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Finite Element Modeling for Replacement of C.I. Pulley with Suitable Material

Deepak Singathia, Dr. M. L. Aggarwal

PG Student, Department of Mechanical Engineering, YMCA University of Science and Technology, India
Professor & Dean Academic Affairs, Department of Mechanical Engineering, YMCA University of Science and Technology, India

Abstract: *FEA is used in many analysis problems like structural analysis, thermal analysis, computational fluids dynamics problems etc. In this paper the maximum stress developed in a flat pulley is determined for different materials using ANSYS software. The maximum stress developed i.e. Von Mises stress is then compared for four materials in order to select best material for pulleys. The simulation stress results were compared and factor of safety was calculated on the basis of stress developed. In this present work, the stress analysis of Alumina, Al alloy 1460, Polycarbonate molded pulley is carried out to replace presently used C.I. pulley.*

Keywords: *Finite Element Analysis, Pulley, Stress*.

I. INTRODUCTION

It is necessary for the designer to know the stress distribution in order to prevent failure. In the present work the developed stress in the pulley is determined using FEA with the help of ANSYS. Stresses near the hub end of pulley were evaluated by varying the materials [1]. The finite element analysis was carried out using ANSYS. The results of the finite element analysis were verified experimentally. There are many causes of pulley failure. Among them the maximum bending stress induced near the hub end is one of the causes of pulley failure. Belt-drive mode is presented by simulating the dynamic response of the complex, serpentine belt-drive with tensioners, which are common in automotive engines [2]. A lot of work has been done on pulleys but still C.I. pulleys are still used for heavy load applications. The major object of this paper is to determine: (i) Von Mises Stress developed in the pulley model for the different materials, (ii) To compare the results obtained from ANSYS so as to select best replacement of presently used C.I. pulley for heavy load applications.

II. GEOMETRIC DIMENSION OF PULLEY

The same pulley model is used for all the materials that are used in this analysis. The dimensions of pulley were as follows:

Diameter of pulley	D = 55 mm
Hub Diameter	d = 17 mm
Thickness	T = 9.5 mm
Hub Projection	H = 6.4 mm
Bore Size	b = 5 mm

III. STRESS ANALYSIS OF PULLEY

Total number of element generated in pulley by ANSYS software is 29237 approximately and the element type considered is solid 45. Boundary conditions are applied on the inner side of pulley, i.e. it is fixed and load is applied on periphery of rim. Fig. 1-4 shows the procedure of stress analysis. Fig. 5-6 shows the Von Mises stress and strain developed for the polycarbonate molded. Fig. 7-8 shows the Von Mises stress and strain developed for the Gray Cast Iron. Fig. 9-10 shows the Von-Mises stress and strain developed for the Alumina. Fig. 11-12 shows the Von Mises stress and strain developed for the Al alloy,1460 pressed profile.

