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COMPARATIVE ANALYSIS OF PLAIN PULLEY AND PULLEY WITH INDENT LINER IN FLAT BELT DRIVE

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ABSTRACT

Belt drives are used as mode of power transmission in variety of machines where in the centre distance are not significant and constant velocity ratio is not desired. The flat belt dries are exclusively used for high speed power transmission. Though the desirable characteristic flat belt is to transmit high speed power, but slip is also prominent. Crowning of the flat belt pulley is one such method used , along with providing serrations on the pulley are other methods. The concept to provide liners on the flat pulley to improve performance is relatively new method ,In this paper we have introduce the application of square indented liners instead of permanent modified pulleys with the view increase adaptability and inter changeability and easy replacement after wear out of liner just as in case of clutch or brake liner facings. The deals with the strength analysis using Ansys 16.0 of the flat belt pulley and its liner , so also comparative experimental results of the plain pulley and pulley with liner.

Belt drives are most widely used in industry for transmission of power from one shaft to another shaft over considerable distance. It provides flexibility in positioning of motor relative to load. Pulleys of different diameters allow the speed of driven equipment to be increased or decreased relative to motor speed. A properly designed belt power transmission system offers high efficiency. It consists of an endless belt which is wrapped tightly over two pulleys which are mounted on separate shafts.Synchronous belt drive generates resonance on the belt span between two pulleys.

Keyword: Analysis ANSYS 16.0, Design, Unigraphix , Slip, Indent Liner, Comparative Analysis,

I. INTRODUCTION

Belt drives are power transmission systems commonly used in the industry. There are different types of belts like flat belts, V-belts, and V-ribbed belts. Flat belts offer flexibility. The flat belt is used for the transmission of power in many engineering applications from a driver pulley to the driven pulley through friction between the belt and the pulleys. The belt drive has been successfully used as drive mechanism in fans and blowers, automotive engines, pump equipment, industrial machines and agricultural equipment among other applications. The drive is frequently used because of its ability to absorb shock, and its ease of installation.the application of a flat belt drive where power is transmitted from motor to engine flywheel. Flat belts were used early in line shafting to transmit power in factories. It is a simple system of power transmission that was well suited to its day. It delivered high power for high speeds (500 hp for 10,000 ft/min), in cases of wide belts and

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large pulleys. These drives are bulky, requiring high tension leading to high loads, so V-belts have mainly replaced the flat-belts (except when high speed is needed over power…A Belt is a looped strip of flexible material, used to mechanically link two or more rotating shafts. They may be used as a source of motion, to efficiently transmit Power, or to track relative movement. Belts are looped over pulleys **.** When a belt is used for power transmission it is called a belt drive Belts are the cheapest utility for power transmission between shafts that may not be parallel. Power transmission is achieved by specially designed belts and pulleys. Belts run smoothly and with little noise, and cushion motor and bearings against load changes, but has less strength than gears or chains.

II. LITERATURE REVIEW

[1] L. Manin_G. Michon D. Remond R. Dufour: The Auther study transmission error measurement to Pulley-Belt slip determination in serpentine belt drives.In The Multi ribbed (serpentine) belt transmission are often used in the industry machinery to transmit power. Another field of application concerns the Front End Accessory Drive of automotive engine, it recently asks for better performances in order to allow the development of new technological innovations as starter-alternator integration in the transmission. Resistant torques of the driven accessories are getting higher and design solutions have to be found in order to prevent pulley-belt slip and belt fatigue. In these transmissions, two kinds of tensioners can be used in order to reduce vibration and insure sufficient belt tension to transmit power and to avoid sliping. Pulley-belt slip has been investigated both numerically and experimentally by auther on vbelt in steady state operating conditions.

[2] Springfield, Missouri: The Auther Study Energy Loss while belt is in Running codition . Power transmission efficiency and parasitic idling losses in belt machine elements have been considered for over 50 years. Most references cite efficiencies between 90 and 98 percent for various belts with 95 percent being a typical value..Power transmission efficiency at rated and representative application power levels for the larger belts is measured with the dynamometer system .The system is digitally instrumented with trunnion mounted 10,000 pound-inch pyrometers, and a tension load cell. The lower power levels of the smaller belts require a more sensitive measuring system which entails a lower capacity prime mover and absorber with a 500 pound-inch torque cell.The tension effect results from frictional sliding as a belt enters and exits a pulley; whereas, the diameter dependence is a consequence of bending hysteresis as a belt flexes from straight span to curved pulley paths. Since pulley speed controls the rate of frictional and hysteretic energy dissipation, it is essentially proportional to power loss.

