A Study Work on Lobe Pump

Mihir Patel[1] Krutarth Patel[2] Nikhil Soni[3] Sujal Patel[4] Jayesh Patel[5]
[1,2,3,4]BE Student [5]Associate Professor
[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]Sardar Patel Collage of Engineering, Bakrol, India

Abstract— Lobe pump rotor profiles radius of base circle, addendum circle and root circle are closely connected with pressure angle. The change of pressure angle has some effect on lobe pump performance. This paper focuses on two-dimensional profile lobe pump and introduces involute rotor profiles and pressure angle parameter equation. We used geometry and two rotor mesh characteristics to establish lobe pump models of different pressure angles. Monitored the lobe pump's pressure and velocity of input and output cross section. We used the K-Epsilon turbulence model and the dynamic meshes to compute the two-dimensional turbulence flow field of the lobe pump and obtained the pressure and velocity pulsation picture of different models and speeds. The results show with increasing pressure angle, the velocity of output decreases. The fluctuation of velocity is kept almost constant. When the pressure angle is 45°, the lobe pump has good comprehensive properties. The increasing of rotor speed makes the output flow and the oil absorption pressure increase. But the pressure fluctuation is acute. The lobe pump has vortex and leakage phenomenon in work progress. It will cause energy losses and decrease efficiency.

Key words: Lobe Pump Ge-Rotor, Lobe Pump Rotor

I. Introduction

The mechanism of Ge-rotor first of all realized by Myron F. Hill in 1906, which describes internal trochoidal gearing. The name Ge-Rotor is derived from the phase Generated Rotor as profile of inner gear is generated from the external profile. Ge-rotor is used 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 for transfer of liquids. Ge-rotor pumps belong to the group of rotational pumps and they have great advantages comparing other types of rotational pumps. Some of the advantages are simple constructions and variety of applications. Due to specific geometry of gear profiles, continuous 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. In design of Ge rotor pumps, the major challenges are related to the fault free design and fabrication of the rotor profile.

Fig. 1: Mechanism of Model

Giovanni Bonandrini, has used differential geometry to generate the conjugate surfaces of epitrochoid gearing. Giovanni Mimmi, et al. [2] has used an original profile for internal rotary pumps, which has many advantages in comparison of common epitrochoid design. Yii- Wen Hwang, et al [3] has generated profile of lobe rotor and the mathematical model of the internal Cycloidal gear with tooth difference is generated by theory of gearing. Scope of this paper is to develop a profile for inner rotor and outer rotor from parametric equations of epitrochoid curve in MATLAB software for the company „Pump square Systems LLP". From generated profile drawings and solid models are to be developed. The objective is also to manufacture developed model using CAM technology. The paper also involves testing of manufactured model for comparing it with existing model. There are two types of lobe pumps. One is external lobe pump and second one is internal lobe pump.

II. Literature Review

[1] Giovanni Bonandrini have explained complete description of a specific geometry applicable for internal rotary pump. They used an original profile for internal rotary pumps, which has many advantages in comparison of common epitrochoidal design. This particular design characterized by superior flow-rate performance and a different contact mechanism in respect with the common trochoidal pumps. The geometric definition of the profile is completely explained parametrically through suitable design parameters by means of the theory of gearing.

They have also considered kinematics and operation of the machine by means of a mathematical formulation. The kinematic analysis considers the possible presence of transmission errors and assures the absence of interference by a tooth contact analysis (TCA). They have developed mathematical model which allows the designer to obtain the complete definition of the rotor profiles in parametric form.

[2] H. Moosavi, et al has developed the optimization problem cost functions and constraints according to volumetric, dynamic and geometric properties. In order to have general optimum solution and reduce number of design variables, all variables are changed to non-dimensional variables by using the outer rotor lobe center radius which causes the non-dimensional cost functions too. The multi-objective optimization problem has been changed to single objective optimization problem by using a multi-objective optimization classical method The single objective optimization problem has been solved by using of a mixed integer nonlinear optimization algorithm.

[3] Lozica Ivanovic, et al has considered the kinematic parameters of the trochoidal gearing in gerotor pumps. The equations for the rolling and sliding velocity at the contact point of the meshing gear profiles were first

determined and then the equations which define specific sliding of the trochoidal profile were derived. The conditions for the phenomenon of the singular points of the specific sliding distribution were analysed Based on the graphic interpretation of kinematic parameters of trochoidal gear pair profiles in contact, conclusions are drawn about the influence of geometrical parameters on the sliding size, and accordingly on the wear intensity of the tooth profiles too.

[4] Alberto Demenego a, et al 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. The developed program enables users to determine how the transfer of meshing during one revolution, the transmission errors of aligned and misaligned pump gears, and the backlash between the rotor profiles that neighbor the contacting profiles were performed. They have also developed computer program for Tooth Contact Analysis (TCA).

