Vehicle Dynamics Project

Modeling and Analysis of Tire Models and comparison with energy harvesting tires

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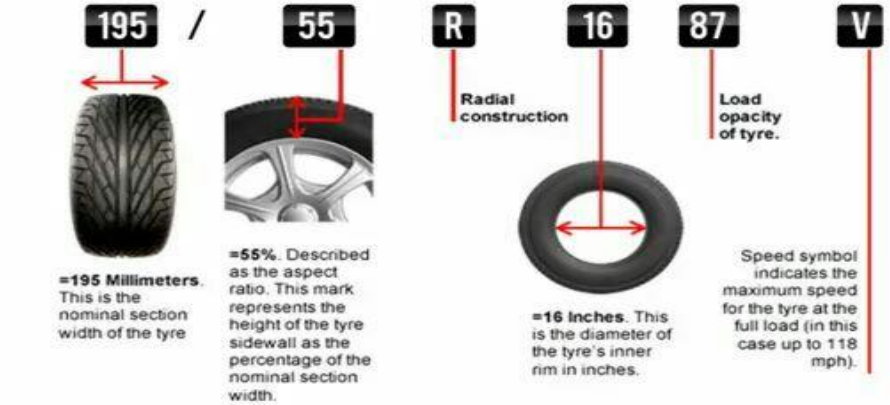
What is Tyre?

- Tyre is a Rubber Material which covers the circumference of the Wheel.
- Used to dampen the Oscillation caused by irregularities in the road surface.
- Protects the wheel from Wear & Tear.
- Provides Friction between the Ground & Vehicle to improve the acceleration & handling.

Nomenclature of a Tyre



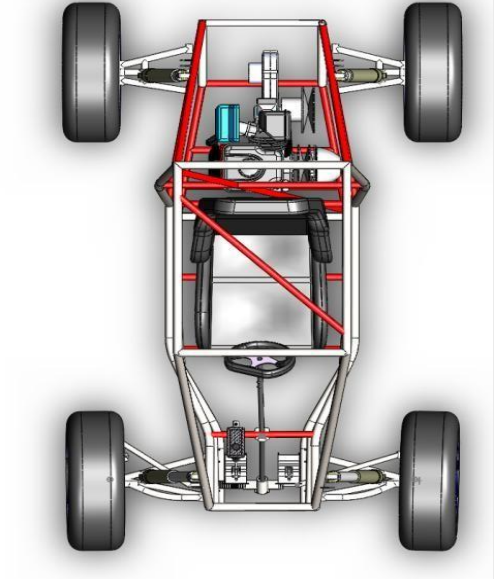
195	55	R	16	87	V
Nominal Section Width	Normal Aspect Ratio (Section Height/Section width)	Construction (R-Radial)	Rim Diameter	Load Index	Speed Symbol

