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DESIGN AND STRESS, STRAIN ANALYSIS OF POLYOXYMETHYLENE SPUR GEAR FOR SUGARCANE JUICE MACHINE

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Abstract

The best way to reduce the weight of the mechanical Components is employing the composite material. Gears are the most effective component in mechanical power transmission system. Conventional material Spur gears like make cast steel can be replaced by Spur gears made of composite materials. This results in light weight Spur gears, which add to the existing list of advantages of Spur gears, such as smooth and silent operation and larger load carrying capacity, while at the same time maintaining higher strengths, which is an important requirement in applications like spacecraft, aircraft and Robotics. The composite materials not only reduce the weight and also possess excellent characteristics of corrosion and fatigue resistant. Further, on Selecting large series production of these gears, large cost saving seem also feasible. In this paper Polyoxymethylene spur gears are designed and analysed to check whether it is capable to replace the cast iron spur gears used in sugarcane juice machine.

Keywords: Cast Iron Spur Gears, Sugarcane Juice Machine, Polyoxymethylene Spur Gear.

1. Introduction

Spur Gears are the most common means of transmitting power in the modern mechanical engineering world. The gear materials used for the manufacture of gears depend upon the strength and service conditions like wear and noise etc.

The gears maybe manufactured from Metallic or non – metallic Materials. The cast iron is widely used for the manufacture of gears due to its good wearing properties, excellent machine ability and ease of producing complicated shapes by casting method. The non – metallic materials like wood, rawhide, compressed paper and plastics like Nylon, Acetal, Acrylic and

Polycarbonate etc. are used for gears, especially for reducing weight and noise. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes.

The plastic materials have corrosion resistance, low electrical and thermal conductivity, easily formed into complex shapes, wide choices of appearance, colours and transparencies. The introduction of plastic materials was made it possible to reduce the weight of the spur gear without any reduction on load carrying capacity and stiffness.

The main objective of the present work is to design and manufacturing a Polyoxymethylene spur gear that substitute the need of metallic gear in sugarcane juice machine.

2. LITERATURE REVIEW

The review mainly focuses on replacement of Cast iron spur gears with the Nylon spur gear in the application of sugarcane juice machine.

R. Yakut, H. Düzcükoğlu*, M.T. Demirci et al

[1] In this study, load carrying capacity and occurring damages of gears which are made of PC/ABS blends were investigated. PC is hard material and ABS is soft material. The usage of materials limits these drawbacks. However PC and ABS polymers combine each other, the PC/ABS blends have suitable mechanical properties for gear applications in the industrial areas. In this study, usability of PC/ABS composite plastic materials as spur gear was investigated. PC/ABS gears were tested by applying three different loading at two different numbers of revolutions on the FZG experiment set.

J.L. Moya, A.S. Machado, J.A.Velásquez, R. oytisolo, A.E.Hernández, J.E. Fernández, and J.M. Sierra et al

[2] In this study they have performed a theoretical analysis of a procedure to determine the Lewis Factor and also performed the contact analysis of spur gears to find the stress distribution between gear teeth.

3. METHODOLOGY

In this project work it is proposed to substitute the metallic gear of sugarcane juice machine with plastic gears to reduce the weight and noise. For this purpose polyoxymethylene plastic material is considered and its viability is checked.

- Initially Gears are designed for same power transmission as that of present metallic Gears used in sugarcane juice machine by using same conventional design procedure.
- The designed gears are modeled using PRO-E software.
- The designed gears are tested for displacement, strain and stress and are Simulated Using cad modelling and FEM, analysis of the plastic gear and its material will be done.

Based on the static analysis, it is analysed to find stress and strain. After analysis experimental testing is conducted to validate the results obtained in Ansys.

4. GEARS

Gear is one of the important machine tool elements which is an integral and inevitable part of power transmission system.

