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Design Optimization of Central Drum in Mine Hoist

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Abstract*— The present paper is based on design and analysis of central drum in Mine Hoist. Central drums in mine hoists are large and heavy; as a result of this they are troublesome for manufacture, installation and operational. Therefore there is required to form it light-weight in weight while not affecting its strength. The design improvement will be achieved by replacement the disc sort structure at the aspect of central drum by arm sort structure. For this we designed totally different abstract models and analyzed them under most loading condition. When after the results best design is chosen and it will be found simply doable for manufacturing and operational.
***Keywords* — Mine hoist, Central drum, Side disc, Arm sort structure, Solidworks, ANSYS etc.**

I. INTRODUCTION

In mining business mine hoist is that the most ordinarily used mining instrumentation used for transportation and conveyancing the mining material. These are normally utilized in coal and iron mines etc. Mine hoists are mechanical instrumentation by using that mining material is to be raised or lowered. Mine hoists works on principle that load is upraised by applying equal and opposite force.

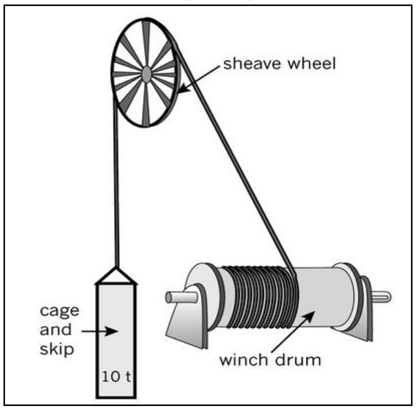

Fig. 1 Mine hoist

Mines are usually power-driven by using the electrical motor. Motorized mine hoists have created mining additional speedy. The foremost common variety of mine hoist utilized in mining industry is drum sort mine hoist. These are principally consisting of central drum, sheave pulley-block and cage or skip. In drum sort mine hoist wire rope is wound on central drum whereas the lifting the cage.

II. PROBLEM IDENTIFICATION

Fig. 2 Central Drum

Central drum in mine hoists is just too huge in diameter, therefore it is troublesome to manufacture. Additionally it is too significant

Volume 4 Issue VI, June 2016
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in weight; as a result of this it is troublesome for producing, installation and for operational with masses. Hence it is required to form it doable to manufacture and operational. Therefore design are created to form it very little light in weight with don't have any impact on its strength.

III. LITERATURE REVIEW

WANG Jiu-feng, XU Gui-yun, ZHU Jia-zhou, YANG Yan-chu, in their paper named as, "*Parametric Design and Finite Element Analysis of Main Shaft of Hoister Based on Pro/E*", advanced parametric design method which realized in the process of modelling of main shaft of hoister was deal by using the interface technology between Pro/E and ANSYS software. The simulation analysis of stress status of the main shaft of hoister designed in Pro/E under a certain load is made. The adoption of this method will dramatically shorten the development cycle and cut down the design costs. Otherwise the research method will reference value to gear model library development and to the optimization design of the main shaft of hoister. [1]

LUO Jiman, XING Yan, LIU Dajiang and YUAN Ye, in their paper, "*Modal Analysis of Mast of Builder's Hoist Based on ANSYS*", For the purpose of researching the factors which affect the dynamic characteristic of mast of builder's hoist and analyzing the impact of different factors over system security, the authors of the paper applied the finite element method to build the model and made the modal analysis for mast which was installed with various installation distances or under different working conditions. [2]

Yang Yuanfan, in the paper named as, "*The Study on Mechanical Reliability Design Method and Its Application*", Through the study on mechanical reliability design and combination with the structure of mine hoist, it is proposed that the crucial procedure of reliability design's application into mine hoist is as to ascertain the statistics of the relevant parameters, then to set up the failure mathematical model, and finally the reliability design can be operated. [3]

J.J. Taljaard and J.D. Stephenson, in the paper named as, "*State-of-art shaft system as applied to Palaborwa underground mining project*", The design of a 30,000 ton per day underground mine at Phalaborwa presented many and various challenges to the owner and the design team. Using modern best and proven practice, innovative engineering, extensive test work and verification by worldwide experts these challenges were met head on and overcome. The state-of-the-art system will be in operation by the end of the year 2000. [4]