[5] Sung-Yuen Jung1, et al have presented an internal lobe pump (ILP) is suitable for machine tool oil hydraulics, automotive engines, compressors, and various other devices. The main components of an ILP are its rotors. The outer rotor is typically characterized by lobes with an elliptical shape, and the inner rotor profile is a conjugate to the outer profile. The paper describes a theoretical analysis of an ILP and the development of an integrated automated system for rotor design. This system is composed of three main modules and has been developed using AutoLISP for the AutoCAD program. The system generates a new lobe profile and automatically calculates flow rate and flow rate irregularity according to the lobe profile generated. Design of Lobe Profile for Positive Displacement Internal Rotary Lobe Pump.

[6] Shih-Hsi Tong, et al have presented gerotor profiles for pumps. Due to the general method for non-circular internal pitch design, gerotors are all generated from circular pitches. Also developed, complete theory and algorithm for the design of non-circular pitch based gerotors and their conjugate rotors. This method is deviation-function based and is a general one. It can be used to design conventional gerotors when circular pitches are adopted.

[7] Moon-Saeng Kim, et al have done theoretical analysis of an internal lobe pump whose main components are inner and outer rotors; the outer rotor is characterized by a lobe with multiple profile shapes (ellipse 1, involute, and ellipse 2), while the profile of the inner rotor is determined as a function of the profile of the outer rotor. The system suggested by them generates a new lobe profile and automatically calculates the flow rate. Taguchi method is used to determine the optimal rotor shapes and design parameters of the pump performance. This method is implemented for obtaining the optimal design of the rotor with the maximum flow rate and minimum flow-rate irregularity.

[8] Lozica Ivanoviü, et al have given the method to determination of the gear geometrical dimensions at the gerotor pump on the base of the specific sliding equality in the point with the greatest sliding velocity. The gerotor pumps have mechanical losses as a consequence of the wearing between the surfaces of the meshing tooth profiles. To reduce these unwanted effects and taking out the gear active tooth surfaces wearing is necessary to realize minimum of the film oil between contact surfaces. Minimum oil film thickness is in function from the numerous different factors. The mathematical model is developed in form of the parametric equations. They have defined the conditions for the equality of the specific sliding in the critical contact points. To observed geometrical-kinematical model of the gerotor pump the computer program is developed and on the base of the obtained results the values of the parameters are chosen to realize concrete teeth pairs of the gerotor pump with the better tribological characteristics.

[9] Chiu-Fan Hsieh, et al have illustrated the use of the envelope theorem for the geometric design of a Cycloidal speed reducer. The mathematical model of trochoidal curves in parametric form is developed and envelope method is used to produce a real cycloidal wheel profile. They have also derived and discussed the inflection points and Design of Lobe Profile for Positive Displacement Internal Rotary Lobe Pump curvature of trochoidal curves and their equidistance. Using the design result parameters, the analysis also compares contact forces and assesses curvature to determine whether the cycloidal Wheel has a non-undercutting or continuous condition.

[10] Danica Josifovic, et al have described the operating characteristics of the gerotor pump with fixed gear axis. Their objective of the solution choice is to obtain the best design of the gerotor pump with minimum energy losses. The subject of the investigation is the internal combustion engines lubricating pump and the possibilities for the new construction solutions with better characteristic with the aim of increasing the pump energy efficiency. The basic objective of their investigation is to define the relation between the single geometrical parameters and the values of the pressure variation in the pump chambers as the consequence of the change of the chamber's current volume. On the basis of the geometrical-kinematical model of the pump gear profile, the determination formula of the chambers current volume and the corresponding pressure variation are defined. The derived analytical formulae and graphical interpretation of the obtained results which are given in the paper to open the possibility for the analysis of the influence of the gearing geometrical parameters on the variation of the instantaneous pressure. The obtained results can be used for the calculation of the precise values of the forces and torques affecting to the gear pair of gerotor pump, as well as its volumetric losses.

[11] Wirawan Sumbodo, et have discussed about generating CNC codes from drawing and manufacturing the component on CNC machine. They have used one of the engine component. Design drawings are generated using AutoCAD software and there after image data is transferred from AutoCAD to MasterCAM X software. Program from MasterCAM X is executed into Siemens Sinumerik 802C Base Line CNC 90(Computer Numeric Control) Frais machine.

