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Static Structural Analysis of a Motorcycle Wheel Using Solid Works

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Abstract: The wheel is a vital component of a motorcycle as it aids in translation motion via its rotation. The condition of the wheel should be such as to maintain its proper function during its service life. This work presents the static structural analysis of aluminum alloy motorcycle wheel under static loading condition. The three - dimensional (3-D) model of the wheel (2.75x17) was generated, discretized, loaded and analyzed using Solid Works. The wheel was constrained at its mounting holes and loaded circumferentially along its rim with combined radial load and inflation pressure of 1800 N and 0.28 MPa, respectively. The displacement, stress and strain on the outer rim circumferential angular locations from 0º degree (deg) to 180º symmetric about the point of contact with the ground were determined. It was observed that the absolute maximum displacement of about 3.09 mm was at 0º angular location, while the overall average absolute displacement within the range was about 1.62 mm/mm. The maximum value of the Von-Mises stress was about 20.9 MPa, which was the same at between 0º and 60º contact angle; with a mean absolute stress was about 20.3 MPa. The absolute maximum axial strain value was about 0.0235 mm/mm, while the maximum resultant strain value was about 0.0342 mm/mm and observed at ground contact. The values obtained for displacement, stress and strain were within their respective limiting values and their maximum absolute and resultant values were observed to occur at the point of contact of the wheel's rim with the ground, which represents the critical location of the wheel.

Keywords: *Structural Analysis, Stress, Strain, Displacement***.**

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I. INTRODUCTION

A wheel is a circular device that is a capable of rotating on its axis facilitating movement or transportation while supporting a Load (Mass). Motorcycle wheels are critical for performance of safety as they encounter hard impact loads from rough roads and potholes. Common examples are found in transport applications [1, 2].

A wheel, together with an axle overcomes friction by facilitating motion by rolling. In order for wheel to rotate, a moment needs to be applied to the wheel about its axis, either by way of gravity, or by application of another external force. More generally the term is also used for other circular objects that rotate or turn such as a ships wheel, steering wheel and flywheel [1].

Motorcycle wheels are made to cope with radial and axial forces. They also provide a way of mounting other critical components such as the brakes, final drive and suspension. Wheels and anything directly connected to them, are considered to be unspring masses. Traditionally motorcycles used wire-Spoked wheels with inner tubes and pneumatic tires. Although cast wheels were first used on a motorcycle in 1927, it not until the 1970s that main stream manufacturers started to introduce cast wheels in their road going motorcycles. Spoked wheels are usually made using steel spokes with steel or aluminum rims. Cast wheels are predominantly made from more-exotic materials, such as magnesium content alloy or carbon fiber [3, 4, 5].

There are so many types of wheels still in use in the automobile industry today- wire spoke wheel, steering wheel, light alloy wheel, aluminum alloy wheel. They vary significantly in size shape and materials used, but all follow the same basic principles [3, 6, 7]. The turn of the century saw the outbreak of World War I, which drove significant developments in motorcycle technology. The two-wheeled marvels played vital roles in military operations, solidifying their reputation as versatile and agile vehicles. The invention of the motorcycle created the self-propelled bicycle**.** Next to controlled fire, the wheel was clearly early man's most significant invention. It advanced transportation, manufacturing, and warfare significantly and to this day is present in multiple forms from rotary tools, electric generators, trains, automobiles and jet engines to cooling fans in electronic computers and drills used in dentistry [7].

Wheel rim is that part of an automotive where it undergoes statics and fatigue loads, because it travels on a lot of roads. This develops heavy stresses in the rim and this it is necessary to determine the critical stress point and shear stress point and shear stress [8]. Wheels are one of the key components that determine the dynamic performance of the motorcycle and blows from the road surface can cause stress and deformation. Therefore, the safety aspect is very important to be taken into account in the automotive world because it is closely related to the lives of passengers. [9, 10].

This work aims at determining the static structural analysis of the mechanical response of motorcycle wheel under static loading condition, to determine the loading effect on the wheel and to identify the location of the wheel with extreme induced displacement, stress and strain values on the wheel's rim.

- *Loading Condition On Rim*

Possible loading conditions on the metal rim are: pressure due to inflation, radial loading on the bead seat resulting from the weight of the motorcycle and local bending moments induced on the rim due to an offset [11]. These are directly influenced by the width of the rim. Fig. 1 shows the force acting on the tire.

