IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **Volume 11, Iss 4 , 2022**

DESIGN AND ANALYSIS OF SPUR GEAR IN STATIC AND DYNAMIC CONDITIONS

Karimulla Syed[#1], K. Prasanth Kumar Reddy[#1]

[#]*Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation (KLEF), Vaddeswaram, Green fields, Guntur, Andhra Pradesh, India -522302*

[1]syedkarimulla@kluniversity.in

DOI : 10.48047/IJFANS/11/ISS4/113

Abstract: A gear is rotating machine part having teeth, which transmits torque. Gears are used for changing direction by which power is to be transmitted. The Spur gear is the essential type of gear, which is the most commonly used gear type. Gear drive plays a vital role in the transmission of power in various industries.

In the current work investigated the characteristics of a gear system including bending stresses, contact stresses and the gear mesh errors in Transmission. Gears are mostly subjected to fluctuating loads. While designing the spur gear mainly concentrate on the stresses for safety operations. In this project designed the physical model of spur gear in "SOLIDWORKS" and imported the model to "ANSYS" software for the static structural analysis and dynamic/transient structural analysis. In the current work, static analysis is carried out to determine the deformation.

This Analysis is done by considering various materials such as Structural Steel, Titanium Alloy, Aluminium Alloy, Carbon, and S-Glass composite, and results are compared with them.

Index Terms: Spur gear, solid works, Ansys, structural steel, titanium alloy, aluminum alloy, carbon, s-glass composite.

I. INTRODUCTION

The spur gear is that the most ordinarily used gear, it's the only variety of gear factory-made in industries and is usually used for the transmission of rotation between 2 parallel shafts. It's the primary alternative of gears for prime speeds masses. Tee pinion is made from a harder material than the wheel. Alternative gears may be most popular to supply additional silent, low vibration operation. One wheel is usually selected to have a relationship that varies between 1:1 and 1:6 with a pitch line speed up to 25m/s.

A gear strives to need to be selected to have the simplest style of teeth in line with a suitable index in strength and wear. The minimum style of teeth on a gear with a regular pressure angle of twenty degrees is eighteen.

A gear train is in an exceedingly| one amongst one in every of the foremost important parts in a mechanical power transmission system, and in most industrial rotating machinery. It's potential that gears can predominate because the simplest means that of sending power in future machines because of their high degree of reliableness and compactness. Additionally, the speedy shift within the trade from industries like building to industries like automobile manufacture and workplace automation tools can necessitate a refined application of substances technology.

A combine of teeth in action are usually subjected to 2 kinds of cyclic stresses: bending stresses causation bending fatigue and speak to stress inflicting contact fatigue. Each these kinds of stresses might not attain their most values at a similar purpose of contact. However, the combined action of each of them is that the reason of the failure of substances tooth resulting in fracture at the basis of a tooth below bending fatigue and surface failure, like corrosion or flaking because of contact fatigue. Additionally, there is also surface harm associated seizure of surfaces because of poor lubrication and overloading. The seizure of surfaces resulting in fastening is sometimes prevented by correct lubrication so that there's continuously a skinny film of material between a combine of teeth in motion. But the fracture failure at the basis because of bending stress and corrosion and flaking of the surfaces because of contact stress cannot be avoided. This kind of failures will be decreased by careful analysis of the matter throughout the planning stage and making correct tooth surface profile with correct producing strategies. Even though necessary actions are taken, these stresses area unit generally high either because of overloading or wear of surfaces with use and wish correct investigation to predict them below accurately stabilized operating conditioned so that unforeseen failure of substances tooth will be decreased.

Gears area unit typically employed in gear is additionally referred to as a speed reducer, gear head, gear reducer, etc., that consists of a collection of gears, shafts and bearings that area unit industrial plant mounted in an interior greased housing speed reducers area unit out there in a very broad variety of sizes, and load-bearing capacity, and varying speed ratios. Gear pair job is to convert the input provided by a first-rate mover (usually an electrical motor) into Associate in Nursing output with lower speed and correspondingly higher force. During this thesis, analysis of the characteristics of spur gears in a very case was studied mistreatment nonlinear Finite Element Methods.

