Comparative Study of Polymer with Existing Metallic Material of Spur Gear for Sugarcane Juice Machine

Submitted in partial fulfillment of the requirements
Of the degree of

BACHELOR OF TECHNOLOGY
IN
MECHANICAL ENGINEERING

By

ABHISHEK GIRI (1614101009)
ADITYA TIWARI (1614101023)
ANKUSH SAHU (1614101040)
SATWIK DWIVEDI (1614101155)

Supervisor: **MANOJ SHUKLA**

SCHOOL OF MCHANICAL ENGINEERING
GALGOTIAS UNIVERSITY
GREATER NOIDA
2020

CERTIFICATE

This is to certify that the Research work titled **Comparative Study of Polymer with Existing Metallic Material of Spur Gear for Sugarcane Juice Machine** that is being submitted by **ABHISHEK GIRI, ADITYA TIWARI, ANKUSH SAHU** and **SATWIK DWIVEDI** is in partial fulfillment of the requirements for the award of **Bachelor of Technology**, is a record of bona fied work done under my guidance. The contents of this research work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

Supervisor

Internal Examiner **External Examiner**

Approval Sheet

This thesis/dissertation/project report entitled **Comparative Study of Polymer with Existing Metallic Material of Spur Gear for Sugarcane Juice Machine**
by **ABHISHEK GIRI, ADITYA TIWARI, ANKUSH SAHU** and **SATWIK DWIVEDI** is approved for the degree of bachelor of technology in mechanical engineering.

Examiners

_____

_____

_____

Supervisor

_____

Dean

_____

Date: _____

Place: _____

Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

_____
(Signature)

Abhishek Giri
Aditya Tiwari
Ankush Sahu
Satwik Dwivedi

_____
(Name of the student)

1614101009
1614101023
1614101040
1614101155

_____
(Enrolment No.)

Date: _____

ACKNOWLEDGEMENT

The contributions of many different people, in their different ways, have made this possible. I would like to extend my gratitude to the following.

We are grateful to my supervisor ……..

_____

_____

(Department of Mechanical engineering)

ABSTRACT

This project report describes design and analysis of polymer Spur gear under static and dynamic loading condition for sugarcane juice machine. In this presented report, the existing cast iron spur gear used for sugarcane juice machine is advised to replace with polycarbonate spur gear. The only purpose to design a gear with polymer is reduction of weight, vibration, free of corrosion and less moment of inertia. To carry out the result, the material of polycarbonate is selected to check the design condition with existing cast iron spur gear. The dynamic and static analysis are analysed theoretically as well as through finite element analysis to check that considered polymer gear is reliable to this particular application. The proposed polymer material has feasible physical and mechanical properties. The polymers give some advantages over metal as weight reduction, vibration observer and anticorrosion. In the static analysis, we carried out von-mises stress and in the dynamic analysis, we carried out fatigue failure of the spur gear. So, we can predict the life of the polymer spur gear made of polycarbonate.

TABLE OF CONTENT

List of figures

1

Introduction

1.1 Project background

Gear is the important part of any rotating part. Due to sudden failure of gear, it may lead a large damage. The design of gear is the most important, according to the application, the geometrical specifications should be calculated. After the dimension, material selection is a major issue. A gear's strength is depended upon which material is to be used. Consideration of these physical and mechanical properties are very important, these properties play a big role to consider the strength of that material for specific application. Now a days, there is much use of polymer for the manufacturing of gear, polymers are the future for the gears. Polymer's gear gives some advantages over the metallic gears, polymer's gear has the ability to absorb the shock and vibration due to the elasticity of the material. Plastic gearing has been increasing in usage as designers better understand their benefits and limitation.

1.2 Research purpose and meaning

However, plastic gears have some advantages over metallic gears but they have some drawbacks like less load carrying capacity compared to similarly sized metal gears.
For the designing of gear to check only strength condition compare to the allowable stress condition for desired gear is not enough. In compare to the meatal gears, polymer gears have less load carrying capacity, cannot hold high tolerances and are less dimensionally stable. So, for a reliable design of gears with polymers, it is necessary to consider the life if gear with the polymer used in manufacturing of gear. Fatigue strength plays a big role in this case. By doing dynamic analysis as well as static analysis, we can calculate the life of gear. So, the use of polymers in gearing will not be cost effective and the design of gear will be safe and more reliable.

