Structural Analysis of Reverse Engineered Rotary Vane Vacuum Pump

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Abstract – *Reverse engineering is techniques, which collects the features from existing component and design a new product with additional features or removing unwanted things. The mechanical industries have increasing demand for replacement of warn out parts. The customers are expecting new product development with better quality, aesthetic wise excellent, minimum time and replacement cost. To fulfill customer demands, new product development techniques are used to reduce thru put time. Reverse engineering required a synthesis of hardware, electrical and mechanical, metals and chemical, and design and integration of such a variety of subjects. Value engineering is a special subset of reverse engineering closer to design upgrade. Due to lack of design data of old components, it is essential to manufacture these components by reverse engineering. Also the use of the modern Design, analysis and manufacturing techniques like Creo 4.0, ANSYS enhances the new product.*

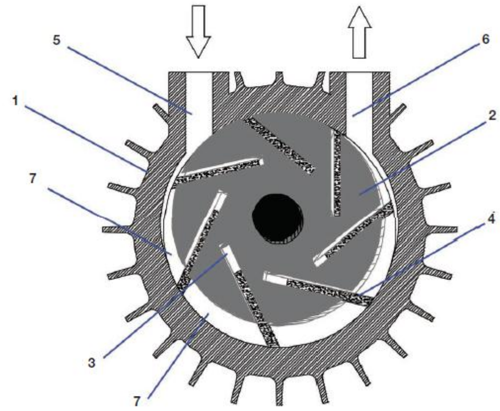
Vacuum pumps are used for a wide range of industrial applications. Vacuum pumps remove gas from a sealed volume to leave a partial vacuum. Fluids then rush into the vacuum due to the difference in pressure gradients. There are three kinds of vacuum pumps: positive displacement pumps, momentum transfer pumps and entrapment pumps. Most of the popular vacuum pumps are positive displacement pumps; Positive displacement pumps repeatedly expand a cavity, increasing its volume. Then part of the chamber is closed off and exhausted, pumping gas or fluids to their target areas. This is repeated over and over. Rotary vane pumps are the most common. The rotary vane vacuum pump is designed by using the reverse engineering technique using the faro arm and redesigned by using the Creo 4.0 modeling software. This model is further analyzed for the strength as well as for fatigue life using ANSYS.

Key Words: Creo 4.0, ANSYS,

1. INTRODUCTION

Vacuum pumps are used for a wide range of industrial applications. Vacuum pumps leave a partial vacuum by removing gas from a sealed volume to. Fluids rush into the vacuum due to the difference in pressure gradients afterwards. Vacuum Pumps are of three kinds: positive displacement pumps, momentum transfer pumps and entrapment pumps. Most of the popular vacuum pumps are positive displacement pumps; Positive displacement pumps repeatedly expand a cavity, increasing its volume. Then part of the chamber is closed off and exhausted, pumping gas to their target areas. This is repeated over and over. Rotary vane pumps are the most common. The rotary vane vacuum pump is designed by using the reverse engineering technique using the faro arm and redesigned by using the Creo 4.0 modeling software. This model is further analyzed for the strength as well as for fatigue life using ANSYS.

1.1 Working Principle



In case of Rorary vane vacuum pump, A rotor (2) is positioned eccentrically in the pump cylindrical housing (1). The freely moving vanes (4) are inserted into a numerous rotor slots (3). When the rotor turns the centrifugal force throws the vanes against the cylindrical wall creating a chamber between the rotor and the cylinder. Due to the rotor positioned eccentrically as the rotor continues to turn the chamber volume between the blades keeps changing . From the inlet (5) then to outlet (6) the chamber volume (7) becomes bigger and then smaller. When the volume gets bigger a vacuum is generated as a result from the rotation of the vanes making air entering the chamber from the inlet (5). When the chamber gets smaller a pressure is produced at the outlet (6).