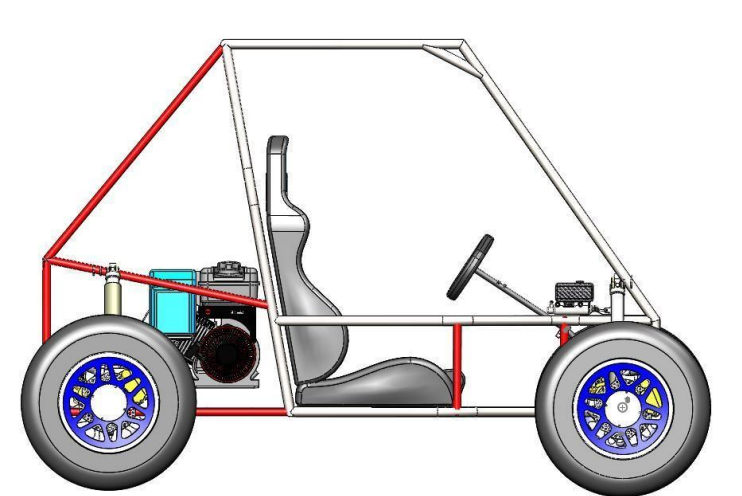
Classification of Tyres

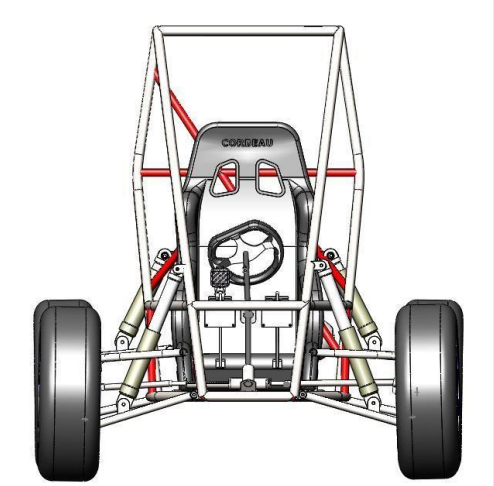
Depending upon skeleton of tyre (Carcass) tyres are classified into following main types:

- Bias Ply :- Ply Cords are at an angle of 30°- 40° to the tyre axis.
- Radial Ply :- Ply Cords are at an angle of 90° to the tyre axis.
- Belted-Bias Ply :- It’s a combination of both types of Tyres.

Solid Car Model:

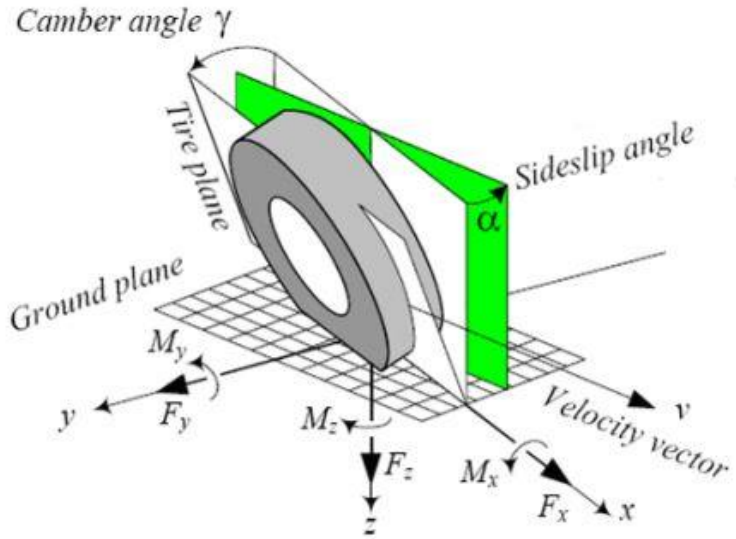






Tyre force and moment

- Tyre force and moment characteristics are introduced in the coordinate system given by the Society of Automotive Engineers (SAE)

