ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Finite Element Analysis of Gear Rotary Pump Impeller

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ABSTRACT
In this thesis, analysis is done on gear rotary pump to determine the strength by varying materials. 3D modeling of the rotary pumps is done in Creo 2.0. The materials considered are Cast Iron, and A356&SiC alloy for impeller. Static and Modal analyses are done at different pressures in Ansys. Comparison is made between all materials to determine the better material.

INTRODUCTION
ROTARY PUMP
A Rotary pump traps fluid in its closed casing and discharges a smooth flow. They can handle almost any liquid that does not contain hard and abrasive solids, including viscous liquids [3]. They are also simple in design and efficient in handling flow conditions that are usually considered too low for economic application of centrifuges. Types of rotary pumps include cam-and-piston, internal-gear, lobular, screw, and vane pumps. Gear pumps are found in home heating systems in which the burners are fired by oil. Rotary pumps find wide use for viscous liquids [4]. When pumping highly viscous fluids, rotary pumps must be operated at reduced speeds because at higher speeds the liquid cannot flow into the casing fast enough to fill it. Unlike a centrifugal pump, the rotary design will deliver a capacity that is not greatly affected by pressure variations on either the suction or discharge ends. In services where large changes in pressure are anticipated, the rotary design should be considered [5].

Fig – External and internal gear pump

GEAR PUMP
Gear pumps are a type of rotary positive displacement pump, meaning they pump a constant amount of fluid for each revolution. Gear pumps transfer fluid by gears coming in and out of mesh to create a non-pulsating pumping action. Gear pumps are able to pump at high pressures and excel at pumping high viscosity liquids efficiently [6].

Working principle
As the gears rotate they separate on the intake side of the pump, creating a void and suction which is filled by fluid. The fluid is carried by the gears to the discharge side of the pump, where the meshing of the gears displaces the fluid. The mechanical clearances are small— in the order of 10 μm. The tight clearances, along with the speed of rotation, effectively prevent the fluid from leaking backwards.The rigid design of the gears and houses allow for very high pressures and the ability to pump highly viscous fluids[7].

LITERATURE SURVEY
David RossingGrandall [1],This research consists of predicting the performance and efficiency of hydraulic pumps and motors, both with experiments and modelling. A pump and motor test stand is constructed to measure the efficiency of an axial piston swash plate pump/motor unit. A regenerative loop hydraulic system is used to reduce the power requirements of the test stand. The test stand uses an XPC Target data acquisition system. Test conditions focused on low displacement and low speed regimes. Efficiency values

Cite this article as: Mr.Palthya Bharathraj & Mr Katravath Bicha, "Finite Element Analysis of Gear Rotary Pump Impeller ", International Journal & Magazine of Engineering, Technology, Management and Research, Volume 5 Issue 8, 2018, Page 67-72.

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ranged from less than 0% to 82%. An existing efficiency model in the literature is fit to the data. Several improvements to the model are suggested. The correlation was satisfactory, but room for improvement still exists. Displacement sensors are recommended in the pump/motor units being tested. This is to avoid the significant uncertainty associated with calculating the derived volume based on the data.**E.A.P. Egbe [2],** Nigeria depends heavily on importation of goods and machines. A shift from this trend requires the development of locally available technology. The design analysis of a gear pump that aimed at delivering 4.0913x10-4m3/s (24.55litres/min) of oil was carried out in this work. Available technology was utilized in the design and fabrication of the external gear pump. The design considered relevant theories and principles which affect the performance of a pump.

The parts of the pump were produced locally from available materials. The performance of the pump was characterized and the test results showed a volumetric efficiency of 81.47 per cent at a maximum delivery of 20litres/minute. The discharge dropped with increase in pressure head at a rate of - 0.344Litres/m.

DESIGN OF GEAR PUMP

Gear pump consists of a driving gear and a driven gear enclosed in a closely fitted housing. The gears rotate in opposite directions. Both sets of teeth project outward from the center of the gears. As the teeth of the two gears separate, a partial vacuum forms and draws liquid through an inlet port [8]. Liquid is trapped between the teeth of the two gears and the housing so that it is carried and a force is developed which drives a liquid through an outlet port[9].

