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Design Modelling & Stress Strain Analysis of Composite Spur Gear Used in Automobile

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***Abstract* - In this paper the spur gear made up of aluminum silicon carbide (Al-Sic) is analyzed for its load carrying capacity. Static stress analysis and modal analysis were performed for the 3-D model using finite element procedure. An attempt is also made to optimize the Al-Sic composite gear based on factor of safety (FOS) and displacement constrain. Performance of the Al-Sic composite gear of various face width is compared with that of the conventional steel gear. The aim of the present study is to focus on the reduction of the weight, in addition of SIC increases the strength of spur gear. It will be concluded from the analysis comparison of Al-Sic composite gear and gray cast-iron gear to find out which is suitable for making power transmission to transmit fairly large amount of power.**

INTRODUCTION

A gear is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque. Two or more gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, torque, and direction of a power source. The most common situation is for a gear to mesh with another gear; however, a gear can also mesh with a non-rotating toothed part, called a rack, thereby producing translation instead of rotation.

The gears in a transmission are analogous to the wheels in a pulley. An advantage of gears is that the teeth of a gear prevent slipping. When two gears of unequal number of teeth are combined, a mechanical advantage is produced, with both the rotational speeds and the torques of the two gears differing in a simple relationship.

In transmissions which offer multiple gear ratios, such as bicycles and cars, the term gear, as in first gear, refers to a gear ratio rather than an actual physical gear. The term is used to describe similar devices even when the gear ratio is continuous rather than discrete, or when the device does not actually contain any gears, as in a continuously variable transmission. The earliest known reference to gears was circa A.D. 50 by Hero of Alexandria, but they can be traced back to the Greek mechanics of the Alexandrian in the 3rd century B.C. and were greatly developed by the Greek polymath Archimedes (287–212 B.C.). The Antikythera mechanism is an example of a very early and intricate geared device, designed to calculate astronomical positions. Its time of construction is now estimated between 150 and 100 BC.

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LITERATURE REVIEW

P.B.PAWAR "Analysis of Composite Material Spur Gear under Static Loading Condition (2015)"Al-SiC composite have been prepared by stir casting and various mechanical tests are conducted for evaluating properties of composite. Following conclusions are drawn from the experimental work and numerical analysis done on gears, Al-SiC composite prepared by stir casting provides improved hardness, Tensile strength over base metal. Better results have been obtained at 18% SiC is added. Gears manufactured from composite provides almost 60% less weight compared to steel gear, while power rating of both gears remains almost same. FE Analysis also shows less chances of failure in Al-SiC gear. Almost 3-4% difference has been observed between theoretical and FEA values of bending stress. These gears can be used for transmitting almost 24kW power.

S.MAHENDRAN "Design and Analysis of Composite Spur Gear (2014)"The polymer gear wear rate will be increased, when the load reaches a critical value for a specific geometry. The gear surface will wear slowly with a low specific wear rate if the gear is loaded below the critical one. The possible reason of the sudden increase in wear rate is due to the gear operating temperature reaching the material melting point under the critical load condition. Actual gear performance was found to be entirely dependent on load. A sudden transition to high wear rates was noted as the transmitted torque was increased to a critical value. This is to be associated with the gear surface temperature of the material reaching its melting point. That is for a given geometry of actual gear, a critical torque can be decided from its surface temperature calculation.

ANUJ NATH "Design and Analysis ofthe Composite Spur Gear"The spur gear is simplest type of gear manufactured and generally used for transmission of rotary motionbetween parallel shafts. The spur gear is the first choice option for gears except when high speeds, loads andratios direct towards other options. Other gear types may also be preferred to provide more silent low-vibrationoperation. A single spur gear is generally selected to have a ratio range of between 1:1 and 1:6 with a pitch line velocity up to 25 m/s. The spur g ear has an operating efficiency of 98-99%. The pinion is made from aharder material than the wheel.A gear pair should be selected to have the highest number of teeth consistent with a suitable safety margin instrength and wear. The minimum number of teeth on a gear with a normal pressure angle of 20 degrees is18. This is a cylindrical shaped gear in which the teeth are parallel to the axis. It has the largest applications andit is the easiest to manufacture.

M. KEERTHI "Static & Dynamic Analysis of Spur Gear using Different Materials"The following conclusions can be drawn from the analysis conducted in this study. It was concluded that the stress values are calculated for composite materials is approximately same as compared to the structural steel, gray cast iron and aluminium alloy. So from these analysis results, we conclude that, the stress induced, deformation and weight of the composite spur gear is almost same as compared to the structural steel spur gear, gray cast iron spur gear and aluminium alloy spur gear. So, Composite materials are capable of using in automobile vehicle gear boxes instead of existing cast steel gears with better results.

DESIGN PROCEDURE:

· Gear Design Procedure

- Following are the Formulas used in Gear Design
- Module =m
- Face width =b
- Number of teeth on pinion =Z1
- Number of teeth on gear = Z2
- Speed of pinion = N1
- Speed of gear =N2
- Gear ratio or Transmission ratio = v v = Z2 / Z1

Design of Spur Gear 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
- Using Lewis equation,
- Tangential load, F =b*y*pc*σ b
- 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.