[3] Lelio Della Pietra, Francesco Timpone : The Author Study the Tension in a flat belt transmission Process The simplest theoretical model (regarded as the first) concerning belt drives, is known as the "Euler model" (or Euler–Eytelwein model), published by Euler in 1762 the tensions at the ends of a stretched ropewrapped around a body in sliding limit condition. The model generally used to study and design flat belt drives is however the Grashof one (also known as Reynolds–Grashof), which dates back to 1883.there is Grashof and Firbank model is use for investigation..

[4] Nurudeen A. Raji Andrew A. Erameh , Abiodun A. Yussouff , Rasheed O. Durojaye The Author Study Methodology of Response Surface Approach for Transmission Optimization of Belt Drive and belts are usually tightened to ensure friction between the belt and the pulleys. However, the installation tension should not be more than necessary to transmit the rated torque otherwise excessive bearing loads and shaft stresses may occur . The pre-tensioning of the V-belt drive is based upon the total tightening force required to transmit the power. In automobile industry, the belt tensions are required to be as small as possible to reduce belt fatigue and prolong bearing life. However the small tension could results in power loss and belt slip which is not acceptable. The belt-pulley function model and the belt interaction with the pulley groove have been identified as a major source of error in the use of such belt drive for power transmission.

[5] L. Della Pietra,F. Timpone [7] studied that they have offered an investigation of Tension in a flat belt transmission experimental investigation,Mech The simplifie model of flat belt drive setup is built based on the linear theory, the performance of the setup is analyzed, and the result shows that using leads to an advantage of isolation vibration, instead of just damping vibrations at a specific frequency, could dampen vibrations over a range of frequencies.

III. PROBLEM STATEMENT

This problem of slip is the most prominent issue with the flat belts Crowning of the flat belt pulley is one such method used , along with providing serrations on the pulley are other methods. This leads to be a costly option and in case of replacement entire pulley has to be replaced.

IV. SOLUTION

The concept to provide liners on the plain pulley to improve performance is relatively new method ,In this we have introduce the application of square indented liners and round indented liners instead of permanent modified pulleys with the view increase adaptability and inter changeability and easy replacement after wear out of liner just as in case of clutch or brake liner facings. The present pulley is developed from aluminium , and liner is also made of aluminium.

4.1 Objectives of Project

1. Design development and analysis of square shape positive geometry flat belt pulley liner . Geometrical profile design using 2-d cad , 3-d modelling using Unigraphix N-x , analysis using Ansys work bench 16.0
2. Design development and analysis of round shape positive geometry flat belt pulley liner . Geometrical profile design using 2-d cad , 3-d modelling using Unigraphix N-x , analysis using Ansys work bench 16.0
3. Test and trial to determine slip and characteristic of percentage slip Vs load and percentage slip Vs torque
4. Comparative analysis of plain pulley, square and round liners pulleys.

V. METHODOLOGY

1. The flat belt plain pulley and square shape and round shape indentation liner will be modelled using Unigraphix NX-8 .
2. Data transfer of modelling data will be done by use of STEP2003 file
3. Analysis of the pulley and liner will be done in ANSYS 16.0 for stress and deformation
4. Test and trial will be conducted on the flat belt drive with and without liner to determine the percentage slip .

5. The data will be used to derive the percentage reduction in slip by use of square and round shape liners on flat belt plain pulley..

5.1 Specification

1. Motor :
2. 50 watt , 0 to 6000 rpm variable speed , 230 volt AC
3. Gear details for drive from motor to pulley :
4. Pinion on motor = 10 teeth 2 module
5. Gear on driver shaft = 40 teeth = 2 module
6. Driver shaft speed = 6000 / 4 = 1500 rpm
7. Torque @ driver shaft = 0.318 N-m = 318 N-mm
8. Considering Factor of safety = 1.5 ---
9. Tdesign = 1.5 x 318 = 477 N-mm

5.2 Design of Plain Pulley

Diameter of the pulley (D) is selected depending upon the required velocity ratio, as discussed in the selection of belts.