Volume of fluid can be calculated as Volume of fluid

Let V = volume of fluid

D1 = outer diameter of gear teeth

D2 = inner diameter of gear teeth

N = speed of pump (rpm)

w = gear teeth width

Therefore volume displaced in one revolution V = \[\frac{\pi }{4}(D{1^2} {\text{}}D{2^{2{\text{}}}})\] x w

Discharge of pump

Discharge per sec . Q = VxN

Efficiency

Efficiency \[\eta\] = \[\frac{{Qa}}{{Qt}}x100\]

Qa = actual discharge

Qt = theoretical discharge

3D MODEL OF ROTARY GEAR PUMP

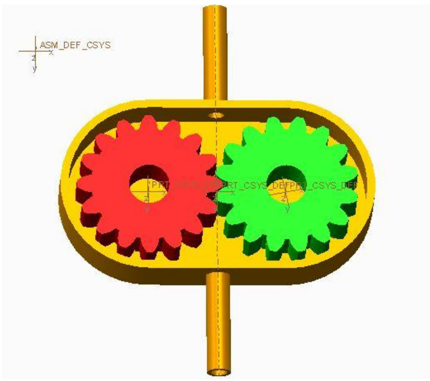

Fig – Final assembly of gears and casing

ANALYSIS OF ROTARY GEAR PUMP

Static Structural Analysis and Modal analysis is done on the rotary gear pump by changing gear material A356&SiC at different pressures 21MPa, 24Mpa, 27MPa, 30MPa.

PRESSURE – 21MPa
GEAR MATERIAL - A356 & SiC
The model is imported from Creo 2.0.

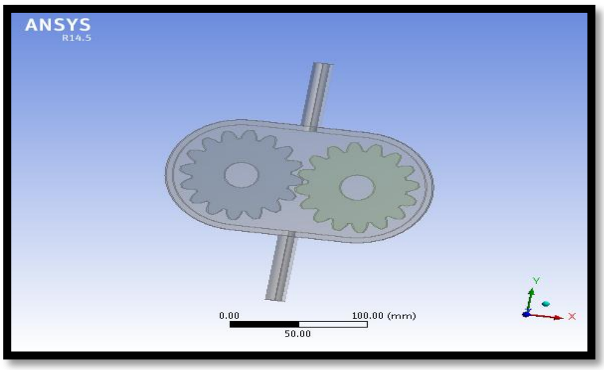

Fig – Imported geometry of rotary gear pump

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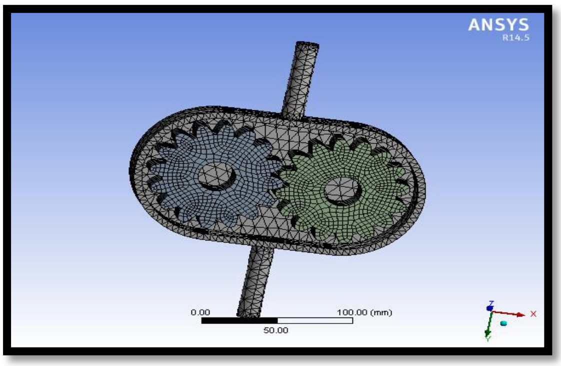

