Design and Analysis and Performance Evaluation of Self Locking of Worm and Worm Gear Manufactured By Moulding and FDM Process

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Abstract- *A self-locking worm gear is a type of worm gear that does not allow the interchangeability of the input and output gears Plastic gears are used to industrial industry in the last 60 years. Today they transfer torque and in cars, sewing machines,and missiles. Plastic gears are alternatives to traditional metal gears in a wide of applications. The use of plastic gears has applied from low-power, precision motion transmission into more demanding power transmission applications. Conventional method of manufacturing is the plastic moulding , but this is only for a substantial batch quantity. In present day situation many a times it is required to produce small quantity of products for which plastic moulding is not a economical solution. In such cases the method of FDM (Fused deposition modelling) can be used. But though the method is extremely fast and economical for small batch quantity, the performance of parts produced by this method are yet to be proven for strength and durability. The project aims at the design development analysis of self locking gears as worm and worm wheel manufactured by moulding process to be compared with those manufactured by FDM process to prove suitability of the new gears as replacement to the conventional moulded gears.*

Keywords- FDM (Fused deposition modelling), self locking gear,use of plastic gears in more demanding power transmission application.

I. INTRODUCTION

Plastic gears have gone from curiosity to industrial mainstay in the past 50 years. Today torque and motion is transferred in products as diverse as cars, watches, sewing machines, building controls, and missiles. Even with all ground they've gained, their evaluation is far from over as new and more demands gear applications continue to emerge.

Many of the larger applications, like clothes-washer transmissions, have pushed the limit on gear size, often as a replacement for metal. Plastic gears are present in many other areas, for example, damper drives in HVAC zone controls, valve actuators in fluid devices, automatic flushers in public restrooms, power screws that shape control surfaces on small aircraft, and steering controls in military applications.

Much of the growth in the use of plastic gears rests on advances in molding and materials that allow for larger, more precise, and more powerful gears. Early plastic gears tend to be spur gears, typically less than 1 inch. across, that delivered no more than 0.25 hp. Now a days gears made in many configurations and commonly operate at diameters of 4 to 6 inch. Gears were molded with the diameters as large as 18 inch. Power levels should rise to 10 hp or more by 2010.

Plastic gears are serious alternatives to traditional metal gears in a wide variety of applications. Plastic gears has been used in the applications varying from low-power, precision motion transmission into more demanding power transmission applications. As designers pushes limits of acceptable plastic gear applications, of plastics in gearing and how to take advantage of their unique characteristics.

II. LITERATURE REVIEW

Research related to self-locking gear system is extensive, and hence the primary aim of this literature review is to place the scope of the material covered in this thesis within the general body of knowledge. The second aim is to identify lacking areas in the field of knowledge and establish the importance of the research conducted.Research and Analysis of the New Modification Theory of Toroidal Worm gearing, International Conference on System Science, Engineering Design and Manufacturing Informatization. In this research paper, Researcher discovers the shortage of the traditional "modification" theory, and then a research method of new modification principle is brought forward. Accordingly, the principle of curvature modification is established and the effect of the curvature modification theory is also analyzed. During the research and analysis, he find that the curvature modification principle solves the long time unsolved problem in the modification of toroidal worm gearing is get in theory and practice. The new toroidal worm gearing modified on the principle of curvature modification have higher carrying capacity and transmission efficiency than the traditional toroidal worm gearing. Experiment proves that comparison with the traditional modification and it can bring higher bearing ability and transmission efficiency. By using the technological measures to improve technology to study the basic structure of toroidal and worm transmission stability the modification principle of toroidal worm is a theory.

III. WORM GEAR

In the worm gear drive worm meshes with a worm gear. A worm drive can reduce rotational speed or allow higher torque to be transmitted. Worm gears are the perfect choice when the need is for producing large motor speed gear reductions in a single step. A single reduction range of 5:1 - 100:1 is considered normal for worm gears. It can climb up to 127:1.

Figure 1, Worm gear.

IV. FDM PROCESS

It is an additive manufacturing technology commonly used for modeling, prototyping, and production applications. It is one of the techniques used for 3D printing.The technology was developed by S. Scot crump in the1980s and was commercialized in 1990.FDM works on an "additive" principle by laying down material in layers; a plastic filament or metal wire is unwound from the coil to supply the material to generate a part.

The technology was developed by S. Scott Crump in the late 1980s and was commercialized in 1990.Theorem fused deposition modeling and its abbreviation to FDM is trademarked by Stratasys. The fused filament fabrication (FFF), was coined by the members of the RepRap to give a phrase that would be legally unconstrained in its use. It is manytimes called Plastic Jet Printing (PJP).