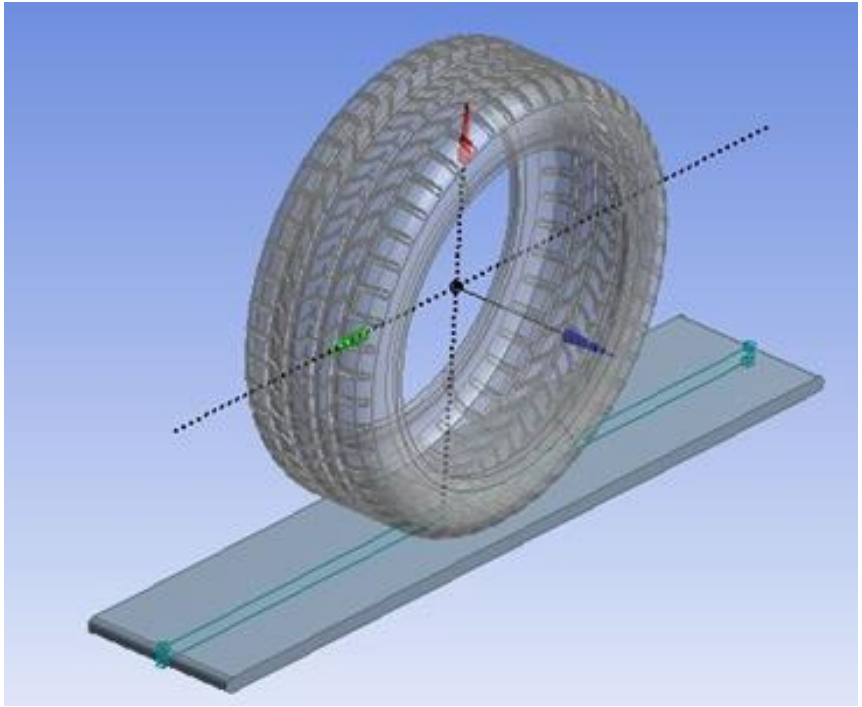


Tyre Stiffness

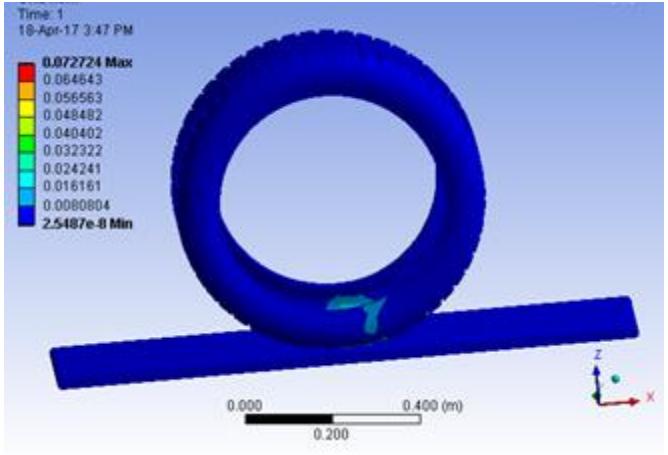
- Tyres carry different loads in service including inflation pressure, externally applied mechanical loads and thermal loads. Due to the effect of these loads and the contact with the wheel rim and road, the tyre geometric shape changes, noted as deformation.

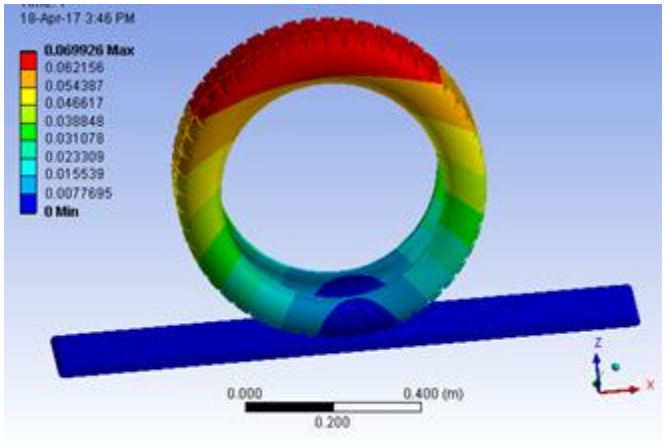
- This deformation can be represented by measuring the displacement of selected locations on the tyre. Specific relationship between mechanical load and tyre displacement is defined to represent the ***tyre stiffness***

Modelling



Simulation


Time: 1
18-Apr-17 3:47 PM
0.072724 Max
0.064643
0.056563
0.048482
0.040402
0.032322
0.024241
0.016161
0.0080804
2.5487e-8 Min
0.000
0.400 (m)
0.200
Z
X


18-Apr-17 3:46 PM
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0.062156
0.054387
0.046617
0.038848
0.031078
0.023309
0.015539
0.0077695
0 Min
0.000
0.400 (m)
0.200
Z
X

Energy Harvesting Types

- Energy Harvesting is a process of harvesting energy from the tyres because of the vibrations caused due to sudden change in the road surface.

- Piezoelectric effect is used for Energy Harvesting from Tyres.

Nanogenerators

- A Nanogenerator is a device that converts the small mechanical or thermal changes into electrical energy
- The Nanogenerator in a tire works on the principle of piezoelectric effect
- If a flexible NG is attached to inner surface of the tire and when this NG passes the compression point an electric pulse is generated
- The Energy harvested in this process depends on the performance of NG and the strain induced
- The Energy Harvested for a number of cycles is stored in capacitor or battery for powering other electronic device