II. CALCULATIONS OF GEAR TOOTH PROPERTIES

- 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

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- 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

MATERIAL PROPERTIES:

AL-SiC (90%-10%)

property	AL-SiC (90%-10%)
Young's modulus, Mpa	$2*10^5$
Poisson ratio	0.3
Yield strength, Mpa	430
Density, kg/m^3	2900
Thermal conductivity W/mk	120

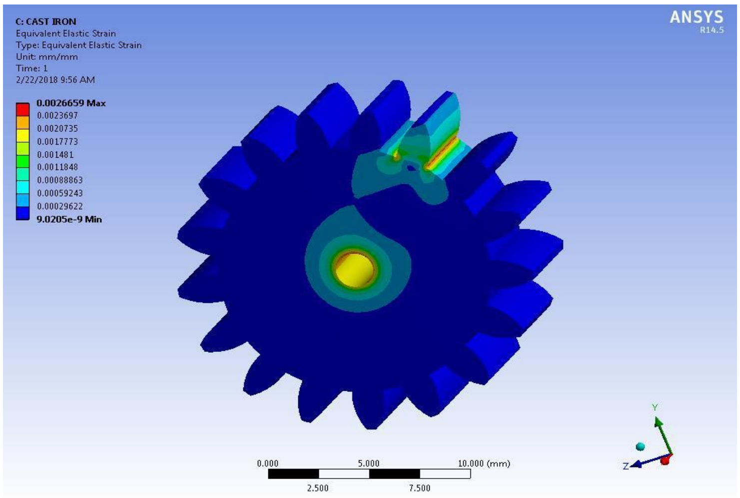
Gray Cast Iron

property	Gray cast iron
Young's modulus, Mpa	$1.1*10^{11}$
Poisson ratio	0.28
Yield strength, Mpa	98
Density, kg/m^3	7200
Thermal conductivity W/mk	52

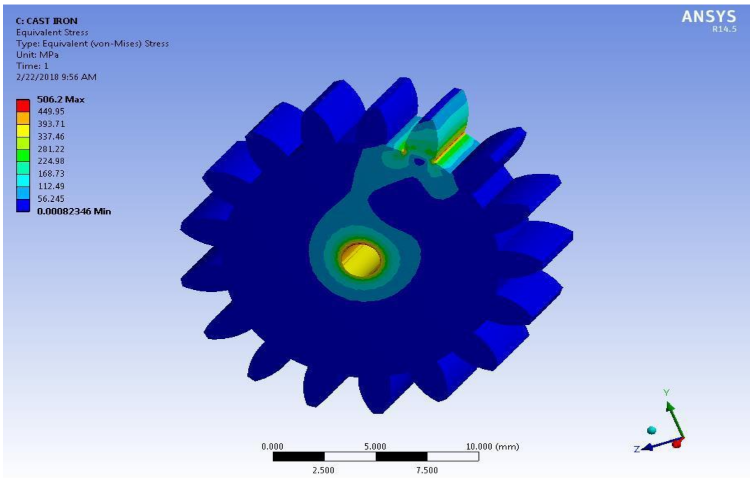
ANALYSIS RESULTS

CAST IRON:

EQUIVALENT ELASTIC STRAIN:



EQUIVALENT STRESS:



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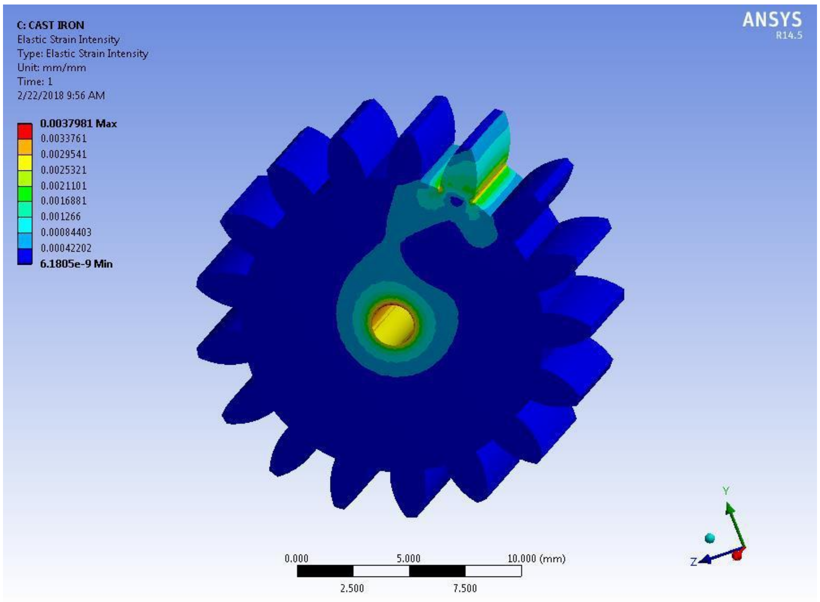
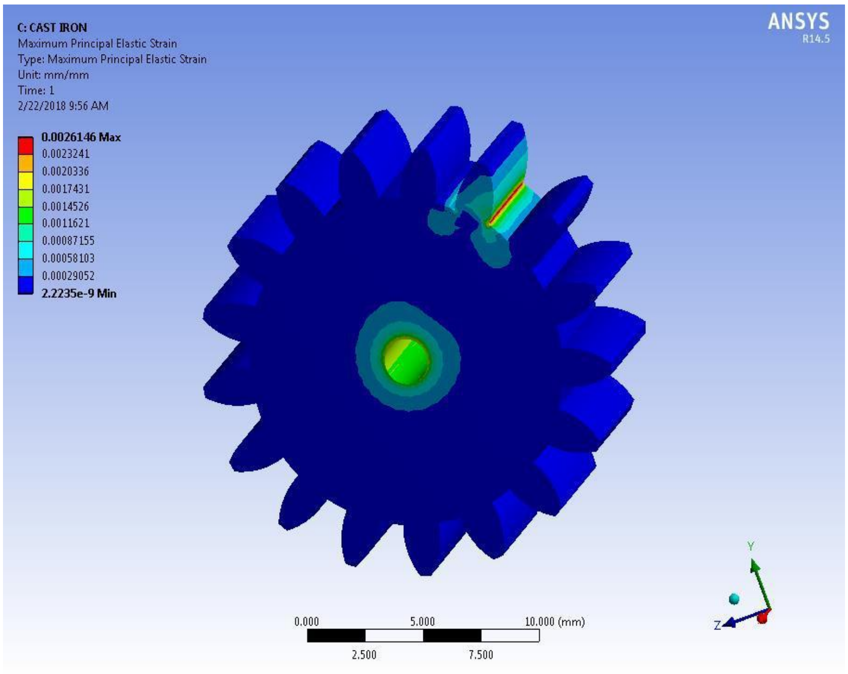
ELASTIC STRAIN INTENSITY:



MAXIMUM PRINCIPAL ELASTIC STARIN:



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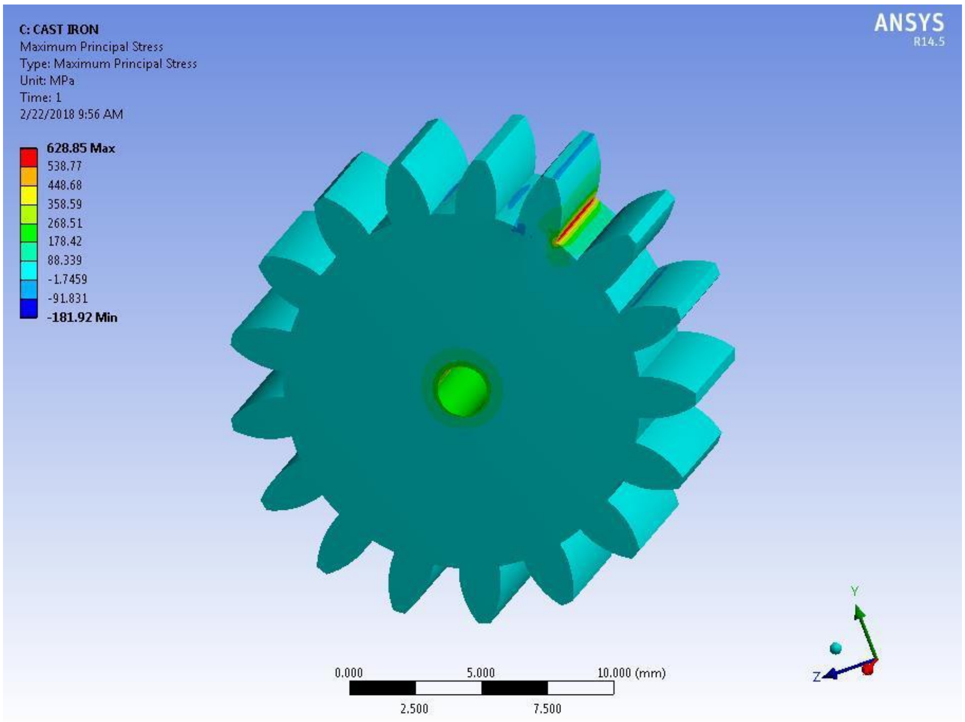
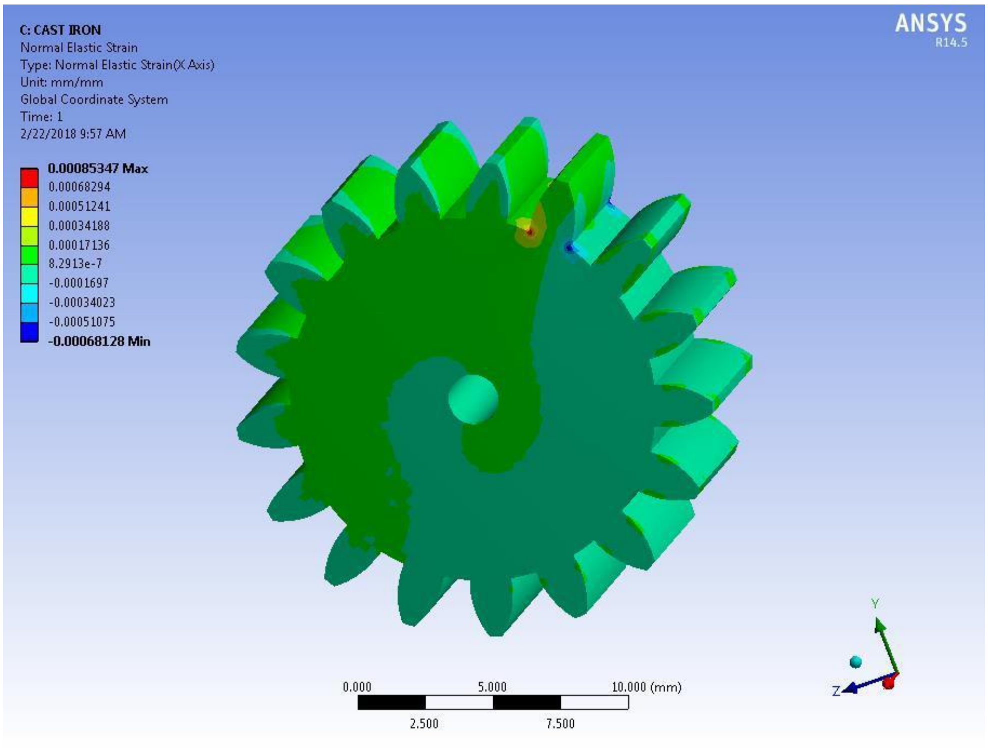
MAXIMUM PRINCIPAL STRESS:



NORMAL ELASTIC STRAIN:



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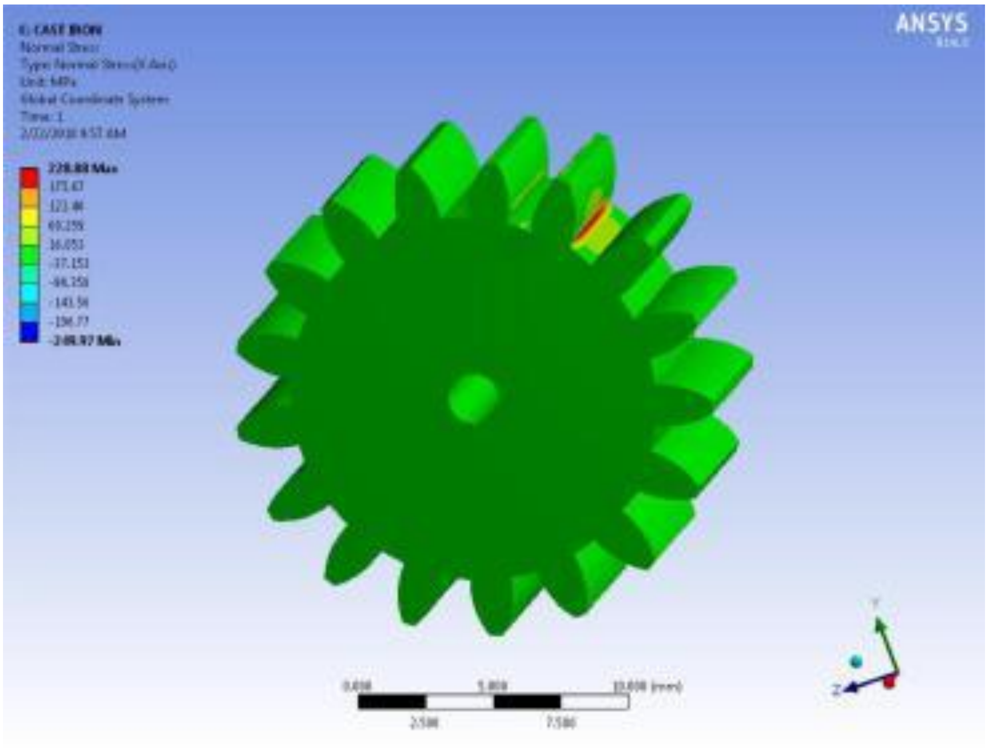
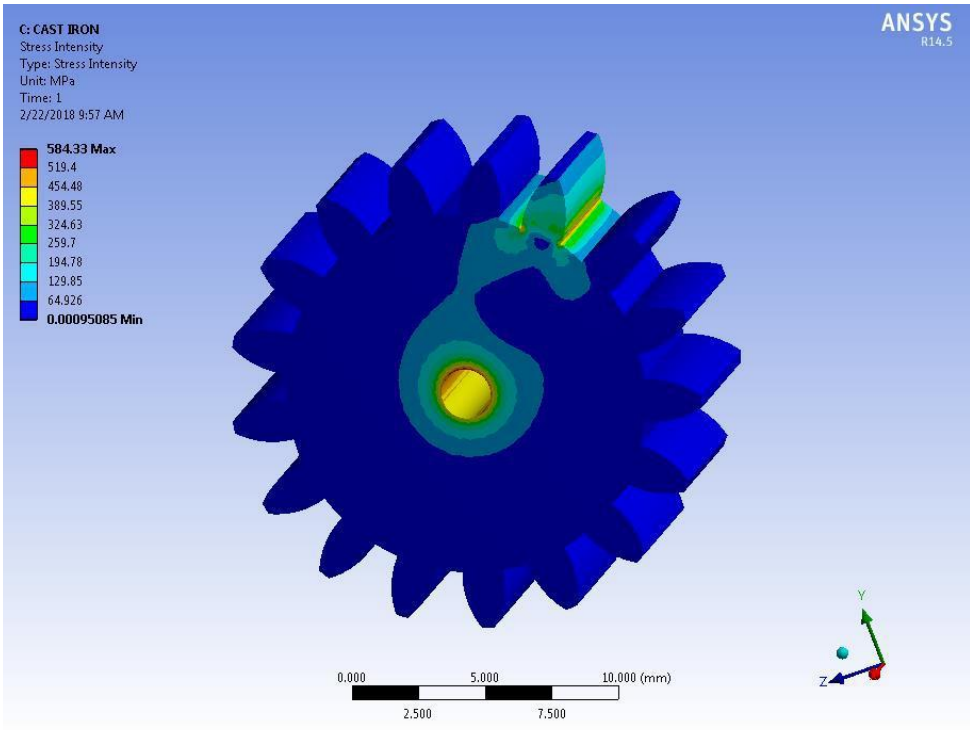


STRESS INTENSITY:



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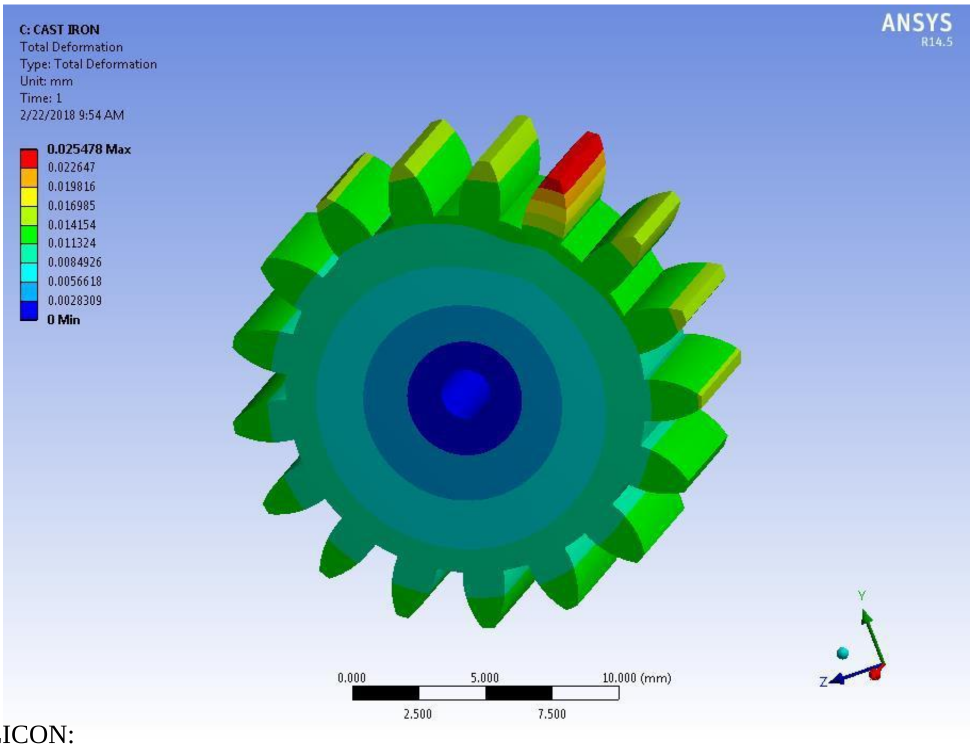
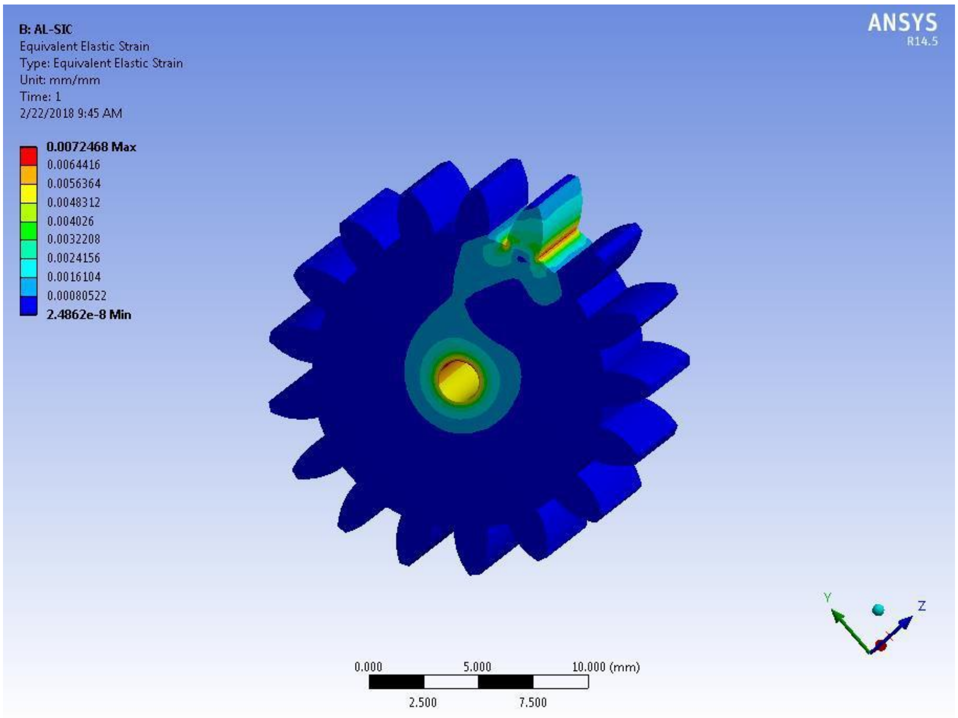
TOTAL DEFORMATION:



ALUMINIUM-SILICON:

EQUIVALENT ELASTIC STRAIN:



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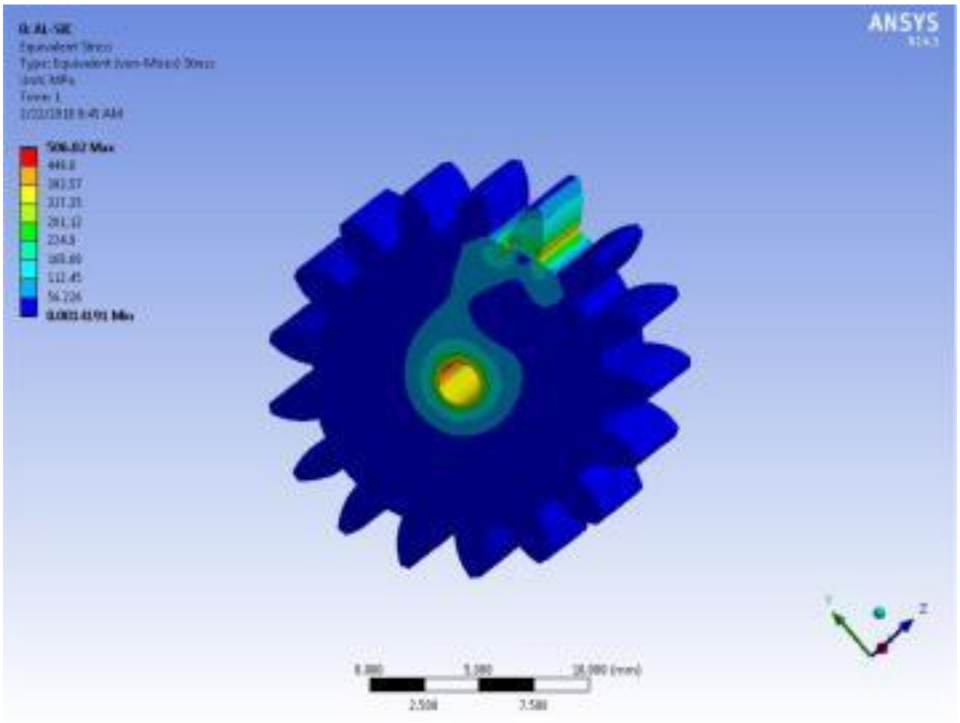
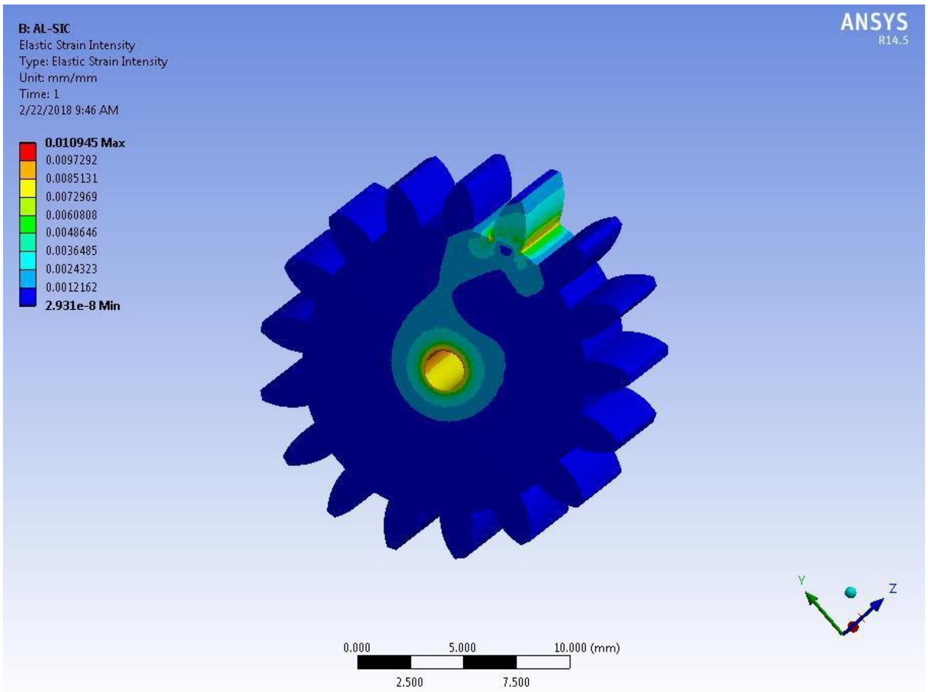