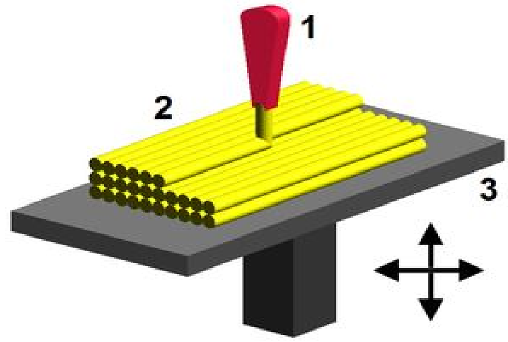


Fig.2 Fused deposition modeling.

Design and Anlaysis of Worm-

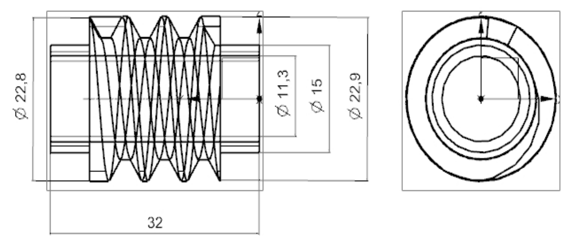


Fig. 3 Design of worm

TORQUE = 0.8 N-m

Assuming 100 percent overload in event of lever blockage or similar conditions where in the control fails to operate.

Tdesign = 0.8 x2 = 1.6 N-m

V. MATERIAL SELECTION

The ABS polymer material is selected with ultimate tensil strength 44 N/mm2 and yield strength 32 N/mm2.

Fs allowable = 44/2 = 22 N/mm2

T design = 1.23 Nm

Check for Tortional Shear failure of shaft.

Td = P/16 x fs act x (D4- d4) /D

fs act = 0.56 N/mm2

As fs act < fs all

Torsion element is safe under torsional load.

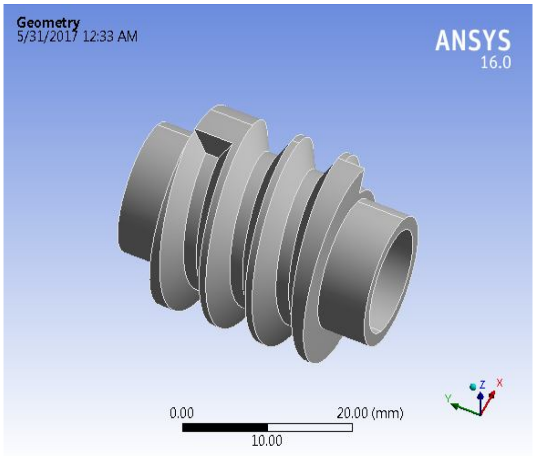
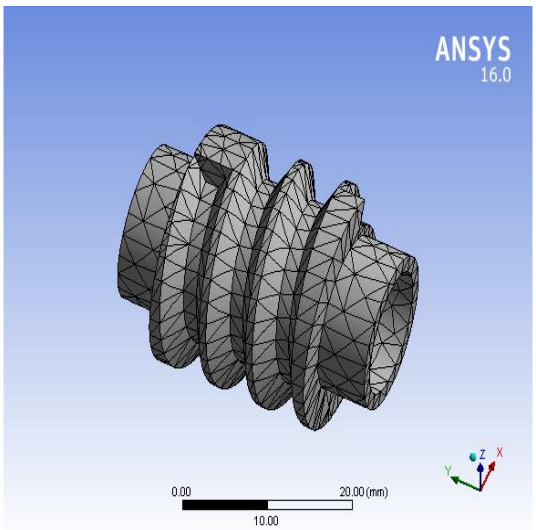
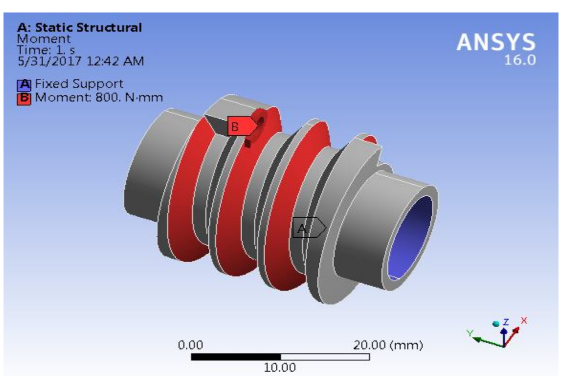


