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Conveyor Pulley Failure Analysis

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Abstract-In this paper different component of conveyor pulley (shell, end disk, hub, and shaft) failure and the stresses generated on them are discussed. The basic idea is to present the state of work about the conveyor pulley design analysis. The outer diameter of conveyor pulley to shaft diameter is a measure of the flexible nature of the end disc. This ratio was approximately 6 to 8 by Leo J Laughlin [1].If the ratio of outer diameter of conveyor pulley to shaft diameter smaller, then conveyor pulley end disc will tend to be rigid. If the ratio of outer diameter of conveyor pulley to shaft diameter larger then conveyor pulley end disc will tend to be flexible. So conveyor pulley diameter to shaft diameter ratio in the range of five to eight then their stresses were fairly low. The paper was mainly focused on the improvement in the design and dimension of conveyor pulley which helpful for computational level.

I. INTRODUCTION

The selection of conveyor pulley is based on tension range of belt transmission. For the lower tension range up to 1300 N/cm of belt width conventional pulley is used. For the higher tension range of 4500 N/cm to 17500+ N/cm of belt width taper profile diaphragm pulley is used. The conveyor pulley is mainly consisting of shaft, hub, shell and end disk and bearing and keyways. With the advancement in the belt material technology, belt is able to take higher tension with relatively low mass belt with a faster revolution per minute. The low mass belts permit the use of small diameter pulley while the tension ratings demand similar to the shaft diameter. The conveyor pulley design is mainly based on tight side tension, slack side tension, and self-weight of pulley under the steady state conditions. Different components parts of the conveyor pulley like as a shell, diaphragm, hub, and shaft are subjected to bending stresses. Thus strength and the rigidity are the main criteria. Design is checked for the permissible deflection and bending stresses. Conveyor pulley is a rotating device under dynamic load for every revolution all of its parts go through a complete reversal of stresses caused due to the load. This leads to the fatigue in the components. Figures below shows the standard construction pulley and taper profile diaphragm type of pulleys.

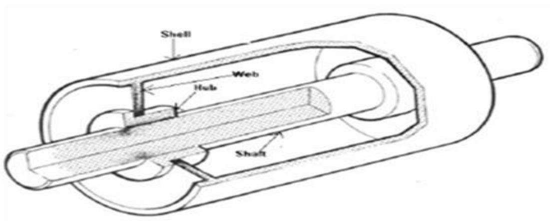

Figure 1 standard construction pulley

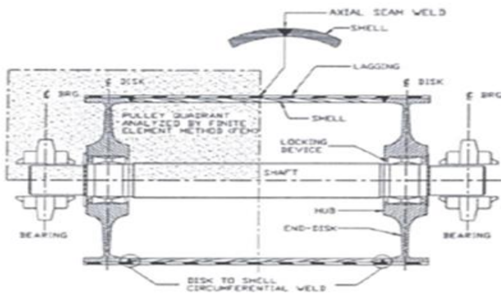

Figure 2 taper profile diaphragm pulley

Hence when designing a conveyor pulley the problem is to provide sufficient strength in the shell, diaphragms, hub, shaft to prevent them from failure due to high stresses and at the same time provide sufficient flexibility in the overall structure so that it neither fails due to fatigue nor wobble effects on the shaft.

So to achieve the optimum design all the parts comprising of the integral units of the conveyor pulley should be designed together is essential. Some of the most important factors include type of pulley construction selected, type of material used, welding processes selected, load scenario of the application, mean stresses created during fabrication type of post weld treatment performed, fabrication workmanship and welding workmanship must be identify and understand to properly predict the fatigue characteristics of conveyor pulley design.

