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Development and Wear Analysis of Polymer-Polyeryl Ether Ketone (PEK) Spur Gear

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Abstract: ***Gears are very useful components which transmits motion and power in mechanical power transmission system and industrial rotating machinery. A spur gear generally is subjected to two types of stresses i.e bending stress and contact stress which causes tooth failure during meshing with another gears tooth.Surface wear is considered to be one of the four major failure modes in gear systems, the other three being tooth bending, fatigue, contact fatigue, and scoring. Gears are subjected to large amount of wear while in motion. It's difficult to control the amount of wear. Gears are generally made from metallic materials but recently advanced polymers were developed which have sufficient strength and properties similar to the metallic materials so they can easily replace the metallic gears .So the work that has been carried out in this project was to find a suitable polymer material which will replace metallic gear where wear is major concern.One such polymer is PEK (Polyeryl Ether Ketone).PEK polymer materials finding its application where component is subjected to high amount of wear due to its high wear resistance capacity. The three materials used in this work are PEK, Nylon and Cast iron.***

Keywords: Wear, Polyeryl ether ketone (PEK), Nylon, Cast iron, Finite element analysis.

I. INTRODUCTION

Over the past decade polymeric gears attracts high attention due to specific characteristics such as less weight to power consumption, low cost, durable, ease of processing and fabrication etc over metallic gears. Researchers have proposed and developed non metallic gear as an alternative to metallic gears because of their superior advantages on wear and fatigue. Gun-Hee Kim, Jeong-Won Lee and Tae-Il Seo [[15]] fabricated prototype plastic worm wheel by the injection moulding process and evaluated it by the experimental method. It was evaluated that durability of the plastic worm wheel, the strength and hardness are comparatively superior to those of metal materials, also they are advantageous in terms of light weight, vibration and noise reduction, and corrosion resistance. A.D. Dighe, A. K. Mishra, V. D. Wakchaure [[16]] examined the wear resistance and torque transmission capacity of spur gears made up of 30% glass filled PEEK and 30% glass filled PA66 on FZG machine. The result shows that tooth temperature increases with increase in torque which results in increase in wear rate. A comparative result of PA66 GF30 and PEEK GF30 shows that wear rate of PA66 GF30 are much higher than PEEK GF30 at all torques and speeds.

Ajitabh Pateriya, Dipak Parasarm Kharat [[6]] and Vijay Bhaskar and TBS Rao [[7]] dealt with finite element analysis to find deformation on CI spur gear teeth by applying static load. The modelling of gear is carried out in Pro/E and analysis in Ansys. The bending stresses in the tooth root are examined using a 3-D FEM model. It is found that ANSYS result shows the deformation and the stresses coming on the gear train as well as on the individual gears. The result showed that deformation is maximum at tooth edge and minimum at fillet region. Ashish Taywade and Dr. Ajarpure [[8]], This paper deals with the idea of gear designing and development for automobile application. Basically, the driver and driven gear material plays vital role for the better performance in wear. Replacement of metal gears by plastic gear is continuing in automobiles, appliances and machinery due to its merits of low noise, less wear, self-lubrication, economic considerations, light weight, simple design and manufacturing. Due to thermal wear acetal gear failed, so to overcome the problem of acetal gear the nylon 66 is better option due to its superior properties and it also meet extreme performance challenges. Tooth load is calculated with help of Lewis equation & dynamic tooth load is calculated with help of Buckingham equation. Static analysis of the gear is done to find the Von-mises stress on the tooth of the gear in while meshing.

The polymer materials not only reduce the weight but also possess excellent characteristics of corrosion and fatigue resistant. Further on selecting large series production of these gears, large cost saving seems feasible too. Thus, a development and wear analysis demonstration are carried out using various related literatures which provides a roadmap in carrying out the present work.

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II. PROBLEM DEFINITION AND SCOPE OF WORK

A. Problem Definition

Surface wear is considered to be one of the four major failure modes in gear systems, the other three being tooth bending failure, contact fatigue, and scoring. It is difficult to control the amount of wear. Due to metal gear wear problem, it is necessary to replace the gears periodically. This can be reduced by use of polymer material gears for the same application which has high temperature strength also which increases gears life. There is need to design gear with polymer material having high wear resistant capacity and to check whether they can be completely replacing metal gears in days to come

B. Scope of Work

The main objective of the present work is to design and develop a polymer material spur gear that substitute the need of metallic gear in industrial applications of specific purpose.

1) To Design the Spur Gear using advance polymer materials and smart materials like PEK and, Nylon.

2) To undergo suitable study to increase the wear performance of the gear and enhance its life by the application of polymers.

3) To study the load carrying capacity for static and dynamic conditions**.**

4) To understand and study rapid prototyping using 3D printer.

III. ORGANISATION OF WORK

For achieving the desired results, it was necessary to study various literature work done on polymer gears. The study thus helped in preparing a road map so as to how this work needs to be carried out. Firstly, to design spur gear, standard procedure was used to understand various parameters and working conditions.

Simulation work was done using Ansys 2015 software. For putting up the boundary conditions, tangential tooth load has been calculated for all three types of material. Static analysis has been done to evaluate maximum stress and displacement induced in the three gear materials. Further to determine the amount of material removed per meter length of contact, contact pressure was needed to be evaluated, for which Ansys contact analysis has procedure been used. The value of contact pressure obtained was then put up in the equation to obtain the amount of material removed per meter contact length.

