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RESEARCH ARTICLE

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DESIGN AND OPTIMIZATION WITH STRUCTURAL BEHAVIOUR ANALYSIS OF CENTRAL DRUM IN MINE HOIST

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ABSTRACT

Our work is based on design optimization of central drum in mine hoists used in coal and other mines. The main objective of our project is to make central drum light in weight without affecting its strength. For this we have replaced the side disc with arm type structure. Then drum behaviour is analysed by using Ansys by applying various boundary conditions. Finally, conclusion is obtained that optimization will be possible or not. We form different designs and compare results and select best.

Keywords: Mine hoist, Central drum, Arm structure etc.

I. INTRODUCTION

Mine hoists are the most widely used mining equipment in the industry. Mine hoists are liable for conveying, manoeuvring, and transporting mined materials through the mine shaft and among machinery parts. Mine hoists can move a variety of shapes and come in several sizes.

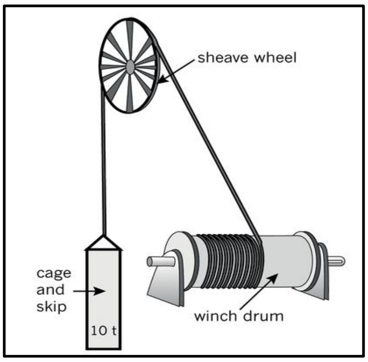

Figure: - Mine Hoist

Mine hoists have made the mining easier, safer, and more efficient. Gold mining and coal mining are easier with mine hoists. Motorized mine hoists make production run at a knowable speed. Most common type of hoist used in mining industry is Drum hoist.

Underground mining equipment requires heavy machinery mine hoists to haul or raise regulated amounts of material from a specified depth and normally into a shaft.

II. METHODOLOGY

A. PROBLEM IDENTIFICATION

Figure: - Central Drum

The central drums in mine hoists are too large in size, hence these are difficult to manufacture. Also these are heavy in weight because of this they are difficult for installation and operating.

Hence it needs to make it little light in weight without affecting its strength.

B. OBJECTIVES

(i) To make optimised design of rotary drum for mine hoist with manufacturability and installation feasibility

(ii) To make light weight drum which optimised ultimately drive configuration.

C. CONCEPTUAL MODEL

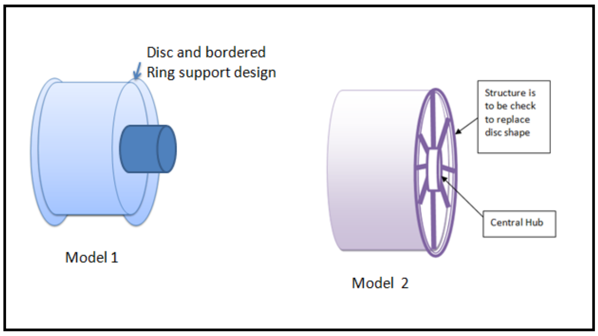

Figure: Actual and Conceptual Model

To optimize design and make central hub little light weight, we replaced the disc and bordered side support with arm type structure.

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. 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 an accurate and reliable theoretical basis for improving the spindle structural design [5].

IV. DESIGN PARAMETERS

According to ASME code for the design of transmission shaft the maximum permissible shear stress (τ) will be,

$\tau = 0.3\ \sigma_{el}$ or $0.18\ \sigma_{ut}$

The shaft will subject to torsion only, hence the diameter of the shaft may be obtained by using [6],

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

We know that, for solid circular shaft, polar moment inertia (j) is given by,

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

For rotating shafts, gradually applied or steady load, combined shock factor (K_t) and fatigue factor (K_m) are taken as 1.

Also from torsion rigidity equation we have,

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

*Let the angle of twist for the shaft 1degree i.e. $\theta = 1^0$.

