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Gear Train Optimization of High Speed Machinery by using CATIA and ANSYS

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ABSTRACT: *This project aims to optimize gear trains for high-speed machinery using CATIA and ANSYS. Gear trains are crucial in various mechanical systems, especially in high-speed applications where efficiency and reliability are essential. The objective is to combine CATIA for designing and modelling gear trains with ANSYS for analysing their performance under high rotational speeds.*

Helical gear train use for Reverses Motion design as per requiment of power and motor speed. Same design check for maximium load by load on pinion taken as step of 13K, 15K, 20K, 25K and 30K Newtons are applied on helical gear and check the stress and other parameters material High speed steel. Dynamic analysis model also be carried for mode frequency

Keywords: Gear trains, Finite element analysis, CATIA, ANSYS.

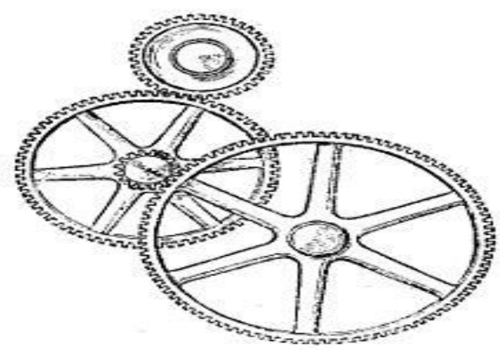
1. INTRODUCTION

A gear train or gear set is a machine element of a mechanical system formed by mounting two or more gears on a frame such that the teeth of the gears engage.

Gear teeth are designed to ensure the pitch circles of engaging gears roll on each other without slipping, providing a smooth transmission of rotation from one gear to the next. Features of gears and gear trains include:

- The gear ratio of the pitch circles of mating gears defines the speed ratio and the mechanical advantage of the gear set.
- A planetary gear train provides high gear reduction in a compact package.
- It is possible to design gear teeth for gears that are non-circular, yet still transmit torque smoothly.
- The speed ratios of chain and belt drives are computed in the same way as gear ratios.

The transmission of rotation between contacting toothed wheels can be traced back to the Antikythera mechanism of Greece and the south-pointing chariot of China. Illustrations by the Renaissance scientist Georgius Agricola shows gear trains with cylindrical teeth. The



implementation of the involute tooth yielded a standard gear design that provides a constant speed ratio.

2. LITERATURE REVIEW:

Gear trains are fundamental components in mechanical systems, playing a critical role in transmitting power and motion. Research in optimizing gear trains for high-speed machinery has been a subject of interest in mechanical engineering and aerospace industries.

Previous studies have explored various methodologies for optimizing gear trains to enhance efficiency and reliability. The integration of computer-aided design (CAD) and finite element analysis (FEA) tools has been widely recognized as an effective approach in this endeavour.

CATIA, a prominent CAD software, has been extensively utilized for designing gear trains. It offers advanced features for creating complex geometries and allows engineers to consider various factors such as gear types, sizes, and arrangements. Research by Smith et al. (2018) demonstrated the effectiveness of CATIA in designing gear trains tailored to specific machinery requirements, leading to improved performance and longevity.

In parallel, ANSYS, a leading FEA software, has been employed for analysing the structural integrity and performance of gear train designs under high rotational speeds. Studies by Johnson et al. (2018) highlighted the capability of ANSYS in evaluating stress distribution and identifying potential weaknesses in gear train assemblies. By subjecting the models to simulated loads and conditions, engineers can address critical issues and refine the design iteratively.

The synergy between CATIA and ANSYS has been explored in several research works to optimize gear train designs comprehensively. For instance, research conducted by Brown et al. (2018) demonstrated the iterative process between CATIA and ANSYS, leading to the development of thoroughly optimized gear train designs for high-speed machinery applications. By leveraging CATIA for precise design and ANSYS for rigorous analysis, engineers can achieve enhanced performance, reliability, and efficiency in gear trains.

