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Failure Analysis & Change the Design of Spokes a Head Gear Pulley Used In Coal Mines

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Abstract – This investigation primarily deals with the probable causes of in-service damage of head gear pulley in a coal mines. In this paper different component of conveyor pulley (shell, end disk, hub, and shaft) failure and the stresses generated on them are discussed. This paper presents proposed methodology meshing, material property and fixed support. In this work Implement new alloy spokes by replace alloy spokes.The proposed work is to design of head gear pulley is based on the stress criteria, according to design specification the ultimate tensile strength. In that the two new designs is proposed in gear head pulley in three different spokes material is used the first material is used is steel, second is titanium alloy and last is magnesium alloy. The result obtained the stress value is under the standard stress limit as well as reduces the overall weight of head gear pulley.

Keywords: Stress analysis, Gear Pulley, Rim, Hub, Spoke

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1. INTRODUCTION

1.1 Head gear pulley

The headgear in coal mines is built for winding the cage from the pit head to the pit bottom and vice versa. It is generally built with four main legs designed to carry the weight of the winding wheels, and two back legs designed to take the resultant of the stresses in the winding ropes.

It developed from an earlier wooden structure to steel. Each shaft had two cages each suspended from a steel wire rope which passed over the headgear pulleys and then down into the engine house to the drum of the winding engine.

Fig.1 Typical head gear pulley

1.2 Components of Pulley [X. Oscar fenn Daniel et. al.]

Drum or Shell: The drum is the portion of the pulley in direct contact with the belt. The shell is fabricated from either a rolled sheet of steel or from hollow steel tubing Diaphragm.

Plates: The diaphragm or end disc of a pulley is circular discs which are fabricated from thick steel plate and which are welded into the shell at each end, to strengthen the drum.

Shaft: The shaft is designed to accommodate all the applied forces from the belt and / or the drive unit, with minimum deflection. The shaft is located and locked to the hubs of the end discs by means of locking elements.

Locking Elements: These are high-precision manufactured items which are fitted over the shaft and into the pulley hubs. The locking Elements attach the pulley firmly to the shaft via the end plates.

Hubs: The hubs are fabricated and machined housings which are welded into the end plates.

Lagging: It is sometimes necessary or desirable to improve the friction between the conveyor belt and the pulley in order to improve the torque that can be transmitted through a drive pulley.

Bearing assemblies: Bearings support the rotating shaft and hence the pulley, which enables the mass of the pulley assembly plus the belt tension, forces to be transmitted for the supporting pulley structure.

1.3 Pulley design

The procedure for selecting pulleys for a conveyor for any given application involves the evaluation of a number of factors pertinent to the installation Consideration should be given to the following:- (X. Oscar fenn Daniel et. al.)

a) Application/Environment

b) Conveyor design

- Angle of Wrap.
- Belt selection.
- Conveyor duty.
- Belt Tension.
- Belt width.

c) Standardization

d) Specifications

e) Layout

f) Pulley design

For the pulley design the main design of the pulley structure is dependent on the shaft design. Hence the shaft design is the initial consideration of the pulley design.

2. METHODOLOGY

Some steps are following in methodology.

- To collect the necessary data of head gear pulley
- Generate the model of head gear pulley by using CAD software.
- After generating 3d model import in ANSYS.
- Applying meshing and given boundary condition.
- Compare the result.

2.1 Material property

In present research four type of material is selected. The mechanical property of material is shown in table.

Table 1 Material property

Material	Density (Kg/m3)	Young's Modulus (Mpa)	Poisson's ratio
Cast iron	7200	98000	0.3
Steel	7750	196000	0.31
Titanium alloy	4620	96000	0.36
Magnesium alloy	1800	45000	0.35