Shuang Chen and Shen Guo, in their paper named as, "*Stress Analysis of the Mine Hoist Spindle Based on ANSYS*", In this paper, the three dimensional modeling of 2JK mine hoist spindle was established by using Pro/ E according to given data. Then the model was inputted into the finite element analysis in ANSYS, the stress distribution of the spindle was obtained, strength check of the dangerous section was made at the same time, which provides a accurate and reliable theoretical basis for improving the spindle structural design. [5]

HuYong and HuJiQuan, in their paper named as, "*Mechanical Analysis and Experimental Research of Parallel Grooved Drum Multi-layer Winding System*", In the present design criterion of multi-layer winding drum, multi-layer winding coefficient is chosen according to the number of wire rope layers. However, the actual wire rope arrangement on the drum and the elastic property of wire rope also play decisive roles in determining the multi-layer winding coefficient value. Analyzing the actual stress of the drum accurately is the precondition of ensuring the drums safety and reliability for meeting the lightweight design requirements. [6]

IV. DESIGN PARAMETERS

According to ASME code the most permissible shear stress (τ) is,

$\tau = 0.3\ \sigma el$ or $0.18\ \sigma ut$

$\tau = 0.3\ \sigma el = 61.5$ MPa   OR $\tau = 0.18\ \sigma ut = 93.6$ MPa

Where,

$\sigma el = 205$ Mpa

$\sigma ut = 520$ Mpa

Hence most permissible shear stress is σel = sixty one.5 MPa

The shaft are subjected to twisting moment or torsion which can be obtained by using torsion equation,

$$\frac{T}{j} = \frac{\tau}{R} \quad \text{............. (i)}$$

Where,

T = torsion working on the shaft

j = polar moment of inertia

τ = torsional shear stress

R = Distance from neutral axis to outer fibre

= D/2.... Wherever D is diameter of the shaft

We know that, polar moment inertia (j) is given by,

$$j = \frac{\pi}{32} D^4$$

Where,

Combined shock issue (Kt) and fatigue factor (Km) are taken as one, for the step by step applied or steady load.

Torque to be transmitted is T = 700 Nm

Hence, from eq. (i)

$$\frac{700 \ x \ 10^3}{\frac{\pi}{32} D^4} = \frac{61.5}{D/2}$$

D = 38.7 mm ~ 40 mm

Also from torsion rigidity equation we've got,

$$\theta = \frac{584TL}{GD^4} \text{ .... (ii)}$$

Where,

θ = angle of twist in degree

T = Torque, N-mm

L = length of shaft, mm

G = Modulus of rigidity, N/mm2 = 70.3 kN/mm2

D = Diameter of shaft, mm

*Let the angle of twist for the shaft 1degree i.e. θ = 10.

Hence,

$$1 = \frac{584 \ x \ 700 \ x \ 10^5 \ x \ L}{70.3 \ x \ 10^3 \ x \ 40^4}$$

L = 440 mm ~ 500mm

A. Rope specification

Length of rope: 50000 mm

Nominal breaking load: 133 kN

Weight: 0.86 kg/m

Rope construction: 6 x 26 RRL(right regular lay) rope

Safety factor of rope = (Minimum breaking load) / Load applied

= 133 / 15 = 8.87

B. Drum calculations

Parameter needed,

maximum load =15 kN

Diameter of rope = 14 mm

Length of rope = 50000mm

C. Calculation

1) Diameter of drum

Ddrum = (ratio between 20 to 25) x drope

=20 x 14 = 280 mm

2) Groove radius,

r = 0.53 x d = 0.53 x 14mm = 7.4mm

3) Groove diameter,

d = groove radius x 2 = 7.4mm x 2 = 14.8mm

Volume 4 Issue VI, June 2016
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4) *Pitch diameter,*
p = 2.065 x groove radius = 2.065 x 7.4mm
= 15.281mm
5) *Groove depth*
h = 0.374 x d = zero.374 x 14.8 = 5.5352mm
6) *Thickness*
tx = P/kp = 15000/(210000000 x zero.0148)
= 4.826mm
7) Y= 520 mm
8) L5 = L6 = 20 mm
9) Number of layer = 3
10) Number of groove = 20
11) Drum grooved length,L3
L3 = (n - 1)P = (20 – 1) 15.281 = 290.24 mm
1) Drum un-grooved length,L1=L2
L1 = L2 = 1/2 diameter of hook + radius of rope
= 47.13 mm
2) Safe factor = 6

V. MODELLING

We have completed modelling work of our project model within the Solidworks package that was user friendly to us. 3D model of project is shown below.