1.3 Objective of study

In this project, we are going to substitute the existing metallic spur gear (cast iron) which is used for sugarcane juice machine by polycarbonate spur gear. By achieving the static loading condition, we cannot sure that the design is reliable if we are going towards the polymer gears. In the dynamic condition fluctuating stress induced on the tooth of gear. They are not changing in magnitude but in the direction. In this condition fatigue failure appears. We are taking the rotation of gear from the center of gear profile so that maximum stress will be induced on the gear tooth. By achieving the result of dynamic analysis of polycarbonate spur gear, we can estimate the fatigue strength and the life cycle of the polycarbonate spur gear in both maximum and minimum condition.

2

Literature review

2.1 Introduction

The review mainly focuses on replacing the existing material for the specific application by polymer spur gear. In these literature survey, we also took attention on the static and dynamic analysis of spur gear which are manufactured from different material. In the survey, we found that through the static loading condition polycarbonate can be substituted in place of metallic spur gear. In many works, the gears made of different material is observed in static condition as well as in dynamic condition. In the static loading condition, simply the Lewis equation is used. The tooth of spur gear is observed as a cantilever and then bending failure study is done on the tooth of spur gear. In the FEA analysis, many authors took the rotation of spur gear through the center of the gear profile of spur gear so the maximum stress is achieved on the tooth of spur gear. Many works have been done for the dynamic analysis of spur gear so that they can give the more reliable result. It may happen that the used material can give a satisfied result in the static condition but it can have a short life. So, the dynamic analysis gives the result for fatigue failure by which we can predict the life cycle of the desired spur gear.

2.2 Reviews

V. Siva Prasad, Syed Altaf Hussain et al. proposed to replace the cast iron spur gear for sugarcane juice machine with the polymer's spur gear to decrease the weight and vibration of the system. To achieve the purpose, different type of polymers has been taken, there's physical and mechanical properties are checked with the existing cast iron spur gear. The gear was designed by the computer aided designing and after solid modeling the design was imported in the Ansys for finite element analysis for static loading condition. Two materials nylon and polycarbonate were taken in which nylon was considered suitable material for the application.

Mr. Samadhan, Dr. A.D. Desai, Prof. A.B. Verma et al. give the idea of substitution of conventional metal spur gear for sugarcane juice machine with the plastic spur gear. Many polymers are assumed for gear manufacturing. The work presents the substitution of metal spur gear (cast iron) with suitable plastic spur gear either nylon or polycarbonate. The plastic gear was proposed to reduce the weight, noise and corrosion. The designing work is done with the CATIA V5 by parametric modeling workbench. The author generated this model by traditional drafting method in CATIA V5 R21. In the static analysis, plane stress, strain and displacement values are observed and polycarbonate was proposed as a suitable material.

Shubham, Nimish Ajmera et al. showed the work of static and dynamic analysis of spur gear. The dynamic analysis stands for the fatigue analysis of spur gear or the life of the tool. The rotation of gear is taken from the center of the gear profile so that the maximum bending stress induced on the gear tooth. In initial condition, the author assumed the velocities and displacements as zero for all degrees of freedom. The presented model of spur gear was modeled by the CATIA. The bending stress was achieved by the Lewis equation and displacement was carried out by Castigliano's equation. By the finite element analysis of static and dynamic condition the viability of spur gear was checked.

Amol C Dhomse, R.K. Agrawal et al. presented the work in which the PEK polymer was used and make a comparitive study with the existing metallic cast iron spur gear. The design and analysis of spur gear by using PEK was done under the static and dynamic loading condition. First of all the sataic analysis was done by Lewis equation and dynamic analysis was done by Buckingham's equation theoriticaly. The propsed gear profile was generated by Solidworks 2015. After the modeling the design was importes in ANSYS for finite element analysis. PEK (Polymer Ether Ketone) is considered a good material over the PEEK material. The gear achieved 70% weight reduction and 80% reduction in moment of inertia as well. Von-mises stress was carried out by the static analysis and according the result PEK was considered a suitable material of gear manufacturing.

