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MODELING AND ANALYSIS OF A PUMP PULLEY

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ABSTRACT

A belt and pulley system is characterized by two or more pulleys in common to a belt drive. This allows for mechanical power, torque and speed to be transmitted across axles. With the successful correlation of test and analytical data, it is felt confident that this method can be utilized to evaluate multiple design proposals with respect to rotor distortion and recommended optimum component design parameters to meet the design specifications for different materials. If the pulley made with of different types of materials, due to change in properties as well as cost consideration of the material we can select the best and economical pulley. In this paper, the statement of the problem is "Load and stress acting on the pulley analyzed by using F.E.A (Finite Element Analysis) and modeling is done by CATIA V5".

Keywords: ANSYS, Belt drive, CATIA, Finite Element Analysis, Pulley system.

I. INTRODUCTION

Pulley drive systems depend on friction to enable the belt to grip the wheel and pull it around with it. To enable this, the belt must be tensioned, even when the wheels are stationary. pulleys are devices which is used for plenty applications like commercial, industrial etc. On many modern systems, toothed belts are used (e.g. timing belt on a car engine) to prevent the belt slipping. This tutorial is only concerned with smooth belts.

1. Objectives of the Paper

The present investigation is aimed to study.

1.1. The given pulley system for its stability and rigidity (for this bending and torsional loads acts on the pulley and its shaft).

1.2. Best combination of parameters pulley system like diameter of pulley and material there by a best combination is suggested. (for this different combinations in each case is analyzed)

In the present investigation of analysis of pulley, a simplified model of the pulley is analyzed by FEM package ANSYS. Due to this we can justify the pulley material.

2. Future Scope of the Paper

As a future work, a model of Centrifugal pump pulley with motor drive system can be taken and there by forces or loads and stresses induced considered in the analysis. The benefit of utilizing analytical methods in the development of components is that multiple design iterations can be evaluated of minimal costs. With the successful correlation of test and analytical data, it is felt confident that this method can be utilized to evaluate multiple design proposals with respect to rotor distortion and recommended optimum component design parameters to meet the design specifications.

The determination of life of pulley within the safe side condition that means optimal load distribution due to this optimal distortion as well as stress acting is possible, with changing the material.

II. METHODOLOGY

The Pulley system in Fig.1 is taken from Centrifugal pump and the parameters are altered for the optimization purposes. The arrangement of pulley system with required belt system is shown inn Fig.1(a). Fig.1 (b) shows the general diagram showing all the positions of pulley on belt drive. This model of the pulley is failed due to the high loads acting on its Circumference. So the load on pulley acts by means of forces acting on its circumference by the belt drive along its self weight. So it is necessary to optimize the pulley material without effecting the design consideration.

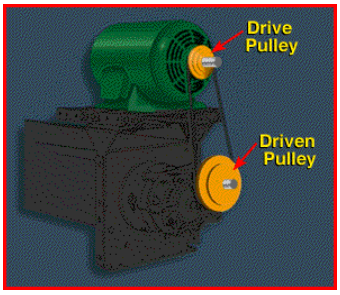

Fig.1 (a)

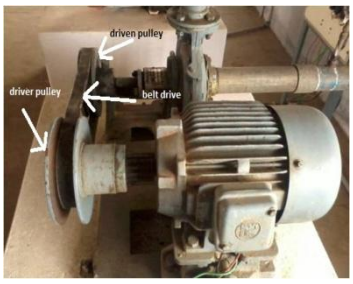

Fig.1 (b)

2.1 Modeling of Pulley

The shape of pulley is circular and at the center a hole provides to insert the pulley into the driving shaft. While it is true that some pulleys were and still are produced according to simple, flat and circular geometry. The belt tension surface is the area on which the maximum load action takes place. A value of load up to 30 KN surface is the basis for calculating size, although this value can change considerably when the disc is very well ventilated and can reach these load. The second function is that of attachment provided by the circumference part of the pulley which has a circular aperture which serves to withstand maximum load. The central part of the pulley is surrounded by grooves for inserting the belt.

In the entire system of pulley and centrifugal pump the maximum load acting on the pulley system only. So desired load acting on pulley is must considered while designing these kinds of systems. Load acting is the form of self weight, belt tensions and initial tension. Considering designed system.