Meshing

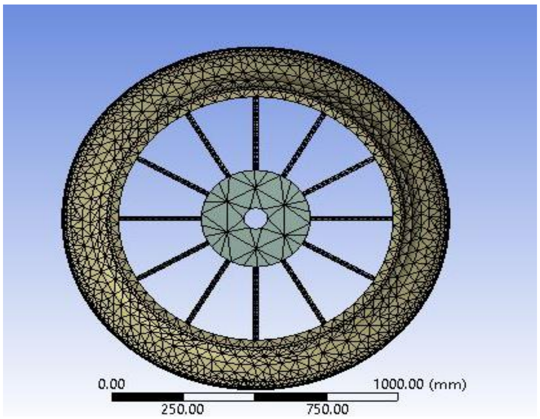

Fig.2 meshing 3D Model

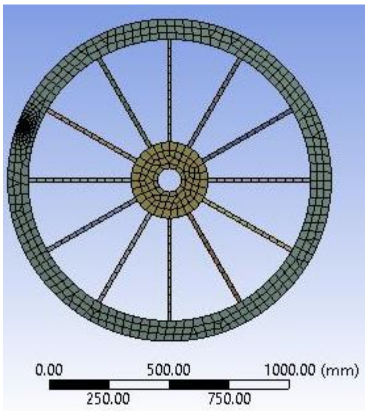

Fig.3 meshing 2D Model

In this meshing method no. of nodes 62908 and no. of element 31982 used in 3D model and no. of nodes 3209 and no. of element 8072 used in 2D model.

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Fixed support

The head gear pulley is fixed in center of hub.

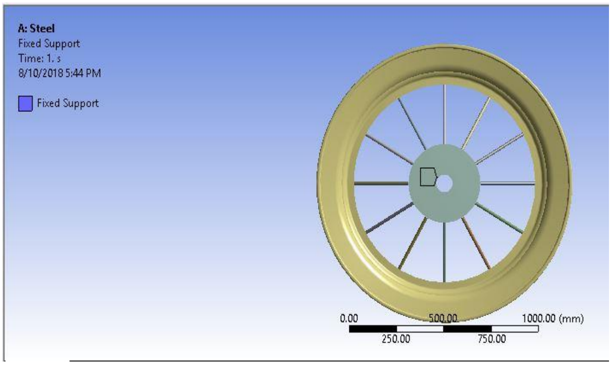


Fig.4 Fixed support in 3d model

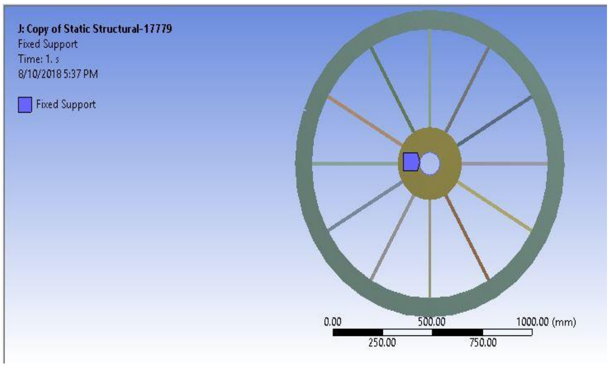


Fig.5 Fixed support in 2d model

Force Apply

Applying 1.813 ton which is equal to 17779 N force in head gear pulley.

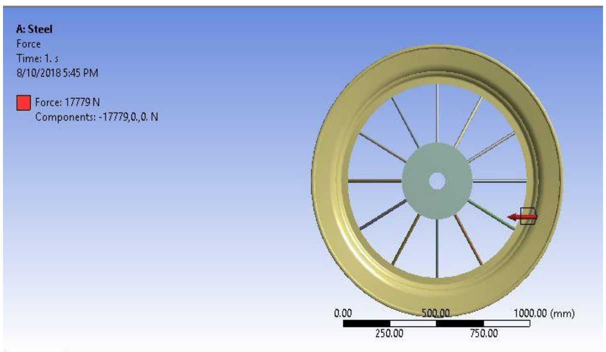


Fig.6 Applying force in 3d model

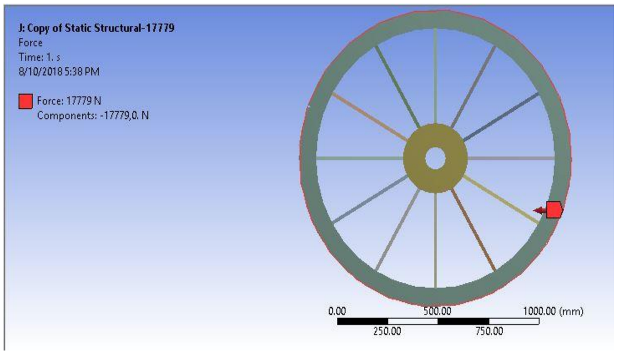


Fig.7 Applying force in 2d model

3. RESULT ANALYSIS

Case -1 In this case hub and wheel are in same material cast iron and steel spokes is used.

