# Design and Analysis of Belt Conveyor Roller Shaft

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***Abstract* — For the continuous transportation of material a belt conveyor are used in the transport of coal and mineral powder it gives high efficiency and environmental protection. In some cases according to requirement if we increase conveyor inclination up to $17^0$ to $18^0$ the impact on the whole assembly of shaft occur due to this impact of material on conveyor shaft it break or bend within few month. An analysis of stress and impact creates on roller shaft with the help of Hypermesh and to develop design of shaft for $17^0$ to $18^0$ create model Analysis using hyperwork. By using design failure modes and effects Analysis (DFMEA) for systematic, proactive method for identifying where and how it might fail.**

**Keywords** — *Existing Roller Shaft, Analysed Roller shaft with DFMEA.*

## I. INTRODUCTION

As a kind of continuous transportation equipment, belt conveyor is widely used in today's modern port, especially in the transport of coal and mineral powder because of its high efficiency and environmental protection. Belt-conveyors are more acceptable than other means of transporting bulk materials; they neither pollute the air nor deafen the ears. Belt conveyor is one of the main transport equipment in coal mine, driving drum and belt is its key part. Friction principle is used to initiate mechanical drive for belt conveyor. So friction is the driving force. In order to raise transportation efficiency of belt conveyor, driving force of drum must be increased. Energy saving & efficiency, friction, fire & safety, maintenance and inspection are the other key factors of belt conveyor design. Most of the researchers focused on design modification to reduce the pulley (drum) and belt failures, maintenance cost, breakdowns, energy consumption and overall cost of the system for continuous transportation of material. The technologies used to reduce failures of the equipment and to increase the operational ability of the system the mechanisms like cam drive system, hydro-viscous soft start, magneto-rheological soft starter, Control strategy of disc braking system to be designed for efficient driving of belt conveyors. Most of technologies focused on Fatigue Failures of welded Conveyor Drums, shell of drums and fracture analysis of collapsed heavy-duty pulleys and other typical failure analysis on pulley shafts by using finite element method. sometimes its incorrect designing also make an important role in conveyor failure. Therefore belt Safety and Eco-design of non-metallic layer composites with a better capability of elongation should be considered. transversal vibrations and tension around a drive drum of a conveyor Belt with a low and Time-Varying Velocity are also considered. Control of whole system, operation & maintenance of belt conveyor and their inspection should be managed.

## II. INFORMATION REQUIRED TO DESIGN A BELT CONVEYOR

1. Length of conveyor from centre to centre of end pulleys.
2. Either degree of inclination, or distance to be lifted or lowered.
3. Average capacity per hour.
4. Maximum capacity per hour.
5. Material to be conveyed, and weight per cubic foot.
6. Average size of material.
7. Size of largest pieces and percentage in feed.
8. (a) Nature of material -dry or wet (moisture content).
   (b) Abrasive or corrosive?
9. How material is to be feed to the belt and particulars of feed point or points.
10. How material is to be discharged from the belt i.e. overhead pulley or by trippers, and particulars of discharge points.
11. General indication of supporting structure.
12. Power available for driving. If by A.C. electric motor, state voltage, phase and frequency. If D.C. motor state voltage.

Items 1 and 2 determine the suitability of belt conveyors, since inclination is a limiting factor. Items 1-7 determine the speed and width of the conveyor belt, the power needed for the drive, the type of drive, the number of belt plies, and size of pulleys, shafts and spacing of idlers. Items 8-10 determine the quality and thickness of the rubber cover on the belt.

### *A. Drum Pulley Assembly*

Conveyor Pulley is used to transmit the motion power to belt and also Pulleys are necessary to change the direction of belt in any direction, and to form endless loop for continuous operation, and it is also used for the material handling system in various industries to transfer raw material from one place to another.

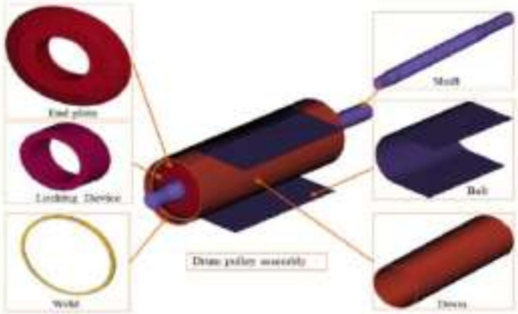


Fig.1 Exploded View of Mashed Drum Pulley Assembly

### B. *Pulley Components*

The main components of a pulley for a conveyor belt application are shown in Figure 1.

