Design and Analysis of Composite Spur Gear using Al-Ti Materials

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***Abstract*:- Gears are the simplest and most widely used components in power transmission. It is required to operate machines at varying load and speed. Gear teeth can normally fail when the load is increased beyond a limit .Apart from other metallic gears composite materials provide much improved mechanical properties such as better strength to weight ratio, hardness and hence less chance of failure. So in this project Aluminium Titanium is used in manufacturing gears. Composite materials can be improved in properties over steel alloys and cast iron and hence these can be used as a better alternative for replacing a metallic gears. To design the spur gear model using designs software and To study the structural analysis for existing and composite materials. Finally, comparing the results for ansys and experimental test of the composite gear with existing gear.**

Keywords:- Gear, Aluminium, Titanium, Composite, Hardness, Strength to weight ratio, Structural analysis, Experimental test

1. INTRODUCTION:

To design the spur gear to study the weight reduction and stress distribution for existing and composite materials. Gearing is one of the most critical components in a mechanical power transmission system, and in most industrial rotating machinery. It is possible that gears will predominate as the most effective means of transmitting power in future machines due to their high degree of reliability and compactness. Gears are used for transmitting power from one part of a machine to another. Gears can increase or decrease the speed of rotation and can easily be used to reverse the direction of rotation. In addition, the rapid shift in the industry from heavy industries such as shipbuilding to industries such as automobile manufacture and office automation tools will necessitate a refined application of gear technology. A gearbox as usually used in the transmission system is also called a speed reducer, gear head, gear reducer etc., which consists of a set of gears, shafts and bearings that are factory mounted in an enclosed lubricated housing. Speed reducers are available in a broad range of sizes, capacities and speed ratios. Their job is to convert the input provided by a prime mover (usually an electric motor) into an output with lower speed and correspondingly higher torque.

2. METAL MATRIX COMPOSITES:

An aluminum based metal matrix composite should have the high ductility and fracture toughness of the aluminum matrix and the high elastic modulus of the reinforcing phase.Aluminum based metal matrix composites containing particulate reinforcements are usually limited to ambient temperature applications because of the large mismatch in higher temperature strength between the aluminum Another problem with aluminum based metal matrix composites is the difficulty of producing a bond between the matrix and the reinforcing phase. To produce such a bond, it is often times necessary to vacuum hot press the material at temperatures higher than the incipient melting temperature of the matrix. It has been proposed that this technique be avoided by mechanically alloying the matrix with the addition of the particular reinforcement. This procedure, referred to as solid state bonding, permits the reinforcing phase to be bonded to the matrix without heating the material to a temperature above the solidus of the matrix. Prior processes in which aluminum based alloys and/or metal matrix composites are mechanically alloyed by means of solid state bonding. The low density and high specific mechanical properties of aluminum metal matrix composites (MMC) make these alloys one of the most interesting material alternatives for the manufacture of lightweight parts for many types of vehicles. With wear resistance and strength equal to cast iron, 67% lower density and three times the thermal conductivity, aluminum MMC alloys are ideal materials for the manufacture of lightweight automotive and other commercial parts.

2.1ALUMINIUM ALLOY 7075:

Aluminium is a silvery-white metal, the 13th element in the periodic table. One surprising fact about aluminium is that it's the most widespread metal on Earth, making up more than 8% of the Earth's core mass. It's also the third most common chemical element on our planet after oxygen and silicon. It is one of the lightest metals in the world: it's almost three times lighter than iron but it's also very strong, extremely flexible and corrosion resistant because its surface is always covered in an extremely thin and yet very strong layer of oxide film. 7075 Aluminium alloy is an aluminium alloy with zinc as the primary alloying element .It is strong,with a strength

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comparable to steels and has good fatigue strength and better corrosion resistance.It is a composition of 5.6-6.1% Zinc,2.1-2.5%Magnesium,1.2-1.6% Copper and less than a half percent of Silicon,Iron,Manganese, Titanium,Chromium and Other materials

Atomic Number	13
Melting Point (°C)	660.2
Boiling Point (°C)	2480
Density (g/cm^3)	2.6898
Modulus of Elasticity (GPa)	68.3
Poisons Ratio	0.34

2.2TITANIUM-GRADE 12:

Titanium is a chemical element with symbol Ti and atomic number 22. It is a lustrous transition metal with a silver color, low density, and high strength. Titanium is resistant to corrosion in , sea water aqua region, and chlorine. Titanium can be alloyed with iron , aluminum,vanadium and molybdenum among other elements, to produce strong, light weight alloys for aerospace (jet engines missiles and spacecraft, military, industrial processes (chemicals and petrochemicals, desalination plants pulp, and paper).