[12] KWON Soon-man, et al gives the wear rate between the rotors of a hypotrochoidal gear pump is characterized. Using the knowledge of shape design on the rotors, the contact stresses without hydrodynamic effect

between the rotors teeth were evaluated through the calculation of the Hertzian contact stress. Based on the above results and the sliding velocity between the rotors, a genetic algorithm (GA) was used as an optimization technique for minimizing the wear rate proportional factor Design of Lobe Profile for Positive Displacement Internal Rotary Lobe Pump
(WRPF). The result shows that the wear rate or the WRPF can be reduced considerably, e.g. approximately 12.8%, throughout the optimization using GA.

The contact stresses without hydrodynamic effect obtained by the analytical method and the FE simulation gave an optimum exactness to take into consideration of the results and to continue this work. Also, using a genetic algorithm as the optimization technique for minimizing the wear rate, the wear rate could be reduced considerably.

[13] Soon-Man Kwon, et al explains geometric approach for the outer-rotor profile as a conjugate to the inner-rotor in a hypotrochoidal rotor pump (hypo-gerotor pump) is proposed by means of the principle of the instantaneous center and the homogeneous coordinate transformation. The inner-rotor profile is defined by the combination of two circular arcs. Next, the radius of curvature of the outer-rotor is derived with the relationships of the trochoid ratio and the inner-rotor tooth size ratio. Then by examining the minimum radius of curvature of the extended hypotrochoidal outer-rotor profile on the convex section, an explicit formula to avoid undercutting in the hypo-gerotor pump is proposed. It is found that undercut or self-intersection does not occur so long as the minimum value of the radius of curvature on the convex section is not less than zero. Design examples are presented to simulate the operation and to demonstrate the feasibility of the approaches using a computer-aided design program developed on C++ language.

The exact outer-rotor profile and some explicit formulae for the limit dimensions to avoid undercutting in the hypogerotor pump have been obtained by the principle of the instantaneous center, and by examining the minimum radius of curvature on the convex section of the lobe profile, respectively. The following conclusions can be drawn:

– The parametric lobe profile equations of the outer rotor in a hypogerotor pump are analyzed and obtained by the principle of the instantaneous center. The present results are easy to understand and exact.
– Simple explicit formulae for no interference conditions are presented by examining the minimum radius of curvature on the convex section of the outer-rotor profile.
– The developed design methodology has been successfully applied to the hypogerotor pump using a computer-aided program, and some examples have been presented to verify the validity of the developed methodology. Design of Lobe Profile for Positive Displacement Internal Rotary Lobe Pump

Sotiris L. Omirou, et al [18] they presents a manufacturing method for parts with trochoidal profile on CNC milling machines. The method is based on a new real-time interpolation algorithm capable to drive the cutter along the offset of trochoid curves with precision equal to the resolution of the machine. The structure of the presented algorithm may be adapted accordingly so as to be used either for parts with an epitrochoidal or a hypotrochoidal profile. Both types of curves, known as trochoid Curves, have important industrial applications such as gears with trochoidal tooth-profile, cams, trochoidal-shaped housings for rotary internal combustion engines and rotary piston pumps etc. The effectiveness and accuracy of the proposed method is verified by simulation tests of the generated tool path for the machining of two representative mechanical parts, an inner rotor of a hypogerotor pump and an epitrochoidal-shaped housing.

[14] Yii-Wen Hwang, et al, this paper shows the theory of gearing to derive the mathematical model of an internal cycloidal gear with tooth difference. Whereas the outer rotor profile is based on a curve equidistant to a hypotrochoidal (or extended hypocycloid) curve, the inner rotor design generally depends upon type of use—e.g., when used as a speed reducer, it is a pin wheel. Therefore, this analysis proposes designs for both a gerotor and a speed reducer. Specifically, for an inner rotor used as a gerotor pump, it outlines a mathematical model to improve pump efficiency and derives a dimensionless equation of non-undercutting. For the speed reducer, it develops and demonstrates with numerical examples, a feasible design region without undercutting on the tooth profile or interference between the adjacent pins.

III. Construction & Operations

The principle of the Lob pumps an epitrochoid is defined as a path, which is traced by a point lying inside the rolling circle that rotates outside of a base circle circumference. As the classical epitrochoid pumps, the assembly of the considered machine is constituted by an inner rotor which can be assumed as a pinion, since it transmits the motion to the outer rotor. Of the speed breaker is converted into the rotational motion, which in turn rotates the generator and generates electricity.

