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Design and Experimental Analysis of Oil Pump Rotor for Improving its Efficiency in IC Engine

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ABSTRACT: Lubrication of IC engine is mostly done using a generated rotor (gerotor) pumps. The inner and outer gear tooth profiles are described by epi trochoidal (Conventional Gerotor) profile. Due to their compact design, low cost and robustness, gerotor pumps are commonly used for lubrication systems for pumping liquids such as oil, transmission fluid, and fuel. Higher demand of automotive research needs higher efficiency gerotor oil pump. Efficiency of gerotor oil pump can be increased by increasing the pocket volume of gerotor, where increasing the pocket volume can be achieved only by deriving a new gerotor profile. Such an attempt is made here and derived a new gerotor profile using a maximum ellipse inscribed inside the root circle of both internal and external gears while ensuring the smoothness of profile to reduce the friction on rotation. Adopting a maximum ellipse profile and changing the number of tooth with conventional epi trochoidal gerotor boundary gives a minimum of 9% pocket volume raise (pocket volume raise will differ from each and every rotor set since the number of tooth has a major impact on pocket volume) in the new eliptor rotor.

KEYWORDS: Gerotor, Eliptor rotor, Gear pumps, Trochoidal rotor, oil pump.

I. INTRODUCTION

Increasing the efficiency of Engine parts and reduction in development time with good accuracy are the challenges in the Automotive Industry. The aim of this project is to modify the Oil pump available in the Tata motors and analyse it to increase the efficiency of I. C. Engine. For any engines, various systems are involved for the safe and reliable operation, in that oil system plays a vital role for the engine lubrication. Oil pump is the most significant equipment as a part of engine oil system. The main function of oil pump in the engine is to supply lubricating oil to various rotating and sliding parts of an engine in order to prevent the wear and tear, excessive heat generated during the engine operation. The oil pump works on the principle of geo rotor (similar to internal gear arrangement) which is a positive displacement pump. The oil pump develops required pressure greater than the bearing chamber pressure and flow for

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maintaining the bearing temperature in the engine. The oil pump gerotor is driven by the engine power through the gear box and quill shaft connected to oil pump driven shaft. The applications of internal gear pump rotors are common in automobiles and oil pumps. Since the demand of fuel consumption is less and the need of hydraulic power is more, volumetric efficiency is expected much, whereas, the size must be lower. In order to satisfy all these, P/M internal gear rotors were designed using new tooth profile. In terms of efficiency, the newly designed pumps show 10% increase in discharge volumes compared to the typical pumps of same size.

Similarly, an attempt is initialized in this work that alters the rotor profile and teeth thus to enhance its discharge volume. Figure 1 and figure 2 describes the gerotor oil pump with its body, cover plate, ports, inner and outer rotor



Figure 1: Front View of Oil Pump

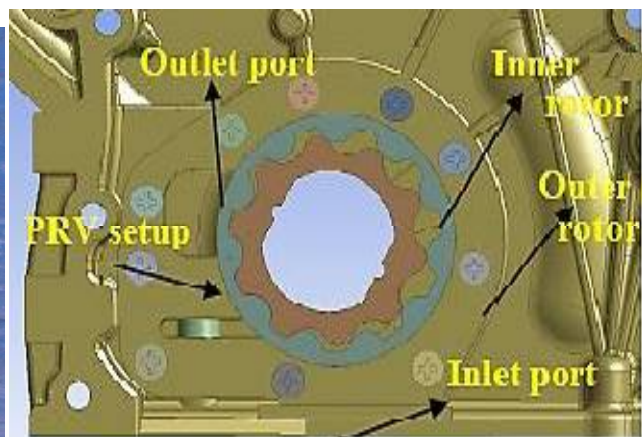


Figure 2: Parts of oil pump

Conventional epi-trochoidal profile

An *epi trochoid* is a roulette traced by a point attached to a circle of radius r rolling around the outside of a fixed circle of radius R , where the point is at a distance d from the center of the exterior circle. The epi trochoid with $R=3$, $r = 1$ and $d=1/2$ is shown in figure 3.