3

Problem description

3.1 Problem description

In this project, we are going to substitute the existing metallic spur gear which is used for sugarcane juice machine with the polycarbonate spur gear. We considered all the physical and mechanical properties of both material cast iron as well as polycarbonate. We did static analysis theoretically by using Lewis equation. The solid modelling is done in Solidworks and then static and dynamic analysis is done in Solidworks. In the dynamic analysis the rotation of spur gear is taken from the centre of gear profile. The motor, we used of 1.5 Kw and it runs at 1400 rpm.

4

Result plotting

4.1 Static analysis of cast iron

Material properties:

Model type	Linear, elastic, isotropic
Elastic modulus	1.9e+11 N/m^2
Yield strength	2.5742e+08 N/m^2
Tensile strength	4.13613e+08 N/m^2
Poisson’s ratio	0.27
Density	7300 Kg/m^3
Shear modulus	8.6e+10 N/m^2

Stress result for cast iron

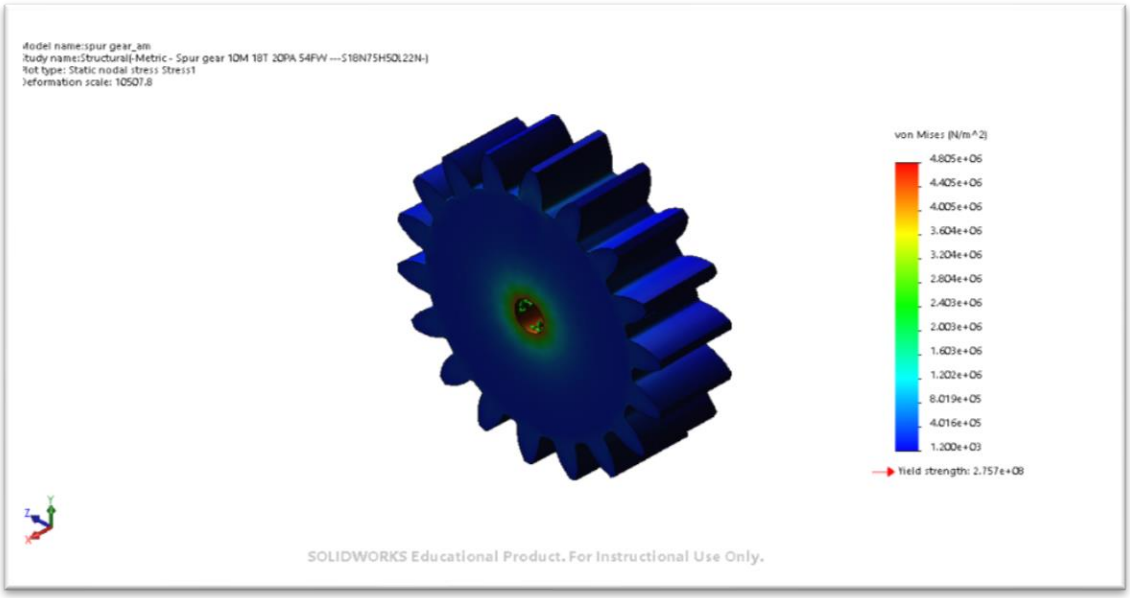

Fig. 1 stress result for cast iron

Displacement analysis for cast iron

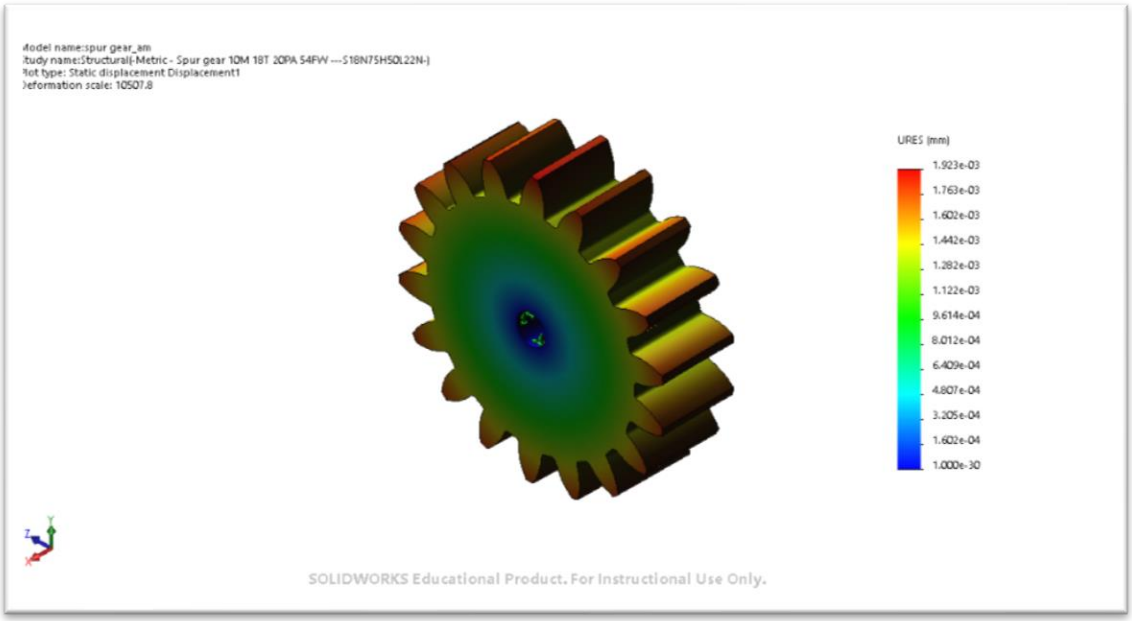

Fig. 2 displacement result of cast iron

Strain result for cast iron

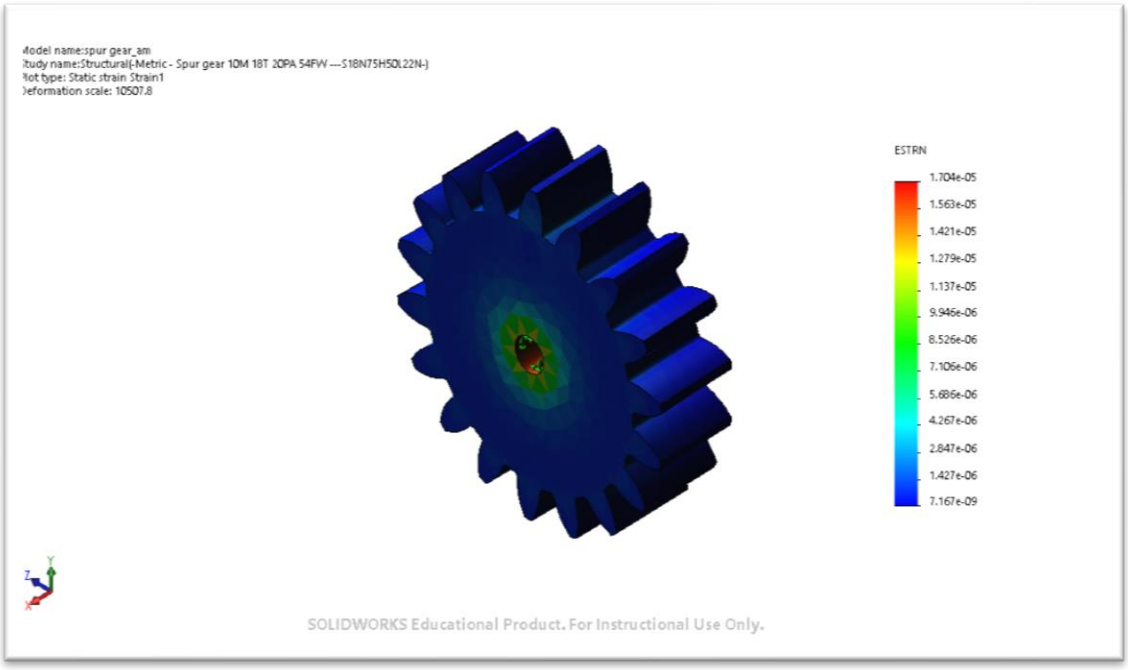

Fig. 3 strain result for cast iron

Result of static analysis of cast iron

Analysis type	**Min**	**Max**
Von-mises stress	1.200e+03 N/m^2	40805e+06 N/m^2
Displacement	0.000e+00 mm	1.923e-03 mm
Strain	7.167e-09	1.704e-05

