Design and Analysis of Gerotors of Main Gear Box Lubricating Oil Pump

Prakash H R, Manjula S

Abstract **- This paper presents a Design and Analysis of Gerotors of Main Gear Box Lubricating Oil Pump. The main objective of this study were to capture the Analysis of Gerotors of main gear box lubricating oil pump used in advanced light helicopters due to increasing the flow rate, stress rate attains should be within the limit and reduce the locking between the mating conjugates of rotors. The design of ge- rotors and analysis to basic minimum requirement have been carried out in this project work leaving scope for optimization of the rotor profile for higher performance with CFD tools for the flow pattern analysis. As a positive displacement pump with variable and stabilized flow, the acceptance of Ge-rotor pumps in industrial applications has to be evolved, in spite of its higher cost comparing to other type of pump.**

Index Terms **- Positive displacement pumps, Gerotor pumps, Trochoidal gearing, finite element method. stress, deformation.**

I. INTRODUCTION

Ge-rotor is the mechanism with internal trochoidal gearing that was realized by Myron F. Hill at 1906. The name Ge-Rotor is derived from the phrase Generated Rotor and described mathematical procedure for generating peritrochoid profile of inner gear by circular arc of the external profile. Ge-rotor can be used in cases where gear pumps with external gearing are present and, also, it can be used where gear Pumps with internal or fixed displacement vane pump are present: for cooling and Lubricating systems, so as for transfer of liquids. Ge-rotor pumps belong to the group of rotational pumps and they have great advantages in relation to other types of rotational pumps. Some of the advantages are simple constructions and variety of applications. Due to specific geometry of gears profiles, continual contacts of all teeth are provided in exploitation that obtains the necessary separation between the low and high pressure zones. During the operation, teeth of the pump rotor act as pistons while chambers (the space between profiles of inner and gears) correspond to cylinders. The lobes of the male and female rotors are designed as a conjugate pair with law of gearing is made applicable. While going through the analogy of lobbed mechanisms like Geneva wheel and Wankel engines to the Ge rotor pumps as the state of the art technology, the major challenges are related to the fault free design and fabrication of the rotor profile.

Litvin ad Feng, et al. [1] have used differential geometry to generate the conjugate surfaces of epitrochoidal gearing. The methodology for developing the mathematical expressions for determination of gerotor pump theoretical flow is presented in this paper Gavin P.Whitham, et al. [2] have devoloped a pump has an inner rotor bounded by an outer peripheral shape which is generated by moving a first circle around a first trochoicL The inner rotor is mounted for rotation about a first axis. Demenego, et al. [3] have developed a tooth contact analysis (TCA) computer program and discussed avoidance of tooth interference and rapid wearing through modification of the rotor profile geometry of a cycloidal pump whose one pair of teeth is in mesh at every instant.

II. DESIGN OPTIMIZATION

When both rotors rotate, the teeth lock together and unlock because of the off-center position, creating intermittent open pockets between the rotors during operation. As the rotors rotate about their respective axes, fluid enters the enlarging chamber to a maximum volume. As rotation continues, chamber volume decreases, forcing fluid out of the chamber. The liquid propels the rotors and spins the gears, creating suction and discharge ports whenever the teeth are meshed together. The process occurs constantly for each chamber, providing a smooth pumping action.

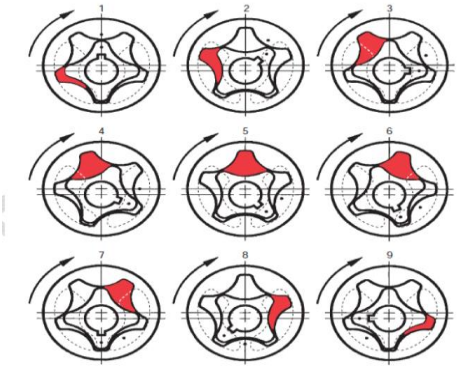

Fig. 1 Movement of fluid suction to delivery

A. Development Of Inner Rotor Profile

The trochoidal profile generated by MATLAB software has been imported to UNIGRAPHICS software for editing and 3D modeling. The profile has been edited by introducing

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new arcs connecting between the lobes. The 3D model and the corresponding 2D drawings are given below.