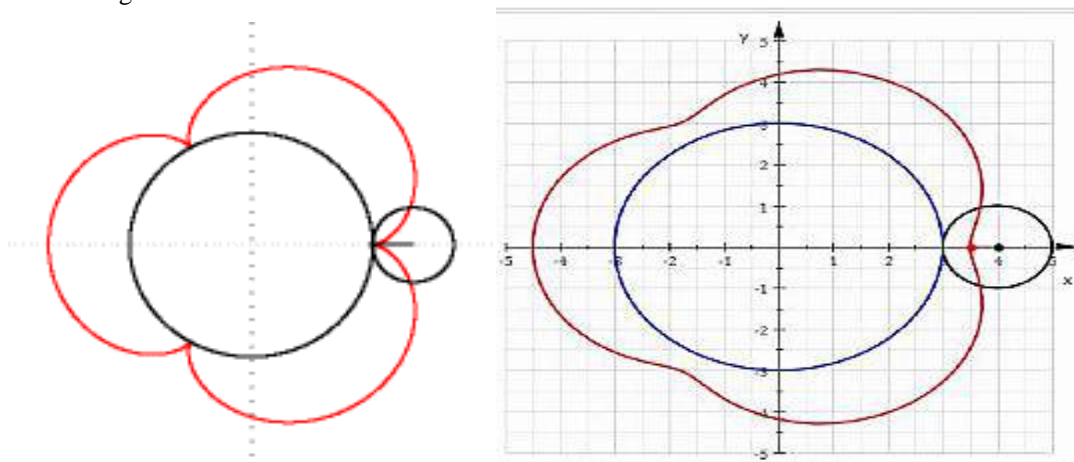


Figure 3: Epi trochoidal profile

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The following are the parametric equations of figure 3.

$$x(\theta) = (R + r) \cos \theta - d \cos\left(\frac{R + r}{r} \theta\right)$$

$$y(\theta) = (R + r) \sin \theta - d \sin\left(\frac{R + r}{r} \theta\right)$$

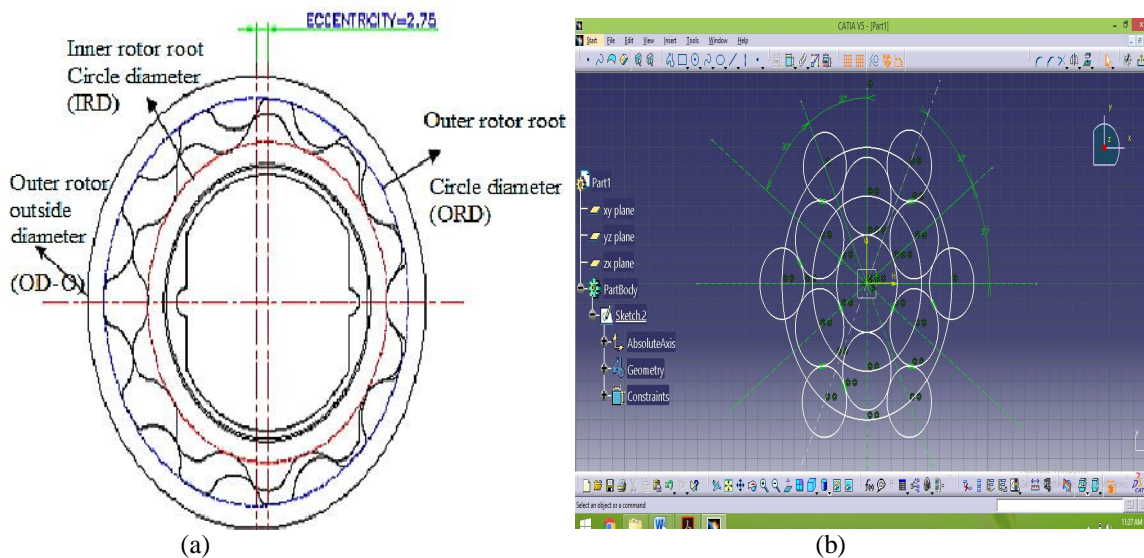
Where, R and r denote base (blue) and rolling (red) circle radius, d refers to the distance between the rolling circle centre and the curve plotting point, θ is a parameter and X (θ) and Y (θ) are the points on X and Y axis in co-ordinate system.

