Design of Main Rotors of the Gerotor Lube Oil Pump

Miss. Ashwini Gourayya Paskanti[1] Prof. P. V. Salunke[2]
[2]Associate Professor
[1,2]Department of Mechanical Engineering
[1,2]Walchand Institute of Technology, Ashok Chowk, Solapur-413006, Maharashtra, India

Abstract— This paper deals with design of Gerotor lube oil pump. The different parameters of pump rotors are inner rotor and outer rotor diameters, tooth thickness and number of lobes but one of the most critical parameter is number of lobes in the rotors. In the present work, the conventional design of pump is carried out using mathematical equations and then the model of inner and outer rotor was generated using AutoCAD2014 software. The project work consists of to design the main rotors of the gerotor pump.

Key words: Rotor Profile Design, AutoCAD2014

I. Introduction

An oil pump is an essential part in the operation of an automotive engine. It converts the mechanical energy to be supplied by the engine into pressure or velocity energy that can be used to feed lubricant oil into the wet parts to prevent lobe wear or the adherence of them. Lubrication pumps feed lubricant from the lubricant reservoir into the tubing system of the centralized lubrication system. The manometric pressure has to be high enough to compensate for pressure drops in the tubing, components (filters, valves, distributors) and friction points.

A gerotor is a positive displacement pump. The name gerotor is derived from "Generated Rotor". A gerotor unit consists of an inner and outer rotor. The inner rotor has N teeth, and the outer rotor has N+1 teeth. The inner rotor is located off-center and both rotors rotate. The geometry of the two rotors partitions the volume between them into N different

Dynamically-changing volumes. During the assembly's rotation cycle, each of these volumes changes continuously, so any given volume first increases, and then decreases. An increase creates a vacuum. This vacuum creates suction, and hence, this part of the cycle is where the intake is located.

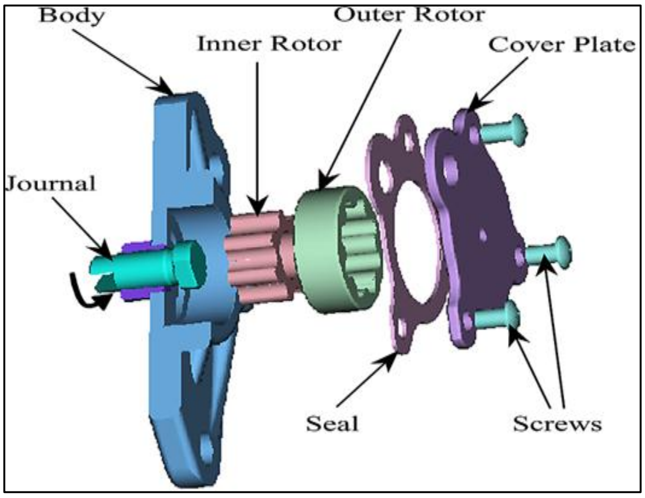

Fig. 1: Exploded View of Gerotor Pump

A gerotor pump is suitable for oil hydraulics of machine tools, automotive engines, compressors, construction, and other various applications. In particular, the pump is an essential machine element that feeds lubricant oil in an automotive engine. The main components of the pump are the two rotors. Fig. 1 indicates the exploded view of pump showing the position of rotors and cover plate and fig 2.shows the movement of fluid from suction to delivery side.

Nowadays, for flow analysis Computational Fluid Dynamics tool is being widely used. Computational Fluid Dynamics (CFD) is branch of fluid dynamics, which uses numerical methods and algorithms to solve and analyze problems that involve fluid flows and used to simulate various design alternatives, identify flow problems, develop solutions and evaluate operating strategies.

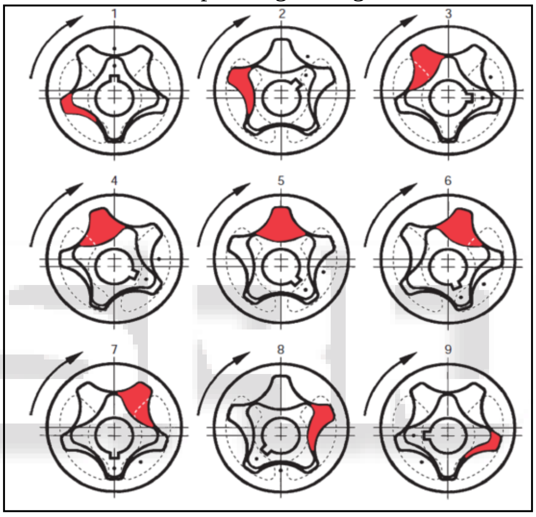

Fig. 2: Movement of Fluid Suction to Delivery

II. Objectives

To perform design, modeling, testing and analysis of the inner and outer rotor by using software with modification and optimization of number of lobes of the rotors in the gerotor pump to investigate the changes in discharge, pressure as well as efficiencies.