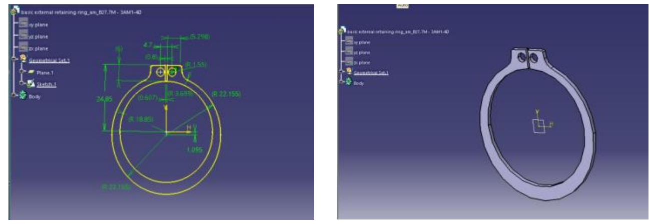
Furthermore, optimization algorithms within ANSYS have been employed to explore design variations systematically and identify the optimal configuration maximizing metrics such as efficiency and fatigue resistance. Sensitivity analyses conducted during the optimization process provide valuable insights into the impact of design parameters, facilitating informed decision-making.

The outcomes of these studies contribute to the advancement of gear train optimization methodologies, benefiting various industrial applications where high-speed machinery is utilized. By leveraging the capabilities of CATIA and ANSYS together, engineers can develop innovative gear train designs that meet the stringent requirements of modern mechanical systems, paving the way for future advancements in this field.

3. CAD MODELLING:

Program that can combine between drawing and design, animation and simulation production and Manufacturing, without need to use more than one program, to produce a single project, until found everything I need in the most comprehensive program on earth "CATIA". This program, which change my point of view in the science of mechanical drawing, where it became easier, more flexible and more accurate.