Stress Analysis

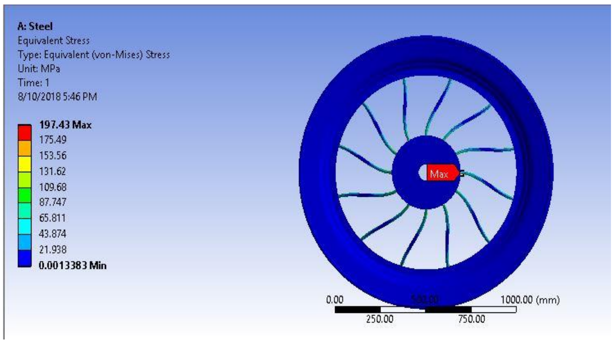


Fig.8 Equivalent stress in 3d model

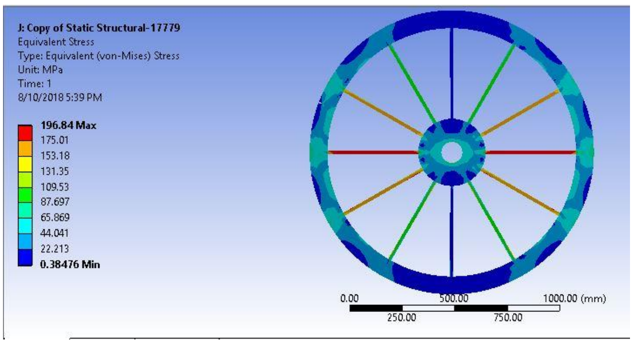


Fig. 9 Equivalent stress in 2d model

This Fig.8 shows 3D model of equivalent stress in this experiment and This Fig.9 shows 2D model of equivalent stress in this research work.

Deformation Analysis

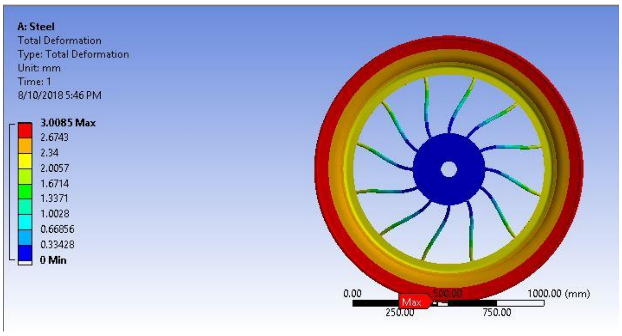


Fig.10 Total Deformation in 3d model

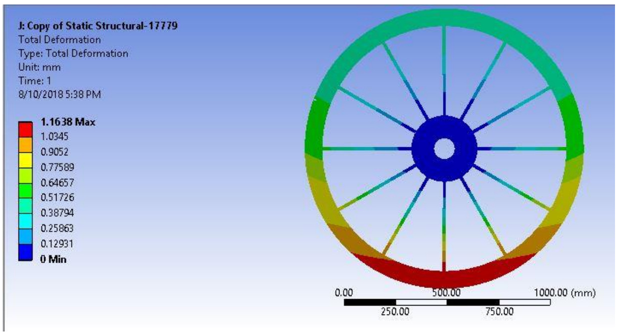


Fig.11 Total deformation in 2d model

This Fig.10 represents the total deformation of 3D model and Fig.11 represents the total deformation of 2D model in this investigation.

Case -2 In this case hub and wheel are in same material cast iron and steel 12 spokes is replaced by 6 spokes.

Stress Analysis

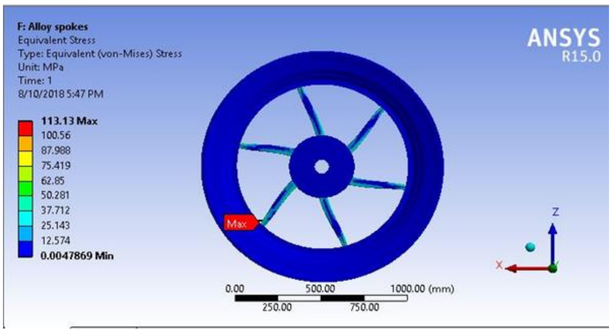


Fig.12 Equivalent stress in case -2

Fig.12 illustrates the model of Equivalent stress in case -2 when hub and wheel are in same material cast iron and steel 12 spokes is replaced by 6 spokes. In this model min. stress is 0.0047869 and max. stress is 113.13.