Width of the pulley or face of the pulley (B) is taken 1.25 times the width of belt (b).

B = 1.25 b

Thickness of the pulley rim (t) is taken between (D/300 +2) mm and (D/300 +3) mm for single belt and for double belt.

Cross-section of arms is generally elliptical with major axis (b_1) equal to twice the minor axis (a_1). The cross-section of the arm is obtained by considering the arm as cantilever, fixed at the hub end and carrying a concentrated load at the rim end and having a length equal to the radius of the pulley. Also, it is assumed that at any given time, the power is transmitted from the hub to the rim or vice versa, through only half of the total number of arms.

Tangential load per arm is given by,

$$F_t = \frac{T}{R \times \frac{n}{2}} = \frac{2T}{R\,n}$$

where,

T =Torque transmitted

R = Radius of pulley

n = Number of arms

Maximum bending moment on the arm at the hub end,

$$M = F_t \times R = \frac{2T}{n}$$

Maximum bending stress is given by,

$$\sigma_b = \frac{M\,y}{I} \leq [\sigma_t]$$

where,

I = Moment of inertia of cross-sectional area of the arm about the axis of rotation

$= \frac{\pi a_1 b_1^{\;3}}{64} = \frac{\pi a_1^4}{64}$ as $b_1 = 2a_1$

y = Distance from neutral axis to the outer most fibre = $b_1 / 2 = a_1$

So, required dimensions of the arm, near the hub, can be determined from above relation for a known value of allowable tensile stress, A taper, generally of 1/48 to 1/32, is provided on the arms, from hub to rim.

5.3 Material Selection

Designation	Ultimate Tensile strength N/mm^2	Yield strength N/mm^2
Aluminium	360	240

$\Rightarrow fs_{\text{max allowable}} = 90$ N/mm^2---- CONIDERING FACTOR OF SAFETY =4

Check for torsional shear failure:-

$$T = \left(\frac{\pi \times fs_{act}}{16}\right) \times \left(\frac{D_o^{\;4} - D_i^{\;4}}{D_o}\right)$$

$$T = \left(\frac{\pi \times fs_{act}}{16}\right) \times \left(\frac{74^4 - 64^4}{74}\right)$$

$$fs_{act} = 0.009 \text{ N/mm2}$$

As; $fs_{act} < fs_{all}$ $\Rightarrow$ Pulley is safe under torsional load .

5.4 Analysis of Plain Pulley

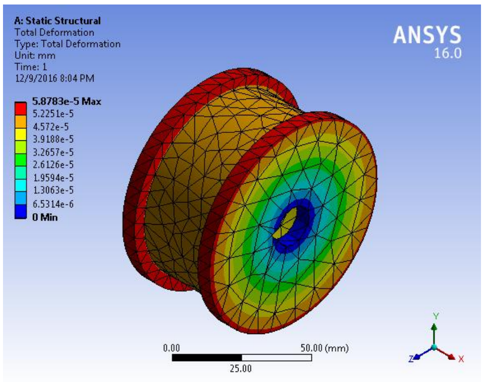

Fig1 Deformation Plain Pulley

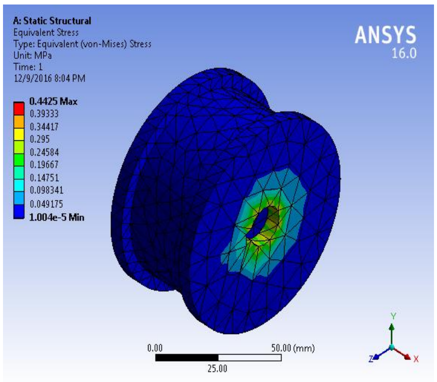

Fig2 Stress on Plain Pulley

5.5 Design of Square Shape and Round Shape Liner

$\Rightarrow fs_{\text{max allowable}} = 90$ N/mm^2---- CONIDERING FACTOR OF SAFETY =4

Check for torsional shear failure:-

$$T = \left(\frac{\pi \times fs_{act}}{16}\right) \times \left(\frac{D_o^{\,4} - D_i^{\,4}}{D_o}\right)$$

$$T = \left(\frac{\pi \times fs_{act}}{16}\right) \times \left(\frac{76^4 - 74^4}{76}\right)$$

$fs_{act} = 0.036$ N/mm^2

As; $fs_{act} < fs_{all}$

$\Rightarrow$ LINER is safe under torsional load .