With the increasing demand for noise-free power transmission in machines, vehicles, elevators, and generators, has created a growing demand for additional precise analysis of the characteristics of substances systems. Within the industry, the biggest manufacturer of gears, higher reliableness and lighter weight gears area unit necessary as lighter vehicles still be in demand.

ISSN PRINT 2319 1775 Online 2320 7876
 Volume 11, Iss 4 , 2022

Additionally, the success in engine noise reduction promotes the assembly of quieter gear pairs for any noise reduction. Noise reduction geared pairs is very important within the quickly growing field of workplace-automation instrumentation because the office atmosphere is adversely tormented by noise, Associate in Nursing machines area unit taking part in an ever-widening role in this atmosphere. Ultimately, the sole effective thanks to attaining gear noise reduction are to scale back the vibration related to them. The reduction of noise through vibration management will solely be achieved through analysis efforts by specialists within the field. However, a shortage of those specialists exists within the newer, lightweight twelve industries in Japan primarily as a result of fewer teenagers area unit specializing geared technology these days and historically the specialists used in serious industries tend to remain wherever they're.

Coming up with extremely loaded spur gears for power transmission systems that area unit each sturdy and quiet needs analysis strategies that may be enforced and additionally offer info on contact and bending stresses, along with side transmission errors. The finite component technique is capable of providing this info. However, the time required to make such a model is massive. To scale back the modeling time, a pre-processor technique that makes the pure mathematics needed for a finite component analysis is also used, like that provided by CATIA. CATIA will generate models of three-dimensional gears simply. In CATIA, pure mathematics is saved as a file, and so it will be transferred from CATIA to ANSYS. In ANSYS, one will click File > Import > IGES > and check No defeaturing and Merge coincident key points.

Gears analyses within the past were performed mistreatment analytical strategies, that needed a variety of assumptions and simplifications. In general, gear analyses area unit multidisciplinary, together with calculations associated with the tooth stresses and to tribological failures like wear or rating. During this thesis, static contact and bending stress analyses were performed, whereas attempting to style spur gears to resist bending failure and corrosion of the teeth, as each affects transmission error.

As computers became additional and additional powerful, individuals have attended use numerical approaches to develop theoretical models to predict the result of no matter the area unit studied. This has improved gear analyses and pc simulations. Numerical strategies will doubtless offer additional correct solutions since they usually need abundant, less restrictive assumptions. The model and also the answer strategies, however, should be chosen fastidiously to confirm that the results area unit correct which the processing time is cheap. The finite component technique is extremely usually accustomed Associate in Nursing analyze the strain state of an elastic body with difficult pure mathematics, like a gear. There are various analysis studies within the space. In this paper, first, the finite element models and solution methods needed for the calculation of two-dimensional spur gear contact stresses and gear bending stresses were determined. The contact and bending stress are calculated using ANSYS 18.0 These stresses are compared to the results obtained from existing methods. The main objective of this paper is to develop a model for studying and predicting the contact stresses, and the torsional stiffness of gears in the mesh using the ANSYS 18.0 software package based on a numerical method.

A thorough literature study is conducted on gear analysis, and an outsized body of literature on gear modeling has been referred. The stress analysis on different gears, the transmission errors, and also the prediction of substances dynamic hundreds, gear noise, and also the best style for gear sets are continuously major issues geared style. Errichello and Ozguven and Houser survey a good deal of literature on the event of a spread of simulation models for each static and dynamic analysis of various varieties of gears. Harris did the primary study of transmission error. The Author had concluded the behavior of spur gears at low speeds and summarized in an exceedingly set of static transmission error curves. In later years, Mark and analyzed the moving excitation of substances systems on paper. A Mathematical expression is derived for static transmission error and used it to predict the assorted elements of the static transmission error spectrum from a collection of measurements created on pairing combine of spur gears. Kohler and Regan mentioned the derivation of substances transmission error from pitch error remodeled to the frequency domain. Kubo et al. calculable the transmission error of cylindrical gears employing a tooth contact pattern. This literature reviews conjointly plan to classify gear model into groupings with specific relevance to the analysis.

The subsequent classification looks appropriate:

- Models with Tooth Compliance
- Models of substances system Dynamics
- Models of an entire shell
- Models for the best style of substances Sets

In 1971, Kasuba determined dynamic load factors for gears that were heavily loaded supported one and 2 degrees of freedom models. Employing a torsional moving model, he thought of the torsional stiffness of the shaft.