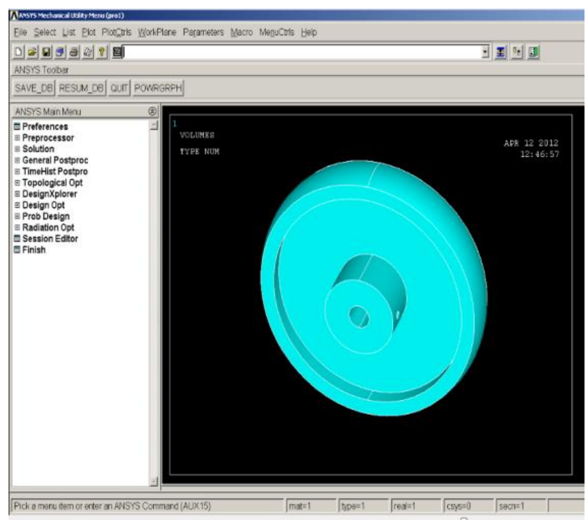


Fig. 1: Imported view of pulley in ANSYS

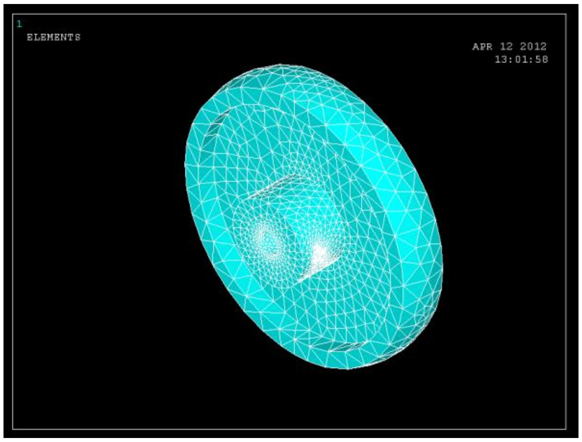


Fig. 2: Meshing

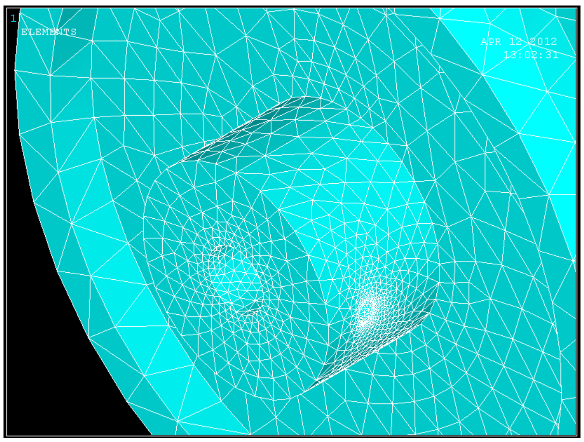


Fig. 3: Meshing closer view

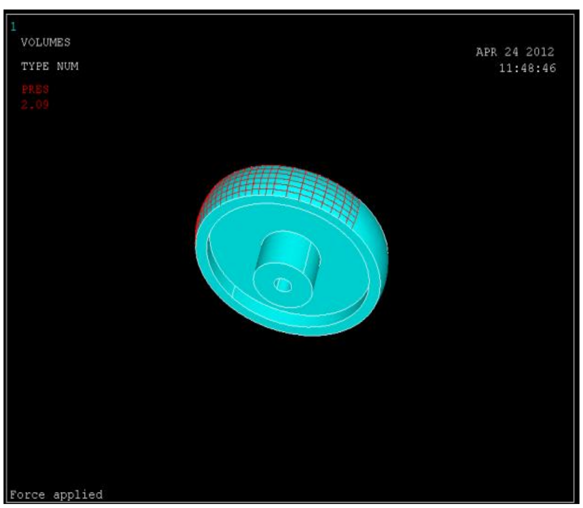


Fig. 4: Load case applied

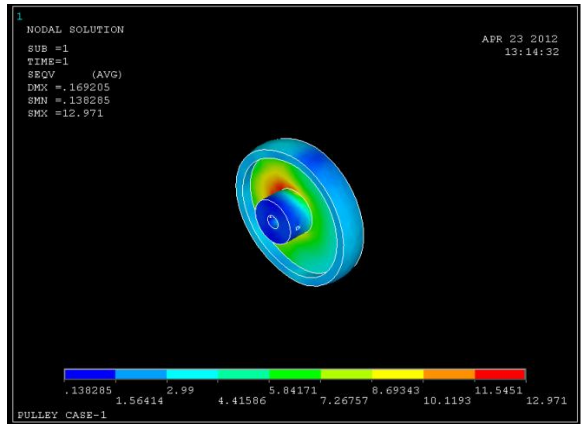


Fig. 5: Von Mises stress developed in Polycarbonate

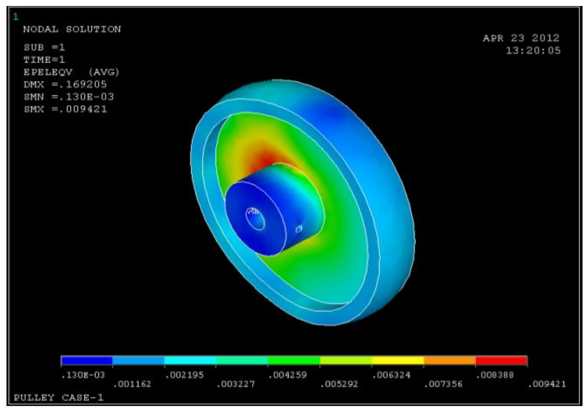


Fig. 6: Von Mises strain developed in Polycarbonate

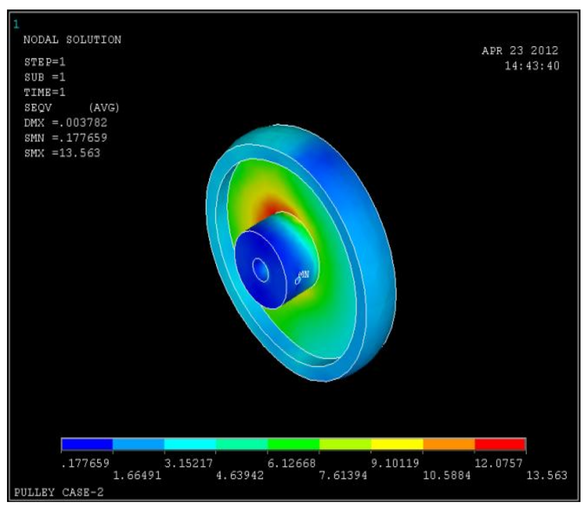


Fig. 7: Von Mises stress developed in Gray Cast Iron

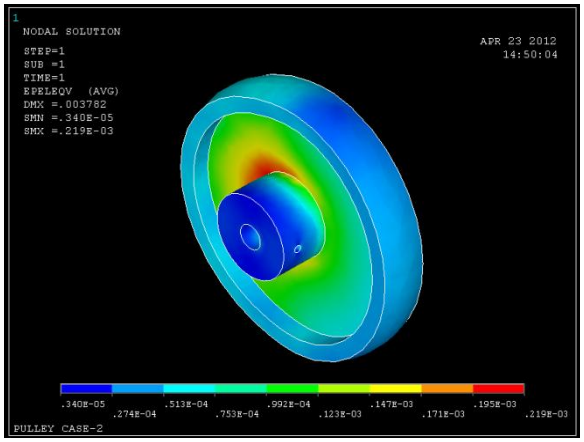


Fig. 8: Von Mises strain developed in Gray Cast Iron

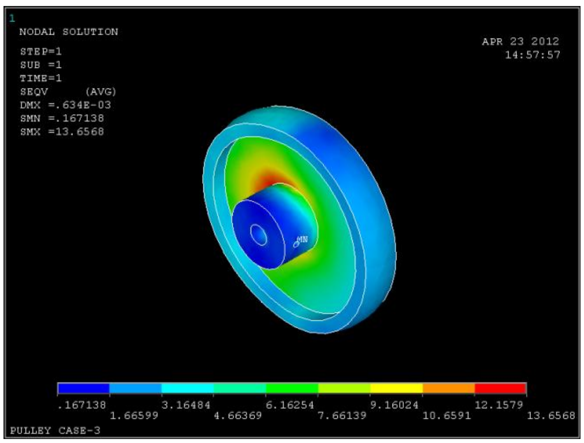


Fig. 9: Von Mises stress developed in Alumina

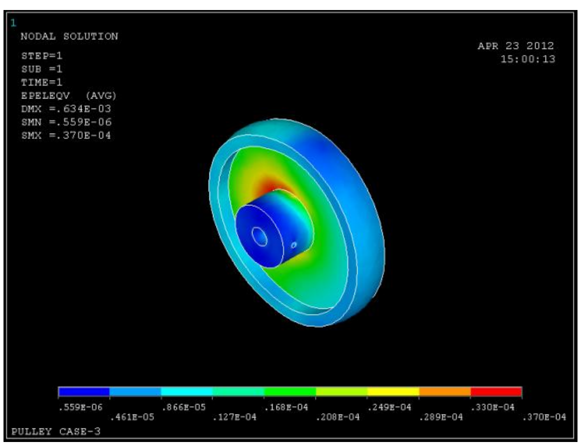


Fig. 10: Von Mises strain developed in Alumina

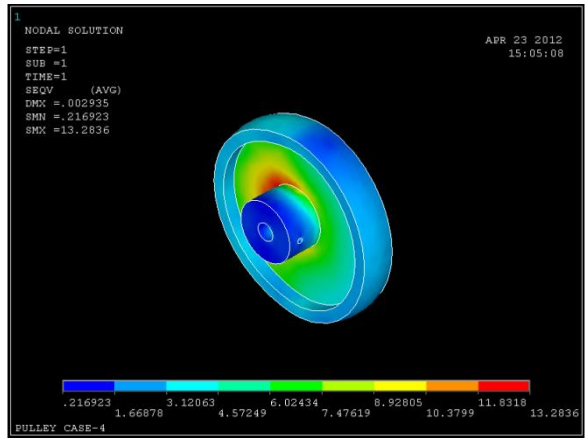


Fig. 11: Von Mises stress developed in Al alloy, 1460

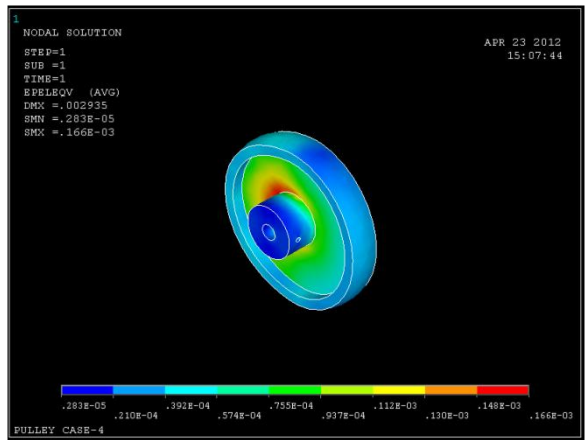


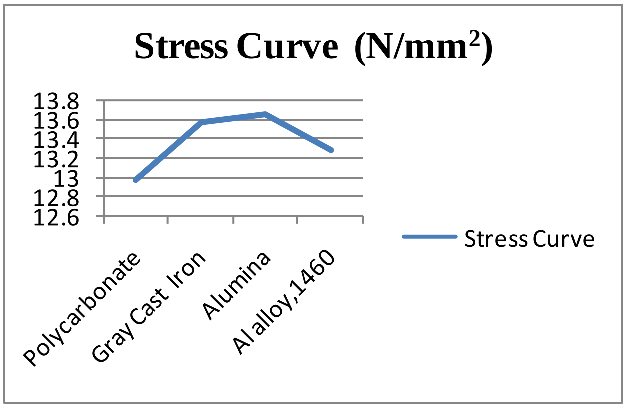
Fig. 12: Von Mises strain developed in Al alloy, 1460

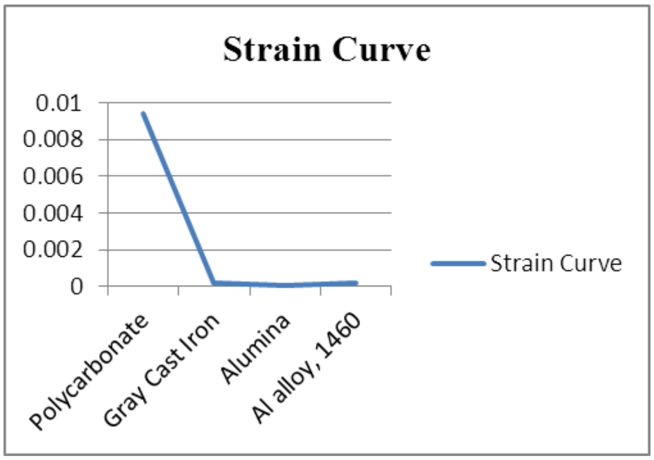