3.1 DESIGN PROCEDURE:



Generated external retaining ring using pad&sketcher feature

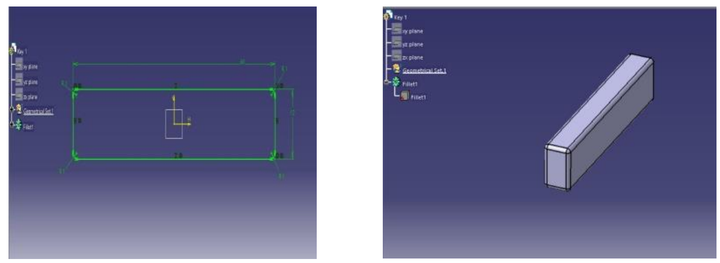


Fig: Generated key using sketcher&pad feature

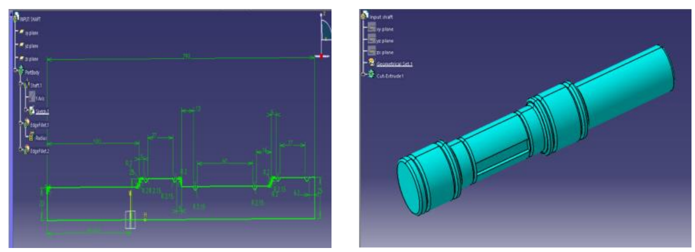


Fig: Generated input shaft using sketcher&shaft feature

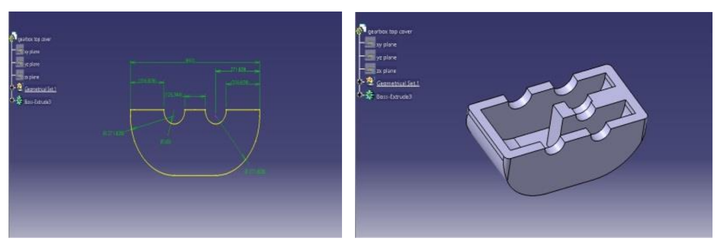


Fig: Generated gear top cover using pad & pocket feature

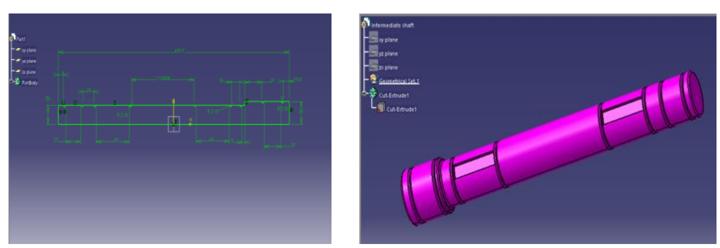


Fig: Generated intermediate shaft using shaft feature

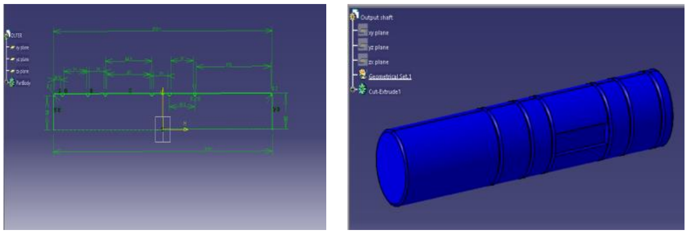


Fig: Generated output shaft using shaft feature

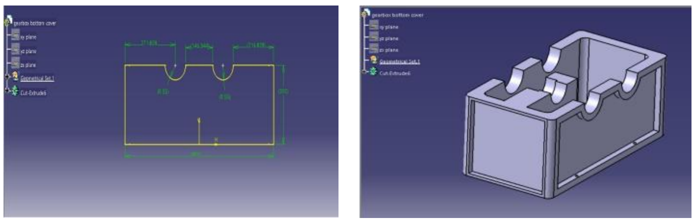


Fig: Generated gear top cover using pad & pocket feature

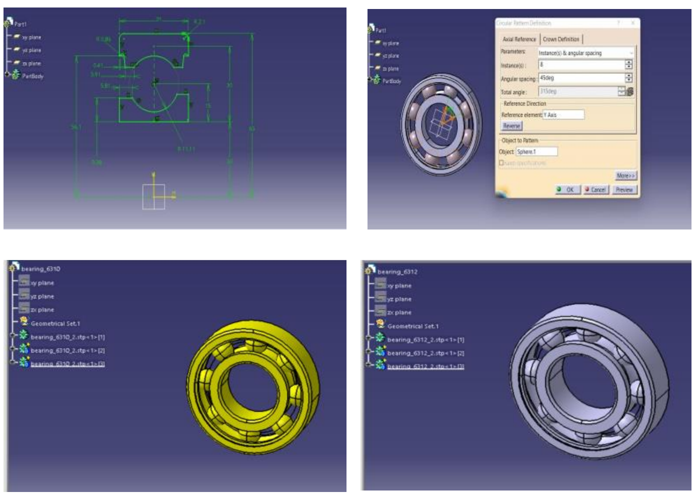
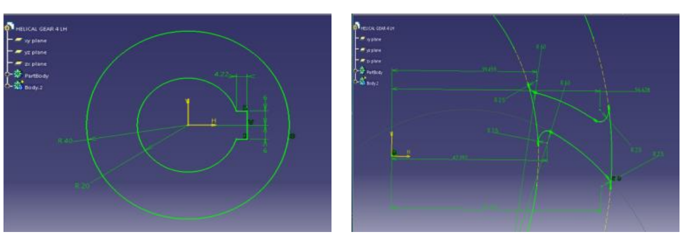


Fig: Generated bearing 6312 using pad feature



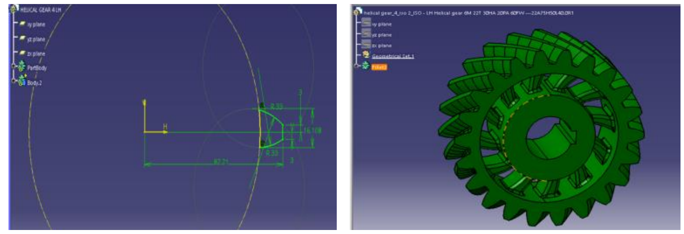


Fig: Generated Helix gear using multi section feature

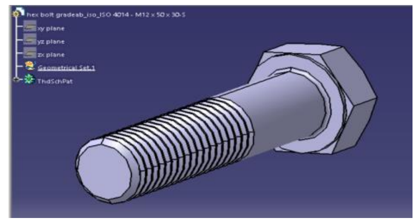
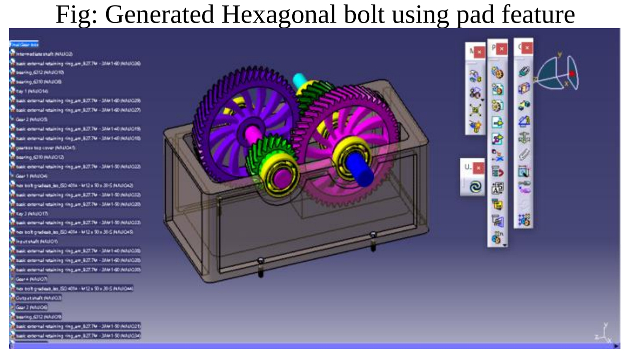