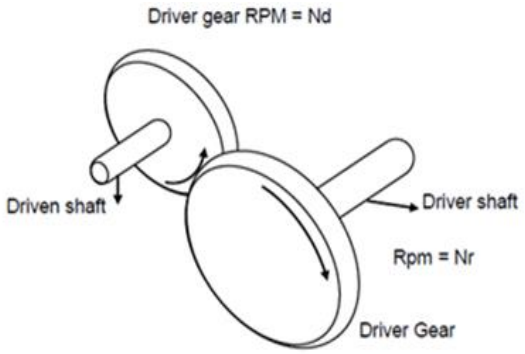

Fig : 1. Power transmission between the driven and driver shafts

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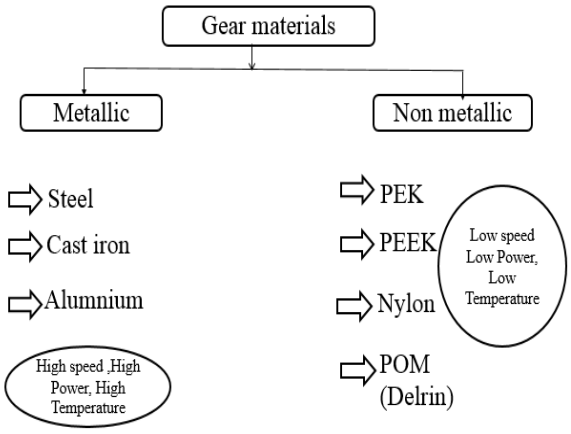
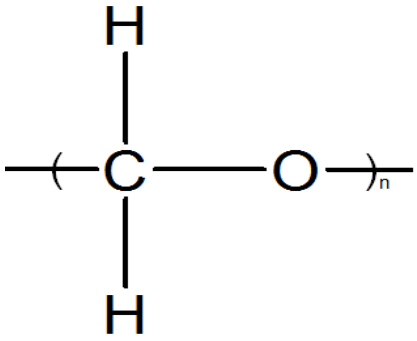


A gear is a round blank having teeth along its periphery. Gears are used to transfer power or torque from prime mover to the place where it is to be used. Along with the transmission of power gears also transfer the accurate velocity ratio between two shafts.

5. INTRODUCTION OF POLYOXYMETHYLENE

Polyoxymethylene is a crystalline plastic which offers an excellent balance of properties that bridge the gap between metals and plastics.



Polyoxymethylene possesses high tensile strength, creep resistance and toughness. It also exhibits low moisture absorption. It is chemically resistant to hydrocarbons, solvents and neutral chemicals. These properties along with its fatigue endurance make DELRIN® ideal for many industrial applications

Polyoxymethylene acetal homopolymer resins have a combination of physical properties not available with either metals or most other plastics. Polyoxymethylene is a thermoplastic engineering polymer manufactured by the polymerization of formaldehyde. It has gained widespread recognition for reliability of performance in many thousands of engineering components all over the world. It is commercially introduced in 1960.

6. DESIGN OF SPUR GEAR

6.1. Specifications of Sugarcane juice machine motor

Power (P) = 1.5 kW = 1500 watt

Speed (N) = 1400 rpm

$$P = 2*\pi*N*T / 60$$

$$1500 = (2*\pi*1400*T) / 60$$

Torque (T) = $(1500*60)/ (2*\pi*1400)$

$$T= 10.2313 \text{ N-m}$$

$$T= 10231.3 \text{ N-mm.}$$

To find Force,

$$T= F * (d/2)$$

$$F= T/ (d/2)$$

$$F= 10231/70$$

$$F= 146.1614 \text{ N}$$

Where,

F= Tangential load

Using Lewis equation,

Tangential load $F = \sigma_b * y * Pc * b$

$146.1614 = \sigma_b * 0.1034 * (\pi * 4) * 30$

$\sigma_b = 146.1614 / (0.1034 * (\pi * 4) * 30$

$\sigma_b = 3.74956\ N/mm^2$

Where,

σ_b = Allowable stress

y = Lewis form factor

Pc = (Circular pitch)

= π * module

B= Face width of the gear

D= Pitch circle diameter of the gear

The Maximum allowable stress as per the design of the desired spur gear,

$\sigma_b = 3.74956\ N/mm^2$

Allowable stress of Polyoxymethylene

(Delrin) = Ultimate tensile strength / 3

= 68.94757/3

= 20.67 N/mm^2 > 3.7495 N/mm^2.