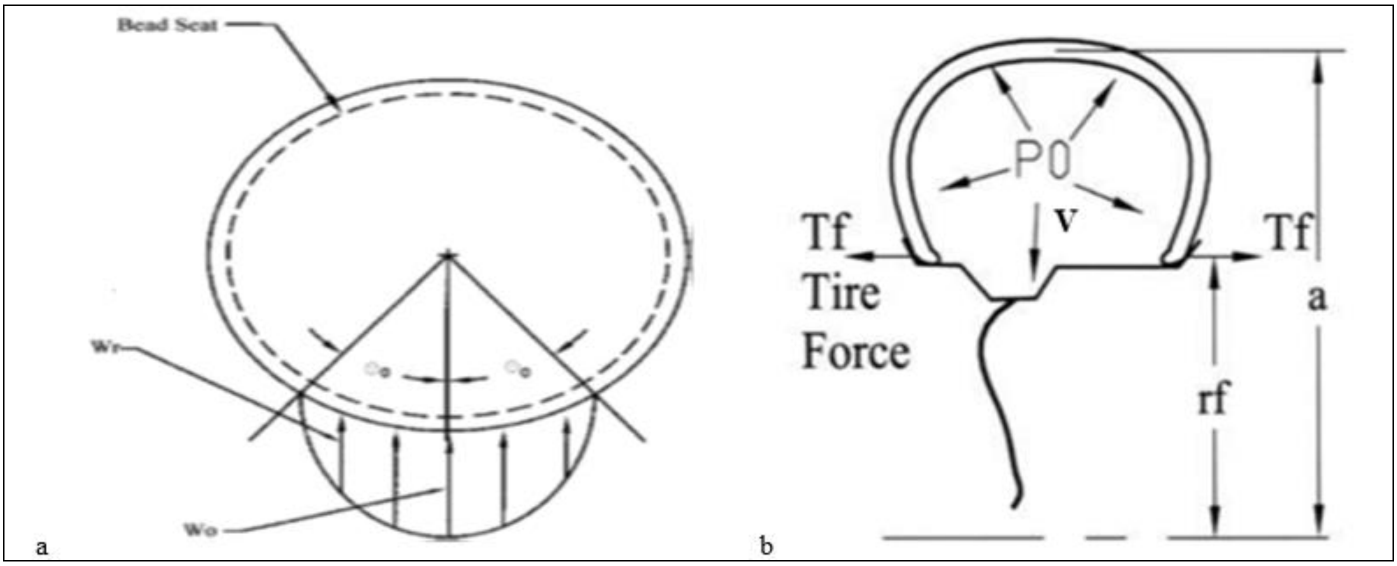

Fig 1 Force Acting on Tire – Rim Interface: (a) Radial Load; (b) Inflation Pressure [Source: 11]

II. METHODOLOGY

The wheel material used is depicted in Tables 1-3 below. It is a 5-armed wheel. Table 1 shows the elements of the aluminum alloy; Table 2 illustrates the mechanical properties, while Table 3 shows the maximum deflection within specific range of wheel's diameter.

Table 1: Elements of Aluminum Alloy

Material Name	**Elements**
Aluminum Alloy	Copper, Magnesium, Manganese, Silicon, Tin and Zinc.

Source: [12]

Table 2 Mechanical Properties of Aluminium Alloy Wheel

Mechanical Property	**Value**
Young Modulus	71000 MPa
Yield Stress	80 MPa
Poison's ration	0.33
Density kg/m^3	2770

Source: [12]

Table 3 Maximum Deflection Limits

Nominal Rim Diameter Code (Inch)	**Deflection (mm)**
15 or less	10
16, 17, 18	15
19 or more	20

Source: [12]

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Fig. 2 shows the geometry and dimensions of the motorcycle wheel. A three - dimensional (3-D) model of the wheel (2.75 x 17) was generated and discretized into elements using Solid Works. The model consists of 2083 elements and 37620 nodes. Figs. 3 and 4 show the 3 – D model and wheel mesh, respectively. The wheel was constrained at its mounting holes and loaded circumferentially along its rim with combined radial load and inflation pressure of 1800 N and 0.28 MPa, respectively, Fig. 5. The displacement, stress and strain were determined at specific locations of the wheel from the point of contact of the wheel with the ground at 0^o to 180^o symmetric about the point of contact so as to determine the critical location of the wheel in terms of the maximum displacement or deflection, maximum stress and maximum strain.

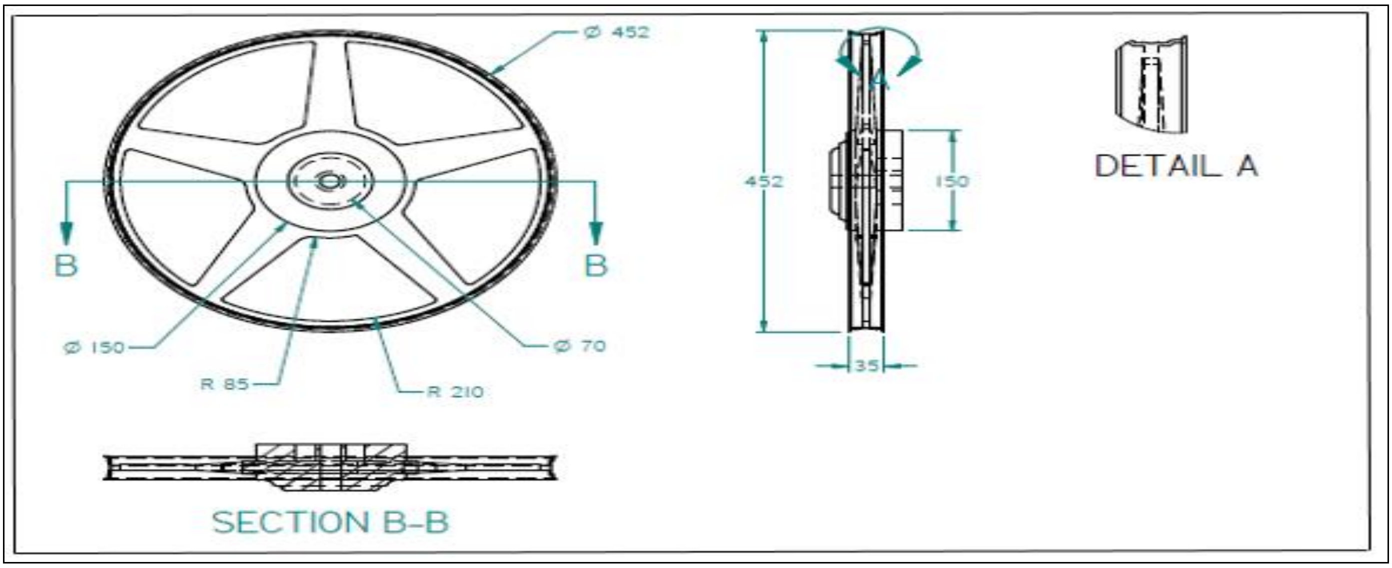

Fig 2 Motorcycle Wheel Views and Dimensions (mm)