Limitation of epi trochoid profile

The highest volume between the rotor teeth is the pocket volume. The role of Gerotor's pocket volume is noted in relation with oil pumping ability. In case of epi trochoidal model, the pocket volume is not variable if the boundary condition is fixed due to the categorization of equation. Changes in pocket volume is achieved by varying r, R and d. Oil pumping efficiency tends to degrade since the pressure angle of the epi trochoid profile is high.

II. ELIPTOR ROTOR DESIGN

Eliptor rotor is described based on epi trochoid profile and the performance between both the eliptor and epi trochoid rotor is compared. The parameters of the typical rotor are represented in figure 5.



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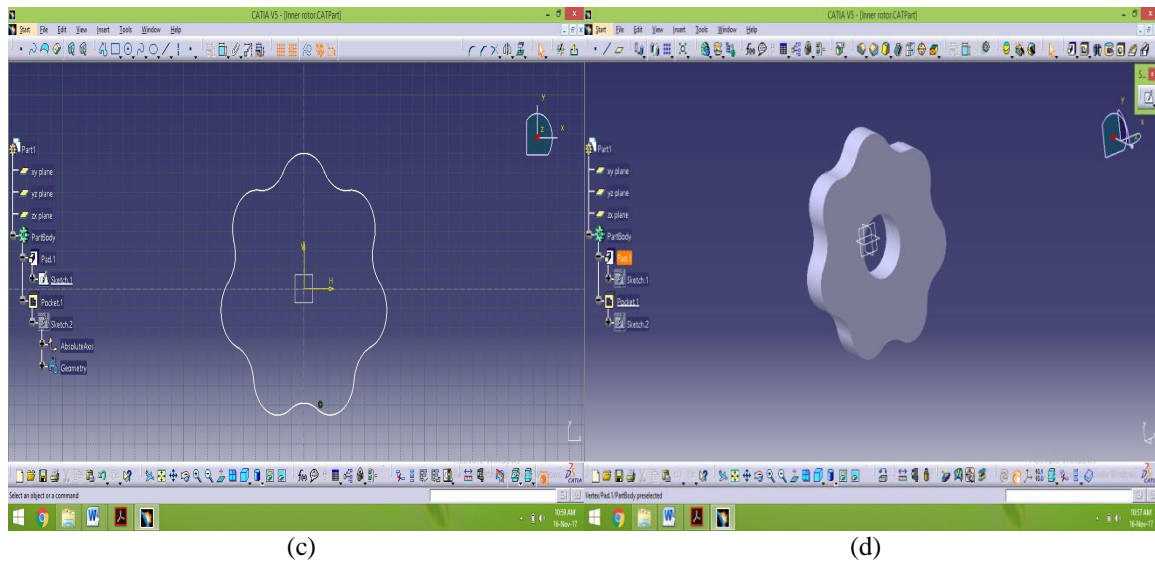


Figure 5: Rotor Design

Parameters of epi trochoid rotor set

- ❖ Outer rotor outside Diameter =65.14 mm
- ❖ Outer rotor Inside Diameter =40.86 mm
- ❖ Outer Rotor Root Circle Diameter =53 mm
- ❖ No of tooth's in Outer rotor =8
- ❖ Inner Rotor Outside diameter =50.8 mm
- ❖ Inner Rotor Root Circle diameter =46.4 mm
- ❖ No of tooth's in inner rotor =7
- ❖ Eccentricity =X-2.62272 mm, Y-0.82694 mm

The parameters do not consider the number of teeth present and all these are employed in the design of eliptor rotor. These parameters aid in dealing with the performance criteria of the eliptor and epi trochoid rotors. In the design process, the inputs of eliptor rotor are obtained from epi trochoid rotor and the development of a novel eliptor rotor is based on the following steps.

III. EXPERIMENTAL TEST RESULTS AND COMPARISON

Test rig:

TATA Motors- VQA Department has its own test rig to evaluate the performance of oil pump, which consists of pressure gauges with inlet and outlet, flow meter with outlet and temperature gauge at oil tank with heater facility to heat oil with specific temperature up to 150°C. Speedometer such as digital tachometer of speed gauge has been coupled with digital display in RPM with 5± tolerance deviation. Separate fixture is made to simulate the real condition of oil pump over the test rig to evaluate the performance of oil pump with different combination of inlet, outlet and RPM with temperature as variable parameters.