The machinery manufacturer has to select a belt from the belt manufacture's catalogue based on the power to be transmitted, speeds and diameters of driving and driven pulleys and the available space to house the pulleys. The modeling is done by taking motor shaft diameter (D) 25 mm, which adopted our pulley, hence the remaining modeling is done by means of following proportions.

a. maximum diameter of pulley: 3.5D to 5D

b. Maximum width: 0.25D to D.

c. maximum groove angle: 5^0 to 15^0

d. clearance : 0.15mm to 3mm etc

2.1.1 Modeling Software

A software process refers to the set of tools, methods, and practices used to produce a software product. Historically, software development have largely been product-centered. Recently, many researchers and practitioners have refocused their efforts on the process dimension of software engineering.

There are plenty of software are available to design or model the any element. On that AUTOCAD, CATIA, Pro- Engineering, Form-Z, MASSIVE, Shade 3D, SolidWorks, Unigraphics, Wings 3D etc.

In this Present Paper CATIA modeling software is used to design the pulley as shown in fig 2. CATIA enables the creation of 3D parts, from 3D sketches, sheet materials, Composites, molded, forged or tooling parts up to the definition of mechanical assemblies. The software provides advanced technologies for mechanical surfacing & BIW. It provides tools to complete product definition, including functional tolerances as well as kinematics definition. CATIA provides a wide range of applications for tooling design, for both generic tooling and mold & die.

CATIA offers a solution to shape design, styling, surfacing workflow and visualization to create, modify, and validate complex innovative shapes from industrial design to Surfacing with the ICEM surfacing technologies. CATIA supports multiple stages of product design whether started from scratch or from 2D sketches. CATIA v5 is able to read and produce STEP format files for reverse engineering and surface reuse.

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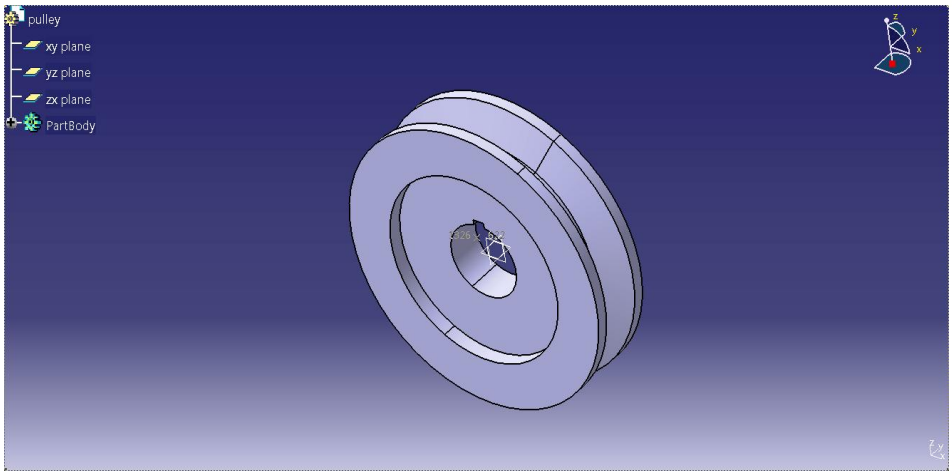

Fig.2 (CATIA Model Diagram)

2.2 ANSYS Results

ANSYS inc. supports the ongoing development of innovative technology and delivers flexible, enterprise wide engineering systems that enable companies to solve the full range of analysis problem, maximizing their existing investments in software and hardware. ANSYS Inc. continues its role as a technical innovator.

2.2.1 Load Acting On Pulley Drive

Generally load acting on the pulley in the form of tangential loads. Because the belts are wounded upon the pulley drive which creates torsoinal loads. Load acting on pulley are due to tensions induced in the belt when it is in at tight side and slack side and also due to initial tension including its self weight. Under the no load condition the total load acting is in the form of its self weight, after that when starting the system the loads in the form of its initial tension induced due to the inertial forces.

So we can say that load acting on the pulley is the sum of the initial tension, self weight, tight side and slack side tensions.

Then, TOTAL LOAD ACTING = INTIAL TENSION+TENSION DUE TO BELT+SELF WIGHT O PULLEY

2.2.2 Selection of Materials

Materials are the main important criteria for designing any manufacturing component. Because of their inherent properties. The coefficient of friction fluctuate the load acting for different materials. In this if surface area is too smooth causes slipping of belt and reduces power transfer. So we can say that there must be optimum and cheapest pulley is designed while considering material only. If materials being changed the properties of entire pulley system also changes.

