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RESEARCH ARTICLE OPEN ACCESS

Investigation and Analysis of Spur Gear Using Different Composite Material

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Abstract:
The title entitled "INVESTIGATION AND ANALYSIS OF SPUR GEAR USING DIFFERENT COMPOSITE MATERIAL" was taken under with the objectives to design and develop composite spur gear and fabricate apple peeler machine. The focus of the manufacturing industry is on the development of newer materials in order to meet the forthcoming worldwide difficulties of supplying safe manufactured materials with particular and well defined properties. Composite materials constitute one of the favorable material zones for tomorrow's sustainable future through identification of materials with higher strength to weight ratio. Therefore, finding some alternative material for automobile applications to accelerate the Indian composite industry is imperative. An attempt has been made to develop light weight, more pressure sustainable and reduce friction industrial components with required properties using composite materials.
Research work is related to spur gear in this thesis first explains what gear is, types of gears in thesis we have explained why choose composite material and its benefits then material is then entered to CREO and ANSYS software and finally fabricate a 1100 Aluminum alloy and composite material spur gear and tested the gear by various loading platform i.e. Tensile test, compressive test and brinell hardness test. The application is apple peeler so apple peeler machine is made and finally after taking the result, it was proved why composite spur gear is good as comparative 1100 aluminum spur gear
Keywords: Spur Gear, 1100 Aluminum Alloys, Epoxy Resin and Silicon Carbide**.**

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I. INTRODUCTION

The goal was achieved by designing and manufacturing composite spur gear to weight reduction, vibration reduction and more pressure sustainability than 1100 aluminum alloys spur gear Gearing is one of the most critical components in a mechanical power transmission system, and in most industrial rotating machinery.

Apple Peeler machine is a device spur gear in a proposed project Usually the spur gear material is structural steel and aluminum alloy has used. But here in the project we finding some new material for making spur gear which reduces weight, vibration reduction and more pressure sustain. Finally,

Comparing and analyzing of the composite gear with existing 1100 aluminum alloys (Al) gear is carried out.

II. LITERITURE REVIEW

Journal papers and patents explored here are related directly or indirectly to the proposed area of work that is modeling and development of space saving seating arrangements. These papers are to support and enlighten the whole process of design in the specific area.
The literature review mainly focuses on replacement of aluminum (AI) with the epoxy resin and silicon carbide within the application of apple peeler machine.

A.Thirugnanam, et.al(2014) The researcher discuss to more than metals in while there are undoubtedly drawbacks to using plastics for gears, the functional and economic benefits far exceed them for many applications. Thermoplastics used in engineering are among those that can be used. They play a crucial role in this industry. Engineering plastics refer to thermoplastics that can be used as a substitute; these materials are most useful in the production of plastic gears. Since the notion of "Engineering plastics" is rather flexible, it is challenging to classify these materials precisely. The primary focus of this project is on developing gears with non-traditional materials. All engineering materials come from finite resources, and their prices continue to rise. A gear is designed and modeled using composite material because of its lower cost and ability to tackle the challenge. A spur gear made from Nylo Cast will be designed and analyzed in this project. The static stress data will be compared to that of more commonly used steel gears.

Mrs.S.Kousalya Devi, et.al (2013) Introduced the investigation, a spur gear made from a composite material was developed, modeled, and analyzed using finite elements. Spur gears often use mild steel or cast iron for construction. Composites have a number of advantages over more traditional building materials, including reduced weight, rust resistance, and maintenance needs. Spur gears are modeled in Solid Works, while FEA is performed in Ansys. The research found that short carbon reinforced (SCF) nylon is preferable to cast iron or mild steel for applications with loads less than 1500 watts.