Deformation Analysis

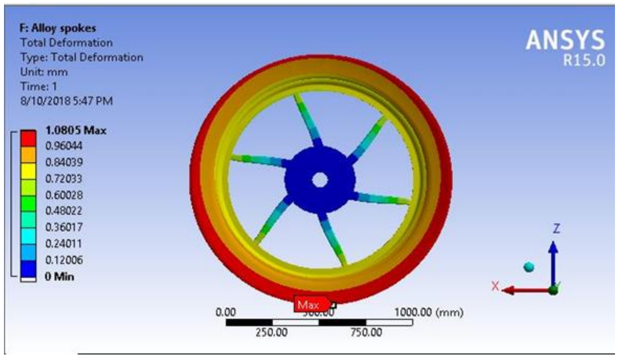


Fig.13 Total deformation in case -2

Fig.13 represents the model of total deformation in case-2 when hub and wheel are in same material cast iron and steel 12 spokes is replaced by 6 spokes. In this model min. deformation is 0 and max. deformation is 1.0805.

Case -3 In this case hub and wheel are in same material cast iron and titanium alloy spokes is used.

Stress Analysis

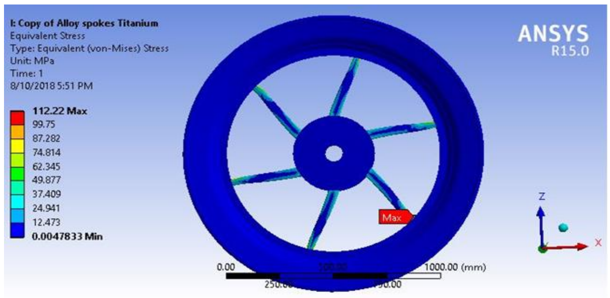


Fig.14 Equivalent stress in case -3

Fig.14 illustrates the model of Equivalent stress in case -3 when hub and wheel are in same material cast iron and titanium alloy spokes is used. In this model min. stress is 0.0047833 and max. stress is 112.22.

Deformation Analysis

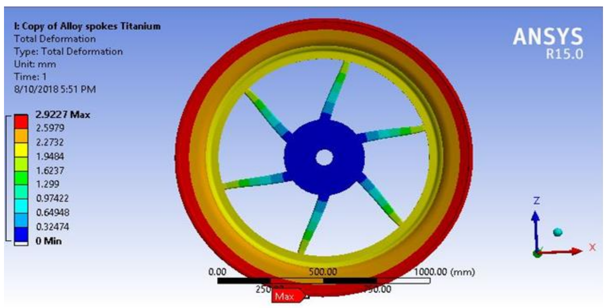


Fig.15 Total deformation in case -3

Fig.15 represents the model of total deformation in case-3 when hub and wheel are in same material cast iron and titanium alloy spokes is used. In this model min. deformation is 0 and max. Deformation is 2.9227.

Case -4 In this case hub and wheel are in same material cast iron and magnesium alloy spokes is used.

Stress Analysis

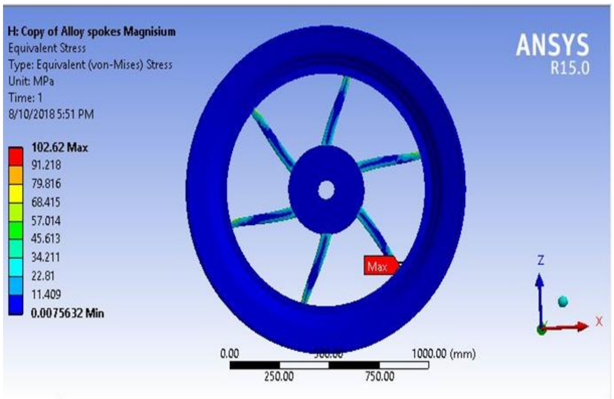


Fig.16 Equivalent stress in case -4

Fig.16 shows the model of equivalent stress in case 4 when hub and wheel are in same material cast iron and magnesium alloy spokes is used. In this model min. stress is 0.0075632 and max. stress is 102.62