Following are main materials to be used for designing pulley

Steel

Steel is an alloy that consists mostly of iron and has a carbon content between 0.2% and 2.1% by weight, depending on the grade. Carbon is the most common alloying material for iron, but various other alloying elements are used, such as manganese, chromium, vanadium, and tungsten.

Cast iron

Cast iron is derived from pig iron, and while it usually refers to gray iron, it also identifies a large group of ferrous alloys which solidify with a eutectic. The color of a fractured surface can be used to identify an alloy. **White cast iron** is named after its white surface when fractured, due to its carbide impurities which allow cracks to pass straight through. **Grey cast iron** is named after its grey fractured surface.

Aluminium

Aluminium is the third most abundant element (after oxygen and silicon), and the most abundant metal, in the Earth's crust. It makes up about 8% by weight of the Earth's solid surface. Aluminium metal is too reactive chemically to occur natively. Instead, it is found combined in over 270 different minerals. The chief ore of aluminium is bauxite.

Table 1.1 Structural material properties of CI, Al & Steel

Properties Material	Cast iron	Aluminium	Steel
1. YOUNG'S MODULUS (E) Gpa	180	170	200
2. POISSON'S RATIO (V)	0.25	0.25	0.25
3. COEFFICIENT OF FRICTION	0.25	0.20	0.12 to 0.16

2.3 Comparison of Results

2.3.1 Calculation Results

By the analytical calculations following data will obtain.

Table 1.2 indicates results through manual calculations.

S.No.	Material	Load in N	Stress induced in N/mm^2	Deformation in mm
1	Cast Iron	2198	4.82	0.004698
2	Steel	2548.5	4.9707	0.00498
3	Al	2979	5.178	0.00466

Note: Above calculation values obtained by manual calculations.

2.3.2 ANSYS RESULTS

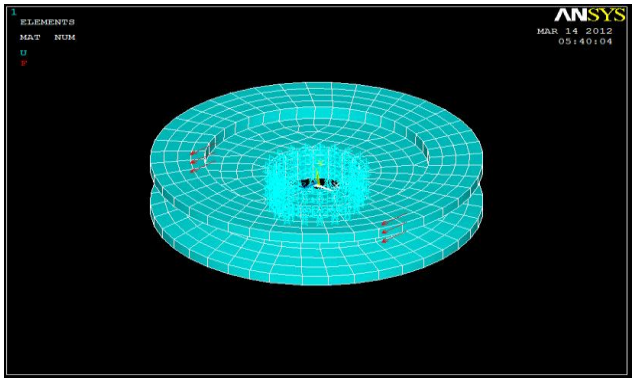

Fig.2.2 (Meshed Model)

In the figure.2.2 indicates about meshing of centrifugal pump pulley and its shape of messing element.

For different materials the ANSYS results are shown as

CASE 1 Aluminium

CASE 2 Cast Iron

CASE 3 Steel

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Case-1: Aluminium

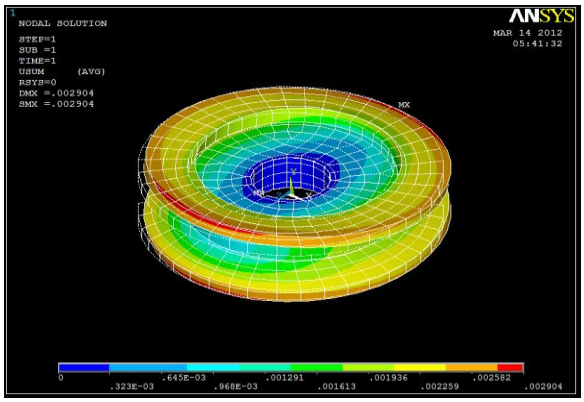

Fig.2.3 (Deformation)

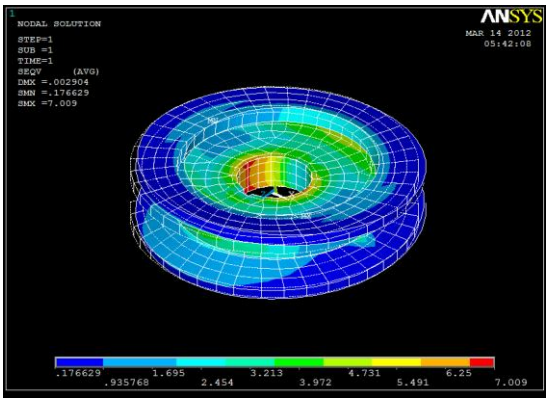

Fig.2.4 (Von Misses Stress)