This important information about conveyor pulley is derived from the I.G.Mulani [2].Conveyor pulley behavior under load is very complicated and therefore the pulley design is complex. The research and design development in last two to three decades particularly in the Germany enables to reasonably determine the pulley components. Formerly it was more based on empirical data. Conveyor pulley is a composite structure which is subjected to radial forces and tangential forces. The source of tangential forces is at the end of the drive shaft and the source of radial forces is at the belt. The pulley composite structure deflects under these forces creating certain value of deflection in each component. The deflection in each components is dependent on its stiffness as well as the rigidity of its connection with other components. The force occurring in the components will be in accordance with the stiffness and deflection. The shaft component is subjected to bending stress radial compression due to hub. It has been observed that the diaphragm joints at the rim and at the hub are the zones of stress concentration due to sudden change in size and bending force on diaphragm is maximum at these points. The shaft deflection at the hubs creates stress concentration between hub and shaft. One side of hub is hard pressed to shaft whereas other side of the hub is less pressed on shaft. This situation reverses every revolution and is critical for shaft and hub.

The conventional pulley is very common in use. However, these are not suitable for very heavily loaded pulleys for steel cord belts up to St- 8000 and fabric belts up to 2000/6 of higher rating. The sudden change of load resisting area from hub to diaphragm and welded joint at hub outer diameter and rim are prone to failure. Some improvement in construction is done by shifting the hub joint radially outward. This is economically possible by using forged steel hubs with extensions on the hub outer radius.

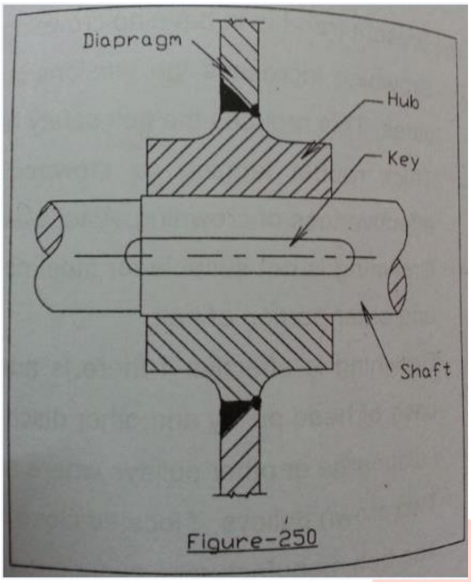

Figure 3 Conventional Pulley

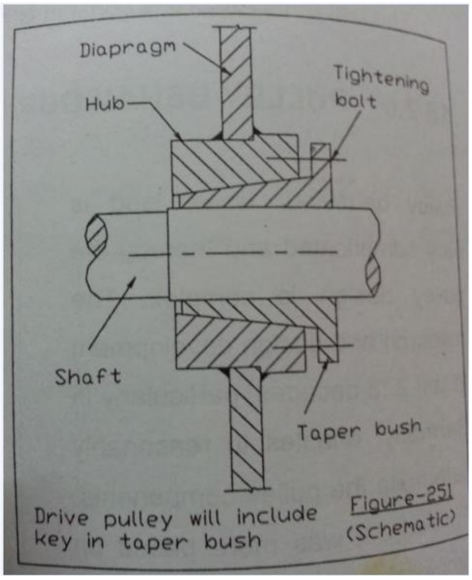

Figure 4 Taper Bush type Pulley

The simple taper bush .are widely used to mount sheaves for flat belt drives. Such taper bush hub for sheave is subjected to torque and radial force, but stress due to shaft deflection is virtually non- existent within hub because it is free to deflect with shaft. Simple taper bush hub when used for belt conveyor pulley is subjected to different kind of stress pattern due to widely spaced two rigid units subjected to shaft deflection. It will be necessary to know the permissible shaft deflection and related life for its use for belt conveyor pulley is subjected to different kind of stress pattern due to widely spaced two rigid units subjected to shaft deflection.