Fig – Meshed Model of rotary gear pump

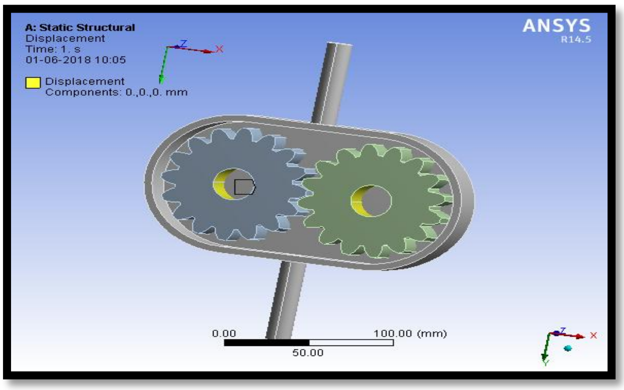

Fig – Displacement is applied inside the gear holes

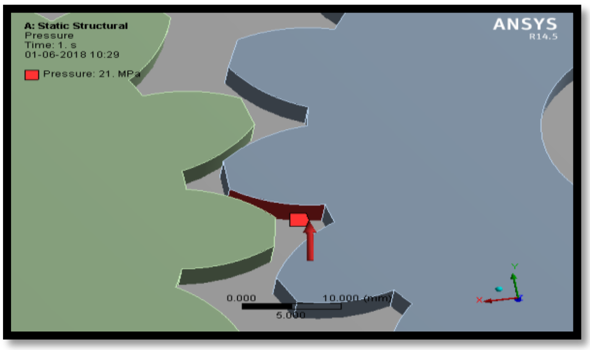

Fig – Pressure is applied on the gears mesh

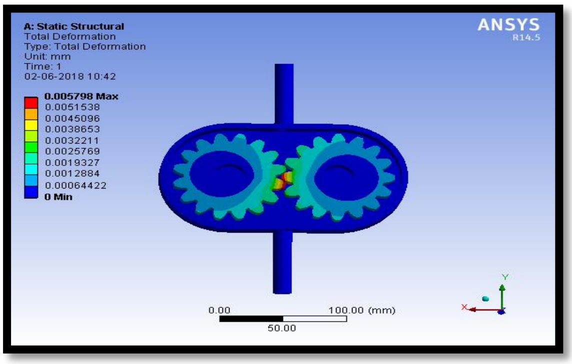

Fig – Deformation of gear rotary pump impeller using A356&SiC at 21 MPa

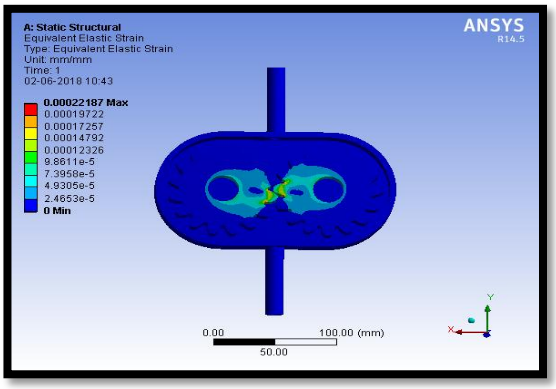

Fig – Strain of gear rotary pump impeller using A356&SiC at 21 MPa

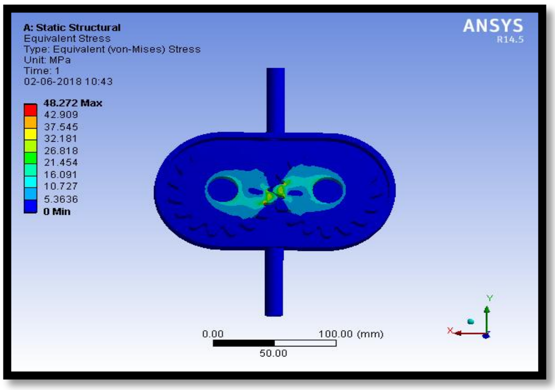

Fig – Stress of gear rotary pump impeller using A356&SiC at 21 MPa

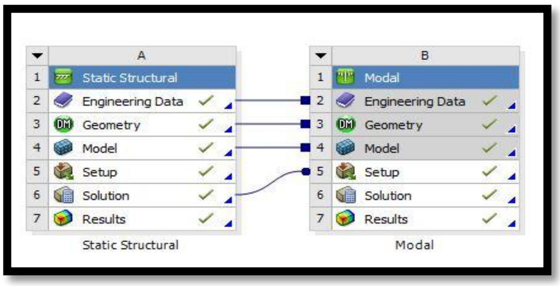

Fig – Static Analysis to Modal analysis

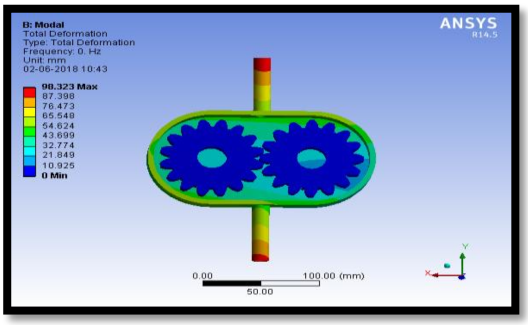

Fig – Mode1 of gear rotary pump impeller using A356&SiC at 21 MPa

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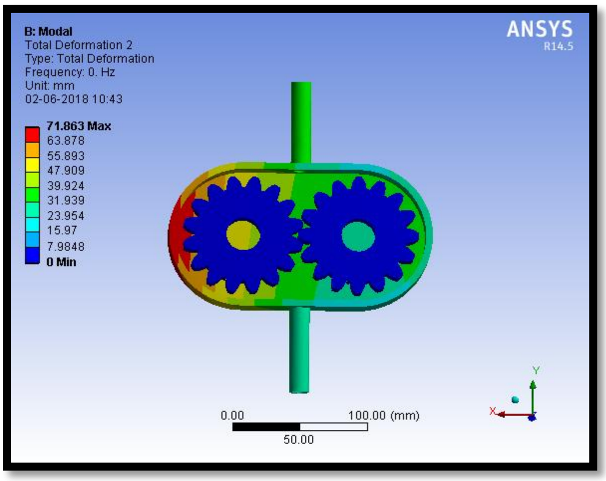