Manufacturing of cast iron gear was done through shaping process whereas for nylon and PEK rapid prototyping technique i.e. Fused deposition modelling were to be used. The gears are then tested on actual running condition. For evaluation and measurement of wear due to friction in dynamic condition, a setup is equipped with an Infrared assisted camera, IR-TCM 384.

The results obtained from theoretical, analytical and experimental work have been cumulated and studied accordingly. The steps followed, results and variations obtained have been explained properly which justifies the overall outcome of the project work.

The project is then concluded by giving reasons so as to which was the best suited material that can be used in high wear application and also the future scope which aims to promote technology innovation to achieve a reliable and efficient outcome from Gear system.

IV. DESIGNING OF SPUR GEAR

A. Selection of an I.C Engine

Different four-wheeler IC engine gears used in gear box are studied for its performance and Durability. In this project work focus is to redesign a spur gear of 1405cc Engine. For that, four-wheeler 1405cc Tata Super Ace is considered.

Consider a 1405cc engine

1) Displacement = 1405CC

2) Maximum Power = 70hp at 4500rpm

3) Maximum Torque = 13.8kg-m at 2500rpm

B. Selection of a Spur Gear (From the vehicle gear box)

Consider a gear made of following parameters of this particular vehicle-

1) Module (m) = 10

2) Number of teeth (Z) = 18

3) Pressure angle(α) = 20deg

4) Face Width = 54mm

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C. Theoretical Calculation of Spur gear

Tooth parameters are calculated by involutes teeth standards

1) Pitch circle diameter (PCD) = module x number of teeth
2) D = 10 x 18 = 180mm
3) Circular pitch (P_c) = $\pi D/Z$ = (πX180)/18 = 31.42mm
4) Diametrical pitch (D.P) = Z/D = 18/180 = 0.1mm
5) Addendum (ha) = m = 10mm
6) Dedendum (hf) = 1.25m = 12.5mm
7) Tooth thickness = 1.5708m = 15.70mm
8) Whole depth (h) = 2.25m = 22.5mm
9) Addendum circle diameter = 2 x Addendum + PCD = 2 x 10 + 180 = 200mm
10) Dedendum circle diameter = PCD – 2 x Dedendum = 180 – 2 x 12.5 = 155mm
11) Clearance depth = 0.25m = 2.5mm

D. Calculation of Tangential load and Bending Stress

Considering gear to transmit power of 36.12 kW rotating with speed of 2500rpm.
Considering factor of safety (FOS) = 4

1) Mean velocity is $Vm = \pi DN/60 = (\pi mZ\ (1\ N))/60 = (\pi$ 0.01 x 18 x 2500)/60 =23.56m/s
2) Velocity factor is Cv = 6/ (6+Vm) = 6/ (6+23.56) = 0.2029

Applying the Lewis equation (Yp)-

$Yp = \pi$ (0.154−0.912/$Z1$) = π (0.154 – 0.912/18) =0.3246

Tangential tooth load (fs) is calculated as follows: -

$fs = mxbxYp\ x\sigma b = mxbxYp\ x\sigma a\ xCv$ = 35.56 σa (N)

Bending strength is given by,

$\sigma b = \sigma a\ xCv = \sigma a\ x$ 0.2029

Power transmitted is given by,

P = $\boldsymbol{fs}$ ×v/Cs KW

The above equations are used to calculate tangential tooth load for all the three materials.

E. Static Analysis Of Spur Gears

Tangential tooth load calculated is used as a boundary condition for FEA analysis as shown below. (As main focus is on PEK; nylon and cast-iron analysis and simulation has not been put-up although it was carried out)

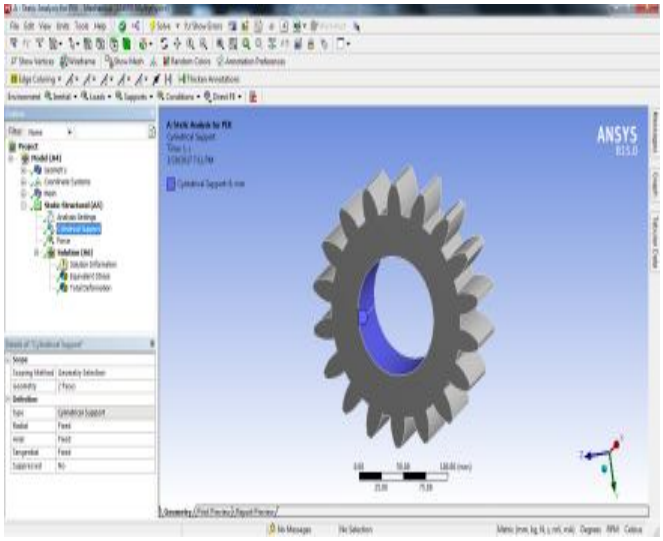


Fig.1: Defining cylindrical support for spur gear

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Von-Misses Stress And Displacement Produced