III. Literature review

A detailed review of the literature on the improvement in design of rotors is presented as follows. Most of the researchers have kept changes in the tooth thickness as well as clearance sizes for design and analysis purpose.

Hao Liu, Alex Yoon et al.[1] [2014]. Explained the design & performance analysis of gerotor pump. The design of gerotor pump (inner and outer rotor profile design) is done by taking input parameters like inner rotor and outer rotor diameters, tooth thickness, number of lobes and speed. After completion of design, the performance analysis is carried out. Performance analysis of gerotor pump is area variation, instantaneous flow rate and pulsation coefficient. For determining characteristic curves of gerotor pump values of area, flow rate etc. are calculated by varying number of lobes.

Prakash H R, Manjula S et al.[2] [2014]. This paper presents a Design and Analysis of Gerotors of Main Gear Box Lubricating Oil Pump. 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.

Lozica Ivanovic et al.[3] [2013]. Explained the design and analysis of gerotor pump by using geometrical and kinematical model. In this paper give the detailed geometrical and kinematical relations for defining gearing profile of the gerotor pump. The important parameters like pressure, flow rate and volumetric efficiency are calculated by using geometrical and kinematical relation and the modeling is done by using AutoCAD 2014 Software. Also explain the analysis of chamber volume variation and pressure variation of the gerotor pump. These calculations varying with simulations as given in this paper for performances. Geometrical and kinematical relation is used for determining values of different parameters. CFD methodology is used for analysis purpose.

Chiu-Fan Hsieh et al.[4] [2012] had undergone design and fluid analysis of mathematical model of rotor tooth profile of the gerotor pump. In this paper the design is carried out by inner and outer rotor, after completion of the performance compared with simulation results. The simulation tool used is CFD package (PumpLinx). For boundary conditions, turbulence model is selected In that paper, however, the estimated sealing was merely a theoretical calculation that was not demonstrated by computational fluid dynamics (CFD) simulation or other methods conventional design method.

IV. PROFILE DESIGN INNER & OUTER ROTORS

The basic geometrical and kinematic relations for generating the equidistance of the epitrochoide and its conjugate envelope used for defining gearing profile of the examined gerotor pump are shown in Figure 1.

In the Figure 1 the geometrical relations to the determination of the area Ai(y) for the kinematic model of a pump with the fixed axis are given. The requested area Ai can be calculated according to the following equation:

Ai = Sa - St + S1 - S2…………….. (1)

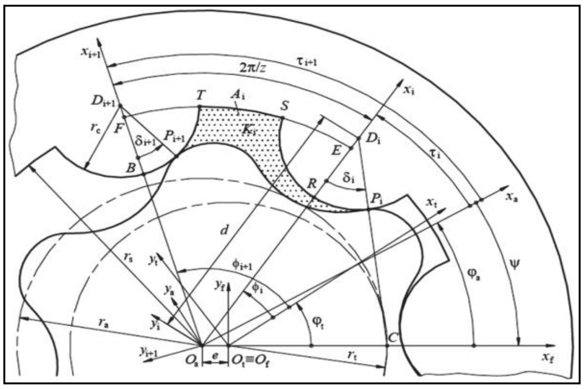

Fig. 3: Schematic of Gear Pair with Basic Geometrical Dimensions

where are: Sa is the segment of area limited with the envelope profile, St is the segment of area limited with the profile of trochoid, S1 is the area of triangle and it is equal to

$$S_1 = \frac{1}{2} e^2 \left[\lambda z \sin(\tau_i - \psi) - c \sin(\tau_i - \psi + \delta_i) \right] \quad \text{………. (2)}$$

$$S_2 = \frac{1}{2} e^2 \left[\lambda z \sin(\tau_{i+1} - \psi) - c \sin(\tau_{i+1} - \psi + \delta_{i+1}) \right] \quad \text{……. (3)}$$