Fig – Mode2 of gear rotary pump impeller using A356&SiC at 21 MPa

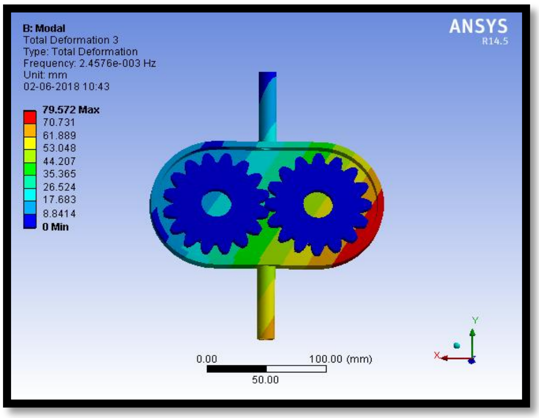


Fig – Mode3 of gear rotary pump impeller using A356&SiC at 21 MPa

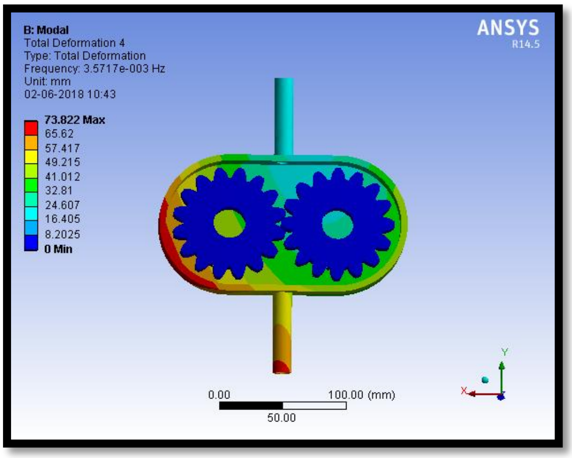


Fig – Mode4 of gear rotary pump impeller using A356&SiC at 21 MPa

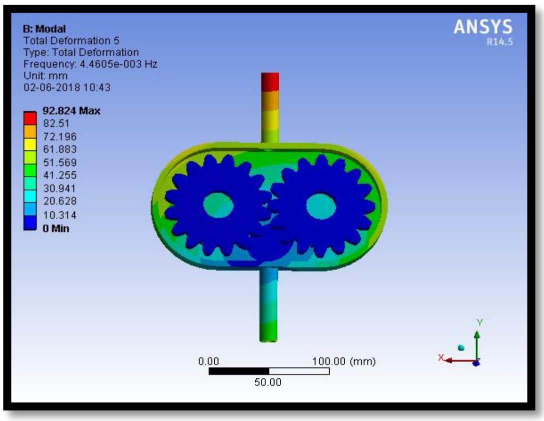
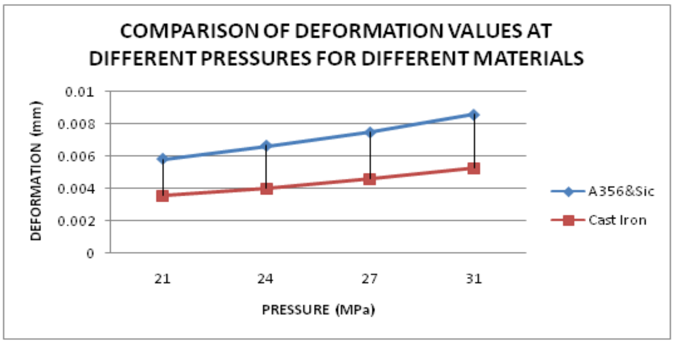
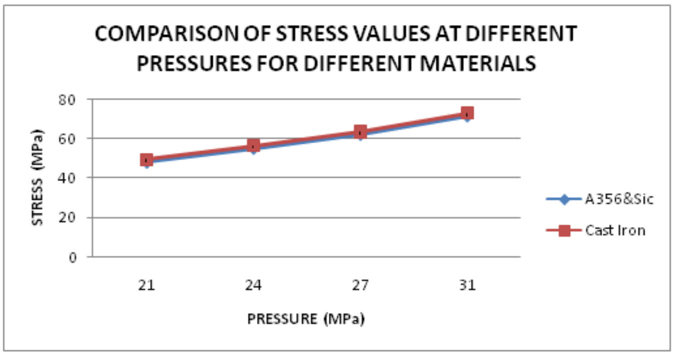
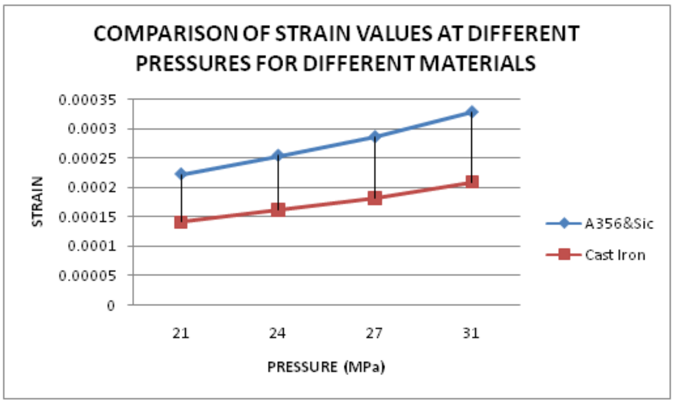