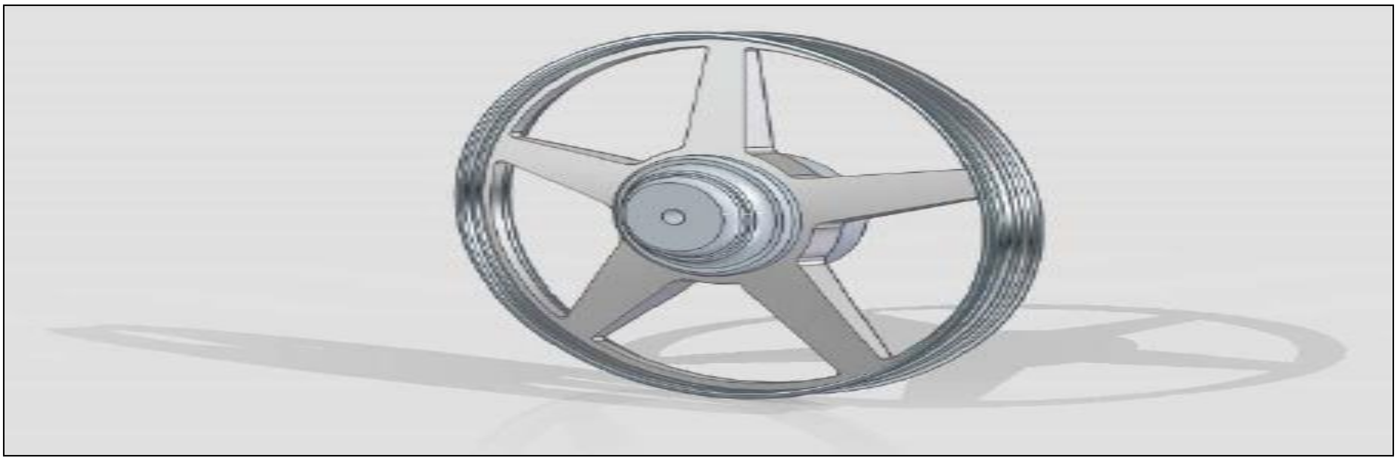
Fig. 3: Three - Dimensional (3 – D) View of wheel