Fig: Generated Hexagonal bolt using pad feature



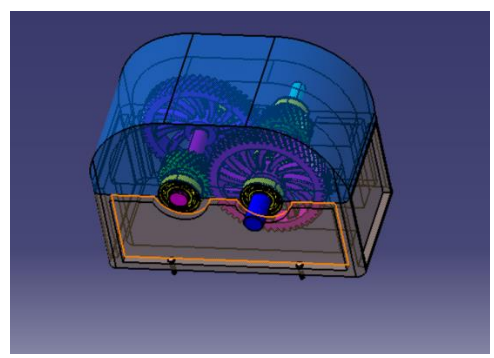


Fig: Assembly Of Gear Box

4. ANALYSIS:

4.1.ANSYS:

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software Implements equations that govern the behavior of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

4.2 ANALYSIS TYPES AVAILABLE IN ANSYS:

There are 14 different types of analysis available in ANSYS 14.5 They are:

1. Design Assessment Analysis
2. Eigen Response Analysis
3. Electric Analysis
4. Explicit Dynamics Analysis
5. Harmonic Response Analysis
6. Magneto static Analysis
7. Random Vibration Analysis
8. Response Spectrum Analysis
9. Shape Optimization Analysis
10. Static Structural Analysis
11. Steady-State Thermal Analysis
12. Thermal-Electric Analysis
13. Transient Structural and Rigid Dynamics Analyses
14. Transient Thermal Analysis

4.3 **PROCEDURE FOR ANSYS ANALYSIS:**

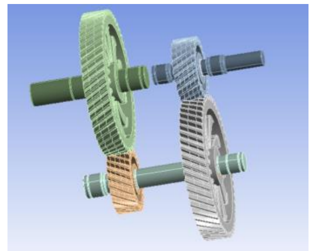
Analysis in ANSYS can be either linear or non-linear. The procedure for any analysis consists of thesemain steps.

1.Pre-Processor Phase (Build the model)

2.Solution Phase (Obtain the solution)

3.Post-Processor Phase (Review the results)

5. STRUCTURAL ANALYSIS GEAR BOX:



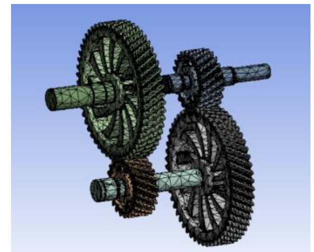


Fig:Model import in ANSYS fig:mesh model

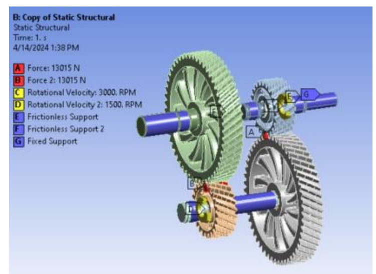
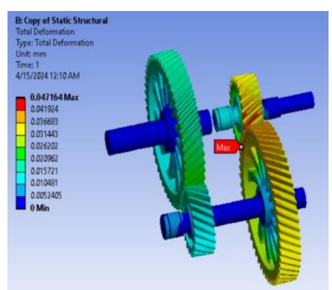


Fig:Load on BC

FORCE: 13015N



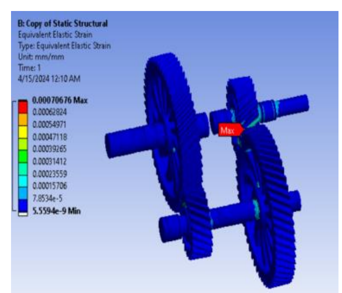


Fig:Deformation Fig:vonmieses strain

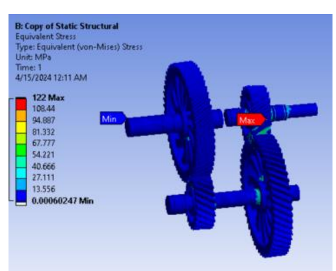


Fig:Vonmieses Stress

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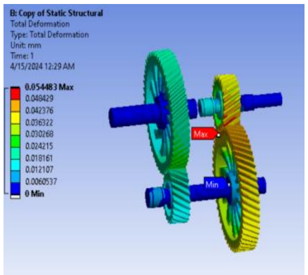
FORCE: 15000N on Pinion