2. REVERSE ENGINEERING: EXPERIMENTATION

Since the design specification data was not available Due to unavailability of technical parameters, it is decided to get technical parameters of similar Pump through reverse engineering techniques.
Following are the Design specifications of the product

- Component: Rotary Vane vacuum Pump, Belt driven
- Rotor- Eccentric with movable blades
- Pump orientation- Top- Top and foot mounted.
- No of Blade Vanes: 8 numbers

The available product was disassembled and following points were observed

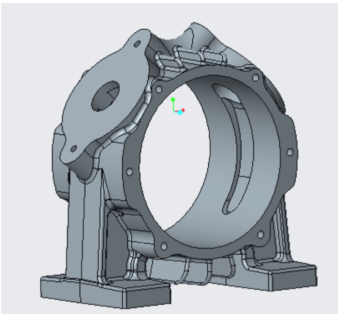
- The surface finish for various contact surfaces
- The cast and fabricated components were identified.
- The MOC of the components were examined.
- MOC and the manufacturing techniques for the prototype were finalized.

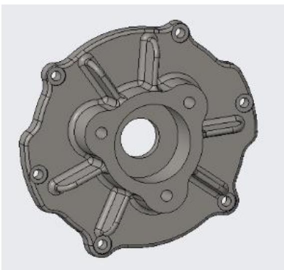
2.1 Use of 3D scanning for the data acquisition.

3D scanning is a non-contact type scanning technique it generates the three dimensional data for all visible surfaces which are under scanning. Some of the components being closed type, some the hidden surfaces are not captured in the 3D scanning images. Since we have committed to customer not to physically damage the existing pump, to prepare the data of the hidden surfaces we need to use interpolation with respect to the data obtained in the conventional method.

2.2 Creation of the 3D models.

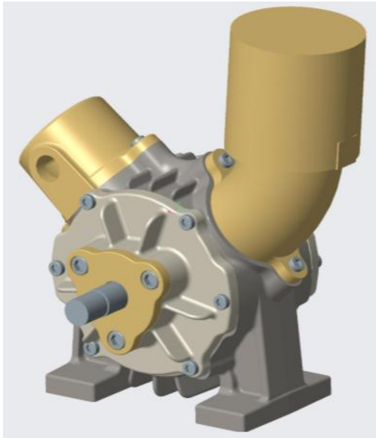
With the help of the data obtained in the 3D scanning and the data from obtained from the conventional techniques for the measurement, the 3D model for the various pump components are prepared. These 3D models are considering the finish machined condition of the components. We have used Creo 4.0 software for the 3D modeling activity. These 3D models are used for all further design and manufacturing activities such as pattern 3D model preparation, 3D proposal assembly preparation and, Manufacturing drawing preparation.





2.3 Proposal Assembly Preparation.

The Proposal assembly for the Rotary vane type vacuum Pump is prepared based on the data obtained in the conventional inspection technique and the finfish 3D models



3. STRUCTURAL ANALYSIS

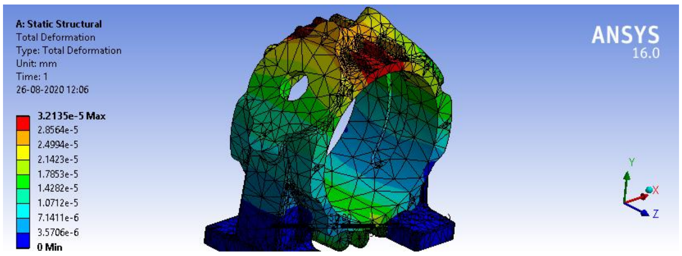
The forces coming on the main body were estimated and the main body is analysed for the total deformation, stress, fatigue life and factor of safety based on fatigue strength.

The MOC of the Blade – Bakelite
Density- 1.3 gm/cm3
Mass of blade=0.01283 kg
Radius of rotation = 0.58 m
RPM=1300
Angular velocity=136.06 rad/sec
Tangential force =13.77 N

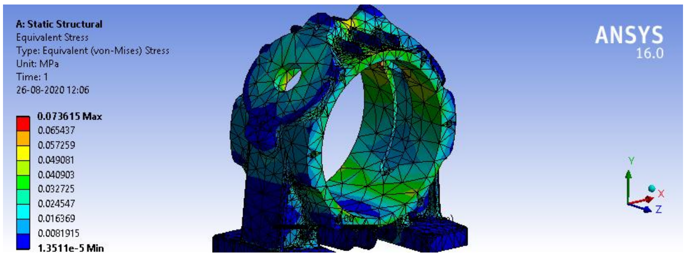
MOC of the Body= FG 260
Tensile strength= 218 MPa
Yield Strength= 661 MPa
Fatigue Strength= 87.2 MPa

Geometric Modelling of Main body which is created using 3D modelling software PTC Creo 4.0 is imported in ANSYS software. Structural and Fatigue analysis is performed to determine stresses and deformations induced in the casing. The details of FE analysis are as below.