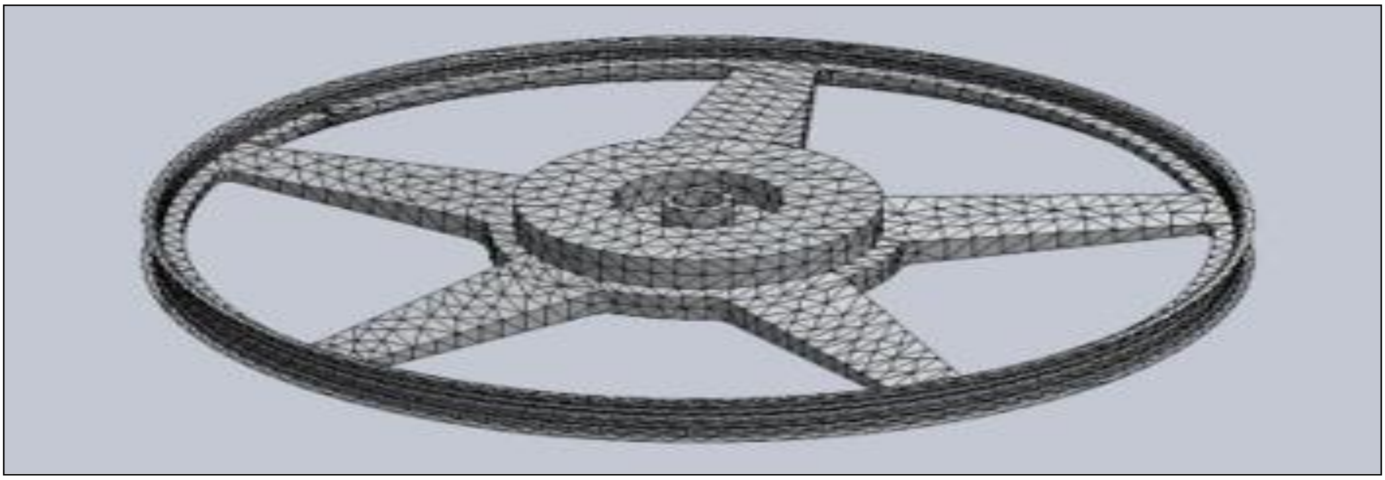
Fig 4 Wheel Mesh

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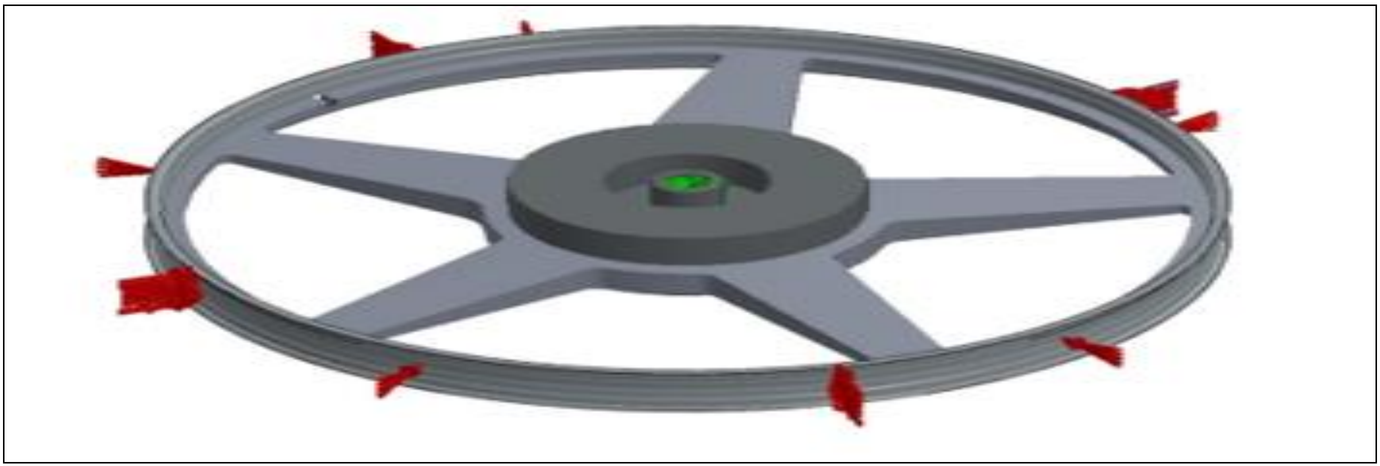

Fig 5 Loaded Wheel

III. RESULTS AND DISCUSSION

Below are the results obtained from the simulation. Table 4 shows the values of displacement, stress and strain at different locations of the wheel. Fig. 6 represents plots of displacement against location; Fig. 7 shows the plots of stress against location, while Figs. 8, 9 and 10 represent strain values in x, y and z directions, respectively, against locations on the wheel. Fig. 11 represents the resultant strain various angular contact, while Figs. 12 and 13 depict the deformed wheel's fringe for displacement and Von – Mises stress, respectively.

Table 4 Results for displacement, stress and axial strains at chosen locations on the wheel.

Angle (Deg)	Displae-ment (mm)	Stress (MPa)	Strain (dx) mm/mm)	Strain (dy) (mm/mm)	Strain (dz) (mm/mm)	Result-ant Strain (mm/mm)
0	-3.09	20.9	0.0195	-0.0155	0.0235	0.0342
30	-1.27	20.9	0.0105	-0.0154	-0.0220	0.0286
60	0.15	20.9	0.0103	-0.0153	-0.0218	0.0277
90	0.15	19.9	0.0160	-0.0143	-0.0207	0.0298
120	-2.15	19.9	0.0169	-0.0145	-0.0214	0.0309
150	-2.39	19.8	0.0181	-0.0164	-0.0226	0.0324
180	-2.14	19.7	0.0108	-0.0145	-0.0225	0.0289

From Fig. 6, it could be seen that the absolute maximum displacemen value was about 3.09 mm at an angular location of 0^o at ground contact, with a positive slope up to about 50^o contact angle. A downward slope was observed to occur between 100^o and about 125^o angular contact. The overall average absolute displacement was about 1.62 mm/mm. The turning points of the plots represent the spike/arm locations.

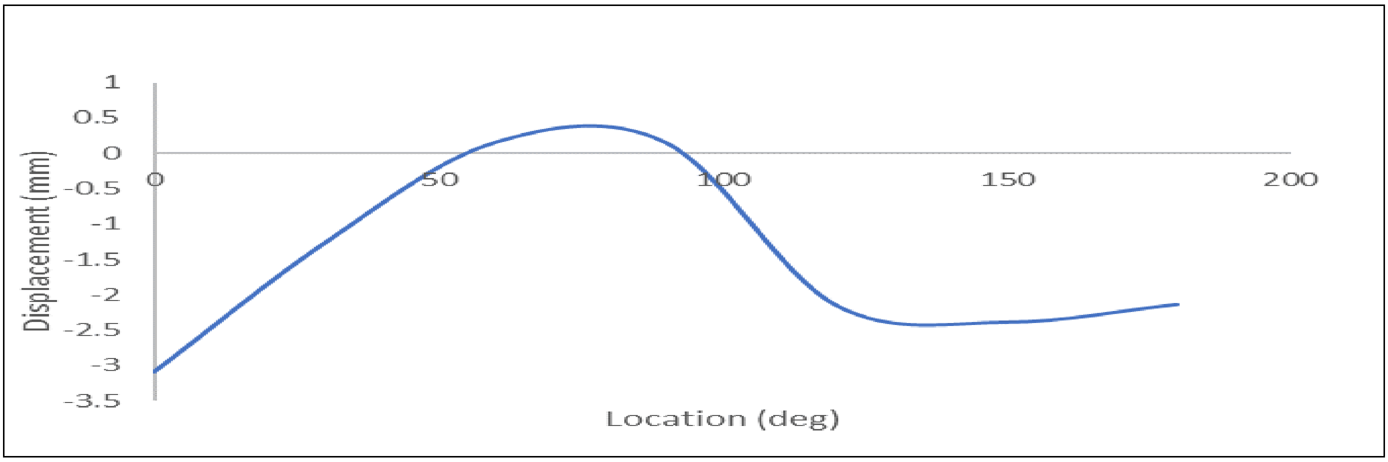

Fig. 6: Displacement at Chosen Locations

Fig. 7 shows plots of Von-Mises stress against selected wheel location. The stress value was greatest at 20.9 MPa at circumferential angles between 0^o and 60^o. A downard slope was observed between 60^o and 100^o angular locations, with a drop from 20.9 MPa to about an average value of about 19.8 MPa from between 90^o and 180^o contact. The mean absolute Von – Mises stress was about 20.3 MPa.