Utkarsh.M.Desai, et.al (2015) when it comes to power transmission, a spur gear is both the most typical and elementary option. Teeth failure occurs when bending stress is applied to a spur Gear. To be sure, it has been noted that the spur gear's performance is not adequate in certain applications, thus it is necessary to investigate some other materials to enhance the gear's performance. Composite materials are becoming a more viable option to replace metal gears since they are strong enough without being too heavy. In this project, an Alloy Steel metal gear is swapped out for a Poly-ether-ether-ketone (PEEK) composite gear with a 30% glass fill. (PEEK). Composites have significantly enhanced mechanical qualities compared to traditional materials, including a higher strength-to-weight ratio, greater hardness, and decreased likelihood of failure. In this study, the feasibility of using composite materials, such as polyetheretherketone (PEEK), to replace metallic gears is evaluated. In the end, SOLID WORK is used for spur gear modeling, while ANSYS V14 is used for bending stress analysis.

Prajwal Gedam, et.al (2015) Researcher design and analysis the composite material spur gear material is carbon fiber and epoxy resin materials Gear is the most crucial parts of every transmission of mechanical power and nearly all industrial machinery. Due to their excellent durability and compactness, gears may become the dominant method of power transmission in future machines. Additionally, a better use of gear technology is required due to the rapid movement industries ranging from the construction of large ships to very lightweight vehicle production and office automation equipment. However, we still need to prolong the gear's service life, which is why the spur gear model can be created in design software. In order to accomplish this, we must investigate the effects of stress distribution and weight reduction on cast steel and composite materials. Researching how cast steel and composites fare under impact analysis and torque loading. Finally, the composite gear will be compared to conventional gear materials including steel, carbon fiber, and cast iron.

V. Siva Prasad, et.al (2012) Fabricate a composite spur gear its design & analysis were first introduced. To lessen its footprint and decibel output, this study suggests replacing the sugarcane juice machine's metal gear with a plastic one. Nylon and polycarbonate, two types of plastic, were evaluated for this, and their viability was compared to that of their metal analogues. (Cast iron) The optimum plastic for the job is suggested after a thorough static study. The ANSYS 10.0 static analysis software was used to examine a three-dimensional model. Nylon gears, as opposed to Cast iron spur gears, can withstand the lighter loads required by the sugarcane juice machine.

III. METHODOLOGY

In this study read near about 150 research paper then studied their properties and composition finally compared Aluminum spur gear as replaced to composite material spur gear

Flow on methodology:

- Study of research material.
- Literature review.
- Material selection.
- Development of composite material spur gear
- Properties & Calculation.
- Different concept of CAD modeling with PRO/E.
- Finite element analysis on models in ANSYS V19.2.
- Analysis with ANSYS V19.2
- Fabrication of spur gear & Testing.
- Ergonomics details
- Fabrication of Pedal operated apple peeler machine and its calculations.

In this project first I studied about 150 research paper then found outstanding research paper and extracted the properties also found new materials.

Table.1 Mechanical Properties of Aluminum (Al) & Composite material gear.

	Aluminum (Al)	Epoxy resin / Silicon carbide(Sic)
Density	2700 kg/m3	2150 kg/m3
Young modulus	150 GPA	226 GPA
Poisson's Ratio	0.3	0.3
Tensile strength	110 MPa	157 Mpa
Compressive strength	140MPa	170MPa
Modulus of Elasticity	70.3 GPA	193 GPA

After checking the 1100 aluminum alloys, epoxy resin and silicon carbide properties like its density, poissions ratio, tensile and compressive strength and modulus of elasticity now started CREO and ANSYS design.

CREO MODELING:

Fig.1 Creo (Meshing of teeth)

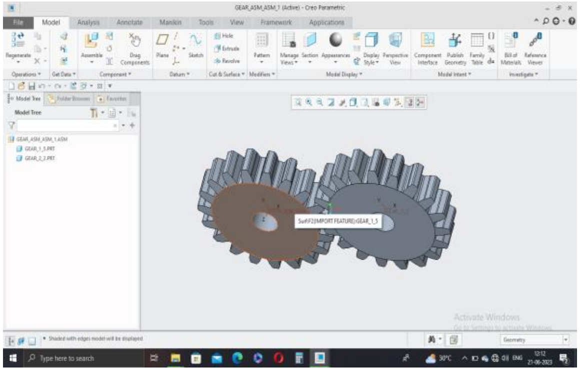

Fig.2 Creo Modeling Gear

CREO analysis and design is completed then checking all parameter I.e. proper meshing, stresses, friction so I will enter CREO design into the ANSYS V19.2 software so that install ANSYS V19.2 software because ANSYS V19.2 is the latest version.