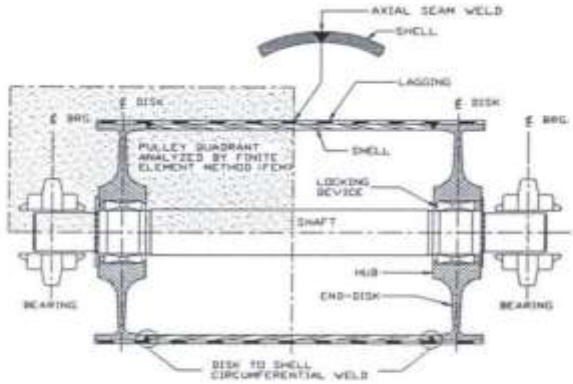



Fig. 2 Cross-Section of Pulley Assembly

Shell, End-disk And Hub Assembly, Locking Mechanism, Lagging.

## III. COMPANY DETAILS

### A. *CRUSH POWER spares & services (Manufacturer)*

Crush power delivers the world's most comprehensive range of heavy-duty conveyor belts. Based on the experience in development, manufacture and applications know-how it manufacture according to requirement, Crush Power designs the unique belts and belt systems to meet specific end-user requirements for high performance and cost-efficiency. It also provides the crusher in coal and mining industries. Depending on the requirement of customer it can be import and export.

**Table No.1** Specification of Belt Conveyor

| Width(mm) | Length (m) Power (kw) | | Speed(m/s) | Capacity(T/H) |
|---|---|---|---|---|
| 400 | 12~20/2~2.4 | 20~25/3.5~7.5 | 1.25~2.0 | 30~60 |
| 500 | 12~20/3~5.5 | 20~30/5.5~7.5 | 1.25~2.0 | 40~80 |
| 650 | 12~20/4~5.5 | 20~30/5.5~11 | 1.25~2.0 | 80~120 |
| 800 | 10~15/4~5.5 | 15~30/5.5~15 | 1.25~2.0 | 120~200 |
| 1000 | 10~20/5.5~11 | 20~40/11~22 | 1.25~2.0 | 200~320 |
| 1200 | 10~20/7.5~15 | 20~40/15~30 | 1.25~2.0 | 290~480 |

***Manufacturer for* :** Mining & Quarry equipments like jaw crushers, Cone Crushers ,VSI, vibrating screen, Horizontal impact crusher ,conveyor system & various capacity crushing plants, spares for new & used equipments, Erection & Fabrication etc.

***Belt* –** Made up of Rubber Materials having 3,4 ply (layers) and according to the Belt Width 500, 600, 1000 etc.

***Bearing* –** UCP Bearing No. 210,211,212 according to shaft size and internal diameter of bearing 55mm

***Shaft* –** Head shaft of outer diameter 55mm made up of M.S. Hard material EN 8, 9.

***Gear Box* -** F series gear box made by Orkey company shaft diameter 55mm Diameter of pulley 150mm.

***Motor* –** 3.7 kW (5 H.P) Motor connected to pulley of 125mm in diameter. And both pulleys are connected by V-belt.

### B. *Causes of Failure*

> Bend Shaft used for drum so it will break.

> Bearing was fails so shaft corrupted on both sides.

> Also sometimes gear box moves to and fro or forward and backward motion then the shaft breaks suddenly.

>When the end disk weld of drum pipe and bushes weld are removed then shaft broken after some days.

>Depending on material of the shaft which is used for drum.

**Photograph No.1** Failed Shaft

### *C. Problem Statement*

In mining and coal Industries Conveyor with an angle of 15degree inclined had a motor and pulley with a conveyor shaft, but if we increase the conveyor inclination up to 17degree. The motor and pulley is used of higher specification but roller shaft is used same.

Due to the impact load of material on conveyor, roller shaft exerts a high force than the desired force; it seems to be break or bend further frequently within year. Due to maintenance issue, customer suffers problems of roller conveyor shaft.

### *D. Methodology*

Methodologies used in different applications to reduce failures, maintenance cost and equipment related fatal accidents occurs during operation. The focus is on methodologies as Design modification, Drum and pulley failures, Belt design and its failure, energy & efficiency, friction, inspection, operation & maintenance and fire & safety.

An analysis of stress and impact when the impact load creates on roller shaft with the help of Hypermesh when the angle is increased to 17 degree. To develop design for 17 degree belt conveyor roller shaft and create a model of the belt conveyor roller shaft with a bottom up approach in Creo Parametric 2.0. By using Design Failure Modes and Effects Analysis (DFMEA) for systematic, proactive method for identifying where and how it might fail.