Deformation Analysis

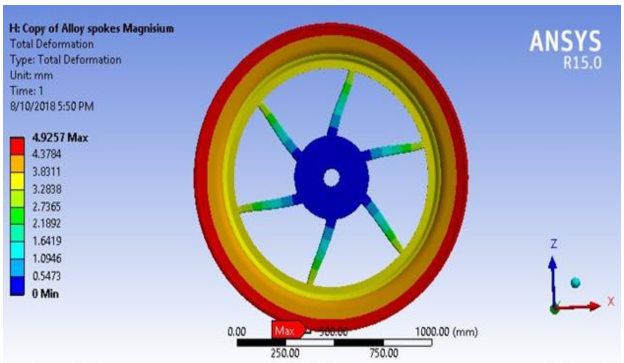


Fig.17 Total deformation in case -4

Fig.17 elaborates the model of Total deformation in case -4 when hub and wheel are in same material cast iron and magnesium alloy spokes is used. In this model min. deformation is 0 and max. deformation is 4.9257.

Case -5 In this case hub and wheel are in same material cast iron and steel spokes is used. In this design the spokes is modified and reduce material.

Stress Analysis

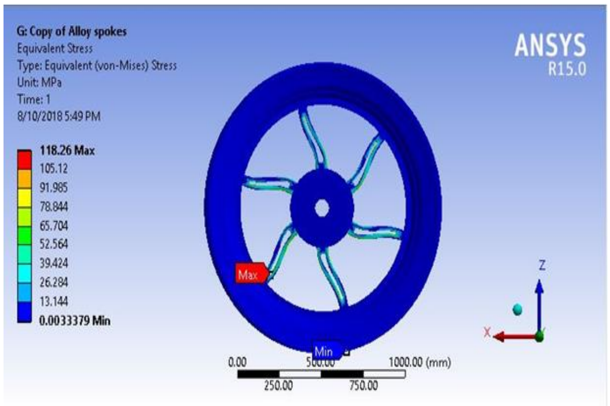


Fig.18 Equivalent stress in case -5

Fig.18 shows the model of equivalent stress in case 5 when hub and wheel are in same material cast iron and steel spokes is used. In this design the spokes is modified and reduce material. In this model min. stress 0.0033379 and max. stress is 118.26.

Deformation Analysis

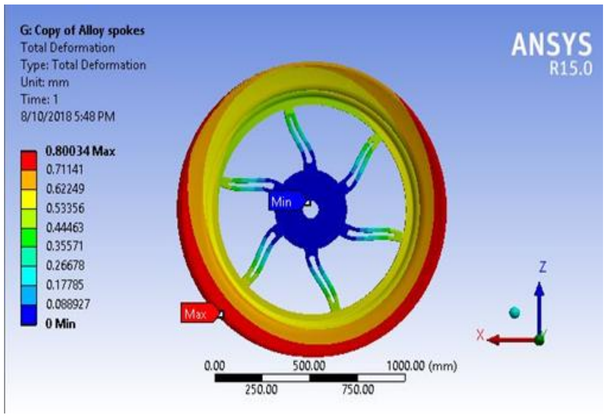


Fig.19 Total deformation in case -5

Fig.19 represents the model of Total deformation in case -5when hub and wheel are in same material cast iron and steel spokes is used. In this design the spokes is modified and reduce material. In this model min. deformation is 0 and max. deformation is 0.80034.

Case -6 In this case hub and wheel are in same material cast iron and Titanium alloy spokes is used. In this design the spokes is modified and reduce material.