Piezoelectric Effect

- Relation between measured output voltage V and open circuit voltage Voc is

$$V = Voc*Rm /(Rg + Rm)$$

- Relation between measured output current I and short circuit current is Isc

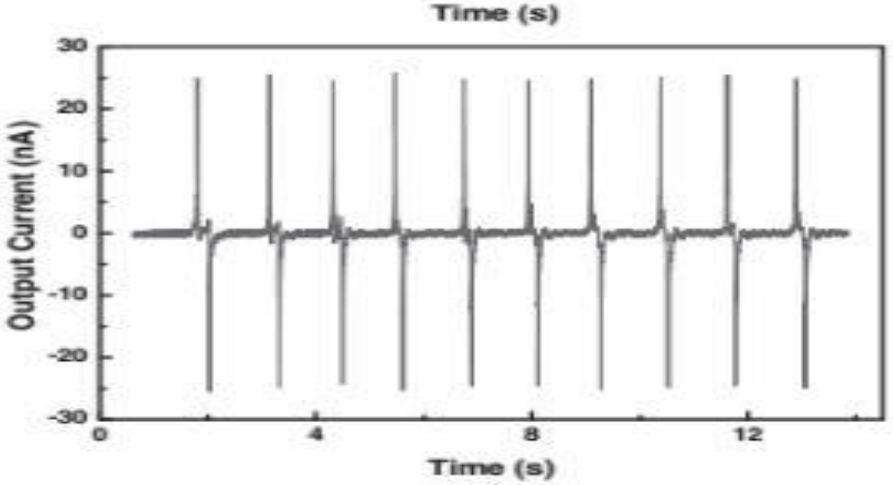
$$I = Isc*RG /(Rg + Rm')$$

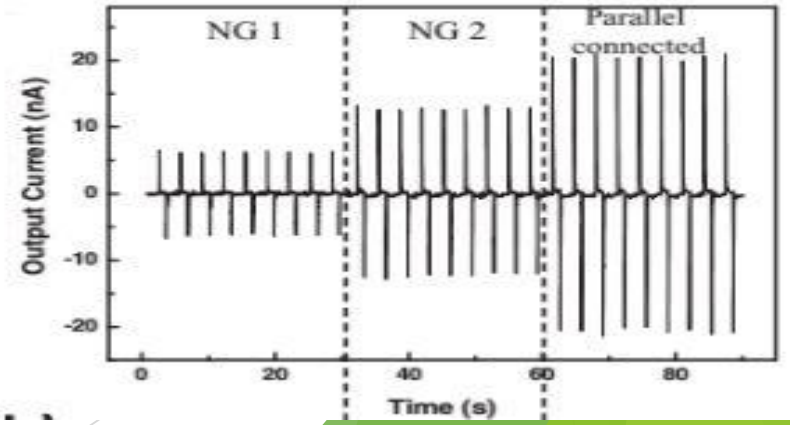
Where, Rg = inner resistance of NG
Rm = resistance of voltmeter = 100MΩ
Rm′ = resistance of ammeter = 10KΩ

Factors affecting output power

- The output power obtained by this Nanogenerators can be scaled by some of the following means :-