## IV. LITERATURE REVIEW

After Studying the Literature it can be concluded that a lot of work has been done in the field of Belt Conveyor Roller Shaft to reduce failures, maintenance cost and equipment related assembly failures in working failures.

[1]**Devendra Kumar ,R.K. Mandloi** present the paper on the Analysis & Prospects of Modification in Belt Conveyor -A Review. The review of belt conveyor design modification and latest technologies or methodologies. The analysis shows different design parameter required for different applications. Some of the common design parameters required in each application and the importance of each parameter which impacts on different application. The focus is on methodologies as Design modification, Drum and pulley failures, Belt design and its failure, energy & efficiency, friction, inspection, operation & maintenance and fire & safety.

**[2] Vinod M. Bansode, Abhay A. Utpat** present the paper on the Fatigue Life Prediction Of A Butt Weld Joint In A Drum Pulley Assembly Using Non-Linear Static Structural Analysis A failure analysis based on stress life approach may be useful for predicting the life time of weld in the structure. This study presents an upcoming methodology in new three dimensional Finite Element Model to calculate the fatigue life of weld. Ansys 12.1 simulation software uses stress-life method, based on a static non-linear Structural analysis. The weld material SN curves were experimentally determined by the Fatigue testing of the dumbell specimen as per 7608 standard. Thus the fatigue life prediction with the material curves from experimentation will give us more accurate and close to actual failure results.

**[3] X.Oscar fenn Daniel, A. Hussain lal** present the paper on Stress Analysis in Pulley of Stacker-Reclaimer by Using Fem Vs Analytical. The main aim of this project is to reduce the stress act on the shaft. This project leads to the stress optimization of the shaft. By producing a middle disc we reduced the stress developed on the shaft. So, that there is increase in shaft life. By applying various thickness of the middle disc we increase the life of the shaft. The load distribution on the shaft is even with the supporting discs. So, that we reduce the total load act on the particular contact on shaft. The main components are shaft, disc, cylinder, and hub. Designing units of this kind requires precise calculations of all loads in static conditions. In this paper the component cross section was analyzed. The stress analysis using Ansys is performed on the cross section of assembly of the reclaimer pulley considered as a reference for the existing design and even for the altered design which is the main task of this project. The cross section of the model was analyzed with the simple loading conditions. With that the cylinder deflection is minimized in the cross section analysis. **[4] Gys van Zyl, Abdulmohsin Al-Sahli** presents the paper on Failure Analysis of Conveyor Pulley Shaft. The shaft of a conveyor belt drive pulley failed in service. An investigation was performed in order to determine the failure root cause and contribution factors. Investigation methods included visual examination, optical and scanning electron microscope analysis, chemical analysis of the material and mechanical tests. A finite element analysis was also performed to quantify the stress distribution in the shaft. It was concluded that the shaft failed due to fatigue and that the failure was caused by improper reconditioning of the shaft during routine overhaul.

**[5] Vinit Sethi and Lawrence K. Nordell** presents the paper on the Modern Pulley Design Techniques and Failure Analysis Methods Published standards and specifications do not adequately cover engineered class pulleys for modern high strength steel cord belt conveyors. This paper discusses the Conveyor Dynamics, Inc. (CDI) design criteria and stress analysis techniques emphasizing the finite element method (FEM), fatigue failure criteria, design limits and manufacturing requirements to ensure successful and safe pulley installations.

**[6] Terry King Pr. Eng. Design Engineer to the Bosworth Group of Companies** presents a paper on Belt Conveyor Pulley Design – Why the Failures. A system for the design and dimensioning of conveyor belt pulleys, in a manner which permits use at drawing office or computational level, is laid out. The theoretical model is used to explain the reason for some common failures and to place in context some of the pulley construction features seen in recent years. Lastly, an account is given of the factors which limit the life of a pulley and a design is proposed for the next generation of long-life, low cost pulleys for the South African market.

## V. DESIGN OF BELT CONVEYOR ROLLER SHAFT

Now, Maximum and Minimum stress induced in shaft

$\sigma_{max} = \frac{M+\sqrt{M2+T2}}{Zp}$

$= 6753395.4 + \sqrt{(6753395.4)^2 + (504043)^2} / (32667.655)$

$= \frac{6753395.4+6772179.027}{32667.655}$ N/mm$^2$

$= \frac{13525574.43}{32667.655}$

$= 414.0357$ N/mm$^2$ ---------------------------- (1)