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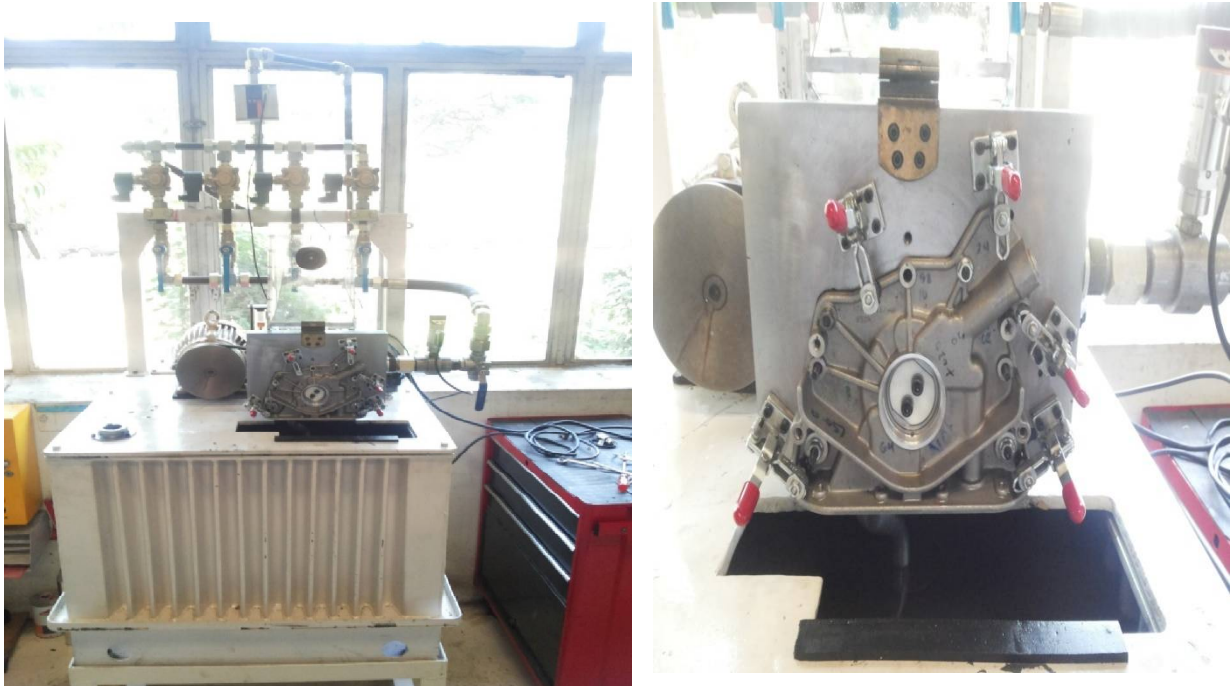


Fig 6: Test Rig

In our case we have chosen four different RPM with different back pressure at outlet as shown in table 1. Flow mapping for both epi trochoid and eliptor rotors are made out with different RPM and back pressure as listed in table 1 and the test results are given in table 2 and table 3. Comparison of flow and power for epi trochoid and eliptor rotor sets are shown in figure 7 and 8

Table 1: Four different RPM at different back pressure at outlet-

No.	Speed in RPM Back	Pressure in bar
1	750	1.6
2	1000	2.8
3	1200	2.8
4	4000	5

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Vol. 7, Issue 1, January 2018

Table 2: Epi trochoid rotor results-

RPM	Back Pressure in Bar	Epi trochoid rotor	
		Flow in LPM	Power in KW
750	1.6	4.0	0.32
1000	2.8	4.2	0.38
1200	2.8	6.2	0.43
4000	5	10.3	1.75

Table 3: Eliptor rotor results-

RPM	Back Pressure in Bar	Epi trochoid rotor	
		Flow in LPM	Power in KW
750	1.6	4.7	0.3
1000	2.8	4.8	0.36
1200	2.8	6.8	0.42
4000	5	12.1	1.65

