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Design and Analysis of Yoke of Mill Rope Coupling

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Abstract: *A conventional tail bar coupling can cause serious complications to the mill drive components. Misalignment between the mill and gearing, shaft cracks, thrust load, sluggish floating of the top roller, rounding of the shaft square ends, damage to the crown pinion, and damage to the last motion gear bearing due to excessive thrust are common problems associated with the tail bar coupling. The mill rope coupling is an alternative to the tail bar coupling that eliminates damage caused by misalignment between mill and gearing and reduces other problems caused by the tail bar coupling. The primary objective of the study is to Design and carry analysis of Yoke for Mill Rope Coupling considering that the cost & weight reduction is extremely important & the availability of the material, Machinability & strength. Data of input power, output speed, Torque, Forces are calculated and analyzed. Strain gauges will be used to measure torque. Study produced the following conclusions: design yoke after changing material & thickness of plate withstand after applying torque & forces.*

Key Word*: Yoke coupling, Tailbar coupling, Torque, Force.*

I. Introduction

The cane sugar factories across the world either use the conventional three roller mills with trash plates or using two roller mill or bagasse diffusers for the extraction of juice from cane. Previously, mills were installed with the turbine drive, high speed gearbox, low speed gearbox and Open gearing, but nowadays electric drives are becoming more popular because of better efficiency and low maintenance. Indian sugar industry has made significant improvement in mill drive system. Introduction of Helical or planetary gearbox and Tailbar coupling or rope coupling with AC motors with VFD has improved the efficiency. In between the gearbox and mill install Tailbar coupling or Mill Rope Coupling to transmit the torque. The detrimental side effects of using conventional tailbar-and-collar couplings to drive sugar mill top rolls are familiar to all sugar-mill engineers. Tailbars generate thrust as well as radial loads that apply bending moments to the driving and, driven shafts. Replacing the tail bar coupling (Fig. 1) with a Mill Rope Coupling (Fig. 2) is emerging as a method of energy conservation. The flexible Mill Rope Coupling was introduced to overcome troubles and limitations associated with the tail bar coupling. In 1987 the first prototype of a radically new design of coupling was installed at a sugar factory in South Africa. It totally replaces the tailbar coupling, is essentially maintenance-free and has shown that it has eliminated all of the detrimental side effects of tailbars.

Fig. 1Tail bar coupling.

Fig. 2 Mill Rope Coupling

The coupling (Fig. 2) comprises of two yokes with back sandwich plates, one on each shaft. The shafts are connected with compression strut installed between yokes in such a way that slings transfer the torque from the driving yoke via compression strut to the driven yoke. This configuration allows both shafts and coupling to have lateral, axial and angular displacements, thus eliminating frictional resistance improving torque transmission efficiency with reduced axial thrust and bending moments on shaft.

Problem Statement

The problem is to Design and carry analysis of Yoke for Mill Rope Coupling considering that the weight reduction & cost is extremely important & the availability of the material, Machinability & strength. Recently using yoke manufacturing material is SA 516, Gr-70 & plate thickness 50 mm which is costly and not enough to keep up with the competitors. If material not changed & weight not reduced, the product will soon become non profitable.

Objectives of Work

In this dissertation work, stress distribution and deformation shall be analyzed on change material i.e.IS:2062 Gr-E300 & plate thickness 40 mm of yoke by using the 3D finite element software, Solid works Simulation. The maximum stress and deformation values are to be observed respectively. The critical location to be identified the transition at maximum tension condition.

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II. Literature Review

Mane C.G., Murugkar V.M. [3] had been investigated A Multi Misalignment Flexible Coupling (MMFC) using steel ropes to transmit the torque was first installed on the zero mill of our factory in 2001 for torque transmission from the final speed reduction gear to the mill top roller. The MMFC completely replaced the conventional tail bar and coupling box assembly

Tosio CT [4] The material of construction of the main coupling components has been changed from cast steel grade A3 to fabricated steel grade 300WA and cast steel grade A4 to reduce its cost. Because of fatigue problems caused by excessive misalignment, steel wire ropes have been replaced by two new types of flexible members: polyester slings and the link plates with spherical plain bearings.