The working of this Lobe pump is somewhat similar in design to external gear pumps. Two pumping elements (lobes) rotates counter to one another to expand and contract volumes. The main difference is the pumping element are always externally timed resulting in on metal-to-metal contact with in the pumping chamber. Each lobe is affixed to a shaft that is supported by antifriction bearings. Bearing are not in the liquid means two stuffing boxes are required to isolate them. Since there are no bearing are no bearing in the liquid the lobes do provided a cantilevered load on the shaft. This principle. The cutaway illustration of a typical lobe type pump them. Since there are no bearing are no bearing in the liquid the lobes do provided a cantilevered load on the shaft. This principle. The cutaway illustration of a typical lobe type pump

IV. Advantages

1) Economical to install.
2) It is eco-friendly.
3) Maintenance cost is low.
4) No metal-to-metal contact.
5) Superior clean-in-place and steam-in- place capabilities.
6) Positive suction, non-pulsing discharge

V. Conclusion & Future Scope

Used the K-Epsilon turbulence model and the dynamic meshes to compute the two-dimensional turbulence flow field of the lobe pump and analyzed different pressure angles and working conditions influence of lobe pump performance. The conclusions as follows:

1) Pressure angle has great influence to velocity with the increasing of pressure angle, the velocity of output decreases. The oil absorption pressure has little relationship with pressure angle. When the pressure angle is 40°, the oil absorption pressure is the maximum but the pressure pulsation is the maximum too. When the pressure is 45°, the comprehensive property of lobe pump is the maximum.
2) In different working conditions, with the rotor speed increasing, the output velocity and input oil absorption pressure has increased obviously. But the pulsation is much more obvious. When the speed increases to a certain extent, the output velocity and the oil absorption pressure doesn't increase.
3) Fluid in the vortex area requires amount of energy. This energy comes from the mainstream fluid, which makes the mainstream energy loss. So, this phenomenon can reduce the lobe pump efficiency.

References

[1] Giovanni Bonandrini*, Giovanni Mimmi, Carlo Rottenbacher, Design and simulation of meshing of a particular internal rotary pump, Mechanism and Machine Theory 49 (2012) 104-116.
[2] G.Mimmi, P.Penncchi, Non-undercutting conditions in internal gears, Mechanism and Machine Theory 35 (4) (2000) 477-490.
[3] Yii- Wen Hwang*, Chiu-Fan Hseih, Determination of surface singularities of a Cycloidal gear drive with inner meshing, Mathematical and Computer Modeling 45 (2007) 340-354.
[4] Mohammad Reza KARAMOOZ RAVARI, Elliptical lobe shape gerotor pump design to minimize wear. Mech. Eng. 2011, 6(4): 429–434
[5] M.R. Karamooz Ravari · M.R. Forouzan · H. Moosavi, Flow irregularity and wear optimization in epitrochoidal gerotor pumps. Meccanica (2012) 47:917–928
[6] Ivanovi´c L, Josifovi´c D (2006) specific sliding of Trochoidal gearing profile in the Gerotor pumps. FME Trans 34:121–127
[7] Demenego A, Vecchiato D, Litvin FL, Nervegna N, Mancos (2002) Design and simulation of meshing of a cycloidal pump. Mech Mach Theory 37:311–332.
[8] Sung-Yuen Jung1, Seung-Moo Han2, Hae-Yong Cho3 and Chul Kim1, Automated design system for a rotor with an ellipse lobe profile. Journal of Mechanical Science and Technology 23 (2009) 2928~2937
[9] Min Soo Kim1, Hyun Woo Lee1, Sung Yuen Jung2, and Chul Kim2, Development of Rotor for Internal Gear Pump using Cycloid and Polycircular-arc Curves Journal of the Korean Society for Precision Engineering Vol. 29, No. 9, pp. 1003-1011
[10] Lozica Ivanoviü , Danica Josifoviü , Andreja Iliü 1 1 1, Blaža Stojanoviü1,Specific sliding of Trochoid gearing at the gerotor pump, Scientific Technical Review, 2010, Vol.62, No.3, pp.60-69 Design of Lobe Profile for Positive Displacement Internal Rotary Lobe Pump 68
[11] Yii-Wen Hwang, Chiu-Fan Hsieh, Geometry design and analyses for trochoidal type speed reducers with conjugate envelopes, Mathematical and Computer Modeling 45 (2007) 360-375.
[12] Lozica Ivanovic, Danica Josifovic, Andreja Ilic, Blaza Stojanovic, Analytical model of the pressure variation in the gerotor pump chambers, Scientific Technical Review, 2010, Vol.61, No.3, pp.40-49
[13] Wirawan Sumbodo, Boenasir, Karsono, Agung Pambudi, "The Making of Workpieces Using AutoCAD Software based Siemens Sinumerik *802C* Base Line Frais Machine" International Journal of Engineering and Industries Volume 2, Number 2, June 2011.
[14] KWON Soon-man, KIM Chang-Hyun, SHIN Joong-ho, Optimal rotor wear design in hypotrochoidal gear pump using genetic algorithm, Central South University Press and Springer-Verlag Berlin Heidelberg 2011: 718-725