1) Stress Induced in PEK

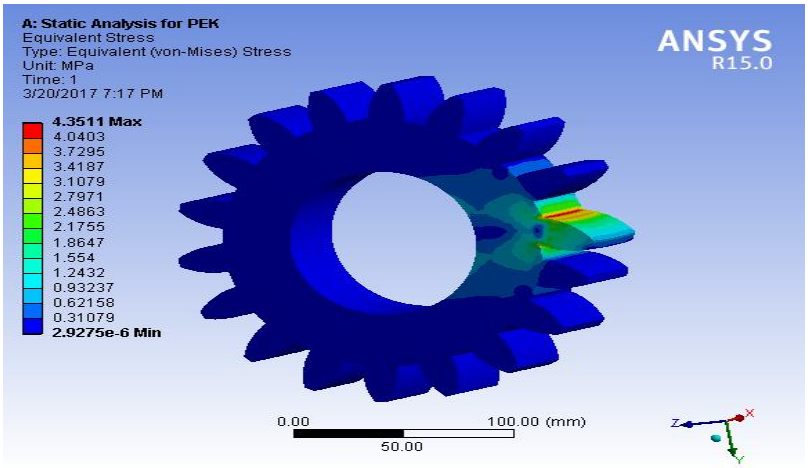


Fig 2. Stress induced in PEK

2) Stress Induced in Cast Iron Spur Gear

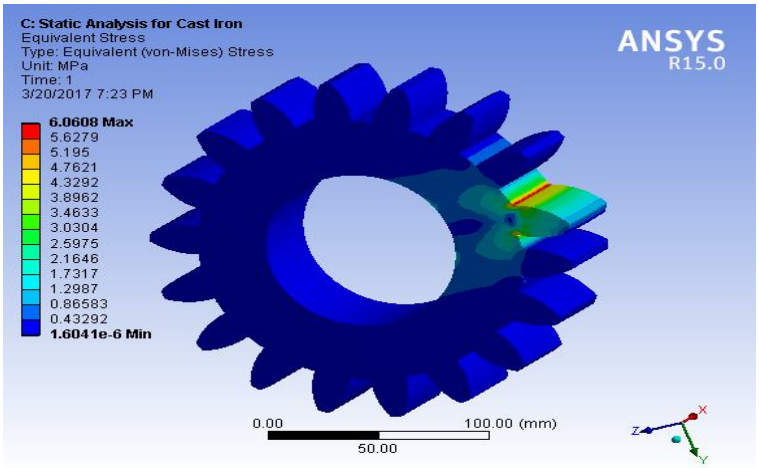


Fig 3.Stress induced in cast iron

3) Stress Induced in Nylon Spur Gear

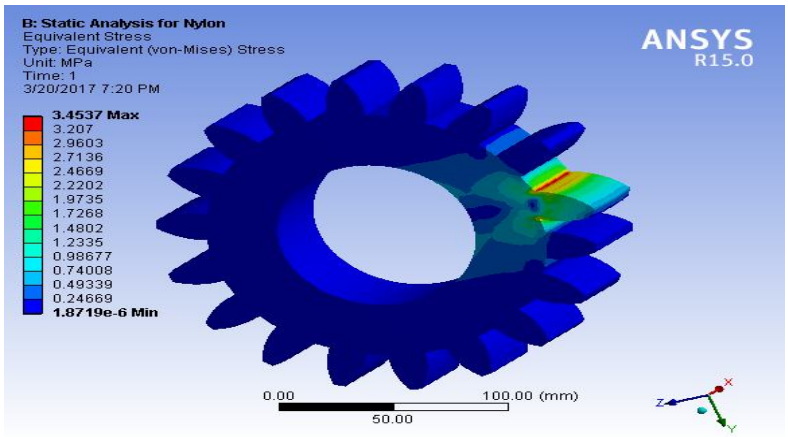


Fig 4. Stress induced in nylon spur gear

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4) Displacement Induced in PEK