Fig – Mode5 of gear rotary pump impeller using A356&SiC at 21 MPa

RESULT GRAPHS







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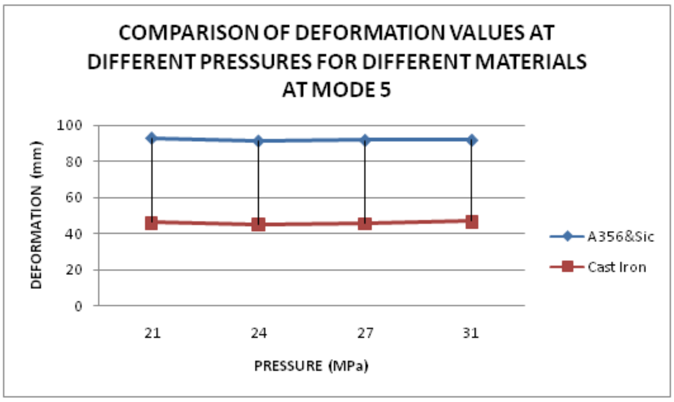

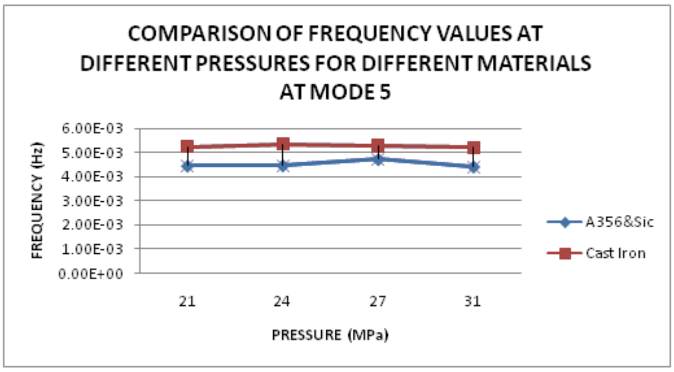

CONCLUSION

From the analysis results, the following conclusions can be made:

By observing the structural analysis results, displacement, strain and stress are increasing by increasing the pressures. The stress values are less when A356 &SiC is used. The stress values are decreasing for A356&SiC by about 1.8% at all pressures when compared with that of Cast Iron. But the deformation and strain values are increasing for A356 &SiC.By observing modal analysis results, the frequency values are less and deformation values are more when A356 &SiC is used. So vibrations will be less when A356 &SiC alloy is used. The frequency values are decreasing for A356&SiC by about 15% at pressure 21MPa, 16% at pressure 24MPa, 10% at pressure 27MPa and 15% at pressure 31MPa when compared with that of Cast Iron.The weight of the impeller is reducing by 60% when A356&SiC alloy is used when compared with Cast Iron due to its less density value. So it can be concluded that using A356&SiC alloy is better for impeller.

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