$\sigma_{min} = \frac{M-\sqrt{M2+T2}}{Zp}$

$= 6753395.4 - \sqrt{(6753395.4)^2 + (504043)^2} / (32667.655)$

$= \frac{6753395.4-6772179.027}{32667.655}$

$= \frac{-18783.627}{32667.655}$ N/mm$^2$

$= -0.57499$ N/mm$^2$

$\sigma_{allowable} = \frac{\text{Yield Strength}}{\text{Factor of Safety}}$

$= \frac{415}{1.5}$

$= 276.67$ N/mm$^2$ ---------------------------- (2)

$\sigma_{allowable}$ $<$ $\sigma_{max}$

276.67 N/mm$^2$ < 414.0357 N/mm$^2$

**So, design is not safe.**

## VI. ANALYSIS

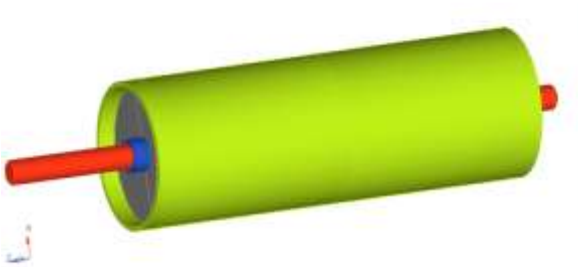
### *A. Description of Finite Element Method (FEM)*

The finite element method (FEM) is a very powerful technique for determining stresses and deflections in complex structures when compared with analytical methods. With this method the structure is divided into a network of small elements connected to each other at node points. Finite element method grew out of matrix methods for the analysis of structures when the widespread availability of the digital computer made it possible to solve system of hundred of simultaneous equations. The FEM is then a computerized method for predicting how a real-world object will react to forces, heat, vibrations, etc. in terms of whether it will break, wear out or function according to design. It is called "analysis", but in the product design cycle it is used to predict what will happen when the product is used.

### *B. Software Used*

***Modelling***: Creo 2.0
***Meshing***: Hypermesh 13.0 (Pre-processor)
***Solver:*** Optistruct / Radioss / Nastran (Processor)

***CAD Model***



***Finite Element Model***

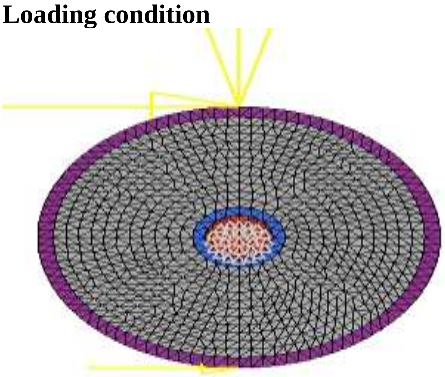
***Boundary Condition***

- Element type- Tetra Mesh
- Element size-10mm
- Loads : Constraints – Except rotation about Z all others fixed.

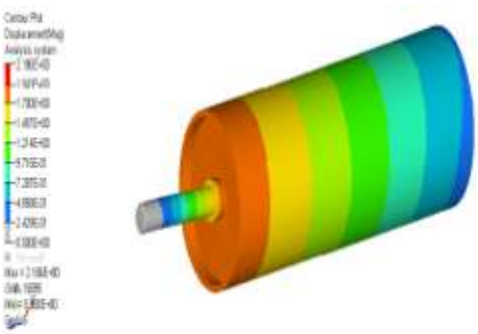
Torque Load= $T_1$- 5701.16N, $T_2$-2599.36N
Load Weight W– 24336.56 N

- Young's Modulus = 210 Mpa
- Poissions ratio = 0.3
- Yield strength = 415Mpa
- Factor of Safety = 1.5

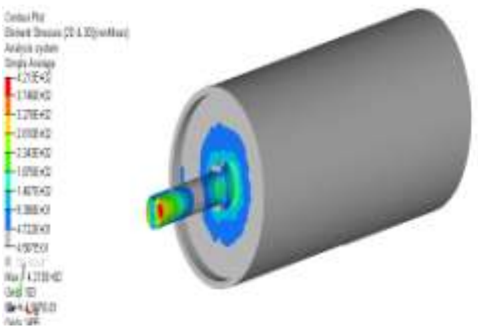
**Loading condition**



**Displacement**



**Bending Stress**



**RESULT**

| | Analytical | Software |
|---|---|---|
| $\sigma_{max}$ | $4.1403 \times 10^2$ $N/mm^2$ | $4.213\times 10^2$ $N/mm^2$ |

### VII. CONCLUSIONS

By observing the causes of failure are material of the shaft, end disk, bushes and gear box. So, to overcome these failures we used the predictive maintenance and design modification. By using the Hypermesh software we analyse the stresses and impact on shaft at higher inclinations we will made changes in design accordingly.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