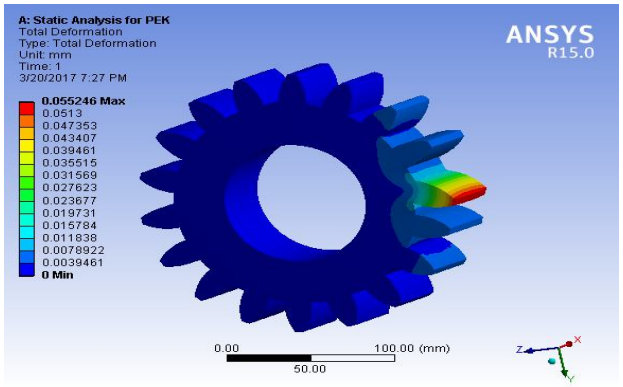


Fig 5. Displacement induced in PEK

5) Displacement Induced In Cast Iron Spur Gear

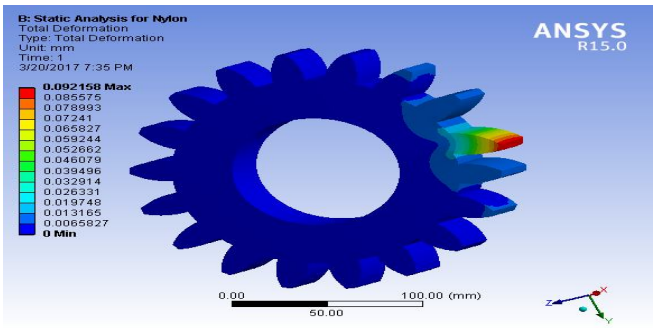


Fig 6.Displacement induced in cast iron spur gear

6) Displacement Induced in Nylon Spur Gear

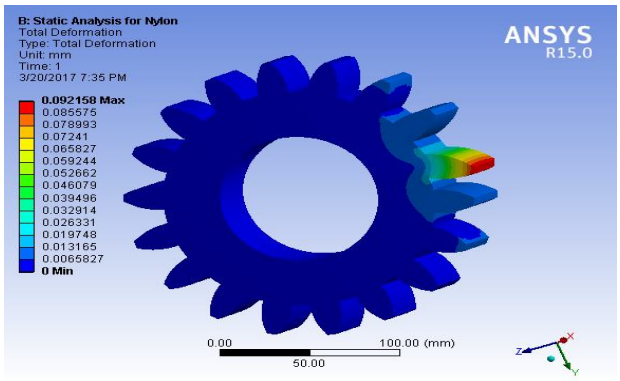


Fig7. Displacement induced in nylon spur gear

Table 1. Stress induced on different material in Original Spur gear

Sr. Nov	Parameters	Yield strength σ_y (MPa)	Allowable stress σ_a (MPa)	Tangential Tooth load f_s (N)	Bending strength σ_b (MPa)	Power (KW)
1.	PEK	110	27.5	977.9	5.579	113.55
2.	Cast Iron	140	35	1244.6	7.101	138.38
3.	Nylon	86.2	21.55	766.31	4.3724	88.981

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F. Amount of Material Removed Per Meter Length of Contact

Gear teeth mostly fail due to inadequate contact and bending strength. Tooth wear plays a vital role in the surface failure of a gear tooth. The present research work gives an idea to reduce the tooth wear and enhance the bending strength of the gear tooth. The Finite Element Model based contact stress analysis is carried out for estimating the tooth wear.

To calculate amount of material removed per meter length of contact, an important parameter to find out is the contact pressure. To do so contact analysis is required to be done which is shown as below.

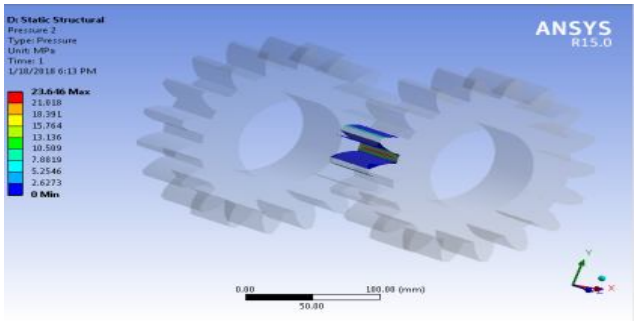


Fig 8. Contact pressure analysis of PEK spur gear

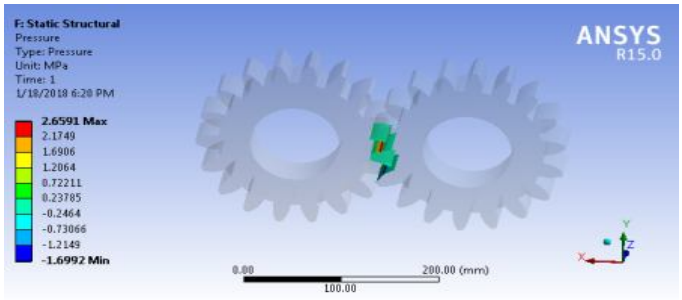


Fig 9. Contact pressure analysis of cast iron spur gear

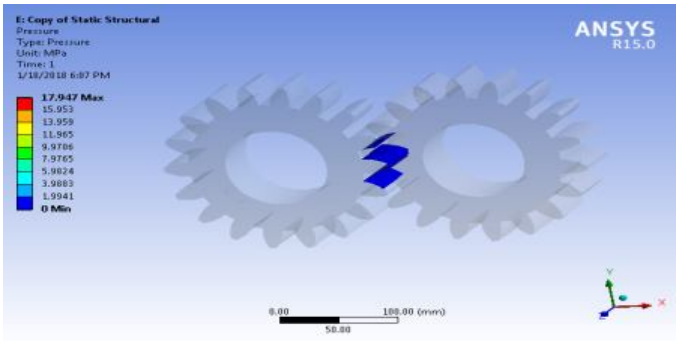


Fig 10. Contact pressure analysis of nylon spur gear

Contact pressure of all the three material thus obtained is put up in the following equation to determine amount of material removed per meter length of contact.

Amount of material removed per meter length of contact can be calculated by the formula.

$$\frac{h}{s} = k \times p$$

Where,

k = Wear Co-efficient of the material, m^3/Nm

p = Contact Pressure or local Pressure, Pa(obtained from Ansys analysis result)

h = Wear depth at point, m

h/s=Wear rate at any time, m/m

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Table 2: Depth of wear per Meter length of contact

	Materials	Dimensionless wear co-efficient K, m^3/Nm	Contact Pressure P, MPa.	Depth of wear per Meter length of contact, m/m
1	PEK	0.5	23.646	11.823
2	Cast iron	5	2.6591	13.295
3	Nylon	1	17.947	17.947

Out of the 3 Spur Gears, PEK Produces less wear rate per meter length as compared to other two Spur Gears.