ELASTIC STRAIN INTENSITY:



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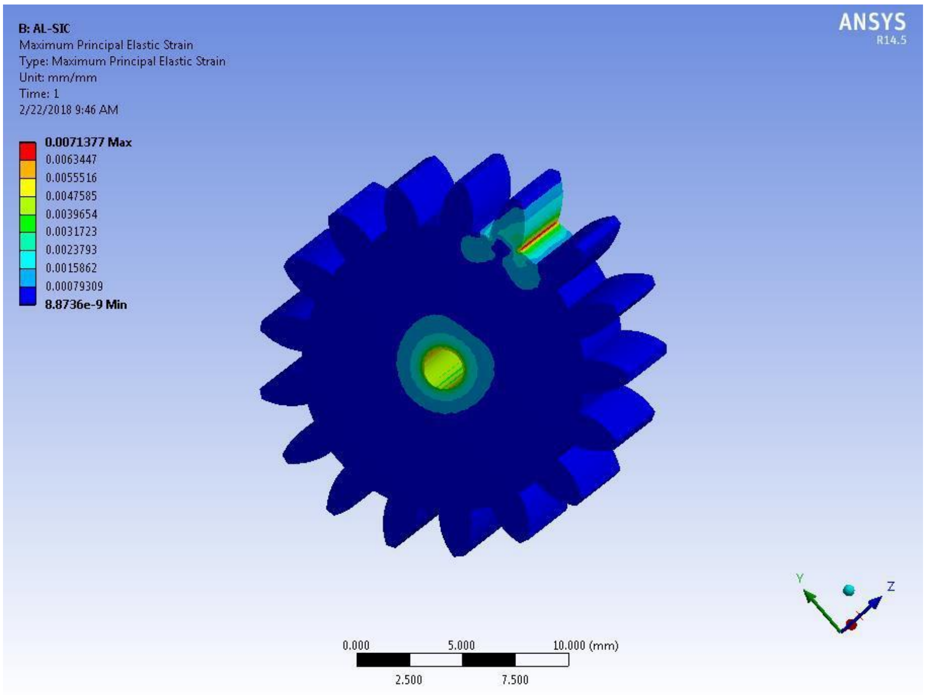
MAXIMUM PRINCIPAL ELASTIC STRAIN:



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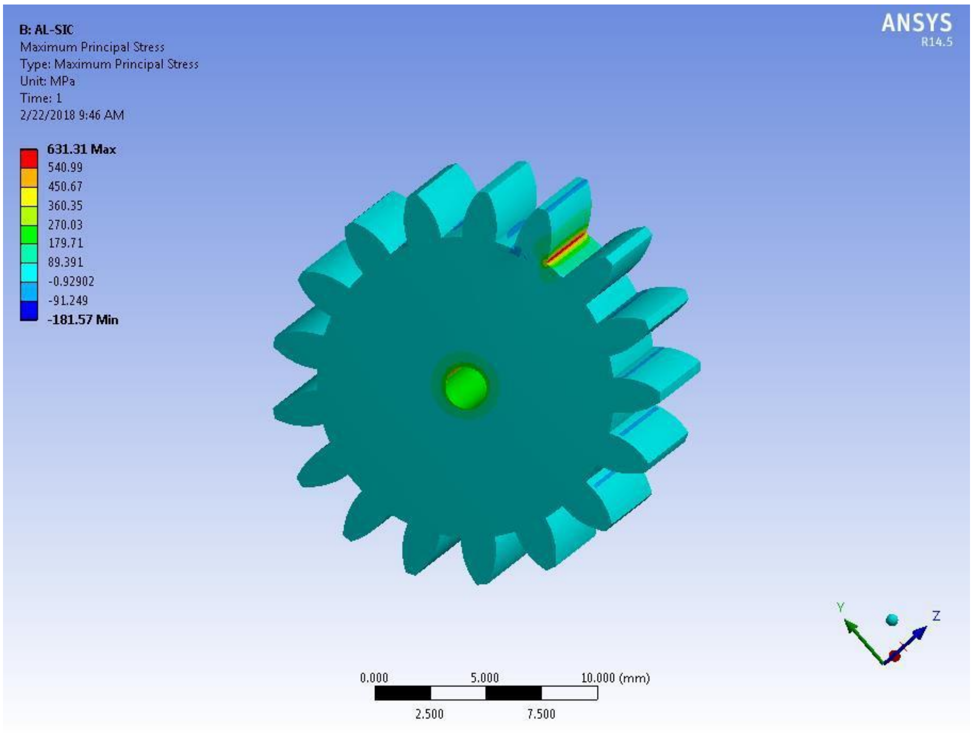

