Design and Analysis of E-Bicycle Wheel converted from normal bicycle

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Abstract*: In recent decades attention has recently focused on the use of electric vehicles as means of reducing the pollution, which has long been a challenge in most parts of the world due to various reasons. Under the present infrastructure the use of electric vehicle is an economical challenge though it is predicted that electric vehicles will be the future of mobility. Coming up with a universal way to convert any conventional vehicle to electric will reduce the cost of owning an electric vehicle and this may be the future. This work focuses on design, analysis, fabrication and testing of e-bicycle wheel The stress analysis is carried out using ANSYS on designed component. The stress is found to be within limits. The test carried out showed promising results interms of speed achieved and the torque*

Keywords: e-bicycle,electric vehicles,rim and wheel, throttle

1. INTRODUCTION

In recent decades attention has recently focused on the use of electric vehicles as means of reducing the pollution, which has long been a challenge in most parts of the world due to various reasons. Under the present infrastructure the use of electric vehicle is an economical challenge though it is predicted that electric vehicles will be the future of mobility. An electric bicycle is a type of electric vehicle based on a traditional bicycle to which an electric motor has been added to help propel it. It is an ecological and urban means of transport and its source of energy is a battery. In the 20th century, electric bicycles began to play a more important role because they were an economic and simple option for urban transport problems and had environmental advantages, especially in highly populated countries like China. The main advantages of an electric bicycle are both economic and environmental coming up with a universal way to convert any conventional vehicle to electric will reduce the cost of owning an electric vehicle and this may be the future. This work also focuses on the same, any conventional bicycle can be converted to electric by just changing the front wheel and also a rechargeable as well as portable battery add up to the stress-free ownership. The ultimate aim of this work is to provide a economical e-bicycle to the masses and in turn help reduce the pollution. The main advantages of this work may be that it can be a replacement for the motorbikes if short distance travel is a priority, this will work with a reasonable speed with less fatigue to the rider. Another major advantage is that it will be cheaper than most of the other conventional bikes or e-bikes out there in the market. This work can be upgraded with minimal changes to charge the battery using pedal assist. The battery can be charged even during riding the bike. This ensures continuous energy input to the bike without any additional cost and also increases the range of the bike as it can be considered for long distance rides as well.

2. DESIGN AND ANALYSIS

The present work is started with the design of the rim and frame such that it equips the idlers, motor and battery. There are two idlers mounted and one motor. The battery is fixed to the one of the arms of the frames. Only the frame will be fixed. When the motor is turned on in clockwise direction, it rotates the wheel in clockwise direction only. The dimensions of the rim were practically measured and based on these dimensions, the dimensions of frame, idlers were decided. And the basic model was designed in the SOLID EDGE V19 software.

The design of the wheel practically started from physical measurement of an actual bicycle wheel for its inner diameter, outer diameter and thickness of wall. Based on these dimensions, the dimensions of frame are assumed. Aluminum and steel combination of material was selected for the spokes and rim respectively for the proposed design. The properties of both materials result from its chemical composition and its method of manufacturing, including processing during fabrication.

The newly designed rim will be tested for attainment of speed and torque will be measured and compared with the conventional bicycle rim

BICYCLE RIM

The rim is commonly a metal extrusion that is butted into itself to form a hoop, though may also be a structure of carbon fiber composite, and was historically made of wood. The design of bicycle rim is shown in Figure 1.Some wheels use both an aerodynamic carbon hoop bonded to an aluminum rim on which to mount conventional bicycle tires. The spokes of the bicycle rim are machined off for the purpose of the design. The dimensions of rim considered for analysis are

Outer diameter = 711mm , Inner diameter = 669mm, Thickness = 37.29 mm. The torque and power calculations are shown in Table 1.

Table 1.Design calculations of bicycle rim

SNo	Parameter	Result
1	Total weight	1kN
2	Static Torque	248.5 N-m
3	Rolling Torque	17.75 N-m
4	Static power	5.82 kW
5	Rolling Power	0.416 kW

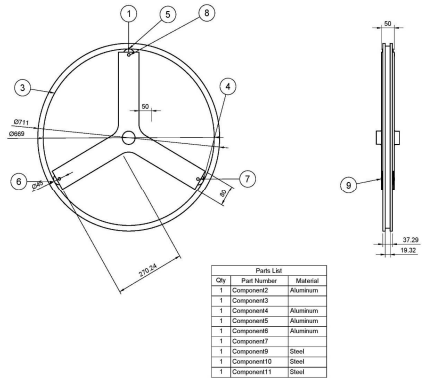

Figure 1. Schematic sketch of bicycle rim

For the purpose of finite element analysis, the geometric model was imported to Ansys 2020 software. The geometric model was assembled and given joints and contact points. The motion to the joints and contacts were also provided. After establishing the contacts, the geometric model was converted to finite element model through meshing. Fusion 360 has automatic mesh feature. The mesh settings are shown in Table 2.