G. FEA Result Summary

Table 3: FEA results of all three gears.

Sr. No	Material	Stress (MPa)	Displacement (mm)	Contact pressure (MPa)
1	PEK	4.351	0.05524	23.646
2	Cast iron	6.0608	0.0921	2.6591
3	Nylon	3.4537	0.0922	17.947

1) Wear Rate Calculation

Archard's wear equation

$$Q = \frac{V}{S} = \frac{kW}{H} \quad , \frac{m^3}{m}$$

Where V = Volume of the worn off material m^3

S = Sliding distance, m

k = Dimensionless wear co-efficient, m^3/Nm

W = loading (Applied normal load) i.e. tangential tooth load, N

H = Material Hardness

Q = Wear rate, $\frac{m^3}{m}$

Table 4: Wear rate of different material

Sr. No	Materials	Dimensionless wear co-efficient K ($\times 10^{-15}$), m^3/Nm	Tangential tooth load W, N	Material Hardness H	Wear rate Q ($\times 10^{-15}$), $\frac{m^3}{m}$
1	PEK	0.5	977.9	90	5.432
2	Cast iron	5	1244.6	190	32.75
3	NYL	1	766.1	88	8.706

Out of 3 spur Gears, PEK Produces less wear as compared to other two Spur Gears.

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V. WEAR TESTING OF GEAR

A. Spur Gear Wear Testing under Dynamic Condition



PEK Cast iron Nylon

For evaluation and measurement of wear due to friction in dynamic condition, a setup is developed equipped with an Infrared assisted camera, IR-TCM 384. The gear pair meshing in dynamic condition is shown in the Figure 9. The Polymer spur gears are subjected to the dynamic test and wear loss is evaluated by weight loss measurement. In dynamic condition, the gear pair runs at high speed, results in high friction between the gear pair at the contact tooth point, leads to wear of the material. These wear characteristics further aided by temperature arising, as a result, the gear performance starts to fall, which results in shorting of the gear life.

All the 3 Gear samples are tested at three different rotational speeds i.e. 600, 1800 and 2500 rpm.

1) Testing Condition

Torque (T) = 13.8kg-m
Speed (N) = 2500 Rpm
Power (P) = 36.12 KW

2) Gear Pair Meshing at Dynamic Condition

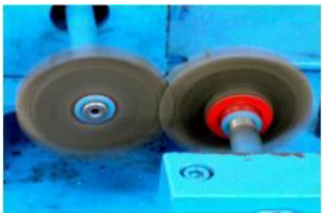
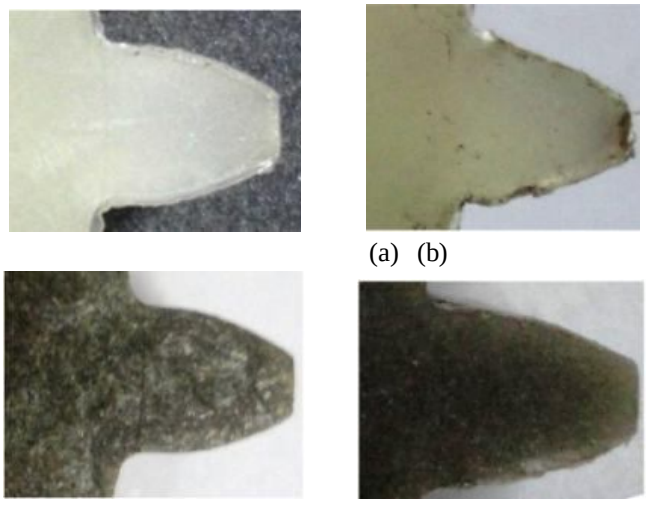


Fig 11: Gear pair meshing at dynamic condition

The photographs of intact tooth profile and tooth profile after test have been given in the Figure 6.



(a) (b)

(c) (d)

Figure 12: Intact tooth profile of (a) Nylon Spur Gear (b) PEK Spur Gear, (c) & (d) Cast iron Spur Gear

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3) Test Results

Table 5: Material removed at various rpm's

Materials	Rotational speed in RPM		
	600 RPM	1800 RPM	2500 RPM
PEK	1mg	1.32mg	1.56mg
Nylon	2.1mg	2.43mg	2.68mg
Cast iron	5.32mg	5.51mg	5.82mg

VI. RESULTS AND DISCUSSIONS

A. Discussion on Theoretical Results

Table 6: Comparison of various theoretical results obtained for spur gears.

Sr. No	Material	Depth of wear per meter length of contact (m/min)	Wear rate Q ($x10^{-15}$), $\frac{m^3}{m}$	Power transmitted (kw)
1	PEK	11.823	5.432	113.555
2	Cast iron	13.295	32.75	138.38
3	Nylon	17.947	8.70	88.981

The result (i.e. contact pressure) obtained from analytical work was used in theoretical calculation to find out depth of wear per meter length of contact as shown in the table above. It can be seen that PEK material produces less amount depth of wear as compared to cast iron and nylon material. Wear rate calculated also shows that PEK and nylon are far superior as compared to cast iron. Power transmission rate of cast iron was a notch better than the two-polymer gear. This suggests although cast iron gears provide better power transmission it still lacks wear resistant property. So, if wear is a major concern in some particular application, usage of polymer gears can be discussed and suggested.