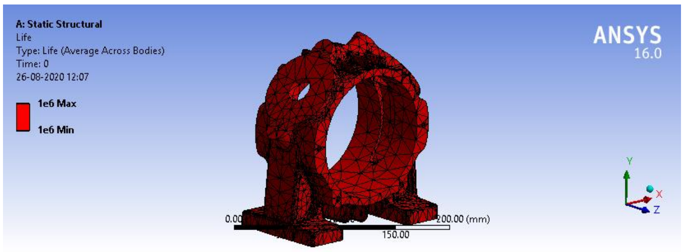
A. Total deformation



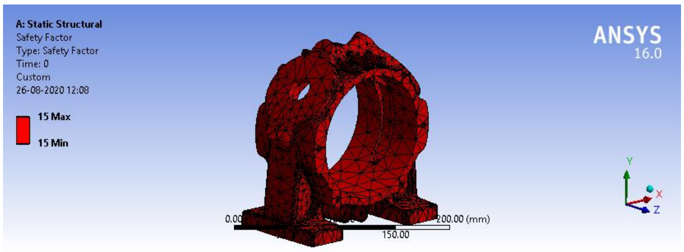
B. Stress



C. Fatigue life



D. Factor of safety



4. RESULT AND CONCLUSION.

The results of the analysis is as beow.

1. The maximum stress the body is going to subject is 0.073 MPa which is less than the tensile and yield strength of the FG 260. Hence design is safe.
2. The total deformation is 32 micron which is also acceptable.
3. The maximum stress the body is going to subject is 0.073
4. MPa which is less than the fatigue strength of the FG 260. The factor of safety based on the fatigue strength is >15. And the component can withstand infinite no of stress cycles. Hence the design is safe.

REFERENCES

[1] FJ Eckle, P Bickert, R Lachenmann "Rotary vane and roots pumps backed by diaphragm pumps-progress in corrosive applications and clean vacuum requirements'' Elsevier Volume 46, Issues 8–10, August–October 1995, Pages 793-796

[2] NS Harris, L Budgen ''Design and manufacture of modern mechanical vacuum pumps ELSEVIER Volume 26, Issue 12, 1976, Pages 525-529

[3] B.S. Ramprasad T.S.Radha ''On some design aspects of rotary vane pumps'' ELSEVIER Volume 23, Issue 7, July 1973, Pages 245-249

[4] J.K.N. Sharma, P.K. Dutta ''Aspects of noise in rotary vacuum pumps'' ELSEVIER Volume 13, Issue 6, November–December 1980, Pages 425-432

[5] Hans-Peter Berges, Dieter Götz Oil-free vacuum pumps of compact design ELSEVIER Volume 38, Issues 8–10, 1988, Pages 761-763

[6] M. Galetto and E. Vezzetti, "Reverse engineering of free-form surface: methodology for threshold definition in selective sampling." International Journal of machine Tool and Manufacturing, Volume 46, Issue 10, Aug.2006, Pages 1079-1086.

[7] XieZexiao, Wang Jianguo and Zhang Qiumei," Complete 3D measurement in reverse engineering using a multi-probe system." International Journal of Machine Tools and manufacture, Volume 45, Issue 12-13, October 2005, Pages 1474-1486.

[8] Joris S.M, "Reverse engineering for shape synthesis in industrial engineering." Delft University of Technology, Netherlands, Sept2000.

[9] Mark Snider, Sudhakar Teegavarapu, D. scottHesser and Joshua Summers, " Augmenting Tools for reverse engineering Methods." , ASME DEC-2006.

[10] Design of Machine Elements by V B Bhandari, Tata McGraw-Hill Publishing company Limited.

[11] M.Sokovic and J.Kopac, "Reverse Engineering as necessary phase with rapid product development" , Journal of Material Processing Technology, Volume 175, Issue 1-3, June2006.

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