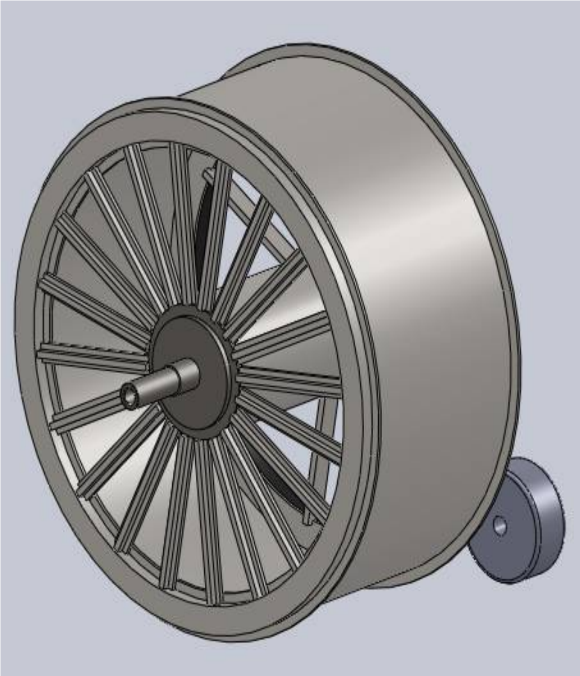

Fig. 3 CAD Model

VI. ANALYSIS

The structural analysis of central drum is completed by using ANSYS package. The ANSYS may be a general purpose Finite element Modelling package; it is used for numerically solving a range of mechanical issues.
First Step in Finite element method (FEM) involves Sub-division of a body or structure into Finite elements called descritization or meshing. Meshing of our project model is completed by using 20 noded solid 95 elements. The meshed model of our project model is as below,

Volume 4 Issue VI, June 2016
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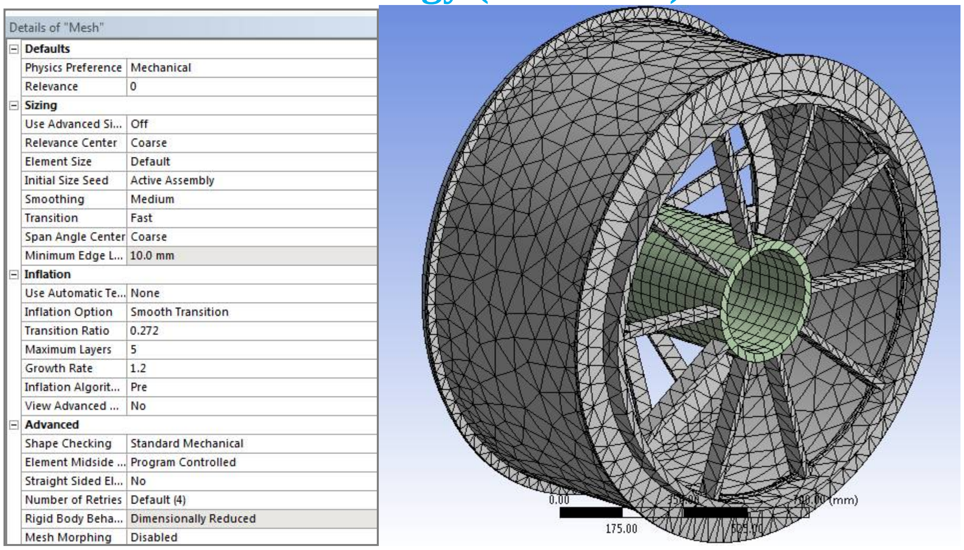