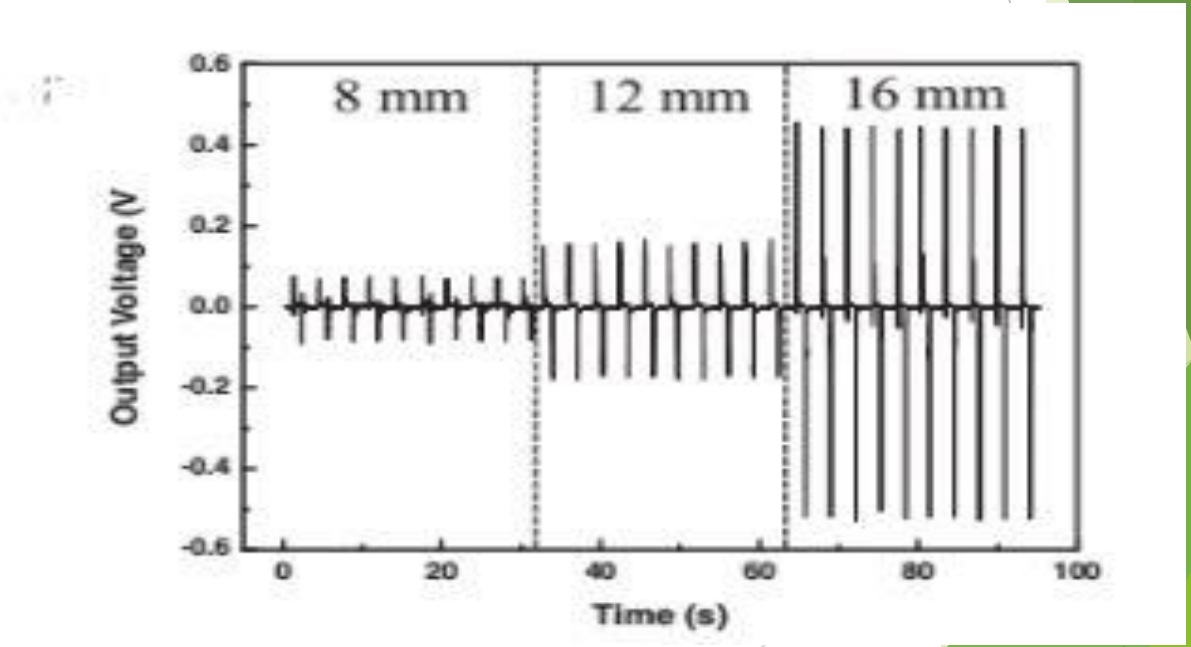
1. By placing these NG's in parallel the output power has been increased as the output of both NG's is will be same phase so the power densities will add up and the resultant output power increases



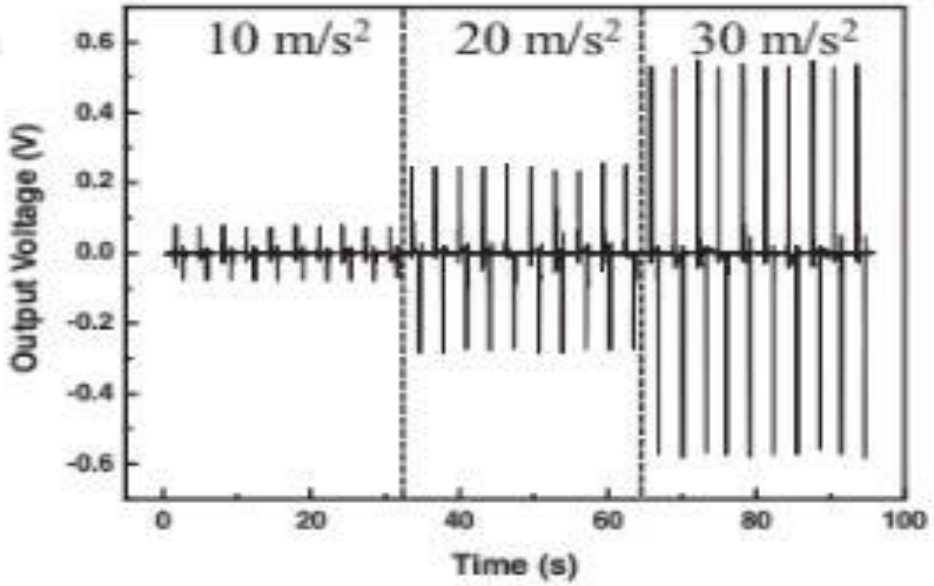


2. Less pressure implies flatter tire and the amount of power output is also increased

3. As the travel Distance increased the deformation of tire increased i.e the strain applied on NG increases that increases output voltage



4. As the velocity of the vehicle increases the strain rate increases resulting in increases in output voltage



Tools and References

- A Nanogenerator for Energy Harvestor from a Rotating Tire and its Application as a Self-Powered Pressure/Speed sensors 2011- Youfan Hu, Chen Xu, Yan Zhang, Long Lin, Robert L. Snyder, and Zhsang Lin Wang
- Piezoelectric Power Generation in Automotive Tyres 2000– Noaman Makki and Remon Pop-Illiev
- Tyre Static Structural Analysis Video by Mechanical Engineering Association (MEA) – BITS Pilani, Dubai Campus
- Ansys Workbench and Solidworks (Tools)

THANK YOU