4.2 Static analysis of polycarbonate

Material properties

Model type	Linear, elastic, isotropic
Elastic modulus	2.32e+09 N/m^2
Tensile strength	6.27e+07 N/m^2
Poisson's ratio	0.39
Shear modulus	8.291e+08 N/m^2
Density	1190 Kg/m^3

Stress result for polycarbonate

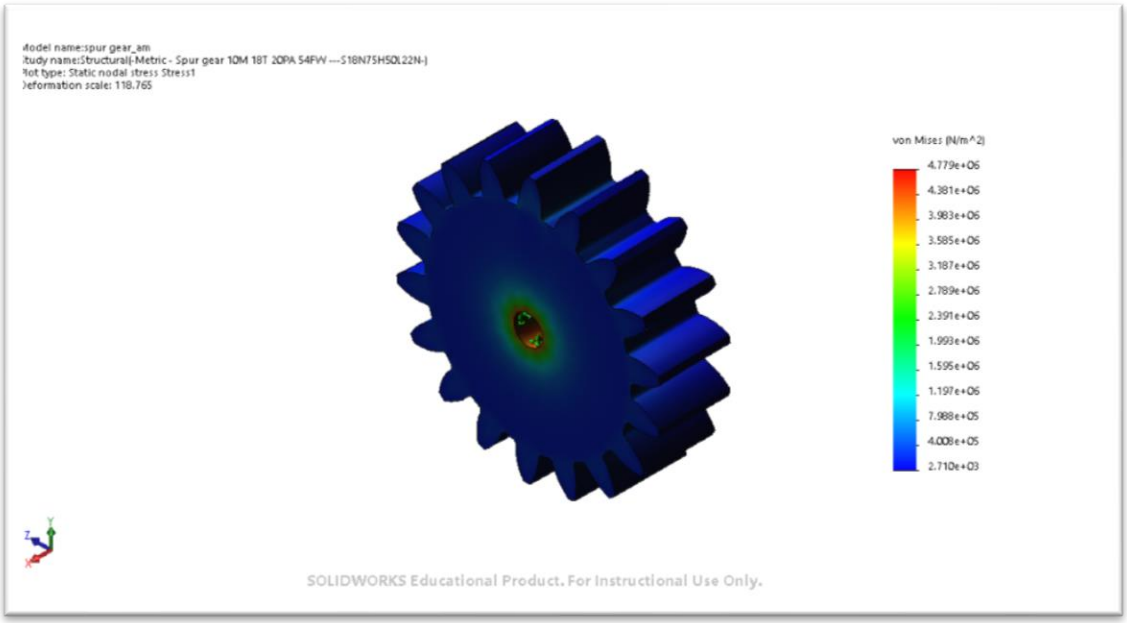

Fig. 4 stress result of polycarbonate

Displacement result for polycarbonate

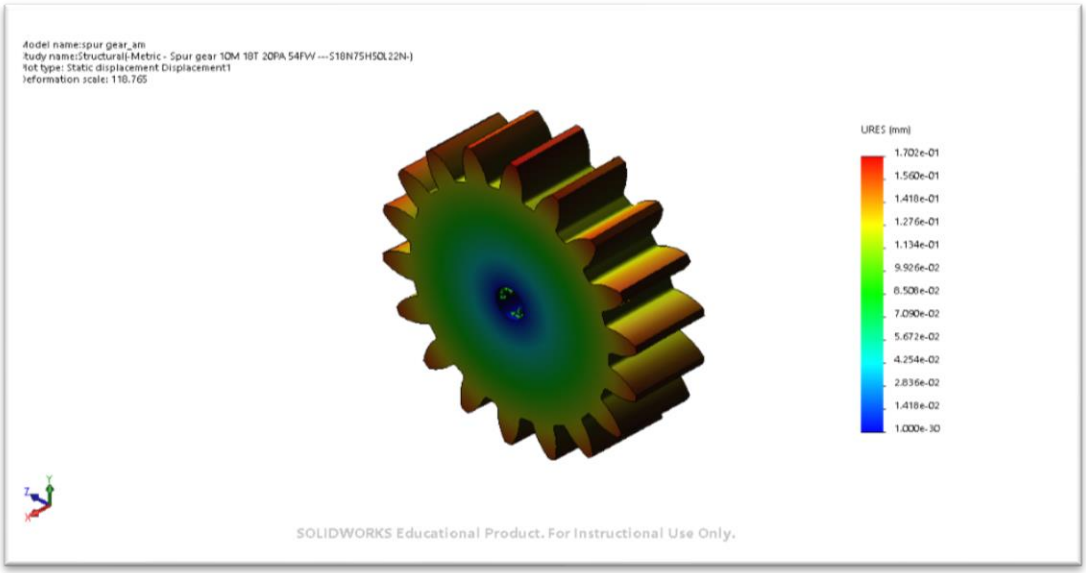

Fig. 5 displacement result of polycarbonate

Strain result for polycarbonate

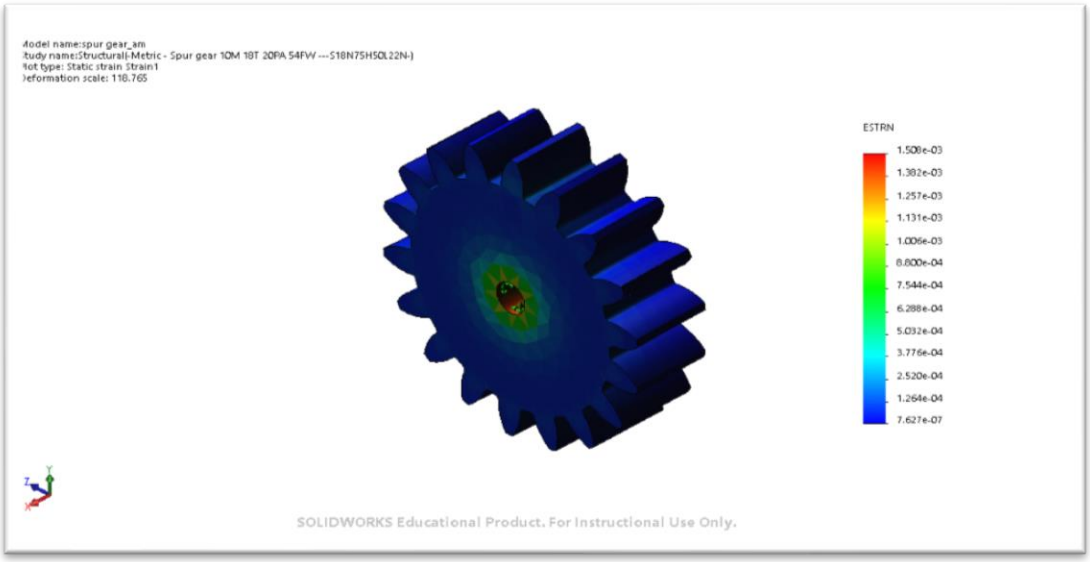

Fig. 6 strain result for polycarbonate

Result of static analysis of polycarbonate

Analysis type	**Min**	**Max**
Von-mises stress	2.710e+03 N/m^2	4.779e+06 N/m^2
Displacement	0.000e+00 mm	1.702e-01 mm
Strain	7.627e-07	1.508e-03

4.3 Dynamic analysis of cast iron

Study Properties

Study name	Fatigue
Analysis type	Fatigue (Constant Amplitude)
Event Interaction	Random
Computing alternating stress using	Stress intensity (P1-P3)
Shell face	Top Face
Mean stress correction	None
Fatigue strength reduction factor	1
Infinite life	Off