In 1981, he revealed another paper. AN interactive technique was developed to calculate directly variable gear mesh stiffness as a operate of transmitted load, gear profile errors, gear tooth deflections and equipment hub torsional deformation, and position of contacting profile points. These ways apply to each traditional and high contact magnitude relation eighteen geartrain. Sure varieties of simulated curved profile errors and corroding will cause interruptions of the traditional gear mesh stiffness to operate, and thus, increase the dynamic hundreds. In his analysis, the gear mesh stiffness is that the key component within the analysis of substances train dynamics. The gear mesh stiffness and also the contact magnitude relation is stricken by several factors like the transmitted hundreds, load sharing, gear tooth errors, profile modifications, gear tooth deflections, and also the position of contacting points.

In 1979 Mark analyzed the vibration excitation of substances systems. In his hypothesis, the formulation of the equations of motion of a generic gear system within the frequency domain is shown to need the Fourier-series coefficients of the elements of vibration excitation. These elements are the static transmission errors of the individual pairs within the system. A general

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **© 2012 IJFANS. All Rights Reserved**, **Volume 11, Iss 4 , 2022**

expression is derived for the static transmission error springs and rotten into elements as a result of elastic tooth deformations and to deviations of tooth faces from good surfaces with uniform lead and spacing.
In the Eighties, though additional and additional advanced models were developed to get additional correct predictions, some straightforward models were developed for the aim of simplifying dynamic load prediction for normal gears.
In 1980, the coupled torsional flexural vibration of a shaft in an exceedingly spur back-geared system was investigated by some researchers. That the output shaft was versatile in bearing, and also the input shaft was rigid in bearing was assumed. Researchers derived equations of motion for a 6-degree-of freedom (DOF) system. The tooth contact was maintained throughout the rotation, and also the mesh was rigid in those models. Four years later, different researchers gave another model that consists of 3 shafts, instead of 2 shafts, one in all them being a countershaft.
In 1992, Kahraman developed a finite component model of a back-geared rotor system on versatile bearings. The gear mesh was sculptural by a combine of rigid disks connected by a spring and a damper with a continuing worth that depicted the common mesh worth. Coupling between the torsional and cross vibrations of the gear was thought of within the model and applied the transmission error because the excitation at the mesh purpose to simulate the variable mesh stiffness.
In 1996, Sweeney developed a scientific technique of shrewd the static transmission error of a gear set, supported the results of geometric parameter variation on the transmission error. He assumed that the tooth (pair) stiffness is constant on the road of action (thin-slice model) which the contact radius for calculation of Hertzian deformation is that the average radius of the two profiles in-tuned. Sweeney 's model applies to cases wherever the dominant supply of transmission error is geometric imperfections and is especially suited to automotive quality gear analysis. The results of his model gave excellent agreement with measurements on automotive quality gears. Randall and Kelley's modifications are created to Sweeney 's basic model to increase it to higher quality gears wherever the tooth deflection part is additionally vital. The tooth deflection compliance matrix and also the contact compliance vector are derived exploitation finite component models. The results on the transmission error of the variation of the tooth body stiffness with the load application purpose are investigated, and a simulation program for transmission error (TE) computation with varied stiffness has been developed. To check nineteen the case wherever the tooth deflection part is that the dominant supply of the transmission error nylon gears was used. All the simulation results are compared with the measured transmission errors from a single-stage shell. In 1999, Kelenz investigated a spur gear set using FEM. The contact stresses were examined using a two-dimensional FEM model. The bending stress analysis was performed on different thin rimmed gears. The contact stress and bending stress comparisons were given in his studies. In 2001, Howard simplified the dynamic gear model to explore the effect of friction on the resultant gear case vibration. The model which incorporates the effect of variation in gear tooth torsional mesh stiffness was developed using FEM analysis, and the gears mesh together. Frictional forces are introduced between teeth into the dynamic equations is given in his paper. The comparison between the results with friction and without friction was investigated through the models developed from the differential equations.
In 2003, Wang surveyed the nonlinear vibration of gear transmission systems. The progress in nonlinear dynamics of a gear driven system is reviewed, especially the dynamic gear behavior by considering the backlash and time-varying mesh stiffness of teeth. The basic concepts, the mathematical models and the solution methods for non-linear dynamics of geared systems were all reviewed in his paper

- Idler Gear
- Module(m)
- Pitch
- Pitch Diameter
- Pitch Point
- Pressure Angle(alpha)
- Profile
- Rack
- Spur Gear
- Velocity
- Whole Depth
- Working Depth
- No.of teeth(z)
- Tooth depth(h)
- root diameter(df)
- Tip diameter(da)

I. PROBLEM DEFINITION:

In the current work, calculations are done analytically and compare results with software results. Any problem can be solved by following the same procedure.