Fig.4 Geometry of worm



Statistics	
Nodes	5266
Elements	2693
Mesh Metric	None

Fig.5 Meshing of worm



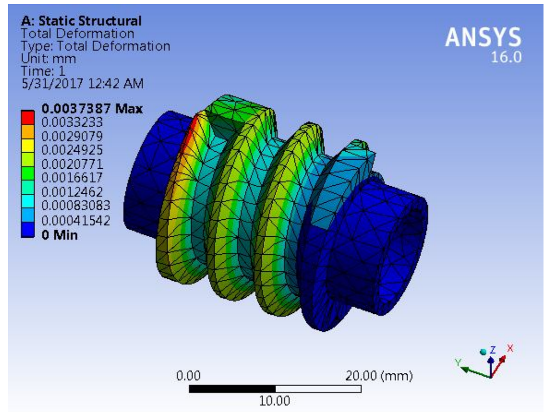


Fig.6 Deformation of worm

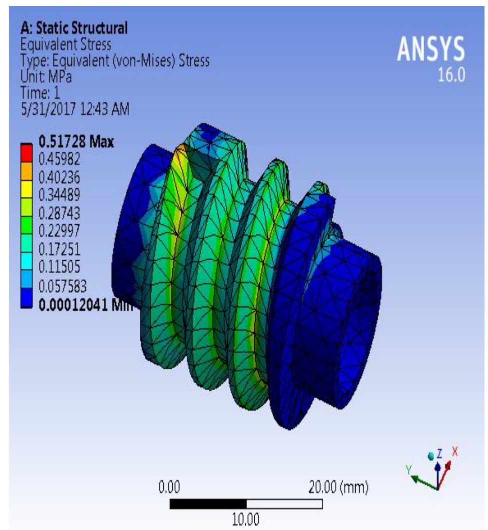


Fig.7 Equivalent Stress

Design and Anlaysis of Worm gear:

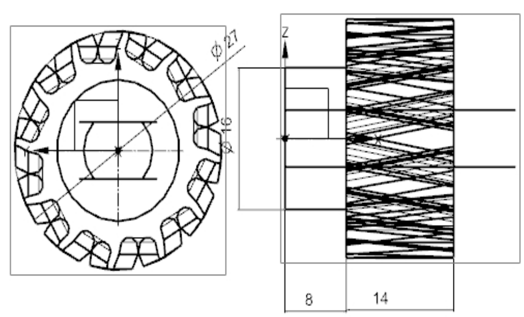


Fig.8 Design of worm gear

TORQUE = 0.8 N-m

Assuming 100 percent overload in event of lever blockage or similar conditions where in the control fails to operate.

Tdesign = 0.8 x2 = 1.6 N-m

Fs allowable = 44/2 = 22 N/mm2

T design = 1.23 Nm

Check for Tortional Shear failure of shaft.
Td = P/16 x fs act x (D4- d4) /D
Fs act = 0.23 N/mm2

As fs act < fs all
Worm gear is safe under torsional load.

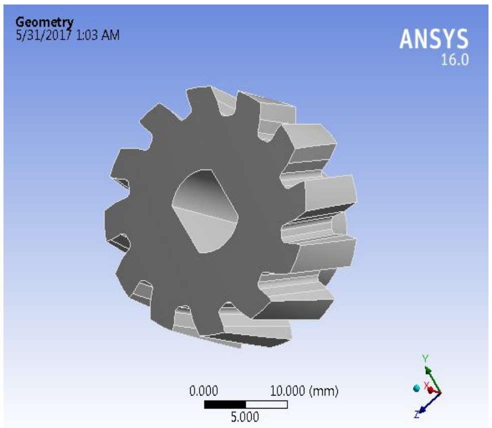
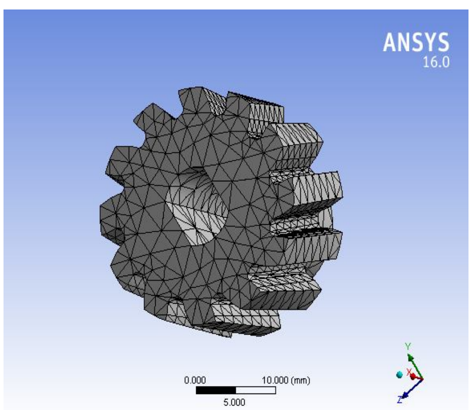