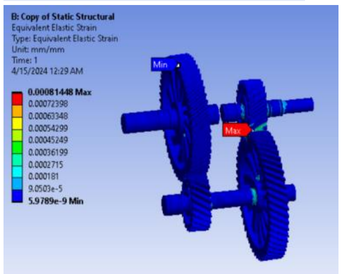


Fig:Deformation Fig:vonmieses strain

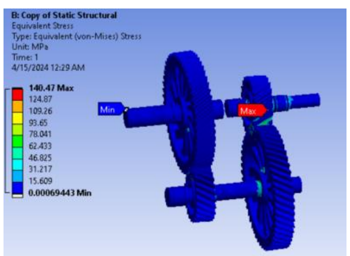
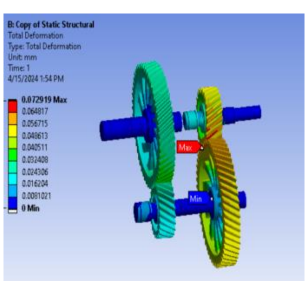


Fig:Vonmieses Stress

FORCE: 20000N on Pinion



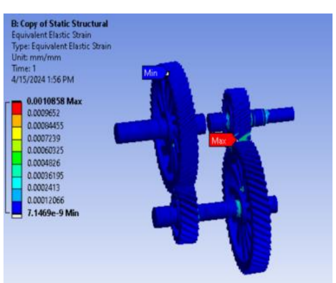


Fig:Deformation Fig:vonmieses strain

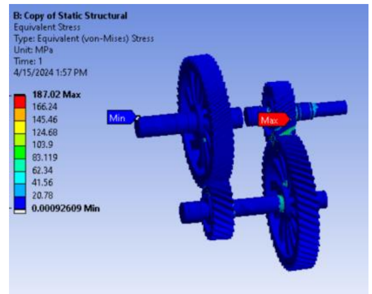
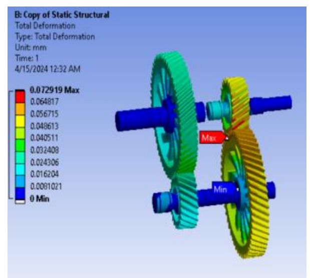


Fig:Vonmieses Stress

FORCE: 25000N on Pinion



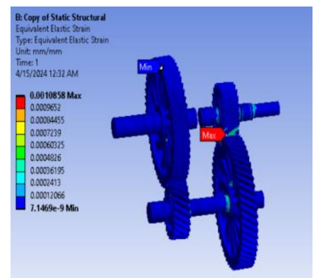


Fig:Deformation Fig:vonmieses strain

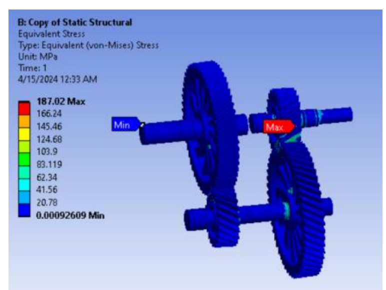
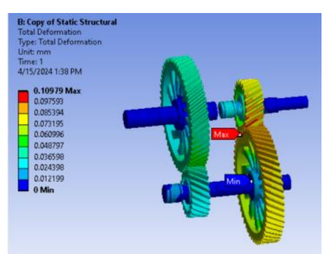