It holds an excellent rating for it's high quality weldability and highly durable alloy that provides a lot of strength at high temperatures It composition of 0.08% Carbon,0.20-0.40% Manganese,0.60-0.90% Nickel,0.30% Iron and and other metals

PROPERTY	VALUE
Atomic Number	22
Melting Point (°C)	1650-1670
Boiling Point (°C)	3287
Density (g/cm^3)	4.50
Modulus of Elasticity (GPa)	116
Poisons Ratio	0.34

3.1. PROPOSED MATERIAL-Al(90%)-Ti(10%)

S.NO	MATERIAL PROPERTIES	VALUES
1	Density (g/cm3)	3.141
2	Young's Modulus(Mpa)	72800
3	Poisson ratio	0.3

3.2 GEAR DIMENSIONS DETAILS:

- Pitch circle diameter (p.c.d) = 180 mm
- Number of teeth = 18
- Outside circle diameter = 200 mm
- Circular pitch = 31.4 mm
- Dedendum circle diameter = 156.86mm
- Dedendum = 11.57mm
- Addendum = 10 mm
- Module = 10 mm
- Fillet radius = 3.9 mm
- Thickness of the tooth = 15.71mm
- Face width (b) = 54 mm

3.3DESIGN CALCULATIONS:

TORQUE (T) = 13.8kg-m@2500rpm
T = 13.8 kg-m; T = 13.8*10 N-m
T = 138 N-m; T = 138000 N-mm
N = 2500 rpm.
POWER (P) = 2*3.14*2500*T/60
P = 2*3.14*2500*138/60; P = 36128 Watt
Power (P) = 36.128 K Watt.
Torque (T) = F*(d/2)
Where,
F-load,
d- Pitch circle diameter (z*m=180mm)T= F*(d/2)
F = T/ (d/2)
F = 138000/90
Load (F) = 1533.33N
Tangential load, F =b*y*pc*σb
Pc = 3.14*module
Pc = 31.4mm
Y= Lewis form factor=0.134mm
b = face width = 54mm
The maximum allowable stress= 8.7413N/mm2.
Ultimate tensile strength for cast steel = 540mpa
Ultimate tensile strength for composite = 52mpa
Allowable stress for cast steel = ultimate tensile strength/3 = 540/3 = 180N/mm2> 8.7413N/mm2
Allowable stress for composite = ultimate tensile strength/3 = 52/3 = 17.33N/mm2>8.7413N/mm2
So, the design is safe.

GEAR TOOTH PARAMETERS

- Pitch circle diameter (p.c.d) = z*m = 18*10 = 180mm
- Base circle diameter (Db) = D cos α
  = 180*cos20
  = 169.145mm
- Outside circle diameter = (z+2)*m= (18+2)*10 = 200mm
- Clearance = circular pitch/20 = 31.4/20 = 1.57mm
- Dedendum = Addendum + Clearance = 10+1.57 = 11.57mm
- Module = D/Z = 180/18 = 10mm
- Dedendum circle diameter = P.C.D -2*dedendum = 80-2*11.57= 156.86mm
- Fillet radius = Circular pitch/8 = 31.4/8 = 3.9mm
- Pitch circle diameter (Pc) = m*z = 10*18 = 180mm
- Hole depth = 2.25*m = 2.25*10 = 22.5mm
- Thickness of the tooth = 1.571*10 = 15.71mm
- Face width (b) = 0.3*180= 54mm
- Center distance between two gears = 180mm
- Diametral pitch = Number of teeth/P.C.D= 18/180= 0.1mm