5.6 Analysis of Square Shape Liner

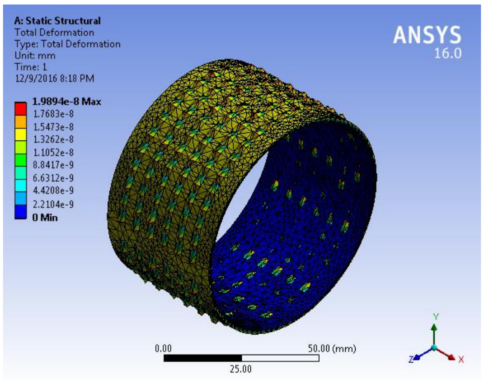

Fig 3 Deformation Square Shape Liner

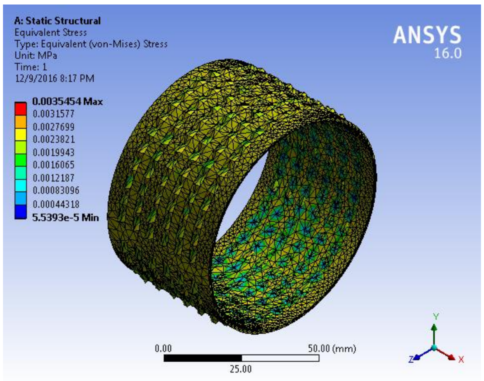

Fig 4 Stress on Square Shape Liner

5.7 Analysis of Round Shape Liner

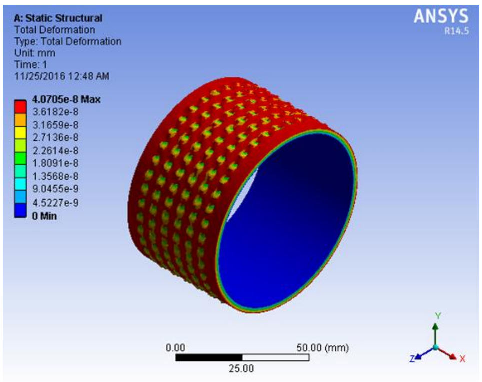

Fig5 Deformation Round Shape Liner

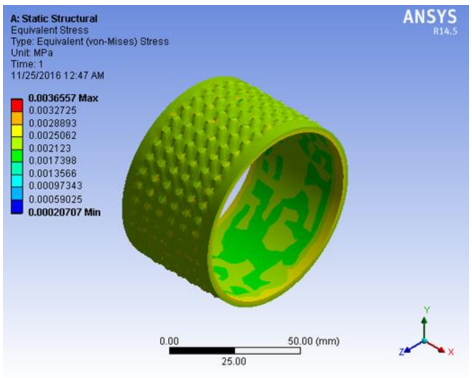

Fig 6 Stress On Round Shape Liner

5.8 Experimental Set-Up Flat Belt Drive

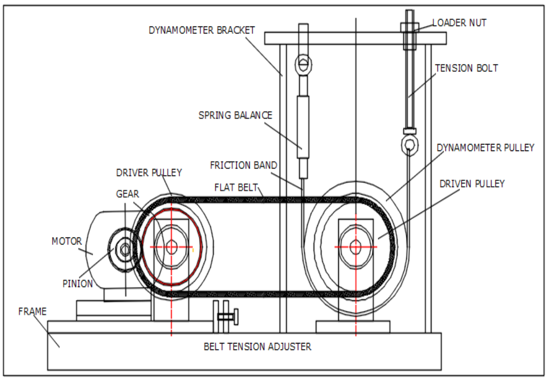

Fig 7 Cad Drawing

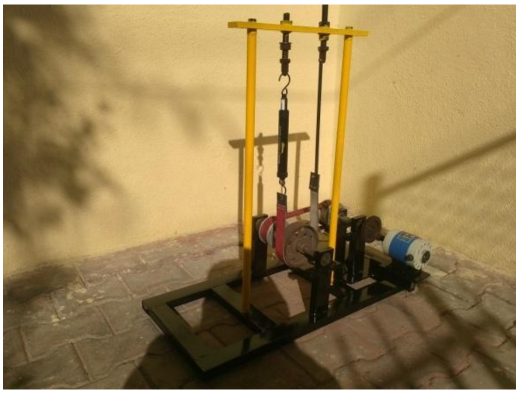

Fig 8 Actual Model

VI. RESULT TABLE

Sr No	Load In (kG)	% slip of plain pulley	% slip of Round shape liner	% slip of Square shape liner
1	0	0.893796	0.368034	0.263158
2	0.5	0.701944	0.592034	0.430108
3	1	1.473088	1.012373	0.898876
4	1.5	1.762632	1.113064	0.935673
5	2	2.649842	0.938673	1.25
6	2.5	3.100264	1.63827	1.568627
7	3	3.287671	1.917808	1.843003
8	3.5	3.746398	2.288984	2.064057
9	4	3.906837	2.541106	2.313433
10	4.5	4.55259	2.950311	2.48062
11	5	5.400982	3.381643	3.052209
12	5.5	5.56962	3.849372	3.666667
13	6	6.13656	4.109589	3.675214
14	6.5	6.811989	3.9819	3.693694
15	7	7.449857	4.174573	3.773585

Result Table of Percentage Slip of Plain Pulley, Round and Square Shape Liner on Pulley