B. Discussion on Analytical Results

Table 7: FEA Results of Spur gear

Sr. No	Material	Stress (MPa)	Displacement (mm)	Contact pressure (MPa)
1	PEK	4.351	0.05524	23.646
2	Cast iron	6.0608	0.0921	2.6591
3	Nylon	3.4537	0.0922	17.947

Analytical procedure has been derived after studying literature review from (12), (13), (14), (15), (16), (17).
Contact pressure refers to the localized stresses that develop as two curved surfaces come in contact and deform slightly under the imposed loads. Also due to contact stresses wear takes place at gear tooth. Wear is nothing but progressive removal of metal from the surface. Consequently, tooth thins down and gets weakened. Pitting is a surface fatigue failure of the gear tooth. It occurs due to misalignment; wrong viscosity selection of the lubricant used, and contact stress exceeding the surface fatigue strength of the material. Material in the fatigue region gets removed and a pit is formed.

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Contact stress analysis between two spur gear teeth was considered representing a pair of mating gears during rotation. The results were presented and finite element analysis results were compared with theoretical calculations, wherever available. Pitting is a surface fatigue failure resulting from repetitions of high contact stress. The surface fatigue mechanism is not definitively understood. The contact affected zone, in the absence of surface shearing tractions, entertains compressive principal stresses. Rotary fatigue has its cracks grown at or near the surfaces in the presence of tensile stresses, which are associated with crack propagation, ends to catastrophic failure. Because engineers had to design durable machinery before the surface fatigue phenomenon was understood in detail, they had taken the posture of conducting tests, observing pits on the surface, and declaring failure at an arbitrary projected area of hole, and they related this to the contact pressure. When loads are applied to the bodies, their surfaces deform elastically near the point of contact; so that a small area of contact is formed. It is assumed that, as this small area of contact forms, points that come into contact are points on the two surfaces that originally were equal distances from the tangent plane. Pitting commonly appears on operating surfaces of gear teeth, a fundamental cause is excessive loading that raised contact stresses beyond critical levels. Contact stress has been expressed clearly in this work by finite element analysis. From the FEA results of both unscaled and scaled spur gear we can see that the stress produced in PEK material is less as compared to cast iron but slightly more as compared to nylon, this shows the stress bearing capacity of nylon is better of all the three materials. Now the displacement produced was considerably less in PEK. This shows that although nylon has slight edge over PEK in terms of stress bearing capacity but it falls way behind PEK when its comes to deformation produced. For cast iron we can see the stress as well as displacement produced was higher as compared with other two materials. This FEA results gives us a clear indication that there are other materials available which can replace cast iron, the justification of which comes from the other results obtained as ahead.

When two surfaces are in loaded sliding contact, stresses are imposed on both solids as a result of normal and tangential forces that arise from sliding. Frictional heat is also generated at. the sliding-contact interface. The imposed stresses and frictional heating at the contact interface are the key driving forces for the occurrence of wear at a sliding-contact interface. Consequently, the wear rates and wear mechanisms are determined in large part by the magnitude of these driving forces. The forces and temperature rise are determined by the contact pressure, the sliding speed, and the friction coefficient. In many wear tests, the friction coefficient is continuously measured, while the sliding speed and the load are held constant. A common practice is to report an overall wear rate, which is less than the full amount of information potentially obtainable during the course of a test. A relationship can then be established between the nominal contact pressure and the wear rate. Such an analysis provides a connection between the wear rate and the driving force for wear, and can help elucidate the mechanisms of wear. The ability to assess the variation of wear rates and wear mechanisms during the course of a single test can help discern trends when conducting multiple tests at differing loads to evaluate the effect of contact stress on wear, The analysis presented in this paper attempts to correlate measured macroscopic wear rates with macroscopic-level nominal contact pressure. The main objective of this paper is to assess, the variation of contact pressure as well as the wear rates in the nonconformal-contact wear tests. Variation in wear rates may indicate the presence or absence of wear transitions.

C. Discussion on Experimental Results

Table 8: Material removed at various rpm's

Materials	Rotational speed in RPM		
	600 RPM	1800 RPM	2500 RPM
PEK	1mg	1.32mg	1.56mg
Nylon	2.1mg	2.43mg	2.68mg
Cast iron	5.32mg	5.51mg	5.82mg

Wear test is carried out to predict the wear performance and to investigate the wear mechanism.

Two specific reasons are as follows:

1) From a material point of view, the test is performed to evaluate the wear property of a material so as to determine whether the material is adequate for a specific wear application.

2) From a surface engineering point of view, wear test is carried out to evaluate the potential of using a certain surface engineering technology to reduce wear for a specific application, and to investigate the effect of treatment conditions (processing parameters) on the wear performance, so that optimised surface treatment conditions can be realised.

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Wear measurement is carried out to determine the amount of materials removed (or worn away) after a wear test, (and in reality, after a part in service for a period of time). The material worn away can be expressed either as weight (mass) loss, volume loss, or linear dimension change depending on the purpose of the test, the type of wear, the geometry and size of the test specimens, and sometimes on the availability of a measurement facility.