Below are the data are given for a spur gear pair with steel as material properties and transmitting a 5KW power from an electric motor running at 720 rpm to a machine:
LET US ASSUME np =21 ng=40 module=5mm

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **© 2012 IJFANS. All Rights Reserved, Volume 11, Iss 4 , 2022**

Pitch line velocity, V=π*Dp*np/(60000)
RPM changes =3.583
Tangential Force = Ft=P/V
= 5/3.9585m/s
=1263.1047N
=1200N
Ft=1200N
Height of the tooth=11.25(9.6535mm)
Thickness of the root=10.614mm(at root) Face width b=50mm

II. RESULTS AND DISCUSSION

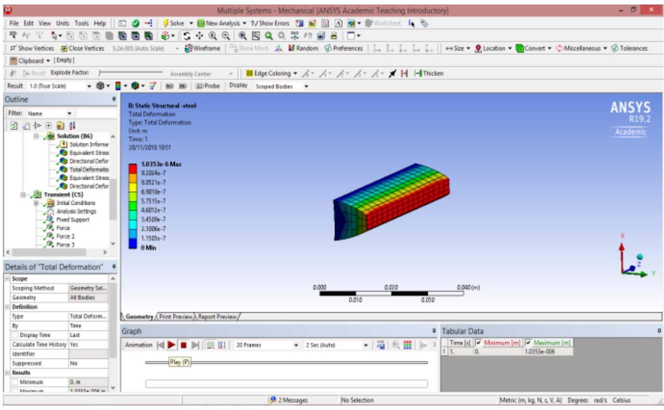

Fig. 1.1 Static Analysis of Structural Steel

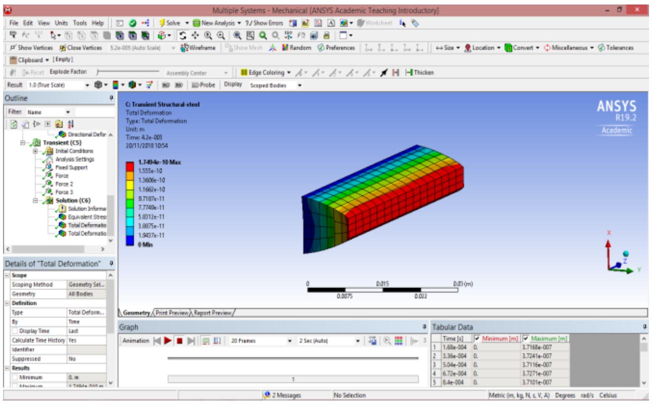