Hence the design is safe.

6.2. Specifications of Gears.

Terms	Symbols	Pinion	Gear
Module	m	4	
No. of Teeth	Z	25 nos.	35 nos.
Face Width	b	30 mm	30 mm
Addendum	h_a	4 mm	4 mm
Deddendum	h_f	5 mm	5mm
Reference Diameter	d	100 mm	140 mm
Tip Diameter	d_a	108 mm	148 mm
Root Diameter	d_f	90 mm	130 mm
Base Circle Diameter	d_b	93.969mm.	131.557mm

Table: 1. Specification of gears

7. ANALYSIS BY FEM

7.1 Analysis procedure

1. The geometry of the gear to be analysed is imported from solid modeller Pro- Engineer in IGES format this is compatible with the ANSYS.

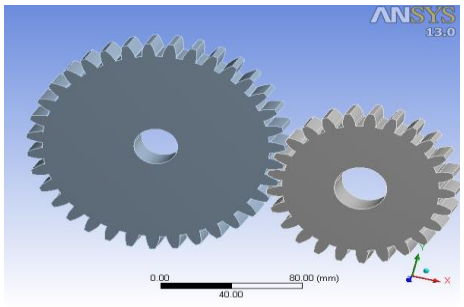


Fig: 2. Imported IGS part

2. The element type and materials properties such as Young's modulus and Poisson's ratio are specified.

3. Meshing the three-dimensional gear model. *Figure 3* shows the meshed 3D solid model of gear.

4. The boundary conditions and external loads are applied.

5. The solution is generated based on the previous input parameters.

6. Finally, the solution is viewed in a variety of displays.

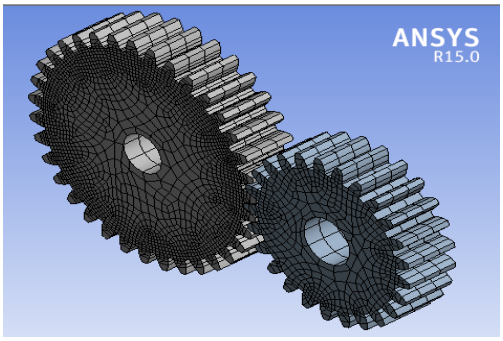


Fig: 3. Meshed spur gear model

7.2.Conditions applied for Polyoxymethylene

Boundary condition play the important role in finite element calculation here, we have taken both remote displacement for bearing supports are fixed.