Table 2.Mesh settings

Average Element Size (% of model size)	
Solids	6
Scale Mesh Size Per Part	Yes
Average Element Size (absolute value)	-
Element Order	Linear
Create Curved Mesh Elements	No
Max. Turn Angle on Curves (Deg.)	60
Max. Adjacent Mesh Size Ratio	2.2
Max. Aspect Ratio	10
Minimum Element Size (% of average size)	20

3.RESULTS

After the completion of meshing, the constraints were applied to the part. The center of the frame was fully fixed. The idlers were allowed to rotate on its center axis. The rim was allowed to rotate about the center axis of the frame. For rotation purpose pins were used. After successful constraint, the assembly was subjected to various loads scenarios and the following results were obtained. The total load of 1000 N is taken to be equally distributed between front and rear wheels. The analysis was carried out considering both 400 N and 500 N on the subject rim The load was applied normal to each arm of the frame and normal to the inner surface of the rim. The results are as shown in Table 3

The analysis was carried out to study the various parameters for the load of 400 N on the bicycle rim and results of stress , shear ,deformation, safety factor and strain shown in Figures 2,3,4,5 and 6 respectively

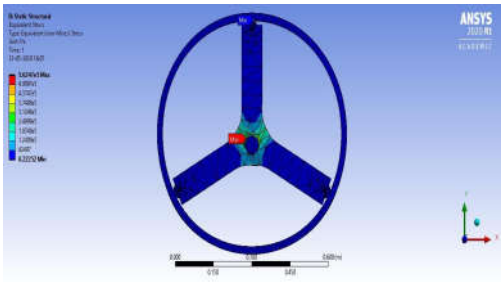

Figure 2. Stress on rim

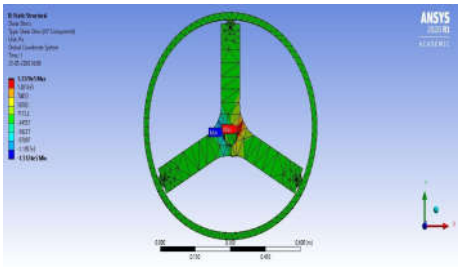

Figure 3. Shear on rim

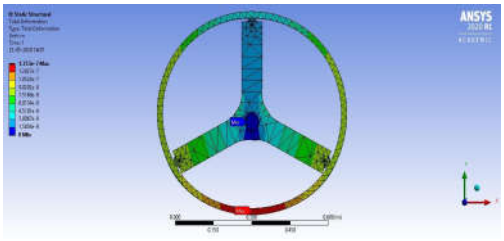

Figure 4. rim Deformation

Figure 5. Safety factor on rim

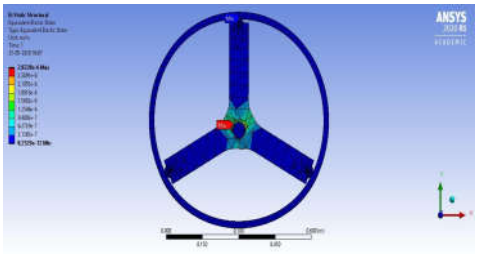

Figure 6. Strain analysis

The analysis was carried out to study the various parameters for the load of 500 N on the bicycle rim and results of stress , shear ,deformation, safety factor and strain shown in Figures 7,8,9,10 and 11 respectively

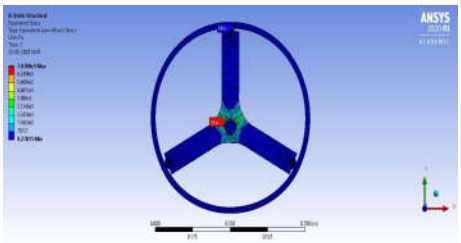

Figure 7. Stress on rim

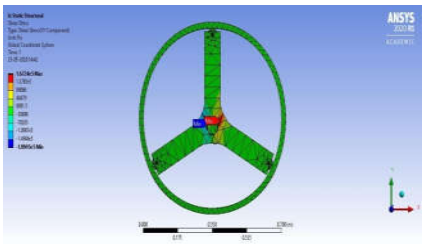

Figure 8. Shear on rim

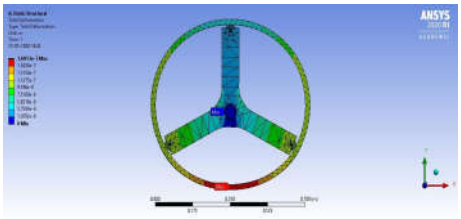

Figure 4. Deformation on rim

Figure 5. Safety factor analysis

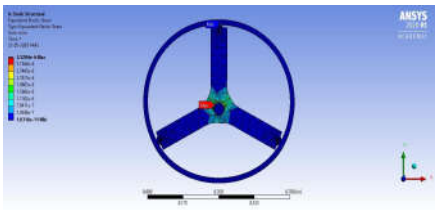

Figure 6. Strain on rim

Table 3.Results obtained under various loads

	For 400N Load		For 500N Load	
Results	Minimum	Maximum	Minimum	Maximum
Equivalent Stress(Pa)	0.22252	5.62E+05	0.27815	7.03E+05
Equivalent Elastic Strain	8.25E-12	2.82E-06	1.03E-11	3.53E-06
Total Deformation(m)	0	1.35E-07	0	1.69E-07
Strain Energy(J)	8.31E-20	7.47E-07	1.30E-19	1.17E-06
Shear Stress(Pa)	-1.51E+05	1.34E+05	-1.89E+05	1.67E+05
Life	1.00E+06	1.00E+08	1.00E+06	1.00E+08

4. CONCLUSION

Use of e-bicycle would be the efficient and environmental friendly. The design parameters are according to the standard design values of any given bicycle wheel. The analysis was carried put considering rider weight of 90 Kg and stress induced is found to be 0.56 MPa for 400 N loads and 0.703 MPa for 500 N load on the rim. The newly designed rim was tested on actual bicycle. The maximum speed of the bicycle found to be 30Kmph at 223RPM and maximum torque was measured and found to be 26Nm. From the analysis, it can be concluded that the design is safe for the parameters mentioned. from the analysis and investigations it may be concluded that the existence rim of bicycle can be replaced by the proposed rim safely for E-bicycle.

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