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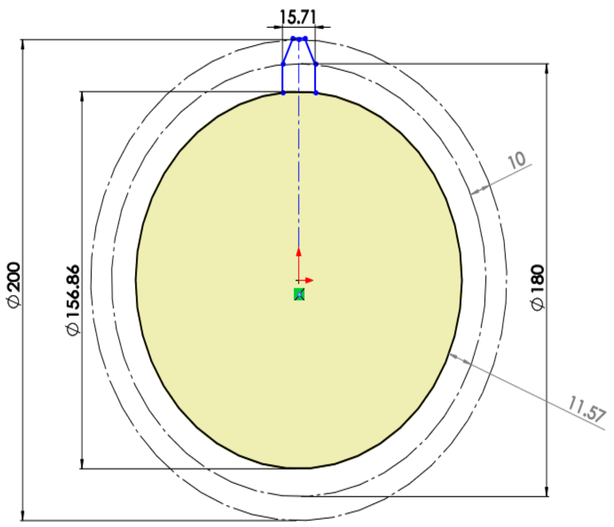

4. STATICSRUCTURAL ANALYSIS:

A static structural analysis were done to analyse the behavior of the structure under the steady loading conditions while ignoring inertia and damping effects, such as those carried by time varying loads. All types of non-linearity are allowed such as large deformations, plasticity, creep, stress stiffening, contact lements etc. this result will determined whether the structure will withstand for the applied external loads..

If the stress values obtained in this analysis crosses the allowable values it will result in the failure of the structure in the static condition itself. To avoid such a failure, this analysis is necessary. In this project the FEA based analysis tool were used to study the structural behaviour of the different composite material under the given boundary conditions by determining the total deformation.