Fig. 2.2 Transient Analysis of Structural Steel

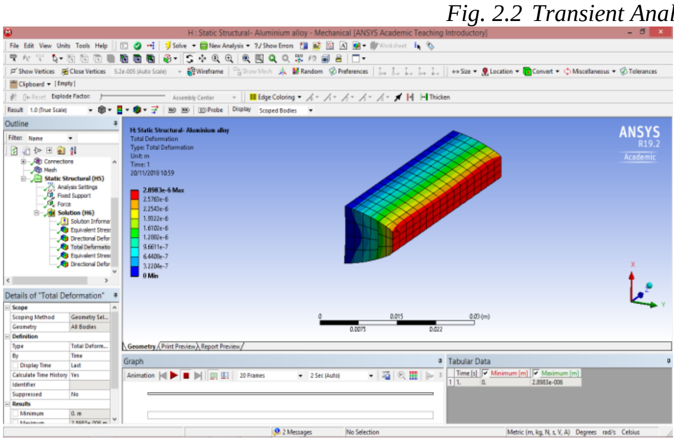

Fig. 3.3 Static Analysis of Aluminum Alloy

IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

ISSN PRINT 2319 1775 Online 2320 7876

 Volume 11, Iss 4 , 2022

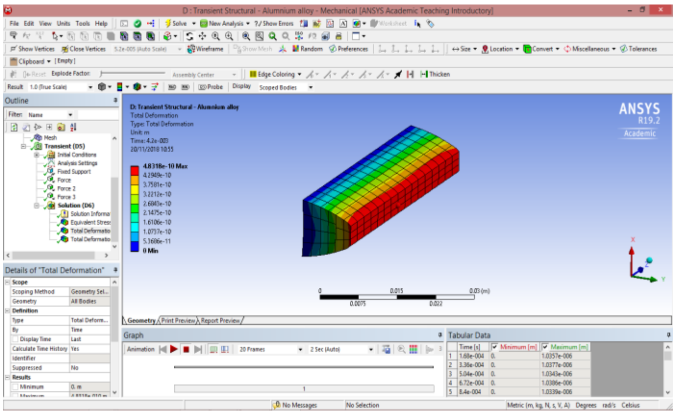

Fig. 4.4 Transient Analysis of Aluminum Alloy

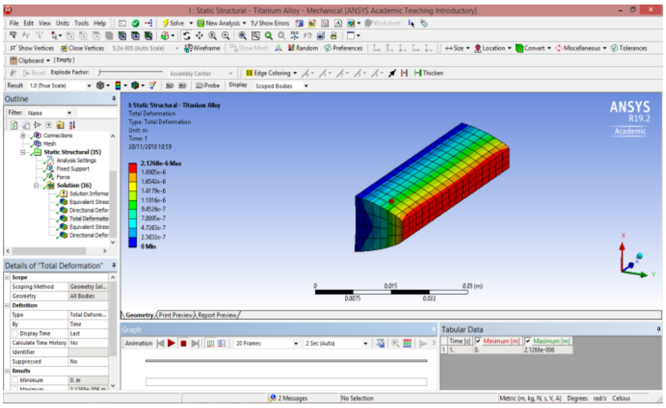

Fig. 5.5 Static Analysis of Titanium Alloys

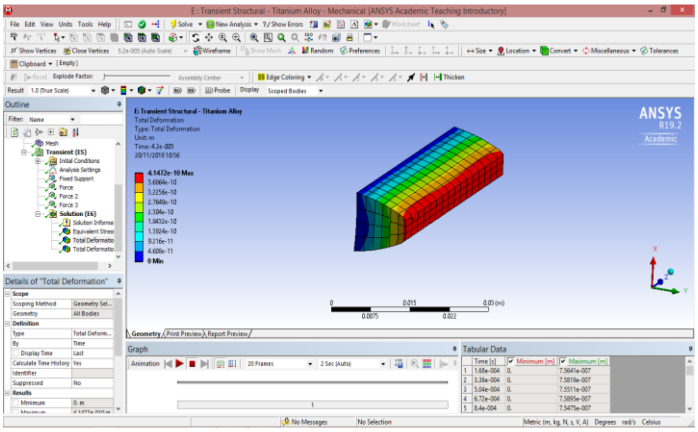

Fig. 6.6 Transient Analysis of Titanium Alloys

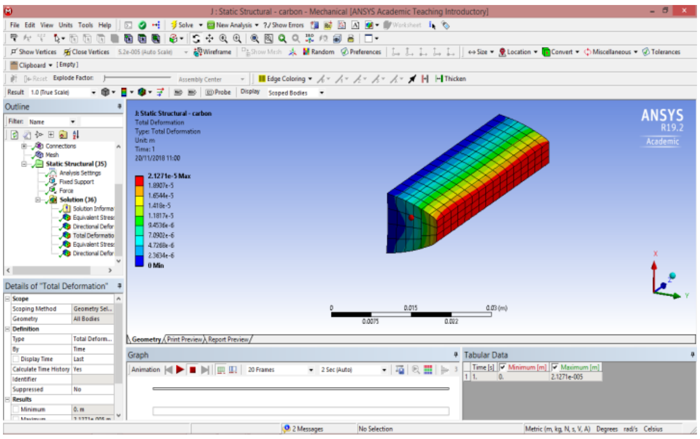

Fig. 7.7 Static Analysis of Carbon Composite

IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **Volume 11, Iss 4 , 2022**