G.A. KENT[9] new equipment and products are being developed with reduced power consumption, lower capital and maintenance costs, and better performance. Methods presented for reducing maintenance costs included the use of a maintenance management system, condition monitoring and material selection.

MS Sundaram, DS Nikam and SS Ghadge[10] deals with A conventional tailbar coupling can cause serious complications to the mill drive components. The Mill Rope Coupling is an alternative to the tail bar coupling that eliminates damage caused by misalignment between mill and gearing and reduces other problems caused by the tail bar coupling.

Lewinski J, Grassmann P And Kallin T [12] investigate Operation of sugar mills with individual variable speed drives corresponds to propulsion of each roll of the sugar mill independently by electro-hydraulic variable speed or electromechanical variable frequency drives. This paper presents the results of the tests carried out in Santa Isabel sugar mill in Brazil, when each four roll mill of four mill tandems was driven by four hydraulic motors of the same size; two of them mounted on the both sides of the top roll and one of them on each inferior roll.

Principle of the Mill Rope Coupling design: Torque is first transmitted from the driving yoke to the diagonal ―compression‖ plate by means of the two horizontal parallel links. The articulation of these links permits vertical or ―Y—Y‖ axis displacement between the driving yoke and the compression plate. The second or vertical set of links in turn transfers torque from the compression plate to the driven yoke, and their articulation similarly allows ―X—X‖ axis or horizontal displacement.

Advantages of mill rope couplings:

1. Improves extraction performance of the Mill. The conventional Tail Bar obstructs free floating of the Mill Top Roller. The Mill Rope Coupling does not impose any constraining thrust on the Top Roller. With free floating of Top Roller, the Mill operates at the designed setting and optimum hydraulic pressure and consequently performs more efficiently.
2. Mis-alignment between square end of the Gear shaft and the Top Roller either due to tilting of the Top Roller or initial alignment error in installations fully absorbed by the Mill Rope Coupling. As a result no significant lateral thrust or bending moment is transmitted to the final gear.
3. Reduced Torque and Power consumption of Mill.
4. Breakage of crown pinion and top roller is completely eliminated.
5. Negligible maintenance.
6. Axial displacement, angular misalignment along with end float more than tailbar coupling & can handle all simultaneously without breaking.
7. Accommodated in minimum space between mill & gear shaft.

III. Material and Methods

The Mill Rope Coupling Consist of;

1. Two yokes Drive (Gear Side) & Driven (Mill Side) welded to hub and tube assemblies. Yokes made from SA 516, Gr-70 & hub and tube IS:2062 Gr-E300
2. One ―compression‖ strut assembly & made from SA 516, Gr-70.
3. One pair of reversing ropes, each with two ―crossby‖ clamps.
4. Polyester slings.

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Modelling

Design Details of Yoke of Mill Rope Coupling:

Torque Load of 900 KN-m & Force 932 N is applied on both the pin equally which approximately about 466 N individually and calculated bellows dimensions;

Table no 1: shows Dimensions of Yoke of Mill Rope Coupling

Sr. No.	Parameters	Values
1.	Pin To Pin distance	2000 mm
2.	Plate thickness of yoke	40 mm
3.	Hub OD	624 mm
4.	Tube OD	664 mm
5.	Tube ID	614 mm

On the basis of above dimensions the following model of Yoke is created by using modeling Solidworks software.