IV. RESULTS & DISCUSSIONS

Stress analysis of flat pulleys for various materials is depicted in Table 1. Stress and strain analysis is shown in Fig. 13 and Fig. 14 for various materials respectively.

Table 1 - Results of ANSYS for stress for various material of Pulley [N/mm^2]

Sr. No.	Material	Stress	Strain
1	Polycarbonate Molded	12.971	0.00942
2	Gray Cast Iron	13.563	0.000219
3	Alumina	13.656	0.000037
4	Al alloy,1460 pressed profile	13.283	0.000166





$$FOS = \frac{\text{Yield Stress of Pulley Material}}{\text{Developed Stress in Pulley Material}} \quad \ldots\ldots(1)$$

Factor of safety was calculated for all the four materials and Alumina was found to be suitable for heavy load applications (Table 2). Al alloy, 1460 is having highest factor of safety but due to its higher cost it may not be substitute of Gray Cast Iron.

Table 2 – Calculated factor of safety for various materials

Sr. No.	Material	Factor of Safety
1.	Polycarbonate Molded	1.99
2.	Gray Cast Iron	3.38
3.	Alumina	7.69
4.	Al alloy, 1460	25.9

Theoretical developed stress was determined from the load and net area in contact with the pulley. Table 3 shows comparison of results.

Table 3 - Comparison of FEA and Theoretical Stress Results [N/mm^2]

Material	FEA Stress	Theoretical Stress	Variation %
Alumina	13.65	11.39	16.55

V. CONCLUSIONS

After the investigations, the real reason of the failure was determined to be associated with the material. It is also observed that, the maximum stress present in pulley varies for various material conditions but a little. It is seen that maximum Von Mises stress for four different pulleys are almost same and the effective factor of safety will be criterion for selecting material of pulleys. Strain doesn't have so much impact on the pulley, therefore, without considering strain we can concentrate on the factor of safety. It can be concluded that the ANSYS results with the assumption of load seems to be acceptable for all the 4 cases. Alumina can replace C.I. for pulley material which is light in weight, corrosion resistant and suitable for heavy duty applications. Variation in the results of FEA developed stress and Theoretical developed stress is 16.55% (approximately), which is in reasonable units.

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