$$S_a = S_3 + S_4 - S_5 - S_6 + S_7 - 2S_8 + 2S_9 - 2S_{10}, \quad \text{……… (4)}$$

$$S_t = e^2 \pi \left(1 + \lambda^2 z + \frac{c^2}{z} \right) + \frac{1}{2} e^2 \left[c^2 \delta - \sin\delta + \frac{\lambda z (z+1)}{(z-1)} \sin(z-1)\varphi \right] \Bigg|_{\varphi_i}^{\varphi_{i+1}} - \frac{1}{2} e^2 c \int_{\varphi_i}^{\varphi_{i+1}} f_1(\varphi) d\varphi \quad \text{……… (5)}$$

Equation (2),(3),(4) and (5) are put in the above equation (1) and certain transformations have been made, formula for calculation the current area is obtained:

$$A_i = e^2 \left\langle \frac{\pi}{z} \left(s^2 - z - \lambda^2 z^2 - c^2 \right) - c^2 \arccos \frac{c^2 + \lambda^2 z^2 - s^2}{2c\lambda z} + c\lambda z \left\{ 1 - \left[\frac{c^2 + \lambda^2 z^2 - s^2}{2c\lambda z} \right]^2 \right\}^{\frac{1}{2}} \right\rangle - r_s^2 \arccos \frac{s^2 + \lambda^2 z^2 - c^2}{2\lambda z s} - \frac{\lambda z^2 e^2}{z-1} \sin(z-1)\varphi \Bigg|_{\varphi_i}^{\varphi_{i+1}} + c e^2 z \int_{\varphi_i}^{\varphi_{i+1}} \left[1 + \lambda^2 + 2\lambda \cos(z-1)\varphi \right]^{\frac{1}{2}} d\varphi,$$

When the differential is done and expressed in the Function of the referent angle y, calculation of Chamber' area variation is obtained:

$$\frac{dA_i}{dt} = \omega_t e^2 z \left\{ 2\lambda \sin\frac{\pi}{z} \sin\left(\frac{2\pi i}{z} - \psi \right) - \frac{c}{z} \left[1 + \lambda^2 - 2\lambda \cos(\tau - \psi) \right]^{\frac{1}{2}} \Bigg|_{\tau_i}^{\tau_{i+1}} \right\}$$

The theoretical displacement of oil pump can be obtained by,

$V = b * Z_1 * (A_{max.} - A_{min.})$

As well as that of the flow rate is,

$Q = V * N$,

Where N = speed in rpm

But here is give the performance using above geometrical and kinematical relations and compare with the graphical values of 6-7 lobes of the gerotor pump.

V. CALCULATIONS

For design calculations, the design parameters of Laxmi T4 type Pump are taken as follows:

Speed, N= 1750rpm

No. of inner rotor teeth, Z_1= 6

No. of outer rotor teeth, Z_2= 7

Tooth thickness= 30mm

We get the values of area variation and flow rate are in table as below:

	Area Variation (mm^2)	
	6-7 Lobes	
Chamber	Theoretical	Graphical
1	93.31	86.86
2	165.44	157.78
3	162.35	156.12
4	91.44	86.83
5	24.99	14.02
6	0.86	0.42
7	3.08	10.08

Table 1: Area Variation Values for 6-7 Lobes

Flow Rate (LPM)	
Lobe 6-7	
Theoretical	Graphical
51.84	49.56
4.60%	

Table 2: Flow Rate Values for 6-7 Lobes

VI. MODELLING OF THE INNER & OUTER ROTOR

Fig. 3 shows the 2Dmodel of inner and outer rotor is created using AutoCAD software for 6-7 lobes.

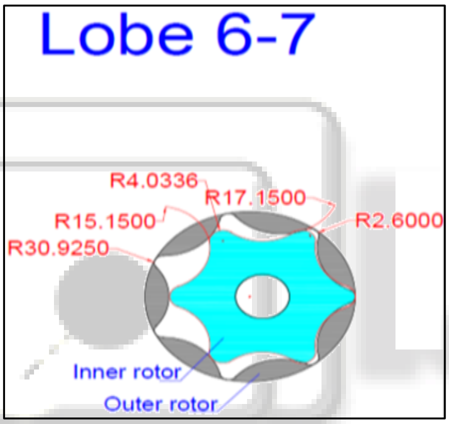

Fig. 4: Graphical 2Dmodel of Inner & Outer Rotor

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