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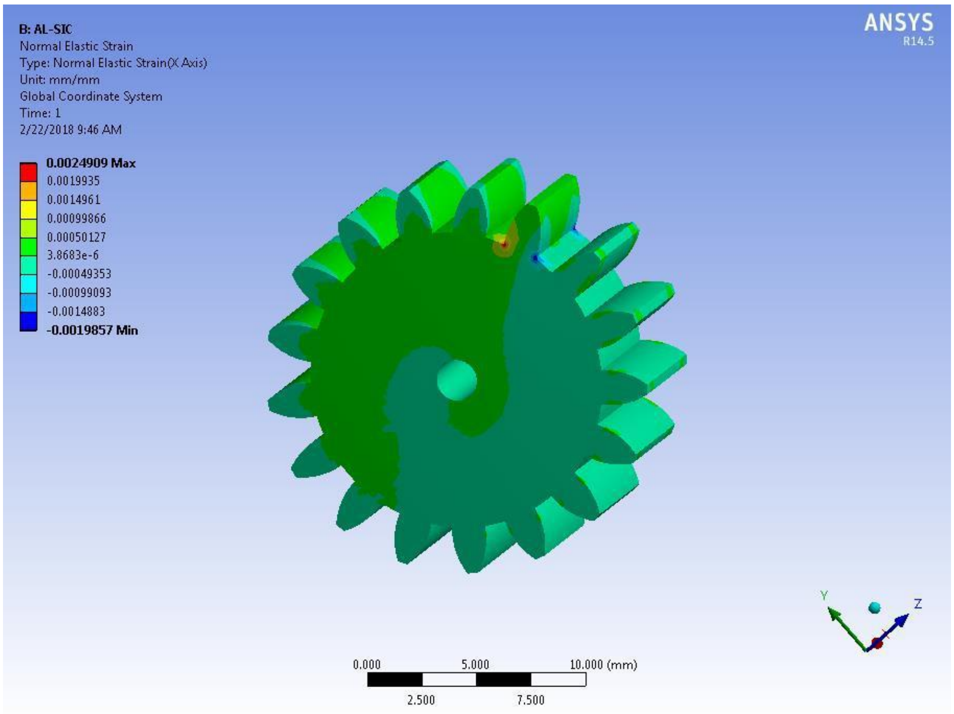
NORMAL ELASTIC STRAIN:



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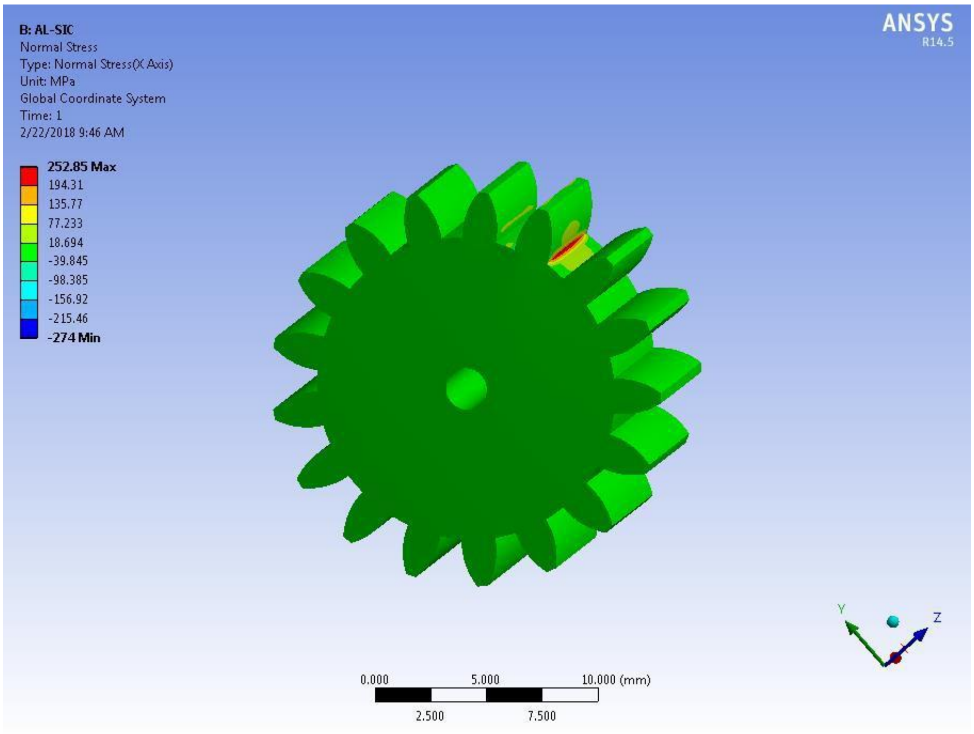