Common techniques of wear measurement include using a precision balance to measure the weight (mass) loss, profiling surfaces, or using a microscope to measure the wear depth or cross-sectional area of a wear track so as to determine the wear volume loss or linear dimensional change.

Mass loss measurement by a precision balance is a convenient method for wear measurement, especially when the worn surface is irregular and unsymmetrical in shape. Sample to be measured is carefully cleaned, and the weight is measured before and after a wear test. The difference in weight before and after test represents the weight loss caused by wear. The unit can be gram **(g)** or milligram (mg)

After testing all the three materials on actual working condition it can seen that weight loss due to wear and wear volume of PEK gear is showing the lowest value at elevated rpm. PEK gear gives lowest weight loss due to its significant higher stiffness and shear modulus compared to other materials. Weight loss in Nylon gear is somewhat higher than PEK gear but Nylon is better than CI Spur Gears for Wear Failure. It is also observed that as the working speed increases amount of weight loss also increases in all the gears irrespective of the materials.

From Both intact edge profile and edge profile after test are taken into account and the weight loss due to wear and wear volume have been calculated for all the 3 samples for actual working conditions.

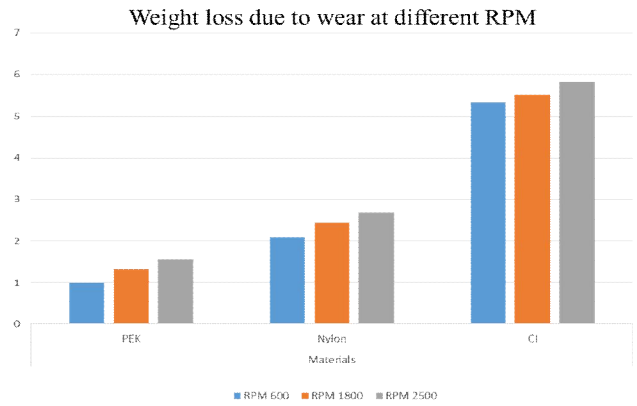


Fig 13: Graphical representation of weight loss at different RPMs (scale; on Y axis-weight loss in mg)

Weight loss due to wear is showing highest value for cast iron gear at elevated rpm. The reason is that the engaged tooth pair comes in contact more frequently when the running speed is 2500 rpm as compared to other variable speeds. Due to repeated contact, more friction takes place between the common tooth pair with less time as compared to other speeds. Whereas PEK and nylon gear shows lesser amount of weight loss for same running speed with PEK showing better weight loss out of the 3 gears. It is also observed that as the working speed increases amount of weight loss also increases in all the gears irrespective of the materials.

As we cannot completely rely on analytical work to determine weight loss, the reason being a lot of factors goes unaccounted in analysis work as compared to actual working condition, so we have instead gone for experimental testing .The unit of results is differing the reason obviously being the kind of method implied to achieve our desired results.

Analytic analysis gives support to the idea theoretically and in mathematical equation. On the other hand, experimental analysis shows whether the idea is physically implementable or not. For the system to be sound it is very necessary for a harmony between these two analyses.

VII. CONCLUSION AND FUTURE SCOPE

The basic objective of this project is to recommend a design for spur gear by changing material of gear which can primarily eliminate wear and other undesirable properties. The material used in this study is polyether ketones (PEK) which have properties such as high wear resistance, high strength to weight ratio, self-lubricating, non-corrosive, and excellent mechanical properties over a wide temperature range Analytical and Finite Element Methods are applied to check the Bending stress produced in the spur gear. The results show that spur gear made from PEK has more bending strength than Cast Iron and nylon Spur gear. Also, the Density of PEK is less than the cast iron.

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So, by replacing cast iron Gear by PEK gear we can achieve high strength, Low Weight and Noise free Motion of Gears. In this study the standard method is used for design of gear and Archard's wear equation for calculating theoretical volume of wear rate and ANSYS 15.0 for analysis of gear for analytical calculation. Both theoretical and analytical calculation shows that in Polyether ketone gear bending stress is less hence tangential tooth load is less as compared to Cast iron, Nylon which have high tooth load and chances of failure is also more. Thus, it can be justified that material that can be used in gear designs where wear can be a major concern is PEK which have following properties summarized in the following table.

Table 9: Recommended material properties

Density (kg/m^3)	Young's Modulus (MPa)	Yield Strength (MPa)	Wear Coefficient (K)	Hardness	Poisons Ratio
1300	4200	110	0.5*10e-15	90	0.4

Result shows that Spur gear made up of polyether ketone (PEK) has high wear resistance than other materials. As in cast iron gear, volume of wear per unit length is very much higher than then volume of wear per unit length in polyether ketone (PEK) gear, hence polyether ketone materials can technically and economically replace the cast iron in gear application where wear is major concern. The results found by FEM method is nearly equal to results found by experimental method. The module is important geometrical parameter during the design of gear. Therefore, selection of proper module size is an important factor before designing gear maximum contact stress decreases with increasing module.