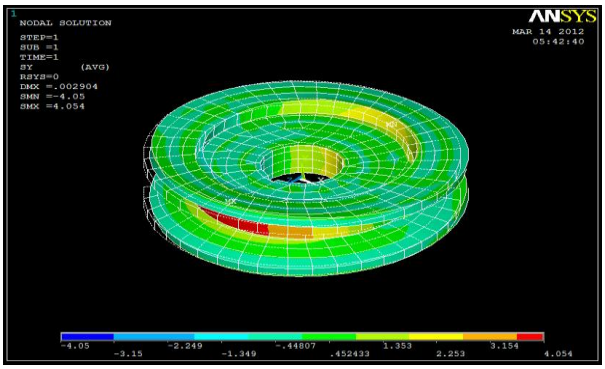

Fig.2.6 (Deformation along Z-Direction)

CASE-2 : Cast Iron

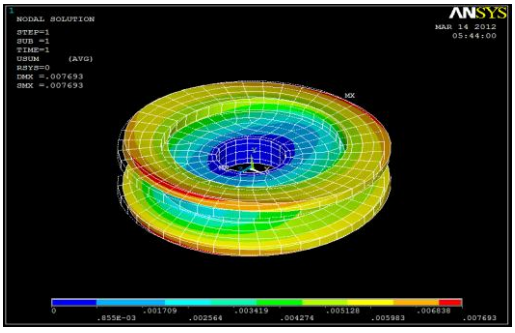

Fig.2.5 (Deformation)

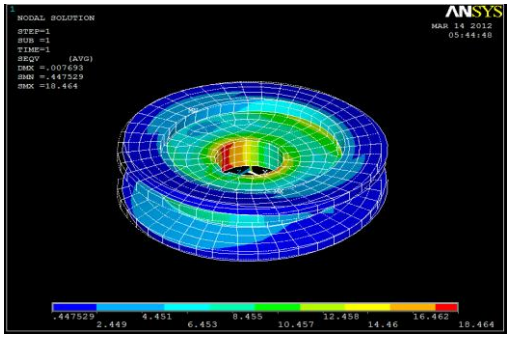

Fig.2.7 (Von Misses Stress)

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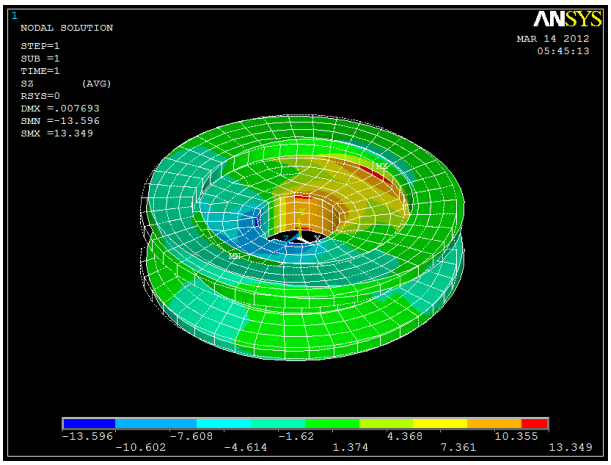

Fig.2.8 (Stress along Z-Direction)

CASE-3: Steel

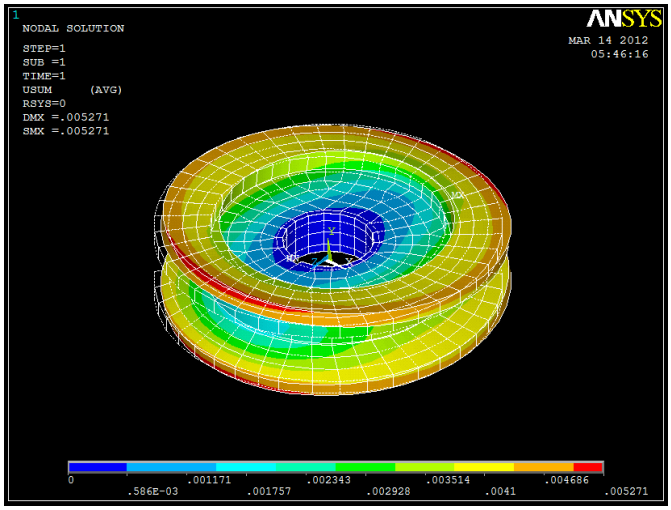

Fig.2.10 (Deformation)