Fatigue result for cast iron

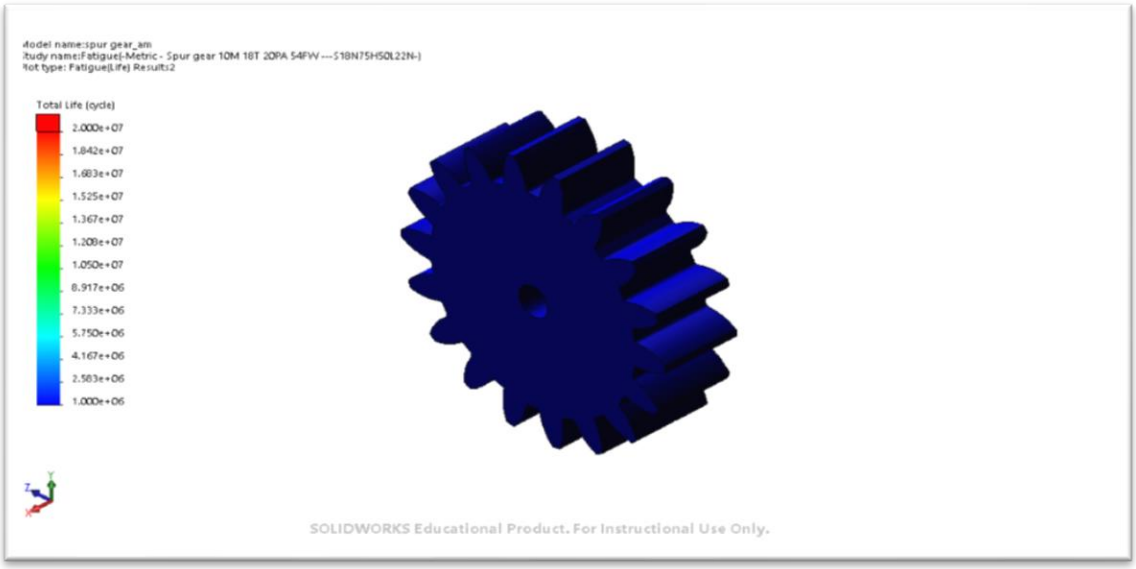

Fig. 7 fatigue result of cast iron

Result of dynamic analysis of cast iron

Analysis type	**Min**	**Max**
Life cycle	1.000e+06 cycle	1.000e+06 cycle

4.4 Dynamic analysis of polycarbonate

Study Properties

Study name	Fatigue
Analysis type	Fatigue (Constant Amplitude)
Event Interaction	Random
Computing alternating stress using	Stress intensity (P1-P3)
Shell face	Top Face
Mean stress correction	None
Fatigue strength reduction factor	1
Infinite life	Off

Fatigue result for polycarbonate

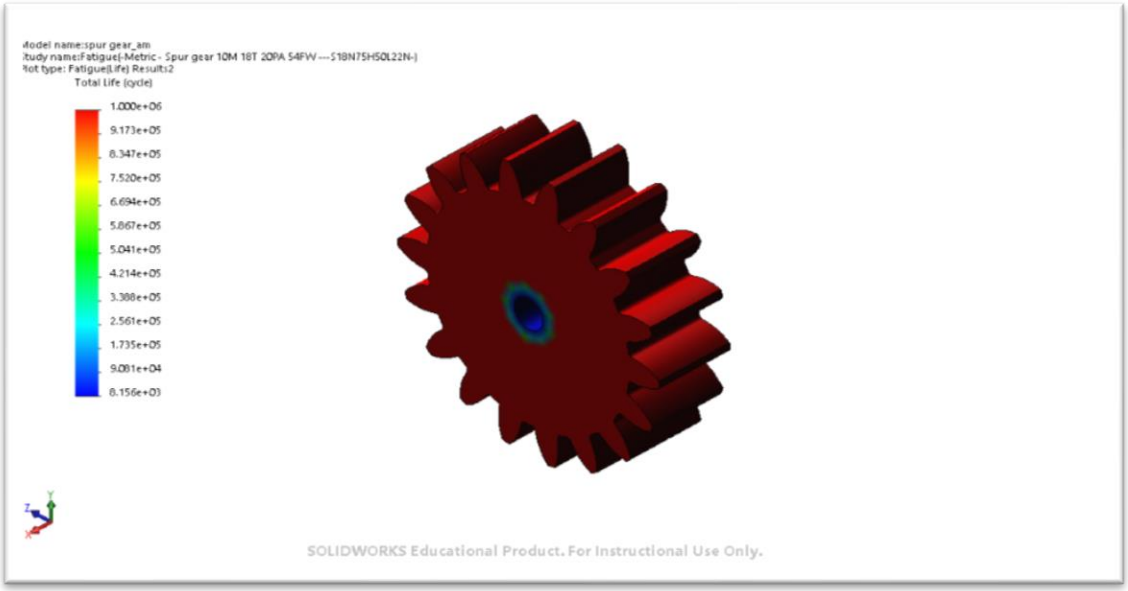

Fig. 8 fatigue result of polycarbonate

Result of dynamic analysis of polycarbonate

Analysis type	Min	Max
Life cycle	8.156e+03 cycle	1.000e+06 cycle

4.5 Comparative study of static and dynamic condition

Material	Von-mises stress	Life plot min	Life plot max
Cast iron	4.805e+06	1.000e+06	1.000e+06
Polycarbonate	4.779e+06	80156e+06	1.000e+06