Different components of conveyor pulley are subjected to stresses and deformation under the loading condition. Various researchers have conducted experiments on different components. The analysis on stresses and deformations of a conveyor pulley shell conducted by the S.P.Das et al [3]. This analysis is done under linear distribution of belt tensions between the slack side and tight side. The analysis result match with the experimental results for steel conveyor pulleys. The analysis is helpful in study of the mechanical behavior of the conveyor pulley shell for various wrap angles. The method is important in the design of the conveyor pulley shell. Other researcher N. Siva Prasad et al [4] has done the finite element analysis for the design of the conveyor pulley shell. Here also deformations and stresses in the shell were calculated. A parametric study is made varying the wrap angle and belt tension. By using this approach improvement in accuracy of shell. The maximum stresses occur at the center of the shell for all wrap angles and tensions. Finite element analysis can be useful for design of conveyor pulley shells. So according to this two researcher linear variation of belt tension in the circumferential directions will give satisfactory results.

The analysis of fatigue in the shell of a conveyor drum is conducted by Ch.Affolter et al [5]. The shell of a belt conveyor broke in operation due to fatigue in the area of the weld seam between the axle disk and the cylindrical shell. The fatigue is mainly due to an overloading of the drum, a deficient design and fabrication lead to the failure. After the first damage of the shell has been done, two finite element models were built to compare the original design with the actually manufactured drum by means of nonlinear calculations. Because of the stresses acts on the components the 'hot spot' created on the circumference, the service life of the drum was calculated for the given loading conditions. The estimated service life of the failed drum corresponded with the effective operation time of the conveyer.

High shear stresses contributed significantly to the deterioration. Since the realization of the design proved to be problematic regarding the welding technique in the area of the seam root and at the shoulder of the axle disk, an optimized design was developed. The fracture in the drum shell occurred due to fatigue in the area of the weld seam, because the manufactured drum differed from the original design regarding shell thickness and execution of the weld seam. Comparatively high shear stresses were possibly not considered adequately in the design. In critical cases, the drum should periodically be tested for cracks. The fatigue life prediction of a butt weld joint in a drum pulley assembly using non-linear static structural analysis was done by the Vinod.M.Bansode et al [6]. A most critical region for the fatigue damage and failure are at the weld joint connection end plate and shell, hub and end plate as well as seam welds in the drum shell. A stress life approach may be useful for predict the life of weld in the structure. The fatigue life prediction with the help of material curves for the weld material of dumbbell specimen and S-N curve was determine and from experimentation will give more accurate and closer result for actual failure and also useful in the simulation. The design was strong enough to sustain 0.5 million cycles for operating loading conditions with various cracks. The failure cause can be stated as the bad quality of weld material, improper welding, occurrences of multiple cracks, overloading, improper surface finishing, corrosive environment variables may have amplified the stress intensity by 20 times. The analysis of weldment fatigue methods on pulley design has done by the Tim Wolf [7]. Weld notch affects on conveyor pulley design and belt conveyor reliability, which describe theoretical fatigue method and fracture mechanics method use in modern weld design.

Affects of changes in alternating stress range, mean stress, and residual stress have been investigated using fatigue tests on a pulley weldment. Comparisons between these results, weldcodes, and theoretical fatigue predictions were made.

Modern weld fatigue methods developed by the Dr. Lawrence's initiation-propagation model [8] in which the stress ratio gives an indication of how much of the stress cycle was in compression and how much of the stress cycle was in tension. If fatigue failures occur in compression it has been observed that as more of the stress cycle becomes compressive the fatigue life increases. The initiation-propagation model was applied to the pulley hub to end disc weld. From the initiation-propagation model stress ratio with a significant portion in compression. The initiation-propagation model can be use to predict the fatigue life at each potential failure location. The initiation-propagation model gives a more balance design. Use of the initiation-propagation model and finite element method gives accurate stress analysis, gives more reliable and practical designs for all applications. In this way more accurate and balance design of conveyor pulley is developed.