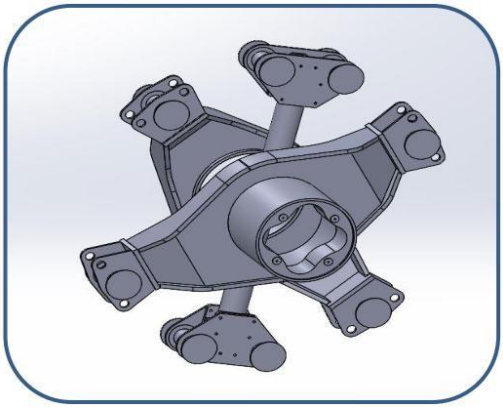

Fig .3 Solid Model used for Solidworks Simulation Program

IV. Result and Discussion

Von Mises stress method used for stress detection of design yoke of mill coupling. Von Mises stress is a value used to determine if a given material will yield or fracture. The von Mises yield criterion states that if the von Mises stress of a material under load is equal or greater than the yield limit of the same material under simple tension then the material will yield.

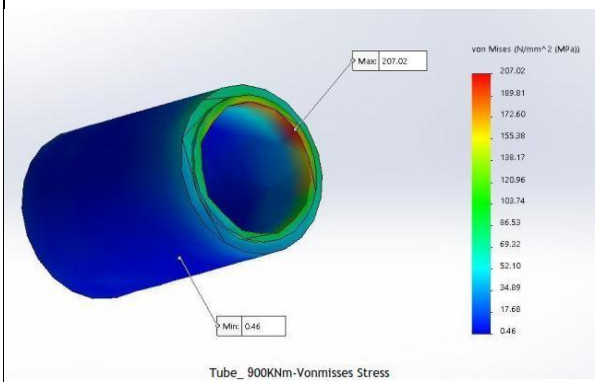

Figure 4: Stresses on Tube of Yoke

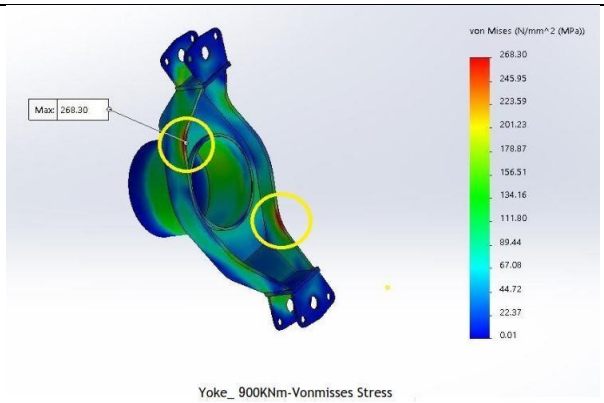

Figure 5: Stresses on Yoke and mill coupling

Table no 2: shows Stresses on Tube of yoke & Yoke of mill coupling.

Name	Type	Minimum Stress	Maximum Stress
Tube of yoke	Von Mises stress	0.46 MPa	207.02 MPa
Yoke of mill coupling	Von Mises stress	0.01 MPa	268.30 MPa

It is observed that in solid Works simulation software as per Von Mises stress method after appling torque 900 kN-m & Force 932 N on both the pins, the minimum stress value is 0.46 MPa & Maximum stress value is 207.02 MPa on Tue yoke of mill coupling and the minimum stress value is 0.01 MPa & Maximum stress value is 268.30 MPa on yoke of mill coupling. This is less than the yield stress value 280 MPa of proposed equipment material i.e.IS 2062 GR E300. During Yoke design phase detected yoke plate thickness & material could cause a superfluous increase of production costs. Therefore we decided to weight optimization through the use of simulation software, which lead to a mass reduction up to 10%. Change in the material strictly aimed to light weighting can lead to a strength improvement & a better distribution of forces.

V. Conclusion

Design of yoke of mill coupling done by Numerical calculation and 3-D modeling analysis, on that basis results concluded below-

1. As per yoke design calculation factor of safety is 4.8 which is greater than the 2.0, so the design is safe.
2. As per model analysis Maximum shear stress value is 268.3 MPa which is less than the yield stress of 280 MPa of proposed material, so yoke of mill design is safe.
3. The value of max. Shear stress is less than yield strength of material, so there is design of plate weight optimization is ok.
4. Based on the total cost of raw materials, IS 2062 GR E300 is the best among given material.
5. on the basis of yoke of mill coupling Model Analysis, we conclude that the selected material & its thickness is suitale to transmit applied torque & force successfully.

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