ANALYSIS WITH ANSYS V19.2:

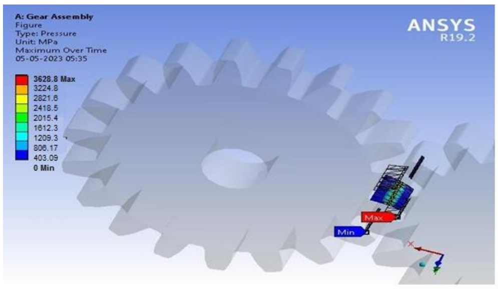

Fig.3 Pressure sustain

In above figure the various colours are indicating the quantity of how much gear
sustain a pressure at different loads. Red colour indicates the highest pressure sustain the highest pressure sustainable is in
the gear showing 3.62 KN and blue colour indicates the lowest pressure sustain is in the gear showing 0.409 KN Form it can be clearly seen that initially pressure sustain was minimum and then it is continuously increasing gradually

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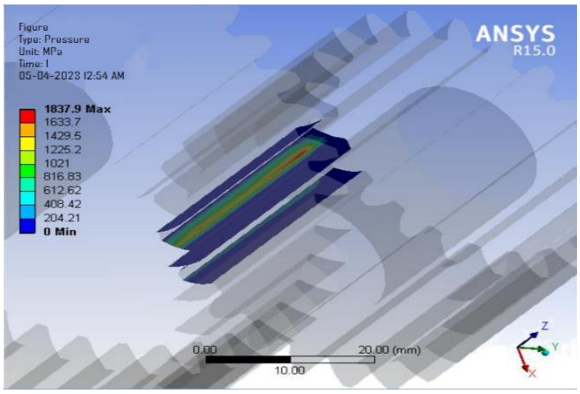

Fig.4 Pressure sustain

In above figure the various colours are indicating the quantity of how much gear sustain a pressure at different loads. Red colour indicates the highest pressure sustain the highest pressure sustainable is in the gear showing 1.83 KN and blue colour indicates the lowest pressure sustain is in the gear showing 0.204 KN Form it can be clearly seen that initially pressure sustain was minimum and then it is continuously increasing gradually.

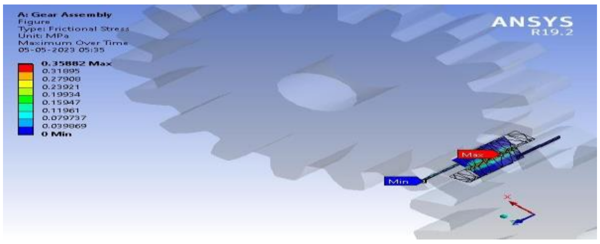

Fig.5 Friction sustain

In above figure the various colours are indicating the quantity of Frictional Stresses at different locations. Red colour indicates the highest Frictional Stresses the highest friction is in the gear showing 0.358 and blue colour indicates the lowest Frictional

Stresses is in the gear showing 0.03 Form it can be clearly seen that initially Frictional was minimum and then it is continuously increasing gradually but ANSYS shows that the friction gear is not high and this gear will remain safe.

After the design and analysis of epoxy resin and silicon carbide Now, I have design and analysis the 1100 aluminum alloys and find out the result

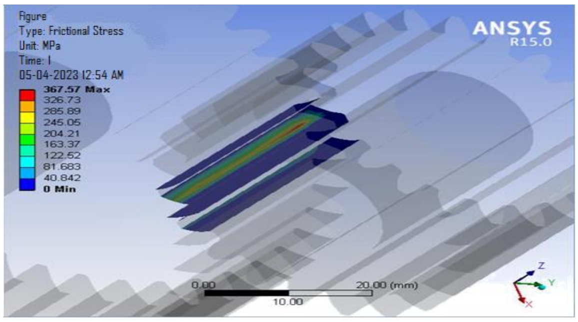

Fig.6 Friction sustain

In above figure the various colours are indicating the quantity of Frictional Stresses at different locations. Red colour indicates the highest Frictional Stresses the highest friction is in the gear showing 0.367 and blue colour indicates the lowest Frictional Stresses is in the gear showing 0.408 Form it can be clearly seen that initially Frictional was minimum and then it is continuously increasing gradually but ANSYS shows that the friction gear is not high and this gear will remain safe.