The analysis on modern pulley design and the failure analysis has been done by the Vinit.Sethi [9]. An engineered class pulley for modern high strength steel cord belt conveyors was not suitable due to inadequate standard and specifications. The conveyor dynamics inc design techniques and stress analysis design techniques were useful in the finite element method, fatigue failure criteria, design limits and the manufacturing requirements for successful and safe conveyor pulley design. The stress criteria comprise of (static and fatigue) strength analyses. These stress criteria occurs in different components of the pulley's shell, disk, hub and shaft. The stress fields consist of radial, tangential and axial stresses of three dimensional types which are analyzed in the pulley. The PSTRESS was useful to predict many failures in the conveyor pulley. The improvement in conveyor pulley design by the development of better standards. The analysis on failures in the conveyor pulley design has conducted by the Terry J King [10].

The theoretical model was useful for understanding some common mode of failures which improve by pulley construction features. The factors which limit the life of a pulley was consider and a design was develop for long-life cover, lower cost pulley. The whole assembly was well suitable with the small diameter large shaft pulleys. Weld joint was made which generate a low stress, where automatic techniques and non-destructive testing can be used. More wear was indicated by change of color in time for re-lagging. This makes a simple construction of pulley. The standard ISO 1536 was use as a guide and making cheaper conveyor pulley in a rational range of the sizes.

The studies on some aspects of conveyor pulley design have conducted by Mr R.R.Patel et al [11]. The paper mainly focused on some of the standards and codes were not cover in the design of the shaft, diaphragm and shell of the conveyor drive pulley. This was mainly due to the inadequacy of the standards and codes were used in design. The different design approaches like classical mechanics, finite element method and modified transfer matrix were considered and their advantages and disadvantages also considered. There are many standards and codes such as IN, ISO, BS, CEMA and MHEA for the conveyor pulley design but they are giving the guidance for designing of individual parts of the pulley. It was necessary to analyze the stress in various conveyor pulley parts and their effect on other components part of the pulley and their inter-dependence of stress and inter-relationship of various parts of pulley was found out.

REFERENCES

[1] Leo J. Laughlin "A comparison of turbine pulley design philosophies with historical perspective" Product Marketing Manager, Precision Pulley & Idler 300 SE 14TH St.Pella, IA 50219

[2] I.G.Mulani "Engineering science and application design for belt conveyors" Formerly Head of Project Engg.Dept.Krupp – India.

[3] S.P.Dash and M.C.Pal "Stresses and deformations of a conveyor power pulley shell under exponential belt tensions" Department of Mathematics, Regional Engineering College, Durgapur 713 209, west Bengal, India.

[4] N. Siva Prasad and Radha Sharma "A finite element analysis for the design of a conveyor pulley shell" Department of Mechanical Engineering, Indian Institute of Technology, Madras 600 036, India.

[5] Ch. Affolter G. Piskoty, R. Koller, M. Zgraggen, T.F. Rutti "Fatigue in the shell of a conveyor drum" EMPA, Swiss Federal Laboratories for Materials Testing and Research, Ueberlandstrasse 129, CH-8600 Duebendorf, Switzerland.

[6] Vinod.M.Bansode and Abhay A. Utpat "Fatigue life prediction of a butt weld joint in a drum pulley assembly using non-linear static structural analysis" Dept. of Mechanical Engineering, College of Engineering, Pandharpur, India.

[7] Tim Wolf "Weld notch affects on pulley and belt conveyor reliability" Senior Pulley Engineer, Precision Pulley, Inc., Pella, Iowa, USA.

[8] Dr.Lawrence F. "Factors Influencing Weldment Fatigue", ASM Handbook, Volume 19, pg.274-286, 1996.

[9] Vinit.Sethi and Lawrence K. Nordell "Modern pulley design techniques and failure analysis methods" Conveyor Dynamics, Inc.1111 West Holly Street, Bellingham, WA 98225

[10] Terry J King "Why the failures in belt conveyor pulley design?" B.Sc. Mech Eng (Hons), Precision design Engineer, Bosworth Group of Companies.

[11] Mr. R.R.Patel, Prof. Shashank P Joshi and Prof.P. M. Agrawal "Studies on some aspects of conveyor drive pulley design" Lecturer, Mechanical Engineering Dept, Birla Vishwakarma Mahavidyalaya VVNagar, Gujarat, India