A. ROPE SPECIFICATION

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

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

B. DRUM CALCULATIONS

(i) Diameter of drum

D_{drum} = (ratio between 20 to 25) x d_{rope}

(ii) Groove radius,

r = 0.53 x d

(iii) Groove diameter,

d = groove radius x 2

(iv) Pitch diameter,

p = 2.065 x groove radius

(v) Groove depth

h = 0.374 x d

(vi) Thickness

tx = P/kp

(vii) Drum grooved length,L3

L3 = (n - 1)*P

(viii) Drum un-grooved length,L1=L2

L1 = L2 = 1/2 diameter of hook + radius of rope

Factor of safety = 6

V. STRUCTURAL BEHAVIOUR ANALYSIS

A. 3D MODELLING

We decided to do our project prototype in the Pro-E software which was user friendly to us. Our 3d model is shown below.

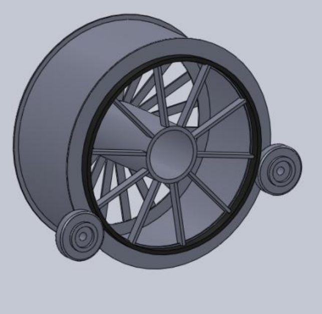

Figure: 3D CAD Model

B. STRUCTURAL BEHAVIOUR ANALYSIS

The structural analysis of central drum is done by using ANSYS software. First Step in Finite Element Method (FEM) is descritization or meshing. The meshed model of our project prototype is as below,

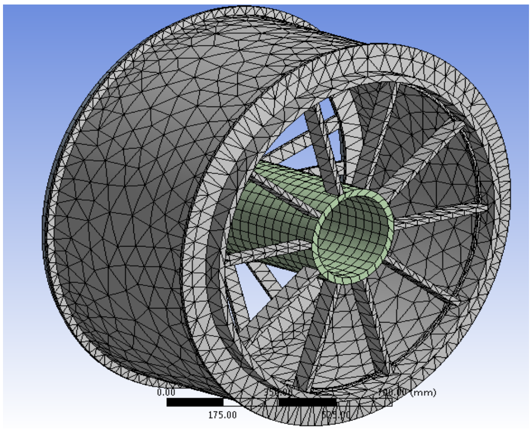

Figure: Meshed Model

VI. RESULTS

The results are obtained by applying boundary conditions as follows,

(i) RPM = 10 Max.

(ii) Force = 5000N

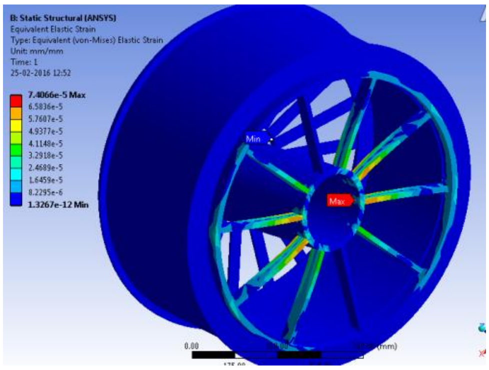

Figure: Equivalent Elastic Strain

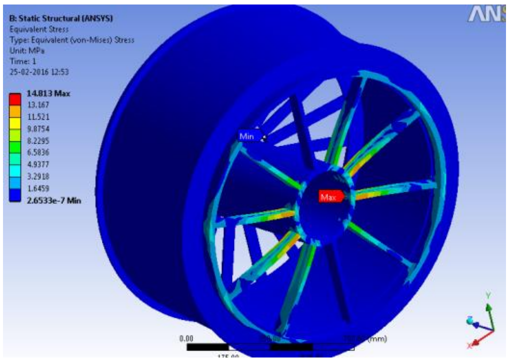

Figure: - Equivalent Stress

VII. CONCLUSION

This paper studies the design and optimization of Central Drum in Mine Hoist. As we see the central drum in mine hoist is large and heavy for manufacturing and installation and to rotate full body with loads. The study gives the new design which can reduce the weight of central drum. The design of side disc type structure is replaced with Arm type structure, which makes the central drum little light in weight without affecting its strength. By reducing the weight of central drum, we made the central drum easy to manufacture and installation.

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