After the CREO and ANSYS design and analysis process I started 1100 aluminum alloys spur gear and composite material means epoxy resin and silicon carbide spur gear manufacturing process firstly I got information what is the procedure for making spur gear how it is manufactured, what is gear machining, hobbing, hobbing speed, broaching, milling, shaving, grinding then started spur gear manufacturing process

Fabrication Process for manufacturing Epoxy Resin & Silicon Carbide Composite material Spur Gear-

After making an 1100Aluminum alloys (Al) mould, for moulding purpose we use clay art instead of moulding sand.

Clay is mineral-rich, naturally occurring, and fine-grained dirt.

Fig.7 Clay material

After that we built up a precise mould using 1100 aluminum alloys (Al) spur gear

Fig.8 Clay Mould

After that the epoxy resin is providing with two parts a Resin and a Hardener. Resin and the hardener are mixed in the ratio 2:1. Then Silicon carbide is a particle form is added then poured in the mould cavity & leaves it to set for 70-72 hrs for getting perfect hardness.

Fig.9 Composite Material Pouring

After 72hrs, take the gear out of cavity and wash it gently with water. Now, composite (epoxy resin & silicon carbide) gear is ready to use in the assembly.

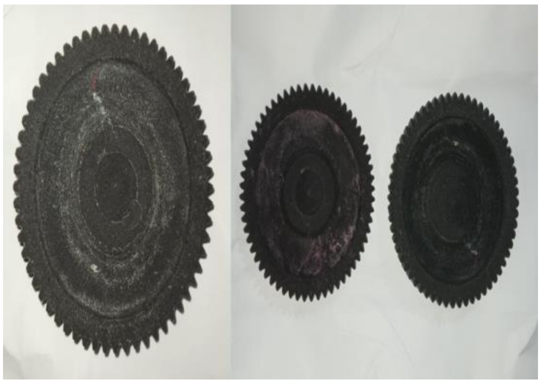

Fig.10 Composite Gear

Then again went to the workshop and use there are five main methods of surface finishing used in gear manufacturing. Once the gear was ready I went to the PRMIT& R, Badenra College Lab and measured the pitch, addendum, dedendum, circular pitch, pitch outside diameter, teeth height, and backslash, and face width, total depth, pressure angle and module of the gear with a tool maker microscope

Fig.11 Tool Making Microscope Testing At PRMIT&R,Badnera

3.11 TESTING PROCEDURE:

Pitch, addendum, dedendum, circular pitch, pitch outside diameter, teeth height, backslash, face width, total depth ,pressure angle and module of the gear is measured on the tool maker microscope and with the help of clay manufacturing method process made three composite material rods and three composite materials blocks are prepared for tensile ,compressive and brinell hardness test

Now after fabricated composite gear 3 rods (50% - 50%, 60% - 40% and 70% - 30%) and 3 blocks are prepared for tensile, compressive and hardness testing.

Fig.12 Composite material Rod & Block

Authentic research we have run a testing on each rods and blocks of composite material to determine its properties and how it will fare in the project's real-world settings. Our project specimen has been put through the following tests:

1) UTM Tensile test
2) UTM Compressive Test
3) Brinell Hardness Test

TENSILE TEST:

I will do the tensile test in PRMIT&R; Badnera College a tensile test

Components having a diameter of 18 mm and a gauge length of 168 mm were machined from the composites and tested for tension strength. The tests were run using a universal testing machine (UTM) that was connected to a computer for later software-assisted analysis. All tests were performed at ambient temperatures.