Al(90%)-Ti(10%)-LOAD 12000N

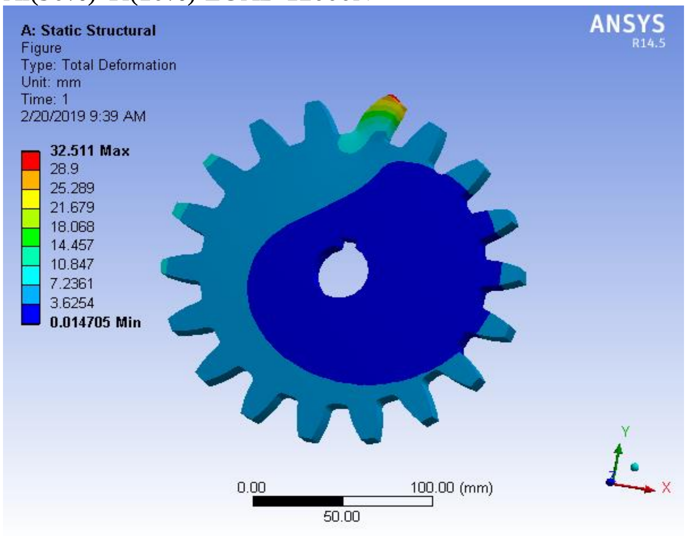

Fig 4.1- Deformation

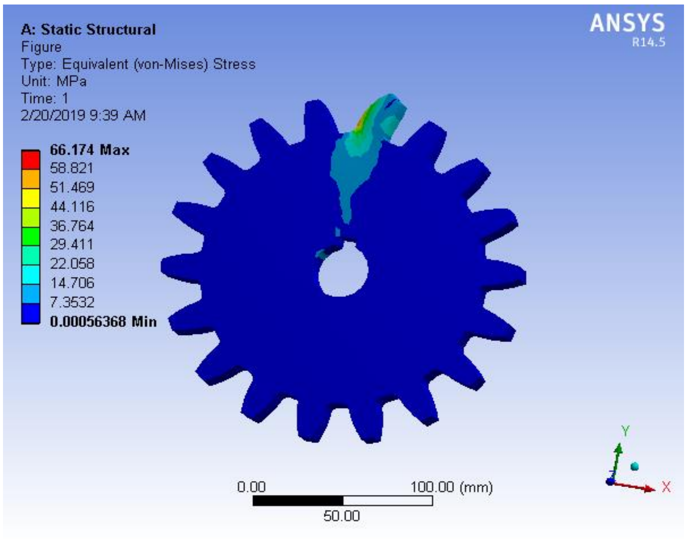

Fig 4.2- Stress

Al(90%)-Ti(10%)-LOAD 15000N

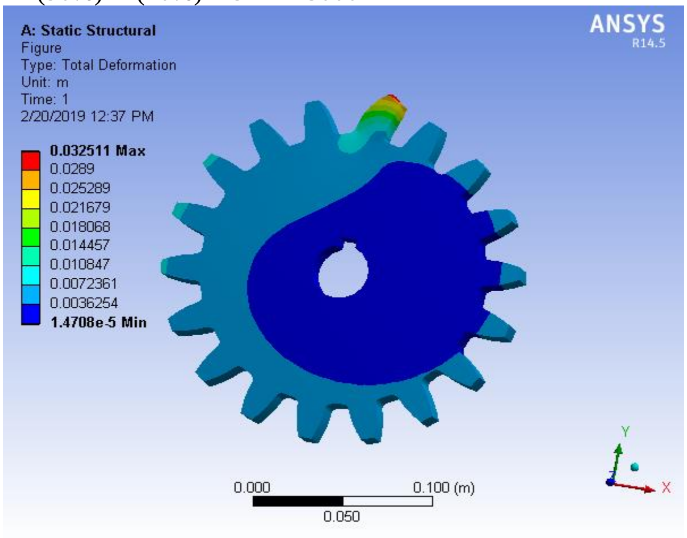

Fig 4.3- Deformation

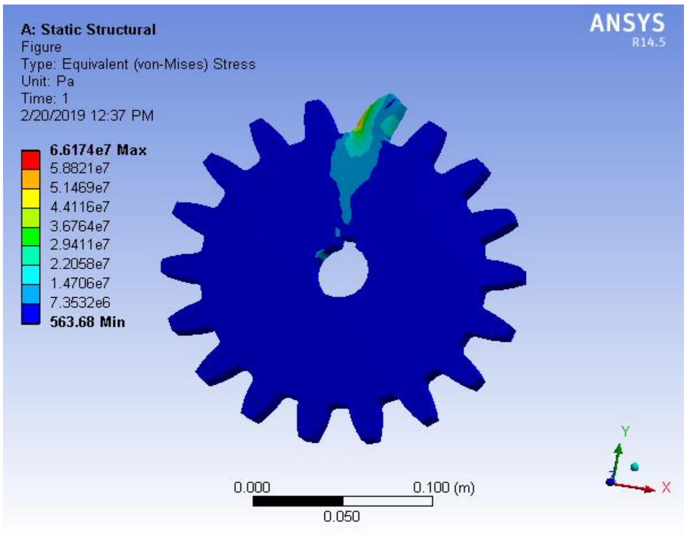

Fig 4.4- Stress

ANALYTICAL RESULTS

MATERIALS	PARAMETERS	LOAD 12000N	LOAD 15000N
Al(90%)-Ti(10%)	Deformation(mm)	32.511	0.0325
	Stress(N/mm^2)	66.174	6.6174*10^7

5.FABRICATION PROCESS-STIR CASTING METHOD

The stir casting is mostly used to produce the PRMMCs because it shown to be a very promising for the manufacture of near net shape composites in a simple and cost effective manner. Firstly the metal matrix composition is to be added and then the stirrer is switched on. The stirring speed can be variable, the constant speed for all metal matrix composite is around 600-800 m/s.The materials are added in powder or particulate or viscous form. In this project powder form of Aluminium and Titanium ingots are added. For attaining the wettability of the material borax powder is added. The amount of addition is for every gram 2-3% is added. The Aluminium and Titanium are added in the ratio of 90:10.

Apart from other casting methods, stir casting overcomes difficulties of other casting methods. The molten solution is then checked for any large particles of Titanium in Aluminium or it is fully dissolved in the solution. After that the material is poured into the pattern that is made in the mould.Then depending upon the solidification time of the material used, the mould is left for some time to solidify. Then the solid material is taken off the mould and is machined. In this project the specimen preparation is done for hardness, impact, tensile tests. The casted material is machined as per the standards for particular tests.