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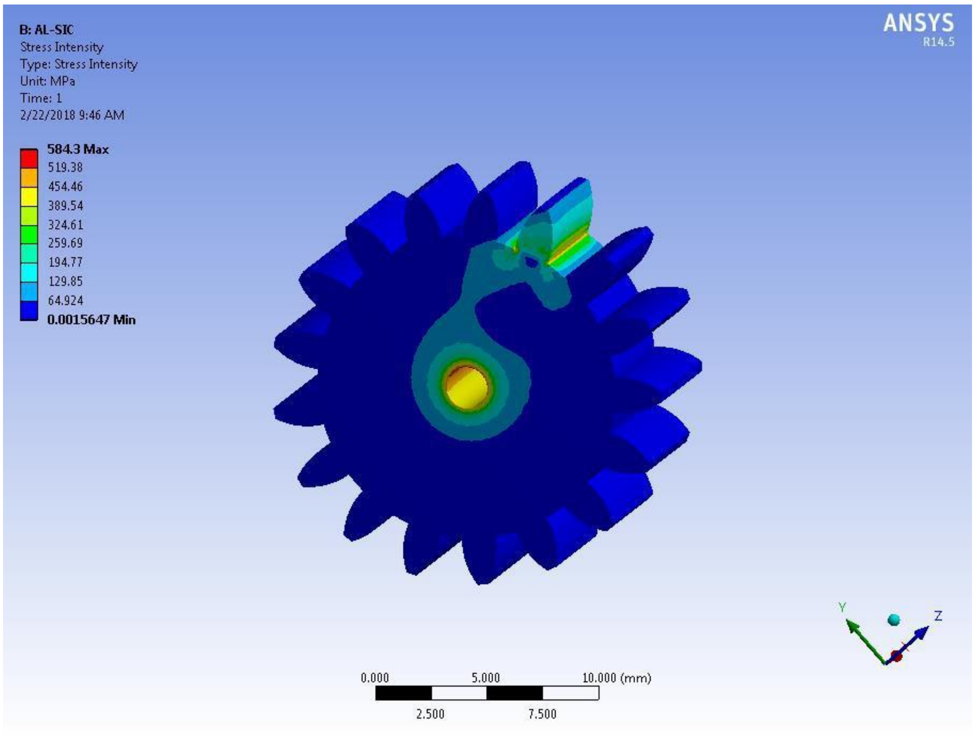
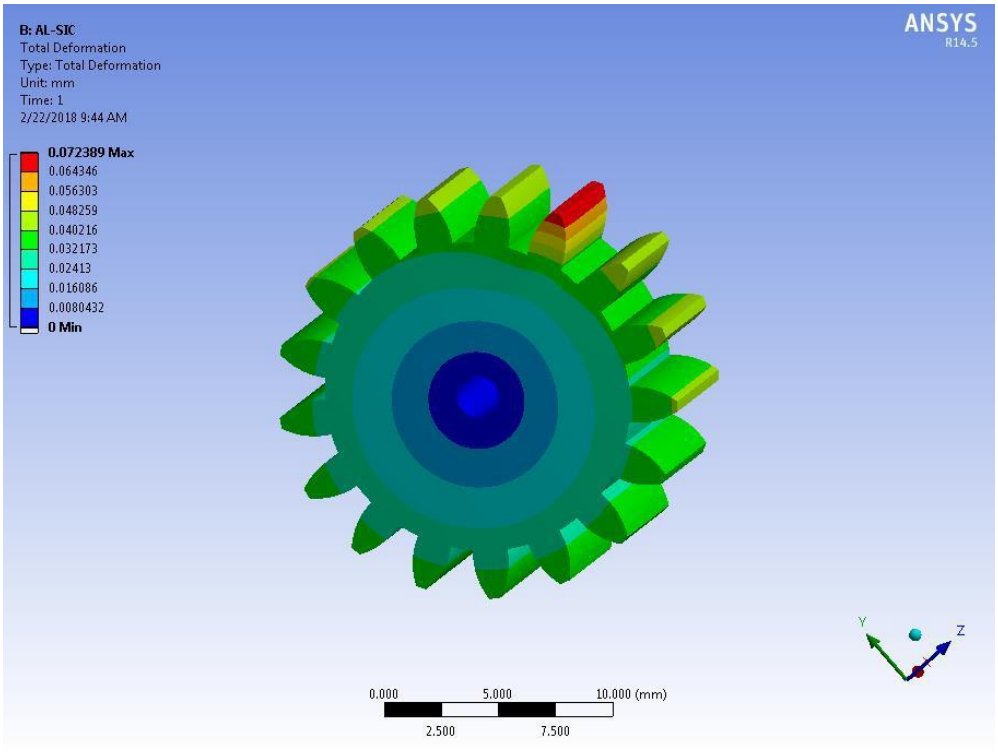
STRESS INTENSITY:



TOTAL DEFORMATION:



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CONCLUSION

In this project we have dine a structural analysis on both aluminum-silicon carbide and the cast iron spur gears and the results were listed the three dimensional model of the spur gear is created in cero 2.0 and the model was analyzed in Ansys 14.5.

MATERIALS	EQUIVALENT ELASTIC STRAIN	EQUIVALENT STRESS	ELASTIC STRAIN INTENSITY	MAXIMUM PRINCIPAL ELASTIC STRAIN	MAXIMUM PRINCIPAL STRESS	NORMAL ELASTIC STRAIN	NORMAL STRESS	STRESS INTENSITY	TOTAL DEFORMATION
ALUMINIUM - SILICON	0.0072468	506.02	0.010945	0.0071377	631.31	0.0024909	252.85	584.3	0.072309
CAST IRON	0.0026659	506.02	0.0037901	0.0026146	628.8	0.00085347	220.08	584.33	0.025478

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