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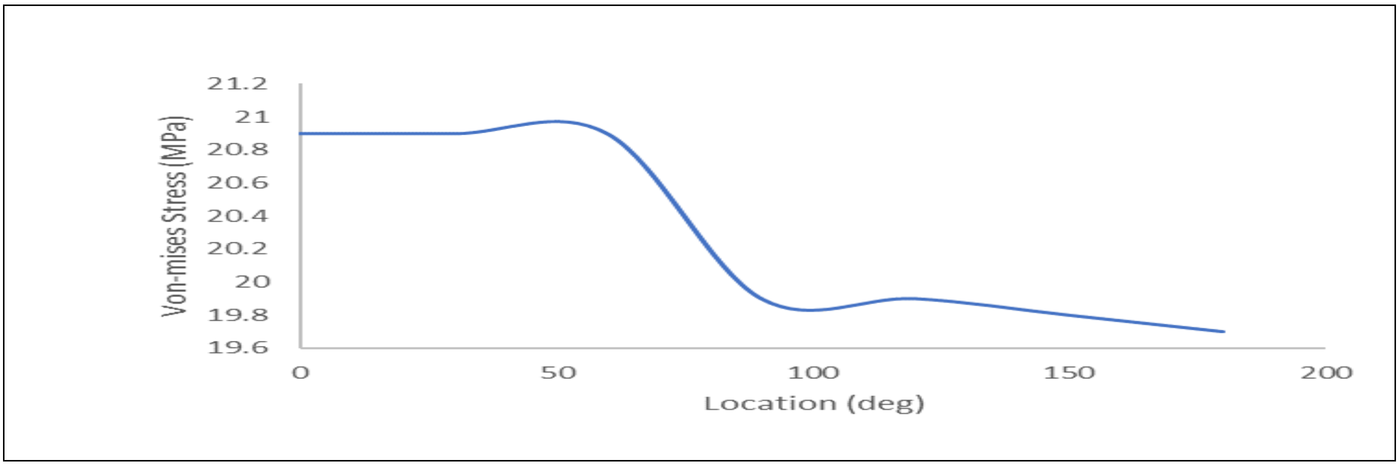

Fig 7 Von – Mises Stress at Chosen Location

Fig. 8 represents the strain-location plots in the x-direction. It was observed that the maximum absolute strain value occurred at ground contact and was about 0.0195 mm/mm; it decreases with a constant slope to about 0.103 mm/mm up to 60^o angular location and, was up to about 0.0169 mm/mm at 120 degree location. The absolute strain values at 150^o and 180^o locations was about 0.0181 mm/mm and 0.0108 mm/mm, respectively. The mean strain value was about 0.0146 mm/mm.

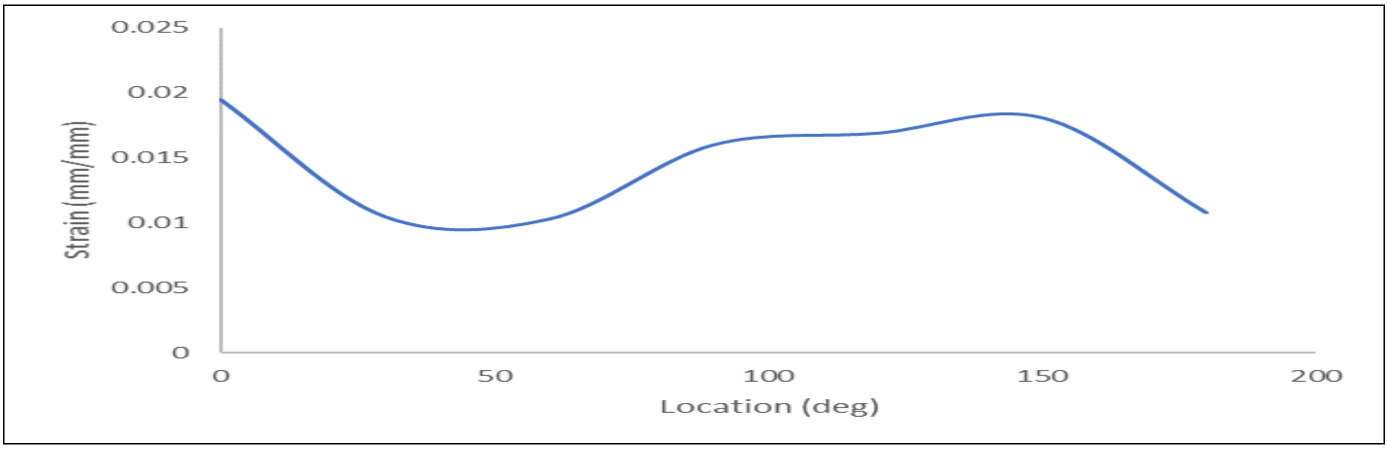

Fig 8 Strain in x-Direction

Fig. 9 shows the plots of strain in the y-direction vesus wheel's circumferential angular location. It could be seen that the absolute maximum strain value of about 0.0155 mm/mm was obtained at 0^o angular location, with the least value of about 0.0143 mm/mm at 90^o angle. The absolute strain value in the y – direction at 180^o angular location was about 0.0145 mm/mm. The average absolute value of strain was about 0.0148 mm/mm.