Stress Analysis

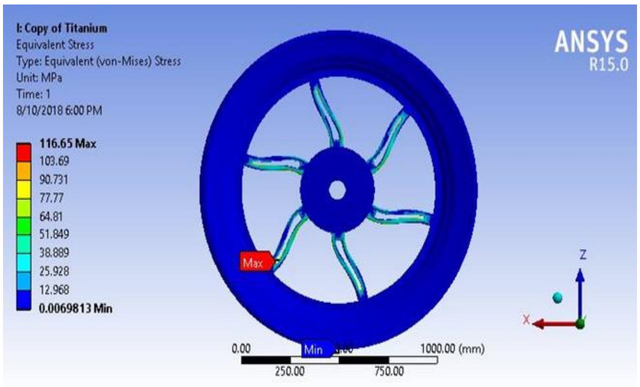


Fig.20 Equivalent stress in case -6

Fig.20 shows the model of Equivalent stress in case -6 when hub and wheel are in same material cast iron and Titanium alloy spokes is used. In this design the spokes is modified and reduce material. In this model min. stress is 0.0069813 and max. stress is 116.65.

Deformation Analysis

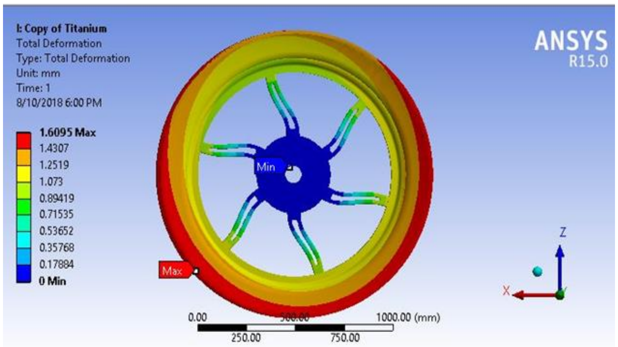


Fig.21 Total deformation in case -6

Fig.21 represents the model of Total deformation in case -6 when hub and wheel are in same material cast iron and Titanium alloy spokes is used. In this design the spokes is modified and reduce material. In this model min. deformation is 0 and max. deformation is 1.6095.

Case -7 In this case hub and wheel are in same material cast iron and magnesium alloy spokes is used. In this design the spokes is modified and reduce material.

Stress Analysis

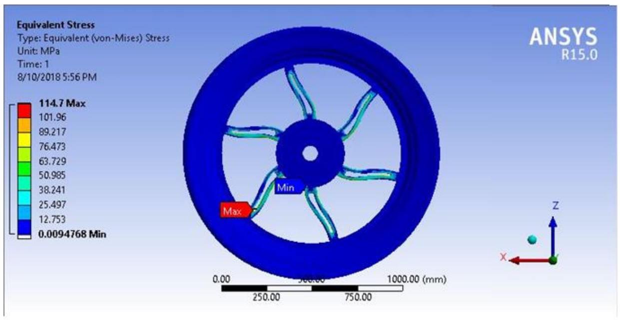


Fig.22 Equivalent stress in case -7

Fig.22 elaborates the model of Equivalent stress in case -7 when hub and wheel are in same material cast iron and magnesium alloy spokes is used. In this design the spokes is modified and reduce material. In this model min. stress is 0.0094768 and max. stress is 114.7.

Deformation Analysis

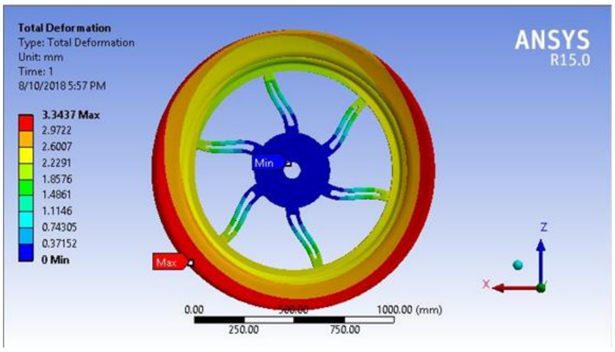


Fig.23 Total deformation in case -7

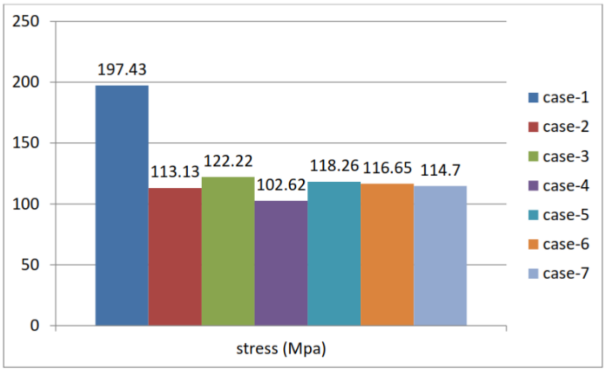
Fig.23 shows the model of Total deformation in case -7 when hub and wheel are in same material cast iron and magnesium alloy spokes is used. In this design the spokes is modified and reduce material. In this model min. deformation is 0 and max. deformation is 3.3437.