Fig.9 Geometry of gear



Statistics	
Nodes	9250
Elements	5091
Mesh Metric	None

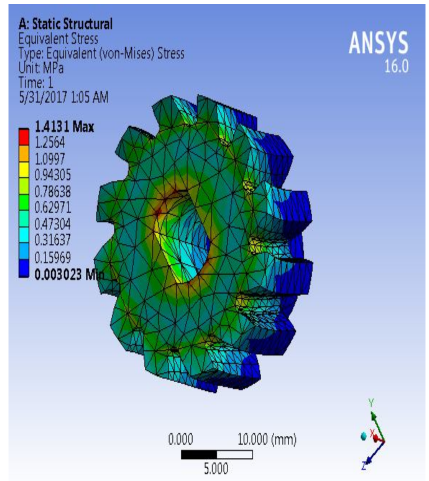


Fig.10 Equivalent stress

As the maximum stress is only 1.4131 Mpa thus the worm gear is safe

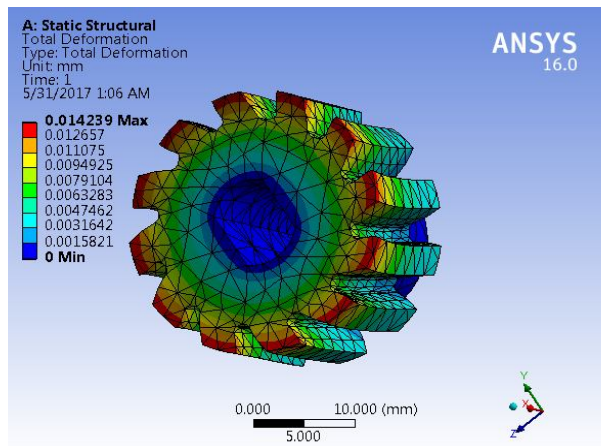


Fig.11 Total deformation of worm gear

Maximum deformation is well below the permissible limit of slip hence the worm gear is safe.

Experimental Set Up:

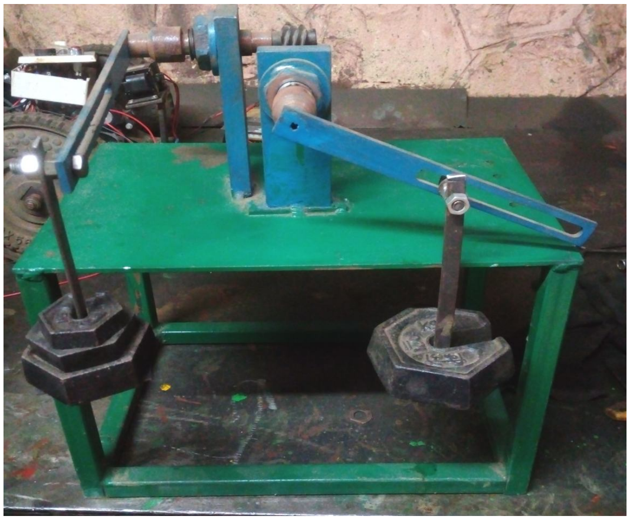
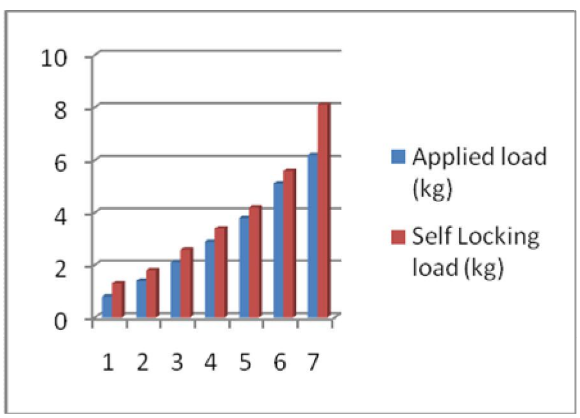


Fig.12 Test rig set up

OBSERVATION TABLE :

Load meter reading (Applied force) Kg	Spring balance reading (selflocking lo11111ad)	Slip
0.8	1.3	0
1.4	1.8	0
2.1	2.6	0
2.9	3.4	0
3.8	4.2	0
5.1	5.6	0
6.2	8.1	0

COMPARATIVE CHART:



The Chart shows that the self-locking force well exceeds the gripping force applied at all points thereby confirming that the gripper functions to 100% efficiency at all points Indicating no slipping of the gear pair thus experiment is validated.

VI. CONCLUSION

Theoretical analysis and finite element i.e. Ansys validation will be done for both FDM gear pair and moulded. Comparative performance analysis of FDM and moulded gears will be done to prove suitability of modified gear pair. The plastic worm gear is safe in torsion by both theoretical as well as analytical method. The Gear pair exhibits self lock characteristic for all range of loads upto design limit.

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