Details of "Mesh"	
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Si...	Off
Relevance Center	Coarse
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge L...	10.0 mm
Inflation	
Use Automatic Te...	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorit...	Pre
View Advanced ...	No
Advanced	
Shape Checking	Standard Mechanical
Element Midside ...	Program Controlled
Straight Sided El...	No
Number of Retries	Default (4)
Rigid Body Beha...	Dimensionally Reduced
Mesh Morphing	Disabled

Fig. 4 Mesh details

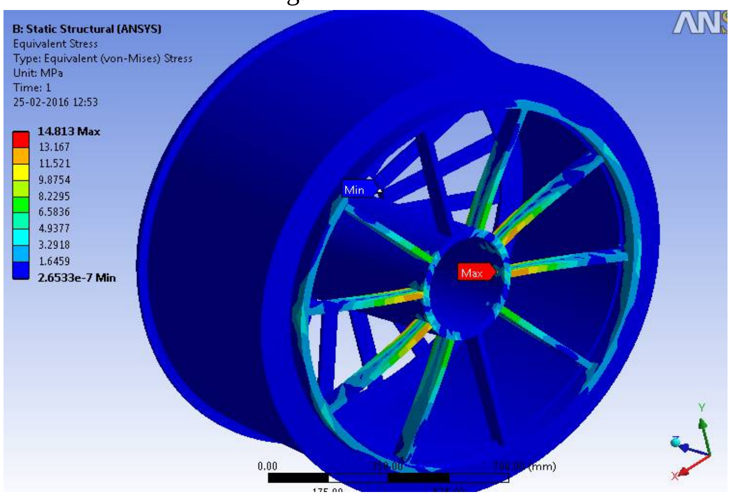

Fig. 5 Static Structural Analysis

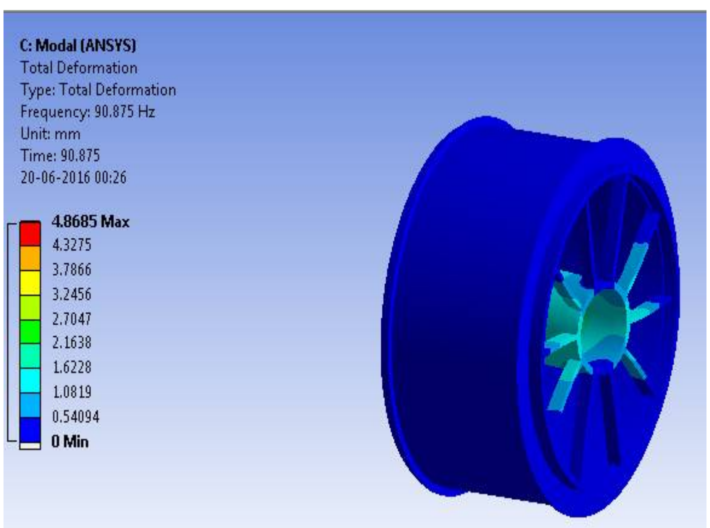

Fig. 6 Modal analysis

	Mode	Frequency [Hz]
1	1.	90.875
2	2.	91.006
3	3.	114.94
4	4.	115.13
5	5.	126.16
6	6.	127.45

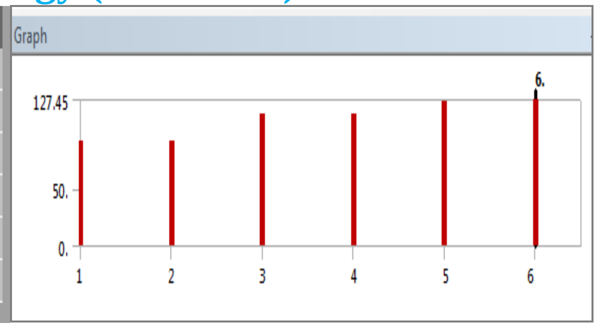

Fig. 7 Range of frequency

VII. CONCLUSION

This paper presents the study of the design and improvement of Central Drum in Mine Hoist. As we have a tendency to see the central drum in mine hoist is large and significant for manufacturing and installation and to rotate full body with masses. The study provides the new design which might scale back the weight of central drum. The design of aspect disc sort structure is replaced with Arm sort structure, that makes the central drum little light-weight in weight while not touching its strength. By reducing the weight of central drum, we created the central drum simple to manufacture and installation.

