aluminium maximum Von-Mises stresses (σ) (MPa)	Composite material (CFRP) failure indices
Skid steering	43.9	0.4<1
Impact loading	26	0.198<1
Rim pull	17.81	0.104<1
Reaction force	2.97	0.014<1
Impact loading with grousers		0.0664<1
Rim pull with grousers		0.05<1
Launch load X Y Z	 0.893 0.868 22.8	 0.00075<1 0.000756<1 0.0309<1

8. FUTURE WORK

Possible future work for this project may include the addition of metal tips to the grousers for improved wear resistance as well as further optimization for weight and tenability of the wheels for improved traction performance. Moreover, the attachment between grousers, rim and spoke can also be improved. Instead of gluing the three parts together after they are manufactured separately, a new layup method could be developed so that weak connection points could be avoided. Fabrication of two more wheels should also be as per previous procedure, so that the rover can be properly assembled. Finally, thorough field testing should be performed to determine the performance, robustness, and longevity of the wheels.

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