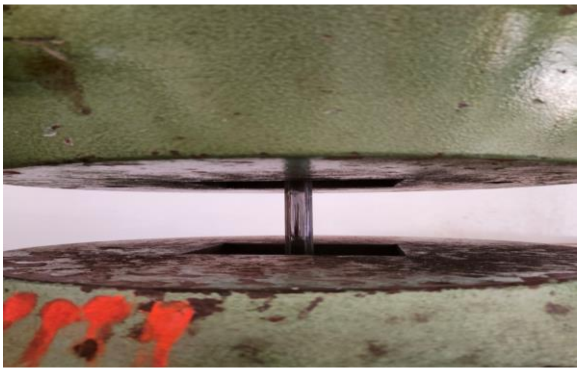

Fig.13 UTM (Tensile Test)

At a strain rate of 0.6 mm/min and in displacement control mode, a 19.6 KN universal testing machine was used to characterize the tensile properties of an epoxy resin and silicon carbide composite material. The tensile strength of the epoxy resin & silicon carbide composites increases at 20wt%.

UTM Compressive Test:

The Universal Testing Machine (UTM) is used to conduct both tensile and compression tests. The compression (force-deformation) test is fundamental to and one of the most crucial analyses for determining the mechanical properties of fresh produce. The force deformation test demonstrates the product's response to varying degrees of compression. The specimen dimensions for the compression test are 12 mm in diameter and 20 mm in length.

Fig.14 UTM Compressive Test

Brinell Hardness Test:

Fig.15 Brinell hardness Tester Machine

FABRICATION OF APPLE PEELER MACHINE:

After fabrication the 1100 aluminum alloys, epoxy resin and silicon carbide composite material spur gear and testing its tensile, compressive and brinell hardness test now next step to design apple peeler machine in CREO software then brought the shaft, apple peeler cutter, frame material, mug, pedal for manufacturing apple peeler machine.

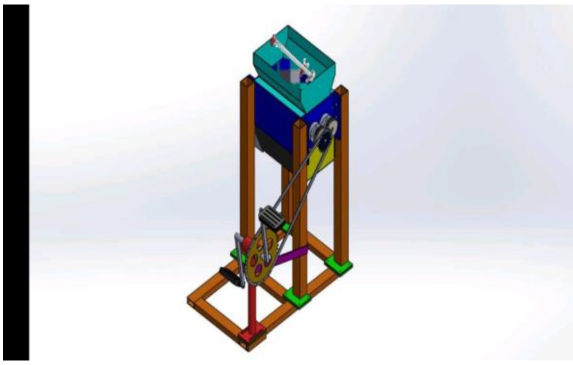

Fig.16 Pedal operated apple peeler machine using CREO Software

Material Requirement**:**

- Frame
- Apple peel Cutter
- Shaft
- Chain and Sprocket wheel mechanism
- Pedal

Fig.17 Pedal operated apple peeler machine

IV. RESULT AND DISCUSSION:

Comparison of 1100 aluminum alloys spur gear & composite material spur gear (Consisting of Epoxy resin & Silicon carbide)

Table.2 Analysis result 1100 Aluminum spur gear.

Sr.No	Applied Force	Compressive Strength
1	18.2 KN	98 MPA

Table.3 Analysis result of composite material Spur Gear (Epoxy Resin & Silicon Carbide)

Module in mm	Equivalent (Von Mises) Stress (Max.)MPa	Pressure (Max.) KN	Frictional Stress (Max.)MPa
1.55	0.8	3.6278	0.35882

Table.4 Tensile test result of Composite materials spurs gear (Epoxy Resins & Silicon Carbide)

The result of mechanical properties testing shows not much difference between them given different composition and the strength decreases in proportion to an increase in the amount of in filler material composition.

The results are compared with the 1100 aluminum alloys materials used for making gears, one metals and polymer material used for gear making is taken and their strength are compared the following table give the comparison between the materials.