Table 10: Summary of Wear Volume

Parameters	Units	PEK	Cast Iron	Nylon
Contact Pressure	MPa	20.81	166.42	31.85
Wear coefficient	m^3/Nm	$0.5x10^{-15}$	$5x10^{-15}$	$1x10^{-15}$
Volume of wear/m^3	m^3	$2081x10^{-15}$	$8321x10^{-15}$	$3185x10^{-15}$

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VIII. FUTURE SCOPE

Every machine has scope for its future modification in dimension for gaining more and more beneficial output with least input. Being technology, it comes under research and development activity. Our project being limited to time; it still has many scopes for its future development as follows:

A. The gear can be developed further to be more compact and lighter in weight.
B. The potential application of the polymer gear has been defined that includes the Rapid prototyping i.e. 3D printing, Printers, watches, food processors, windshield wiper drives. Hence the gear body can be improved so as to sustain higher temperature arising in certain situation in the future.
C. Metal material in gear application can be replaced by PEK material in many systems.
D. PEK material has a higher durability and strength. These materials can improve the life of the gear. Soon in the future these materials might get cheap and will aid in production of gear system.
E. Various composite materials can be applied instead of currently used materials.
F. The input conditions can be varied to parameters and study on wear, friction can be extended.

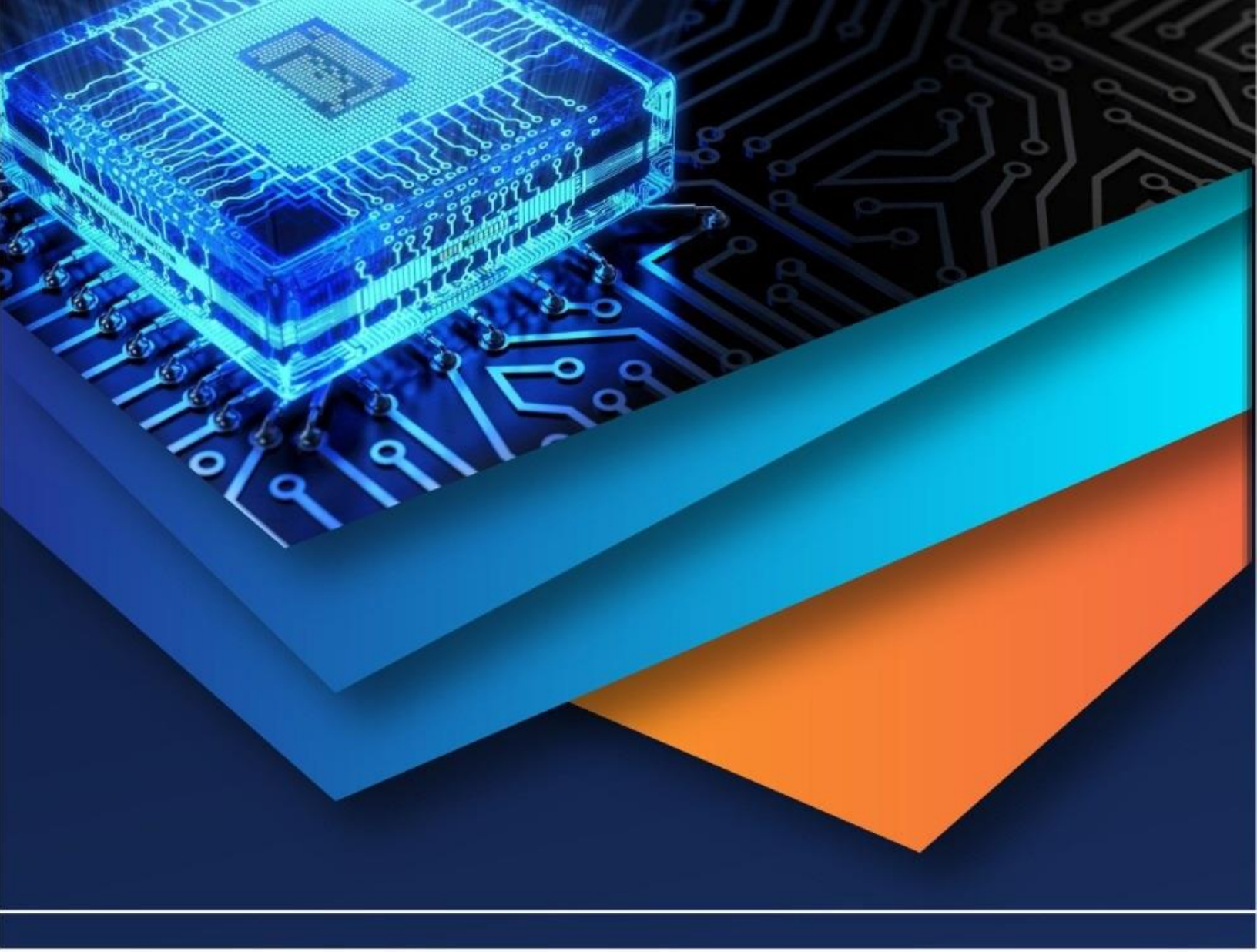
This project is about designing of spur gear by replacing metal by polymer PEK. It aims to promote technology innovation to achieve a reliable and efficient outcome from Gear system. The day is not far when this technology will push its way into your house hold, making you lazier. This project presents the major features and functions of various concepts that could be used in this field in detail through various categories. Since this initial work cannot address everything within the proposed system design and vision, more research and development efforts are needed to fully implement the proposed system of various.

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