7.3. Theoretical Test results obtained from ANSYS

7.3.1. Equivalent Von-Mises Stress

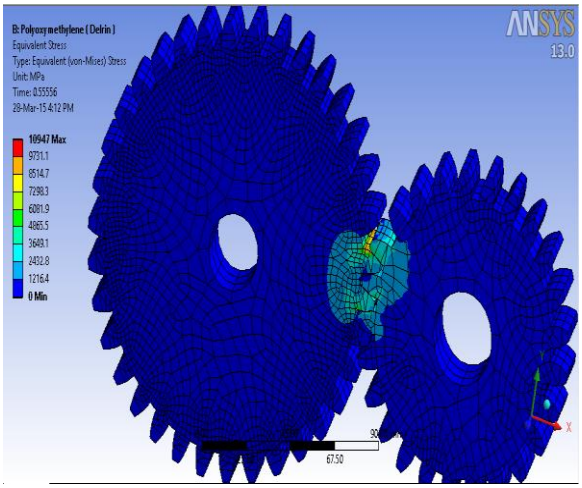


Fig: 4. Equivalent Von-Mises Stress of Polyoxymethylene

7.3.2. Total Deformation

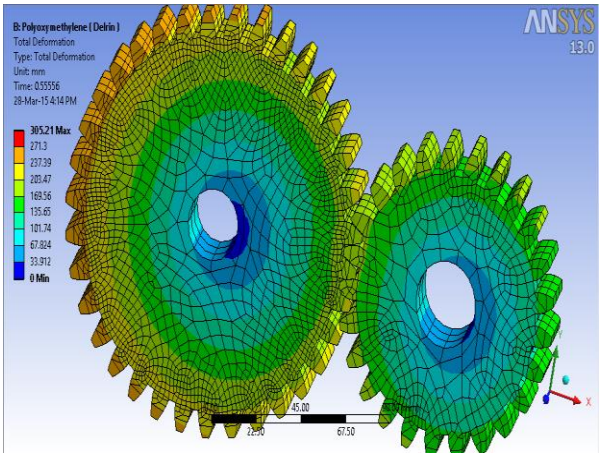


Fig: 5.Total Deformation of (POM) Polyoxymethylene

7.3.3. Equivalent Elastic Strain

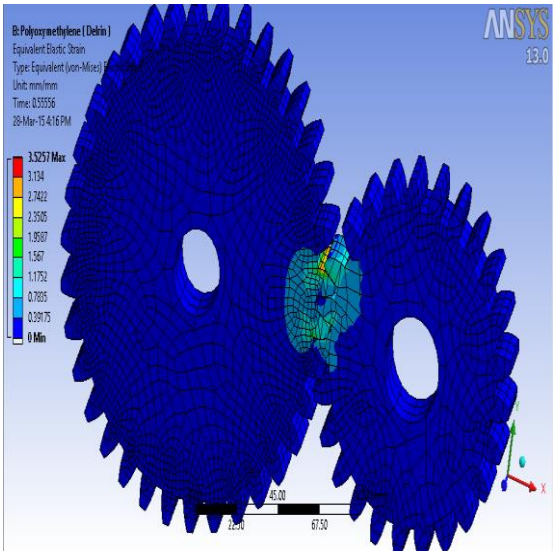


Fig: 6. Equivalent Elastic Strain of Polyoxymethylene

Table: 2. Analysis Results

S.No	Result	Unit	Polyoxymethylene
1	Von – mises stress	Mpa	10947
2	Total deformation	mm	305.21
3	Total equivalent strain	mm/mm	3.5257
4	Strain energy	mJ	1.1386×10^6

Table: 3. Testing Results

S. No	Parameter	Conditions
1	Applied Torque in Nm	10.42
2	Rotation Speed in rpm	960 Rpm to 1500 Rpm
3	Temperature	32.8˚C
4	Environment	Air
5	Operating duration	1hour

8. EXPERIMENTAL ANALYSIS

Experimental analysis was conducted to validate the results obtained by ansys.

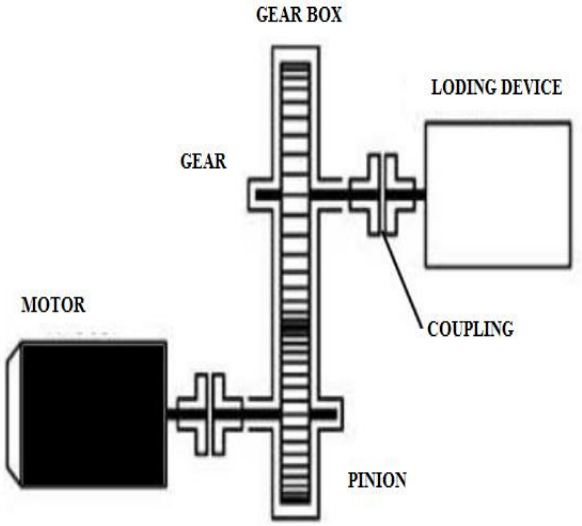


Fig: 7. Running test arrangement

9. CONCLUSION

From ansys results the von-mises stress, Strain and Deformation induced in polyoxymethylene gear is within the allowable limit. Hence polyoxymethylene gears has the capacity to replace the cast iron gears in sugarcane juice machine.

According to the study, analysis (Theoretical as well as Experimental), and results we recommend, Polyoxymethylene gears are suitable for the application of sugar cane juice machine under limited load conditions. Hence by replacing the conventional material spur gears by polyoxymethylene gears we can reduce noise, weight, cost and lubrication needs.

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