Sr. No	% of Epoxy Resin added	% of Silicon Carbide added	Applied Force	Tensile Strength
1	50%	50%	19.550 KN	116 MPA
2	60%	40%	19.35 KN	115 MPA
3	70%	30%	19.12 KN	113 MPA

Table.5 Tensile test result of 1100 Aluminum alloy spurs gear

Table.6 Compressive test result of Composite materials spurs gear (Epoxy Resins & Silicon Carbide)

Sr.No	% of Epoxy Resin added	% of Silicon Carbide added	Applied Force	Compressive Strength
1	50%	50%	30.350 KN	151 MPA
2	60%	40%	36.280 KN	180 MPA
3	70%	30%	39.452 KN	196 MPA

Table.7 Compressive test result of 1100 Aluminum alloy spurs gear

Sr.No	Applied Force	Compressive Strength
1	29.165 KN	145 MPA

Table.8 Composite materials (Epoxy Resin and Silicon Carbide) Brinell hardness test result:

Material	Ball Dia.(mm)	Test Load (Kgf)	Dia. of Indentation	Brinell Hardness No.
Epoxy Resin and Silicon Carbide	10 mm	1000	3.1 mm	130
		1500	3.7 mm	134
		2000	4.1 mm	145
		2500	4.3 mm	164
			4.4 mm	188

Table.9 1100 Aluminum alloy Brinell hardness test Result:

Material	Ball Dia.(mm)	Test Load (Kgf)	Dia.of Indentation	Brinell Hardness No.
1100 Aluminum alloy	10 mm	1000	2.4 mm	117
		1500	2.9 mm	133
		2000	3.2 mm	141
		2500	3.5 mm	142
		3000	4 mm	143

V. CONCLUSION EXPERIMENTAL INVESTIGATION:

It can also be seen from the table that the density of the composite material made of epoxy resin and silicon carbide is significantly lower than the density of 1100 aluminum alloy, which results in a significant decrease of weight in the case of the composite material that we have demonstrated to be effective in power transmission.

It was found that the compressive strength of composite material is higher than that of 1100 Aluminum Alloy by around 10–20 percent indicates that composite material can withstand more compressive stress. This was shown from the results.

It is also seen that the pressure sustainability in composite material is higher indicating in the 1100 Aluminum alloys, the maximum pressure sustainable is found to be 19.550KN, while in composite material, epoxy resins and silicon carbide are discovered. This is seen by looking at the table.

The stresses that are formed in composite material also found to be higher in composite material. This means that composite material is more dependable for the higher stresses that are generated during the functioning of spur gear in comparison to 1100 Aluminum Alloy spur gear material. The frictional stress resulted in lower composite material stress than 1100 Aluminum alloys.

Epoxy resins and silicon carbide appear to be the better alternatives to the 1100 Aluminum Alloy when it comes to replacing the spur gear material. This is based on the result that was presented earlier.

CONCLUSION FROM ANSYS:

In this study Role of ANSYS is to validate the Design and validate the data sample collected form data collection instrument i.e. experimental investigation. 3rd chapter explain detail study about analysis done in ANSYS Fluent module.

AS the stresses generated by a composite made of epoxy resin and silicon carbide are lower than those generated by 1100 Aluminum Alloys at around 55%, this gives rise to a reduction in stress in the case of composite materials, and this has led to successful results in gear. The stresses that are formed in composite material also found to be higher in composite material. This means that composite material is more trustworthy for the higher stresses that are generated during the functioning of spur gear in comparison to 1100 Aluminum Alloy spur gear material.

In the 1100 Aluminum Alloys, the Maximum pressure sustainable was found to be 1.837 KN, while in the composite material of Epoxy Resin and Silicon Carbide, the maximum limit was found to be 3.6278 KN. This can be observed by looking at the ANSYS table, which shows that the pressure sustainability in composite material is higher. This means that the maximum pressure sustainable in the 1100 Aluminum Alloys was 1.837 KN. It is very obvious that composite materials were unable to endure too much pressure. It can also be seen that there is less friction in composite materials by looking at the ANSYS table. This means that the maximum friction that can be found in 1100 Aluminum Alloys is 0.3675 MPa, but the maximum friction that can be found in composite materials containing Epoxy Resin and Silicon Carbide is 0.35882 MPa. This shows that composite materials produce less friction than aluminum alloys.

Form above the ANSYS result it seems that Epoxy Resins and silicon carbide is an effective replacement for the 1100 Aluminum Alloy to replace for the material of a spur gear.

In the comparison between ANSYS and Experimental investigation, graphs shows that both graphs are following near about same patterns. It means they are forming good agreement in between them.

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