4. COMPARISON RESULT

Stress deformation and weight result are shown in table.

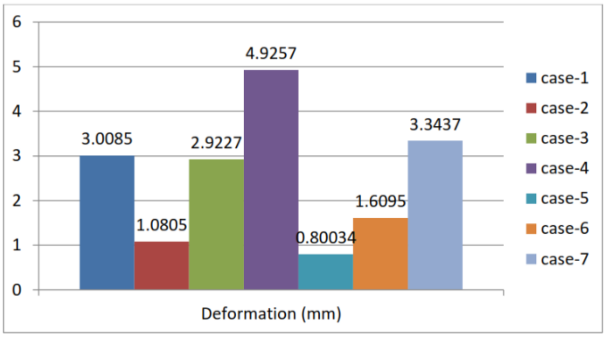
Table 2 Comparison of All case

Case	Stress	Deformation	Weight
1	197.43	3.0085	455.77
2	113.13	1.0805	455.77
3	112.22	2.9227	451.74
4	102.62	4.9257	448.11
5	118.26	0.80034	453.83
6	116.65	1.6095	450.59
7	114.7	3.3437	447.67



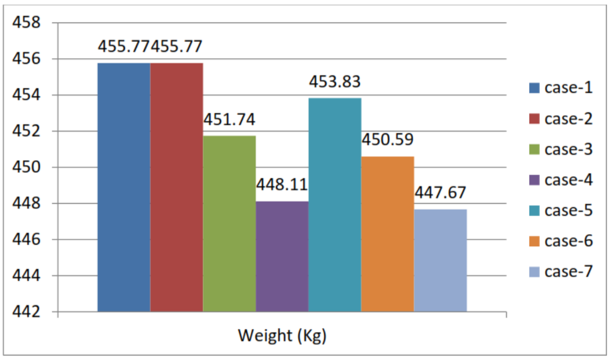
Graph 1 Stress comparison graph

Graph 1 shows comparison of stress. This graph represents the higher stress is in first case when hub and wheel are in same material cast iron and steel spokes is used. And lower stress is in case seven when hub and wheel are in same material cast iron and magnesium alloy spokes is used. In this design the spokes is modified and reduce material.



Graph 2 Deformation comparison graph

Graph 2 shows comparison of deformation. This graph represents the higher deformation of case four when hub and wheel are in same material cast iron and magnesium alloy spokes is used. And lower deformation of case five hub and wheel are in same material cast iron and steel spokes is used. In this design the spokes is modified and reduce material.



Graph 3 Weight comparison graph

Graph 3 shows comparison of Weight. In this graph seven cases weight represented at different colors. In this graph first and second case weight is same and high when hub and wheel are in same material cast iron and steel spokes is used. When hub and wheel are in same material cast iron and steel 12 spokes is replaced by 6 spokes, respectively and minimum weight is in case seven when hub and wheel are in same material cast iron and magnesium alloy spokes is used. In this design the spokes is modified and reduce material.

5. CONCLUSION

It includes following conclusions are:

- The design of head gear pulley is based on the stress criteria, according to design specification the ultimate tensile strength of head gear pulley is 148 Mpa.
- In case 1 when simple spokes is used in gear head pulley show the maximum equivalent stress is 197.43 Mpa. It is above the standard ultimate stress value so in this case the design is fail.
- After that the two new design is proposed in gear head pulley in three different spokes material is used the first material is used is steel, second is titanium alloy and last is magnesium alloy.
- All the design is under the standard ultimate stress value, so all the present design is safe.
- It is seen that the minimum stress is found in case 4, when magnesium alloy spokes is used in gear head pulley. This design is also show the minimum weight 448.11Kg. The reduction of weight in present design is 7.66 Kg for traditional design.
- The all case show the stress value is under the standard stress limit as well as reduce the overall weight of head gear pully.

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