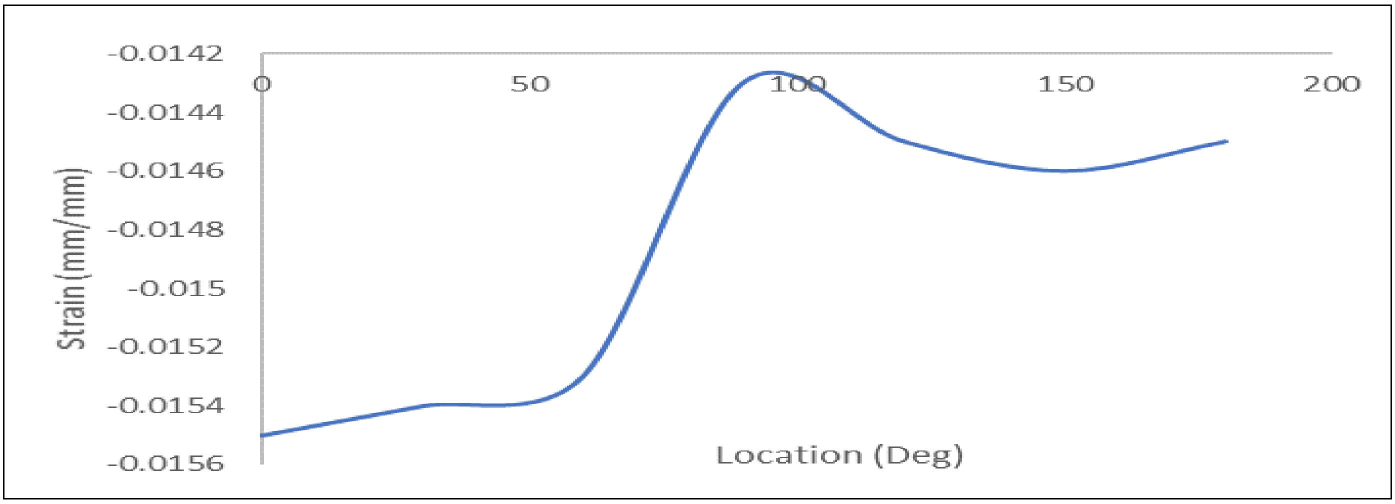

Fig 9 Strain in y-Direction

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The graph of Fig. 10 represents the plots of strain in the z-direction against location on the wheel. The absolute maximum strain value was about 0.0235 mm/mm and, was perceived to occur at 0º anglar location. The least absolute strain value was at 90º contact angle, with a value of about 0.0207 mm/mm. Overall, the mean absolute strain value was about 0.0221 mm/mm.

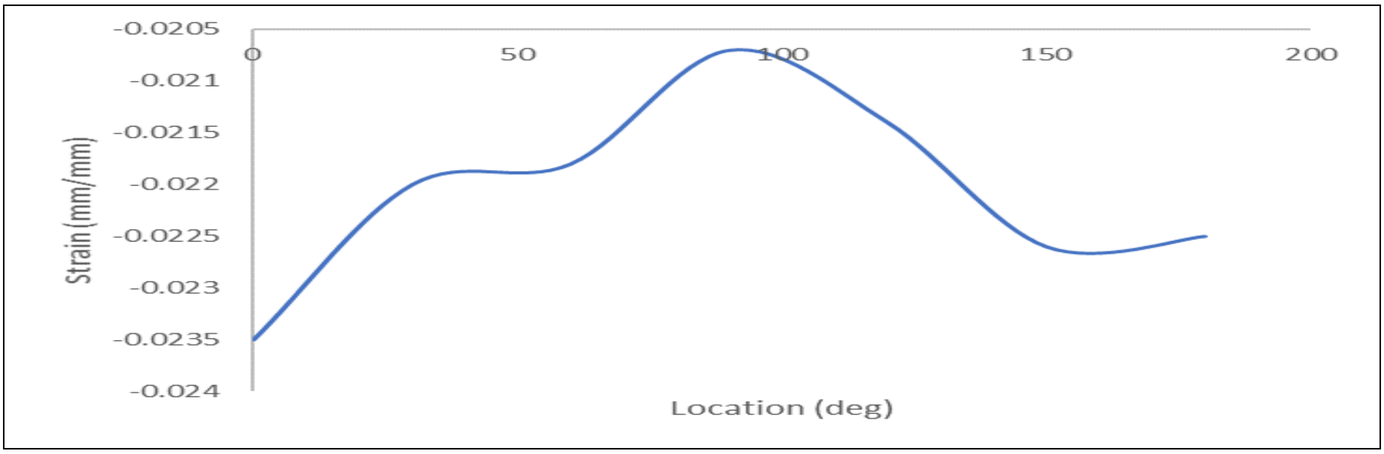

Fig 10 Strain in z-Direction

Fig. 11 shows the resultant strain values relative to angular locations. The maximum resultant strain was at ground contact of 0º, with a value of about 0.0342 mm/mm, while the minimum resultant strain value of about 0.0277 mm/mm was observed at contact angle of 60º. The average resultant strain was observed to be about .0304 mm/mm.