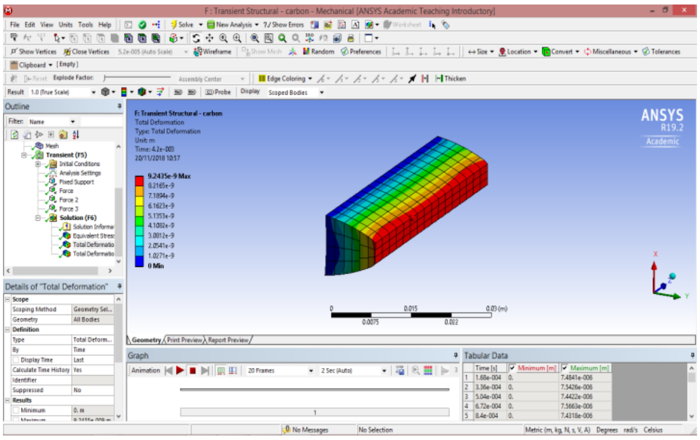

Fig. 8.8 Transient Analysis of Carbon Composite

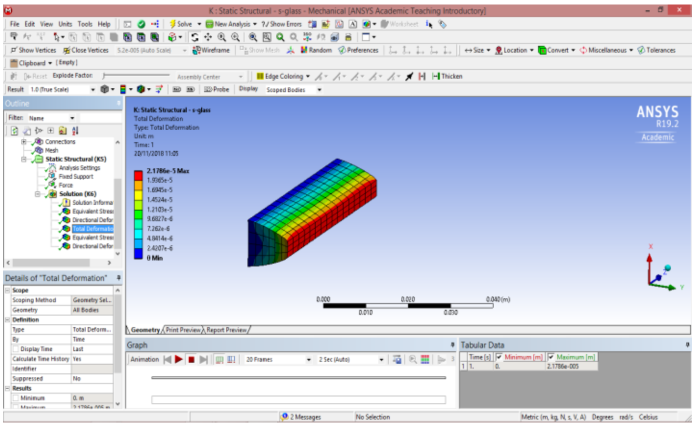

Fig. 9.9 Static Analysis of S-Glass Composite

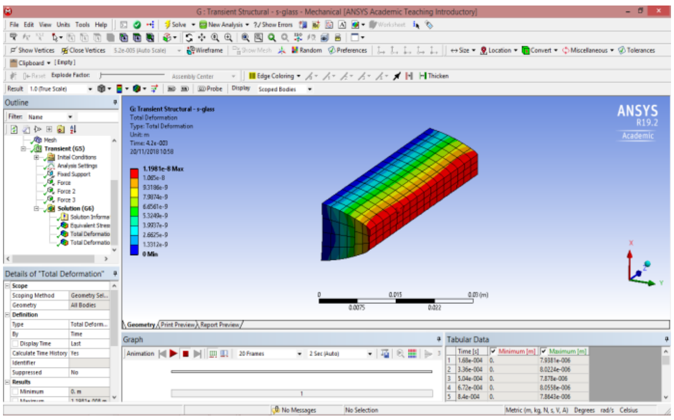

Fig. 10.10 Transient Analysis of S-Glass Composite

Comparison of Gear with Different Materials

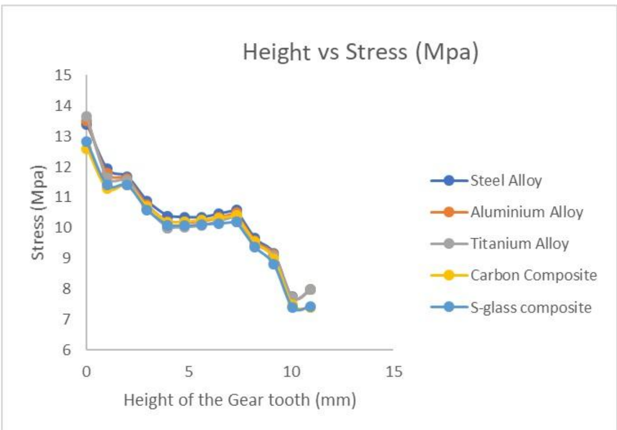

Fig. 11.11 Height of Gear Tooth vs. Stress

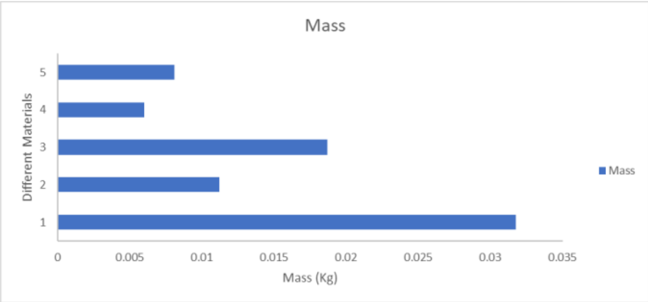

Fig. 12.12 Comparison of masses of different materials

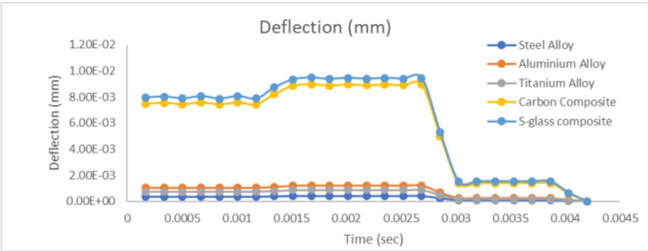

Fig. 13.13 Deflection vs. Time

III. CONCLUSION

Thermal design optimization of SHE is carried out using a gradient-based search algorithm, "fmincon," to minimize the total cost. The optimized design parameter values are 107.254, 43.592, 1.5, 5, and 0.855 for pressure drop on the hot side, pressure drop on the cold side, overall diameter, length and width of SHE. Results reveal that the cost of SHE obtained is lesser than the ones repeated by Moretta [4], Bidabadi [1] earlier and only slightly more than the value reported by WDO algorithm [2]. But the value of the overall heat transfer coefficient obtained in the present study is superior to all the above three studies.

Therefore, in the future, a study with a dual objective of minimizing the cost and maximization of overall heat transfer coefficient can be carried out for getting better insights into design optimization.

REFERENCES

[1]M., Bidabadi, A. K. Sadaghiani, and A. V. Azad, "Spiral heat exchanger optimization using a genetic algorithm," vol. 20, pp. 1445–1454, 2013.