6.MECHANICAL TESTING METHODS:

The mechanical test can be conducted by the following parameters.To know about the material elongation,strength,hardness,withstand load capacity.

- Tensile Test
- Impact Test
- Brinell hardness Test

MATERIALS	TENSILE TEST		BRINELL HARDNESS TEST	IMPACT TEST (Joules)
	Ultimate Tensile load(KN)	Ultimate Tensile strength(N/m m^2)		
Al(90%)and Ti(10%)	19.46	120	81.3	58

7.ADVANTAGES:

- Composites are light in weight when compared with most metals
- Composite gear can be design to both strong and light weight .Hence It has more Strength to weight ratio when compared with other metals
- Composite gear can be more harder than other metals
- Composite material can be molded into complicated shape more easily than other metals
- Composites resists damage from whether
- Composite gear can have less porosity

8.APPLICATIONS:

- Automobile gear boxes
- Metal cuing machines
- Gear motors and Gear pumps
- Rack and Pinion mechanism
- Material handling equipment
- Steel mills
- Rolling mills
- Washing machines

9.CONCLUSION:

In this project Aluminium Titanium metal matrix composite material is suggested for the manufacture of spur gears. The MMC is prepared and tested by both mechanically and analytically. The results show that this MMC has properties that can replace the existing material that is used conventionally. Thus providing less weight,more life and withstand more load than conventional gears.It has better strength to weight ratio,better hardness than conventional gears.These gears can be able to transmit up to 40kW power. These gears can be used in automobiles and other machinery where spur gears find an application.

10.REFERENCES:

[1] S Rajeshkumar and R Manoharan, Design and analysis of composite spur gears using finite element method , IOP Conf. Series: Materials Science and Engineering 263 (2017) 062048

[2] Mrs.S.Kousalya Devi S,Finite element analysis of composite spur gear ,IJRDO-Journal of Mechanical And Civil Engineering ISSN: 2456-1479, Volume-3 | Issue-1 | January,2017

[3] M. Keerthi, K. Sandya, K. Srinivas, Static & Dynamic Analysis of Spur Gear using Different Materials,International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 03 Issue: 01 | Jan-2016

[4] Utkarsh.M.Desai, Prof.Dhaval.A.Patel,Modeling and stress analysis of composite material for spur gear under static loading condition International journal of advances in production and mechanical engineering,VOLUME-1,ISSUE-2,2015

[5] T. Albert*, C. Pravin Tamil Selvan,Preparation and Properties of Aluminium composite,International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2277-9655

[6] Chhabra Pankaj, Bhatia Amit, "Design and Analysis of Composite Material Gear Box", International Journal of Mechanical and Civil Engineering, Vol.1 (2012), Issue1,pp 15-25.

[7] Lijesh K.P. and Harish Hirani , Probabilistic Design of Spur Gear ,International Journal of Current Engineering and Technology E-ISSN 2277 – 4106

[8] El-Sayed S. Aziz*, Constantin Chassapis ,Probabilistic Simulation Approach to Evaluate the Tooth-Root Strength of Spur Gears with FEM-Based Verification ,Scientific research, Engineering, 2011, 3, 1137-1148

[9] R.M. Mohanty, K. Balasubramanian, S.K. Seshadri, Boron carbide-reinforced aluminium 1100 matrix composites: fabrication and properties, Materials science and engineering, 498(2008), p 42-52

[10] Ali Raad Hassan, „Contact Stress Analysis of Spur Gear Teeth Pair" WASET 58, 2009.

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ISSN: 2278-0181
Vol. 8 Issue 03, March-2019

[11] V.B.Bhandari,"Design of Machine Elements", 3rd Edition, Tata McGraw Hill Publication,(2013) pp-646-690 .
[12] Hashim J.,Looney L Hashmi M.S.J., Metal Matrix Composites: Production by the Stir Casting Method, Journal of Material Processing and Technology,(1999),pp. 17.
[13] VI. PSG Design Data Book, PSG College of Technology Coimbatore, 1966, pp 8.1-8.64