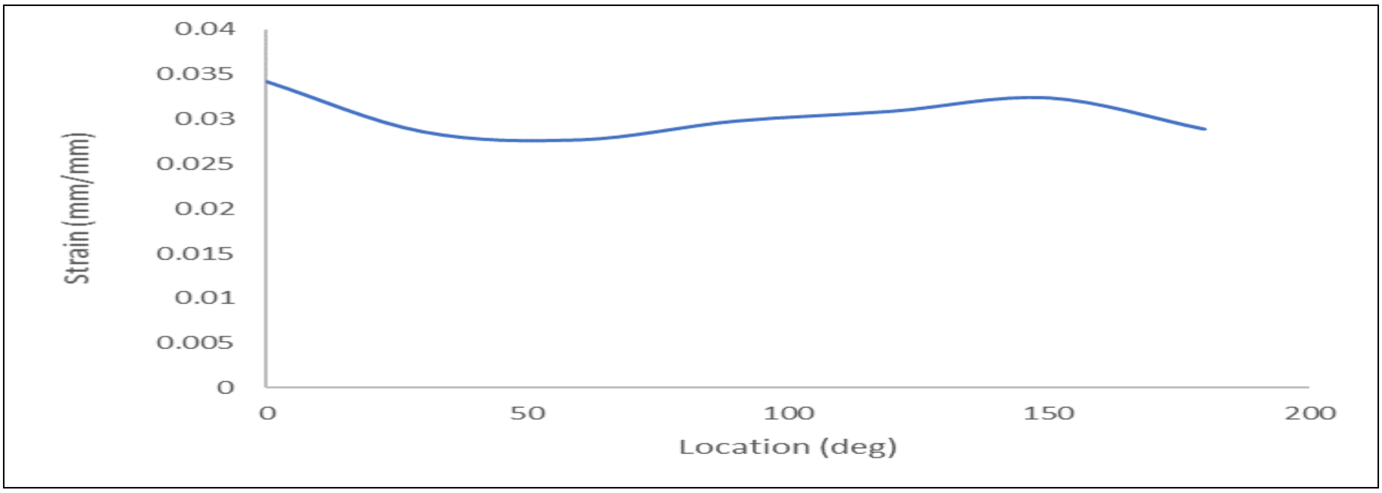

Fig 11 Resultant Strain

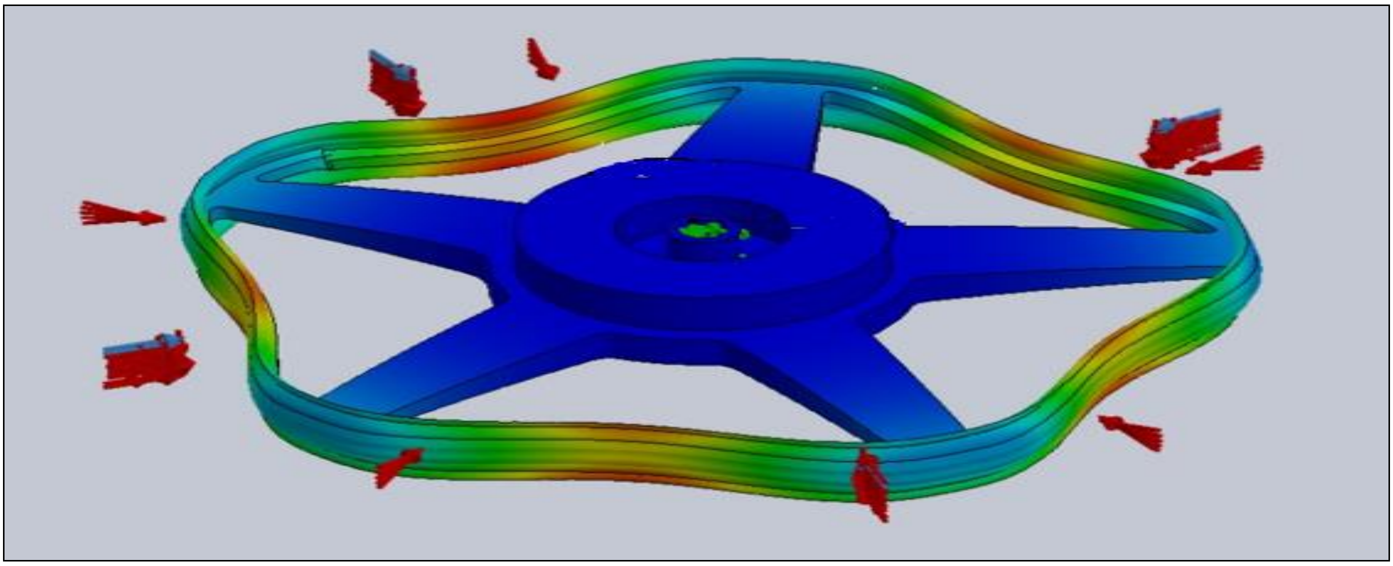

Fig 12 Displacement Fringe.