[2]O. De and E. Dos, "Spiral heat exchanger optimization using a wind-driven algorithm," *SBAI*, 2015.
[3]A. V. Azad and M. Amidpour, "Economic optimization of shell and tube heat exchanger, based on constructal theory," *Energy*, vol. 36, no. 2, pp. 1087–1096, 2011.
[4]Moretta, A.A. "Spiral plate heat exchangers: Sizing units for cooling non-Newtonian slurries", *Chemical Engineering* (May,2010)
[5]B. Wilhelmsson and A. Laval, "Consider spiral heat exchangers for fouling applications Consider spiral heat exchangers for fouling applications," no. July, 2005.
[6]Cengel, Y.A. (2002) Heat Transfer: A Practical Approach. 2nd Edition, McGraw-Hill, New York.
[7]M. Pico, "SHORTCUT DESIGN APPROACH FOR SPIRAL," vol. 85, pp. 322–327, 2005.
[8]J. Mičieta, V. Jiří, J. Jandačka, and R. Lenhard, "Optimization principle of operating parameters of heat exchanger by using CFD simulation," *EPJ Web Conf.*, vol. 114, p. 02074, 2016.
[9]Kondahkar, G.E. and Kapatkat, V.N. (2012) Performance Analysis of Spiral Tube Heat Exchanger Used in Oil Extraction System. International Journal of Modern Engineering Research, 2, 930-936.
[10] P. Naphon, "Thermal performance and pressure drop of the helical-coil heat exchangers with and without helically crimped fins ☆," vol. 34, pp. 321–330, 2007.
[11] M. W. Egner, L. C. Burmeister, and M. Asme, "Heat Transfer for Laminar Flow in Spiral Ducts of Rectangular Cross Section," vol. 127, no. March 2005, 2014.
[12] L. C. Burmeister, "Effectiveness of a Spiral-Plate Heat Exchanger With Equal Capacitance Rates," vol. 128, no. March 2006, pp. 295–301, 2016.