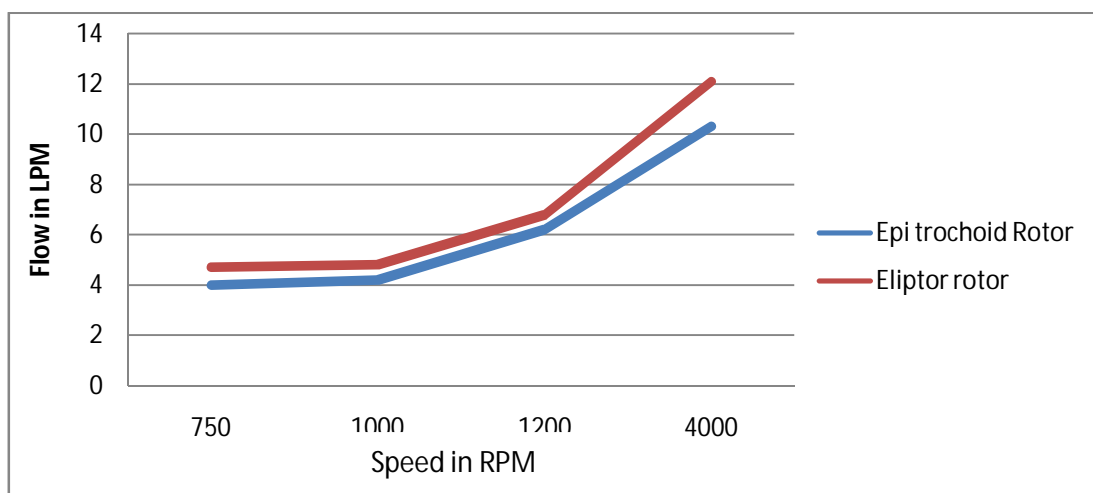


Figure 7: Flow comparison

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Vol. 7, Issue 1, January 2018

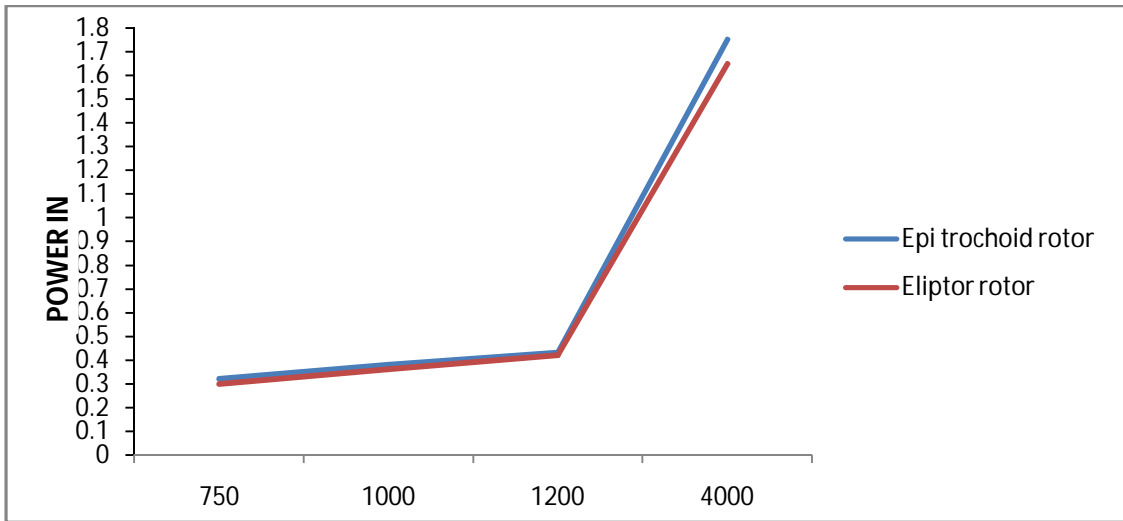


Figure 8: Power Comparison

IV. COMPARISON RESULT

On comparing the new eliptor rotor and epi trochoid rotor we found a minimum of 9% flow raise and a minimum of 2% power saving in all given specifications as listed in table 4:

No.	RPM	Flow raise in %	Power saving in %
1	700	17.5	6.25
2	1000	14.2	5.26
3	1200	9.7	2.33
4	4000	17.5	5.71

V. CONCLUSION

In this study, we have developed a rotor profile named "Eliptor" with varying number of tooth and rotor profile to achieve the higher theoretical volume of higher flow rate and less power consumption. These two parameters save the power consumption of IC engine. A new rotor is developed with a new profile methodology of ellipse approach. Both epi trochoid rotor and eliptor rotor sets are tested using same oil pump with different specification of RPM and back pressure. We observed a minimum of 9 % flow raise and 2% power saving with all specifications which is highly desirable for meeting out the current expectation of engine makers.