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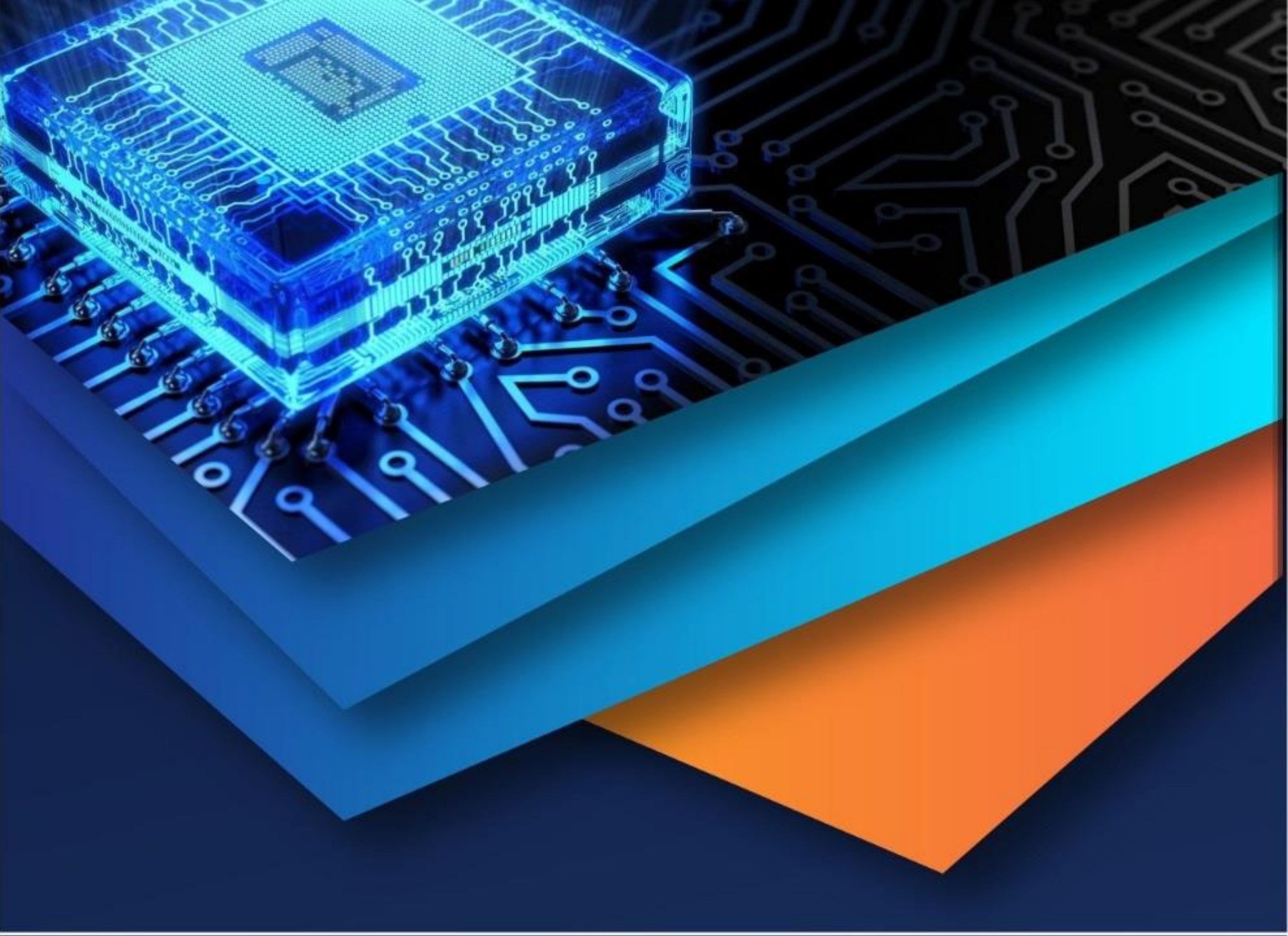

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