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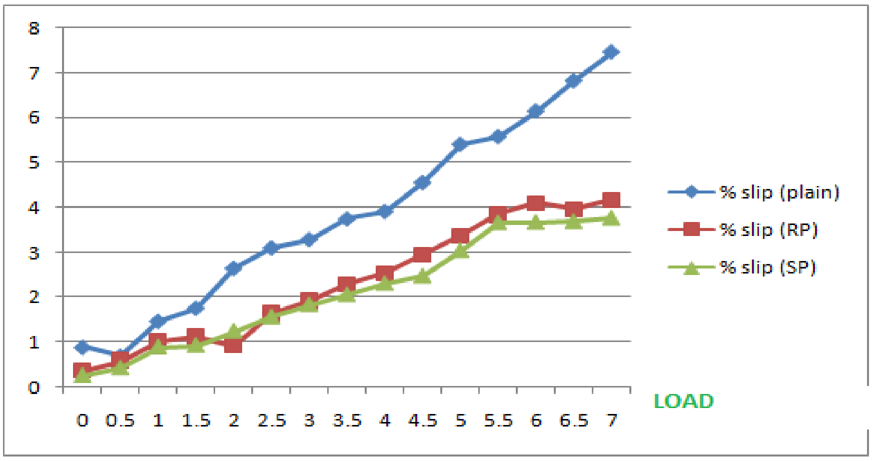
Comparison Graph of Percentage Slip of Plain Pulley, Round And Square Liner Pulley



VII. CONCLUSION

1. The Plain pulley is safe in design by theoretical method as well by analysis , as the maximum stress is well below the allowable stress and deformation is negligible.
2. The Liner is safe in design by theoretical method as well by analysis , as the maximum stress is well below the allowable stress and deformation is negligible.
3. The % slip in case of the square shape liner pulley is maximum of 3.77% and round shapr liner is maximum of 4.17% where as in case of the plain pulley 7.44.% of slip indicating the effect of liner is to improve drive accuracy and reduce slip in transmission.
4. The Overall characteristics indicate that the Liner pulley serves far better than the Plain pulley.
5. Plain pulleys shows maximum slip indicating poor efficiency
6. Square Geometry liner shows lowest slip indicating maximum efficiency
7. The best performance is of square geometry followed by round geometry and then the plain
8. Round geometry will be preffered over plain pulley
9. Square Geometry will be preffered over round geometry as well plain geometry.

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