5

Conclusion

After doing the static analysis, it is carried out that the von-mises stress analysis observed for cast iron is more than the von-mises stress of polycarbonate. So, in this case polycarbonate sustained less stress on the tooth face of spur gear. The strain and displacement value for the cast iron spur gear and polycarbonate spur gear is carried out through the finite element analysis. In the dynamic analysis, we took the rotation along the center point of the gear profile so that it exerts maximum load. In the dynamic condition, a gear always gets fatigue failure because in this case the magnitude of load remains same but it varies in direction. The life plotting stands that in the maximum load condition life cycle of both cast iron and polycarbonate are equal. In the minimum condition the life cycle of polycarbonate is less than the cast iron but it nearest to the minimum cycle of cast iron. Thus, through this analysis polycarbonate is suitable material for this application.

REFERENCES

[1] V. Siva Prasad, Syed Altaf Hussain, V.Pandurangadu, K.PalaniKumar, "Modeling and Analysis of Spur Gear for Sugarcane Juice Machine under Static Load Condition by Using FEA", International Journal of Modern Engineering Research (IJMER), ISSN: 2249-6645, Vol.2, Issue.4, July-Aug (2012).

[2] Mr. Samadhan M. Land Prof. Dr.A.D.Desai , " Prof. A.B.Verma, Stress Analysis of Polycarbonate Spur Gears for Sugarcane Juice Machine Using FEA", International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE), ISSN: 2349-7947, Volume: 2 Issue: 10,(2015).

[3] Shubham A. Badkas and Nimish Ajmera, "STATIC AND DYNAMIC ANALYSIS OF SPUR GEAR", International Journal of Mechanical Engineering and Technology (IJMET), Volume 7, Issue 4, July–Aug (2016).

[4] AMOL C Dhomse, R.K. Agrawal,"Design and Analysis of Polymer PEK Spur Gear Under Static Loading Condition Using FEA", International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), Volume 5, Issue 2, Feb(2016).

[5] M. Keerthi, K. Sandya, K. Srinivas, "Static & Dynamic Analysis of Spur Gear using Different Materials", International Research Journal of Engineering and Technology (IRJET) , Volume 3, Issue 1, Jan(2016).

[6] Rajesh Kumar, Sivasankar M, Arun Kumar, " Design and Contact Analysis of Plastic Spur Gears Using Finite Element Analysis", International Journal of Advanced Research Trends in Engineering and Technology (IJARTET), Volume 3, Issue 19, April (2016).

[7] Mahebub Vohra, Kevin Vyas, "Design Stress Analysis of Metallic and Non metallic Spur Gear", International Journal of Scientific Research and Development (IJSRD), Volume 2, Issue 4, (2014).

[8] R. Yakut, H. Duzcukoglu, M. T. Demirici, " The Load Capacity of PC/ABS of Spur Gear and Investigation of Gear damage", International science Journal, Volume 40, Issue 1, Nov (2009).

[9] Mr. A Gopi Chand, Prof. A V N L Sharma, K Pawan Kumar, "Design of Spur Gear and Its Tooth Profile", (IJERA), Volume 2, Issue 2, Apr (2012).

[10] Dighe A K , Mishra A K , wakchaure V D, "Investigation of Wear Resistance and Torque Transmission Capacity of Glass filled Polyamide and PEEK Composite Spur Gears", IJEAT, Volume 3, Issue 3, February (2014).

Publication details

Journal name: international journal for research in applied science and engineering technology (IJRASET).

Title name: comparative study of polymer with existing metallic material of spur gear for sugarcane juice machine.

Volume: 8

Issue: 5

Date: May 2020

Author's name: Abhishek Giri, Aditya Tiwari, Ankush Sahu, Satwik Dwivedi.