REFERENCES

- [1] S. Mancò, N. Nervegna, G. Armenio, C. Pachetti and R. Trichilo, "Gerotor Lubricating Oil Pump for IC Engines", Society of Automotive Engineers, Inc., 1998.
- [2] V. Diwakarand K. Venkatesh, "Analysis of Inner Rotor in a Gerotor", International Journal of Scientific and Research Publications, Volume 6, Issue 7, July 2016 ISSN 2250-3153.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 1, January 2018

- [3] Harumitsu Sasaki, Naoki Inui, Yoshiyuki Shimada and Daisuke Ogata, "Development of High Efficiency P/M Internal Gear Pump Rotor (Megafoild Rotor)" SEI Technical Review, Number 66 April 2008
- [4] Xiaohu Sang, Xiaojun Zhou and Xiaoguang Liu, "Performance optimization of an oil ellipse gerotor pump for automotive Engine", 5th International Conference on Advanced Design and Manufacturing Engineering (ICADME 2015).
- [5] Hao Liu and Jae Cheon Lee, "Profile design and volumetric efficiency analysis of gerotor pumps for AWD Vehicles" Proceedings of Research World International Conference, Bali, Indonesia, February, 2017, ISBN: 978-93-86083-34-0.
- [6] Prof. M. A. Khot, Prof. T. B. Shaikh and Prof. P. C. Dagade, "Design of epi-cyclic internal gear pump for maximum discharge" International Journal Of Innovations In Engineering Research And Technology [IJIERT], Volume 1, Issue 1 Nov-2014.
- [7] Seung Won Jeong, Won Jee Chung, Man Su Kim and MyungSik Kim, "Application of SolidWorks & AMESim based Updated Simulation Technique to back flow Analysis of Trochoid Hydraulic Pump for Lubrication" Changwon National University, 2013 -2014.
- [8] Massimo Rundo, "Models for Flow Rate Simulation in Gear Pumps: A Review", Energies 2017, 10, 1261; doi: 10.3390/en10091261.
- [9] E.A.P. Egbe, "Design Analysis and Testing of a Gear Pump", International Journal of Engineering and Science Vol.3, Issue 2 May 2013.
- [10] A. R. Noorpoor, "Optimization of Gear Oil Pump in Order to Energy Saving and Environmental Impact in a Diesel Engine" International Journal of Automotive Engineering Vol. 3, Number 3, Sept 2013
- [11] P. Lingeswaramurthy, J. Jayabhaskar and R. Elayara, "Development of Analytical Model for Design of Gerotor Oil Pump and Experimental Validation" SAE International 2011 doi:10.4271/2011-01-0402
- [12] Guillaume Houzeaux and Ramon Codina, "Numerical Simulation of Gear Pumps", International Center for Numerical Methods in Engineering (CIMNE) Edificio C1, Campus Nord UPC JordiGirona 1-3, 08 034 Barcelona (Spain)
- [13] T. Ikeda, K. Makino, Y. Hashimoto and H. Terada [13], "A Design Method of Asymmetric Rotor Teeth for an Oil Pump Based on Trochoidal Curves" The 14th IFToMM World Congress, Taiwan, October 2015 DOI Number: 10.6567/IFToMM.14TH.WC.PS8.009
- [14] Shinya Arinaga, Kentaro Yoshida, Shoichi Takada and Kiyotakinoue, "The Latest Trends in Oil Pump Rotors for Automobiles" SEI Technical Review, Number 82 APRIL 201 6
- [15] Mr. DipenRana, Mr. Nirmal Kumar, "Experimental and Computational Fluid Dynamic Analysis of Gear Pump" IJEDR, 2014 Volume 2, Issue 2 ISSN: 2321-9939