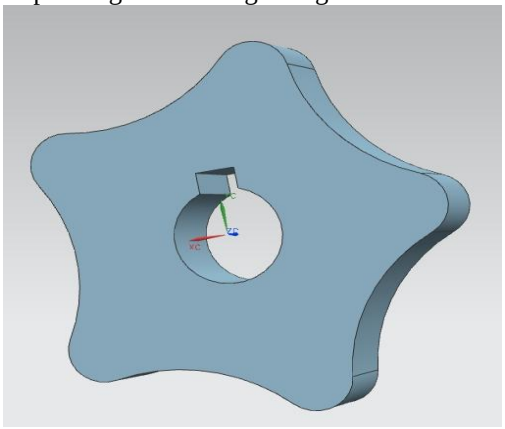

Fig. 2 3D Modal for Inner Rotor

B. Design of Outer Rotor

Outer rotor is modeled in UNIGRAPHICS as a conjugate pair for the inner rotor. The dimensions of outer rotor are chosen accordingly to fit and rotate the inner rotor. The dimensions are finalized by trial and error by analyzing the assembly clearances each time in UNIGRAPHICS. The 3D model developed and the drafted 2D drawings are given below.

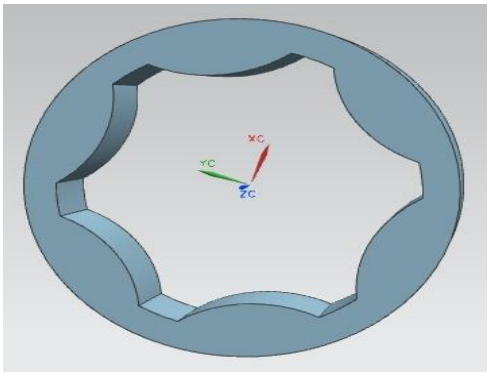

Fig. 3 3D Model for Outer Rotor

C. Assembly of Ge-Rotors

The rotors are assembled with an eccentricity of 3.6 mm in order to get the variation in entrapped volume between the male and female lobes of the rotors. The assembly model of the rotors is shown in the figure below.

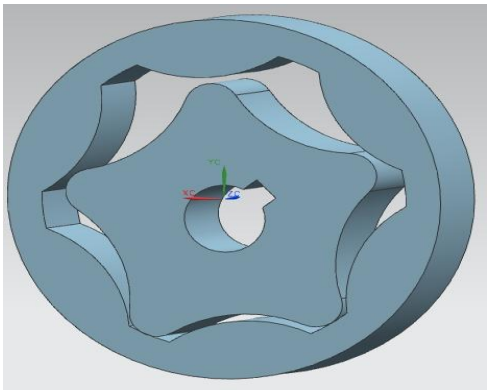

Fig. 4 3D Assembly Model of Rotors

III. Flow Rate Calculation For The Ge-Rotor Pump

Instantaneous flow rate of the pump can be calculated from the volume variation of working chambers in unit time. Since the inner as well as outer rotors are rotating at differential speed, the change in volume of each chamber becomes a function of both rotation angle as well as time. A mathematical modeling and analysis of flow rate using dedicated computer program involves tremendous amount of work. A more practical way of determining the flow rate, though this may not be an accurate method, by assuming that each working chamber is delivering the fluid volume equal to the volume of the chamber just before the outlet port is adopted for calculation purpose. The calculated flow rate needs to be experimentally verified after fabrication of the rotors. The rpm of the inner rotor is taken as 5037 for the calculation.