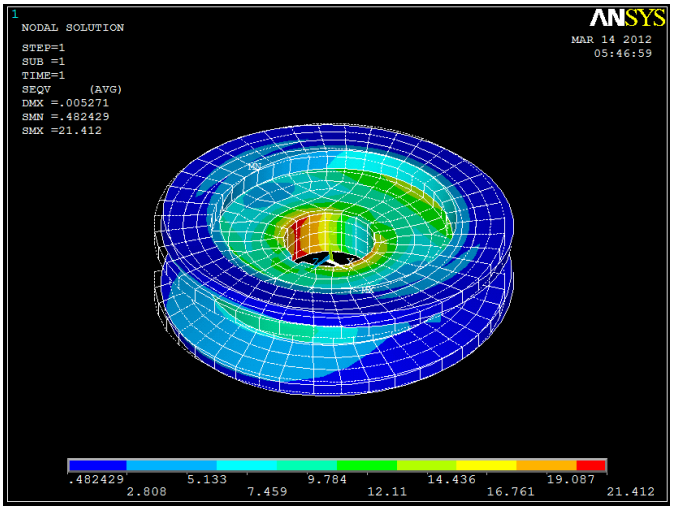

Fig.2.9 (Von Misses Stress)

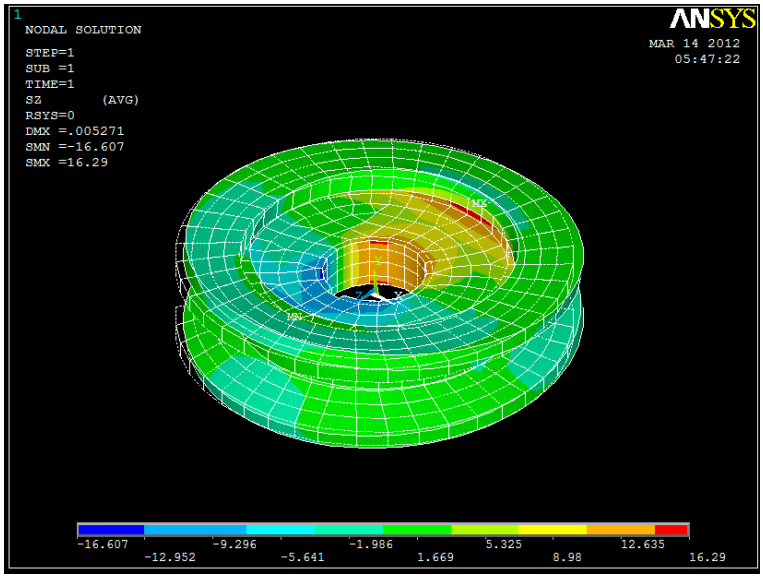

Fig.2.11 (Stress along Z-Direction)

2.3.3 ANSYS Results:

The following table shows that results from ANSYS Workbench,

S.No.	Material	Max.Deformation (mm)	Von Misses Stress(N/mm2)	Stress Alon Z-Direction(N/mm2)
1	ALUMINUM	0.002904	7.009	4.094
2	CAST ION	0.007693	18.464	13.349
3	STEEL	0.005271	21.412	16.29

III.CONCLUSIONS

The following conclusions are drawn from the present work.

a. The importance of using cast iron to make pulley universally compare to other materials.

b. Even change in materials to make and design pulley all those materials are satisfy the requirements and also within the safety condition.

c. Stress induced in given materials also within the limit.

d. The pulley is under the safe side while applying maximum load up to 3KN or 306kgs without failure.

e. An axis-symmetric analysis of pulley has been carried out using ANSYS R 5.4 (F.E.A) software

f. Comparison between calculated results to ansys results also in satisfactory condition, in this optimum level of load acting, less heat generation, cheaper cost pulley also determined. And finally cast iron is the best possible material to use as pulley material. Life of pulley also maximum for using cast iron pulley.

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