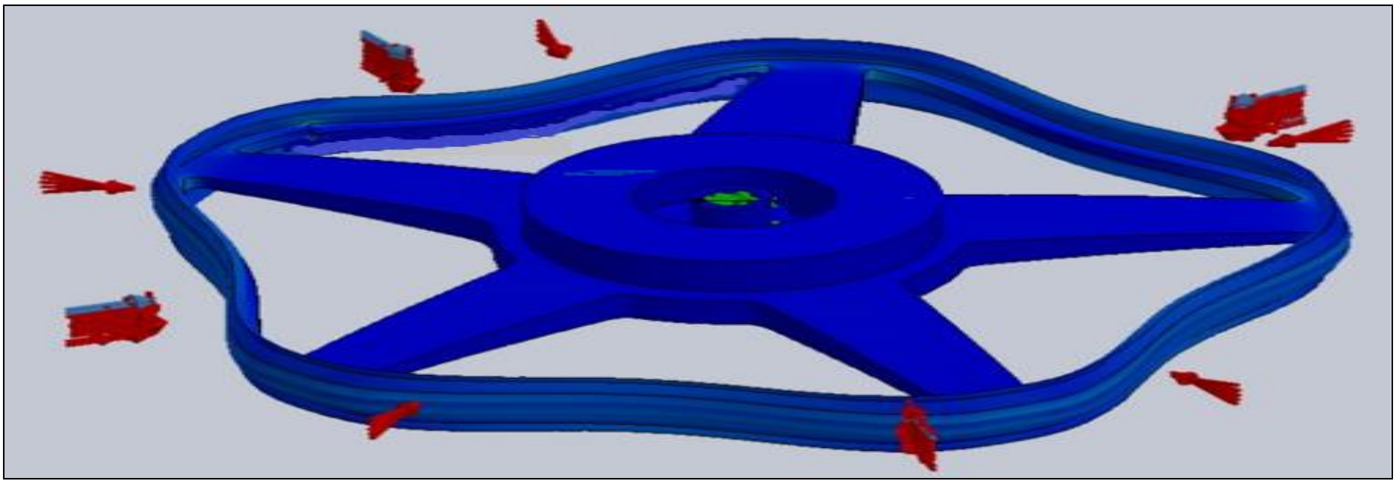

Fig 13 Von – Mises Fringe.

IV. CONCLUSION

The static structural analysis of aluminum alloy motorcycle bike wheel has been undertaken using Solid Works. The displacement, stress and strain on the outer rim circumferential angular locations from 0^o to 180^o symmetric about the point of contact with the ground were determined. It was observed that the absolute maximum displacement of about 3.09 mm was at 0^o angular location. The overall average absolute displacement within the range was about 1.62 mm/mm. The maximum value of the Von-Mises stress was about 20.9 MPa, which was the same at between 0^o and 60^o contact angle; with a mean absolute stress was about 20.3 MPa. The absolute maximum axial strain value was about 0.0235 mm/mm, while the maximum resultant strain value was about 0.0342 mm/mm and observed at ground contact. The values obtained for displacement, stress and strain were within their respective limiting values and their maximum absolute and resultant values were observed to occur at the point of contact of the wheel with the ground.

REFERNCES

[1]. Nasution, A. K., Alfindo and Sunaryo (2024). The Effect of Motocycle Wheels (Original Equipment Manufacturer) Recognition Process on Mechanical Properties and Microstructure. Rekayasa Energi Manufaktur (R.E.M), 9(2). DOI: https//doi.org/10.21070/r.e.m.v9i2.1714.

[2]. Putra, A. D., Septiawan, D. R., Pradani, Y. F., Rakhmaddian, N. N.& Huda, M. A. N. (2025) Performance Evaluation of Motorcycle WheeL Racing Cast Wheels Under Dynamic Load Using Finite Element Method With Aluminum Material. G-Tech Jurnal Teknologi Terapen. 9(1). DOI:https://doi.org/10.70609/gtec.v9i1.6166.

[3]. Dennis, B. (2015). https://en.m.wikipedia.org/wiki/Motorcycle_wheel

[4]. Rao, K. S., Rajesh, M. & Babu, G. S. (2017). International research journal of engineering and technology (IRJET) 4(61) June-2017. Design and analysis of alloy wheel.www.irjet.net

[5]. Henning, A. (2020). How To Perform A Motorcycle Pre-Ride Inspection · Pre-ride checks that could save your life. *Mc Garage* · https://www.motorcyclistonline.com › authors › ari-henn...

[6]. Gondhali, S. L., Dhale, A. D. & Pagare, S. (2019). Static Structural Analysis of Car Rim. In H. Vasudevan, V. K. N. Kottur and A. A. Raina (Eds.), Proceedings of International Conference on Itelligent Manufacturing and Automation (Pp. 181-193). Singapore.

[7]. Bowie, D. (2023) The World’s First Motocycle: Timeline and features. https://science.com/innovation/inventions/ first – motorcycle htm

[8]. Saurabi M. P. 7 Sameer, J. (2013). Material science 2013, motorcycle wheel https://www.semanticschooler.org

[9]. Tokunaga, H., Ichikawa, K., Kawasaki, T., Kogirima, M., Sakurada, E. &Yamamoto, T. (2025) Development of High Performance Motocycle Wheel Using Numerical Shape Optimization. SAE Technical Papers. DOI: 10.4271/2015-32-0810.

[10]. Gunawan, Y.,Masudi, F., Yamin, M., Nanang, S. & Muslimin, E. (2020). Design and load Analysis Toward the strength of rim modification using work software on motorcycle as a Transportation. Advance in Engineering Research, volume193 2nd International Symposium on Transportation Studies in Developing Countries (ISTSDC).

[11]. J. Steans, T. S. Srivastan, A. Prakash, P. C. Lam (2003). Modeling the Mechanical Resonse of an aluminum Alloy Automotive Rim. Univ. Akron. Pp. 1-4.

[12]. Karteek, N., Pothamsetty Kasi V Rao, P. K. V., K. Ravi Prakash Babu, K. R. P. & Rao, D. M. (2021) Structural Analysis of Motorcycle Alloy Wheel. 3rd International Conference on Design and Manufacturing Aspects for Sustainable Energy (ICMED-ICMPC https://doi.org/10.1051/e3sconf/202130901158