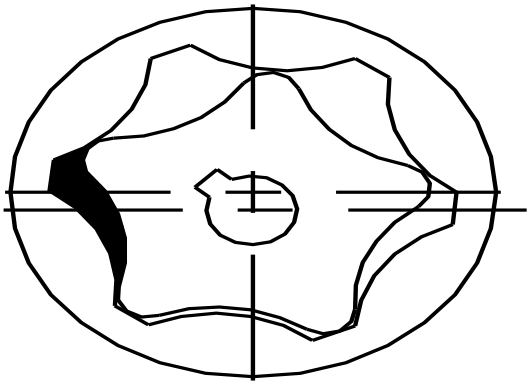

Fig. 5 Displaced volume between lobes

Area of the shaded chamber (A) = 118 mm^2
Volume of the chamber (A* width) = 118*15 = 1770 mm^3
Volume displaced by all the chambers in one complete rotation = 5*1770 = 8850 mm^3
Total Volume displaced in one minute for rpm of 5037 for the inner rotor (Q) = 8850*5037
Q = 44,577,450 mm^3 =45 liters/min

IV. Results And Discussion

The FE model for Ge-rotor assembly has been solved using NX-NASTRAN solver. The stress level and reaction forces were analyzed and found within acceptable level.

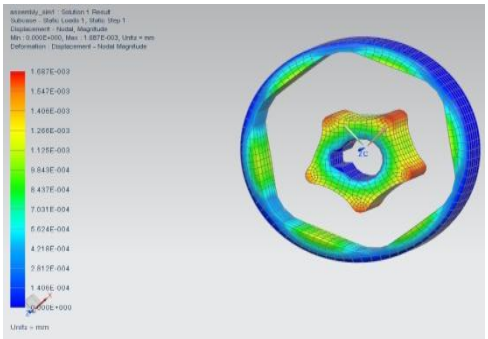

Fig. 6 FE Simulation Results on Deformation

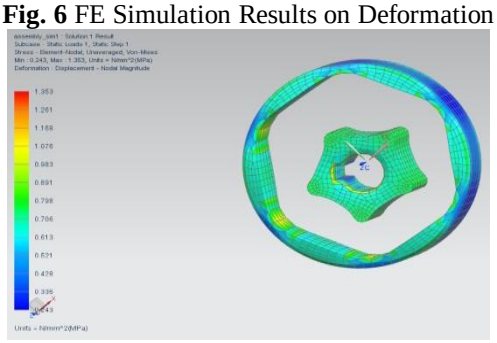

Fig. 7 FE Simulation Results on Von Mises Stress

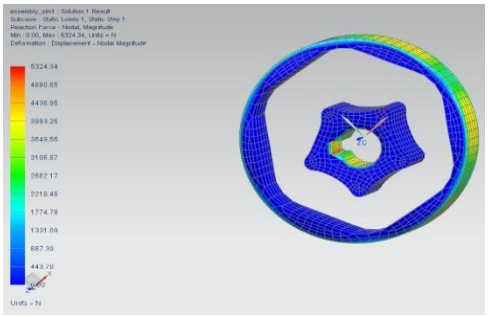

Fig. 8 FE Simulation Results on Reaction Forces

Table 1 Tabulated displacement and stress values

	Displacement (mm)				Stress (mN/mm^2(kPa))			
	X	Y	Z	Magnitude	Von-Mises	Min Principal	Max Principal	Max Shear
Static Step 1								
Max	1.38E-03	1.46E-03	4.04E-04	1.69E-03	1.01E+03	-4.11E+02	4.28E+02	5.75E+02
Min	-1.61E-03	-1.60E-03	-4.04E-04	0.00E+00	2.42E+02	-1.30E+03	-4.04E+02	1.21E+02

V. CONCLUSION

The design of Ge- rotors and Analysis to basic minimum requirement have been carried out in this project. The main objective of this study were to capture the Analysis of Gerotors of main gear box lubricating oil pump used in advanced light helicopters due to increasing the flow rate, stress rate attains should be within the limit and reduce the locking between the mating conjugates of rotors. As a positive displacement pump with variable and stabilized flow, the acceptance of Ge-rotor pumps in industrial applications has to be evolved, in spite of its higher cost comparing to other type of pumps. The conclusion is implicated that in order to reduce the pulsations of flow it is recommended to use the odd number of chambers at the pumps.

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