Fig:Vonmieses Stress

FORCE: 30000N on Pinion



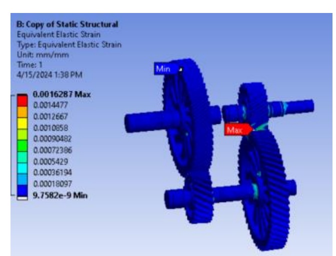


Fig:Deformation Fig:vonmieses strain

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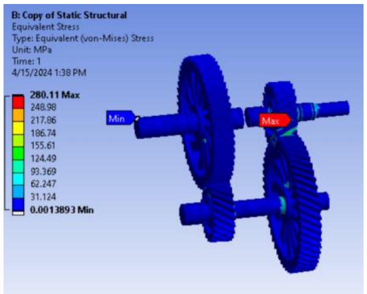
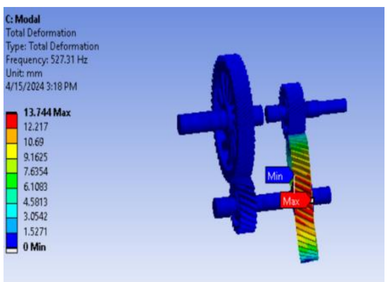
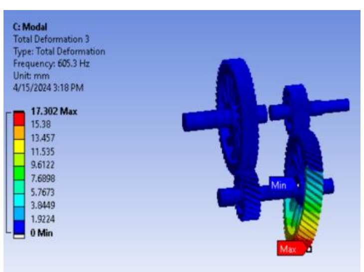


Fig:Vonmieses Stress

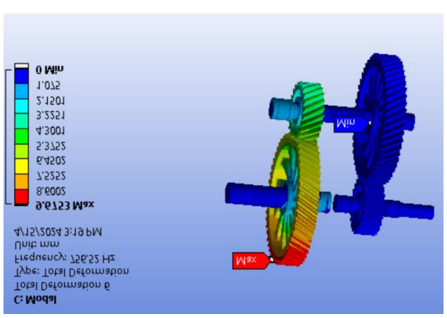
6 . DYNAMIC ANALYSIS OF GEAR BOX:



Deformation at Mode Freq 527.31 Hz



Deformation at Mode Freq 605.3 Hz

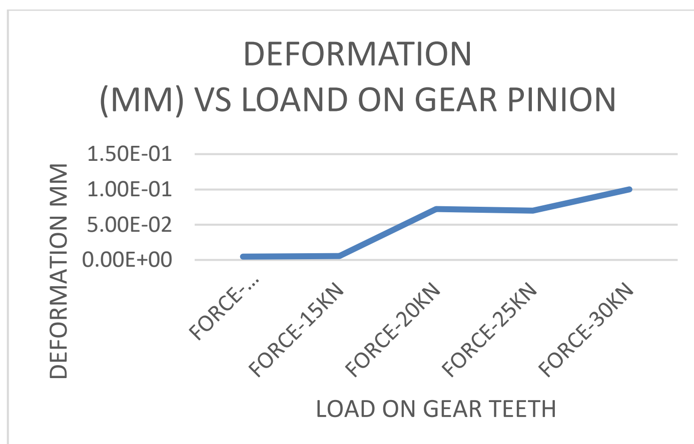


Deformation at Mode Freq 756.52 Hz

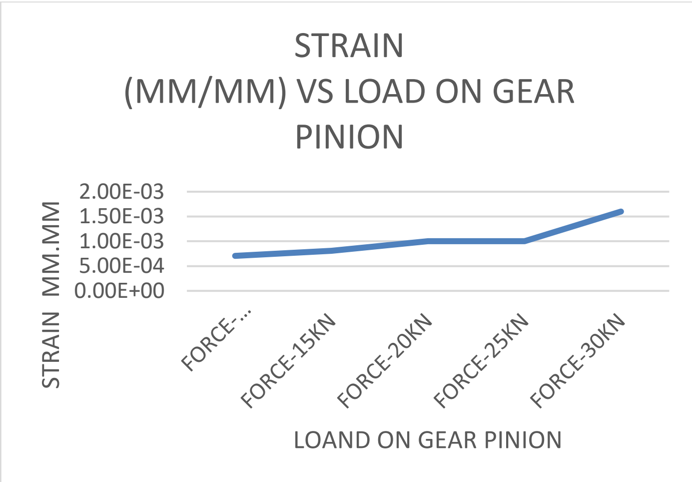
6 . RESULTS:

6.1 STRUCTURAL ANALYSIS:

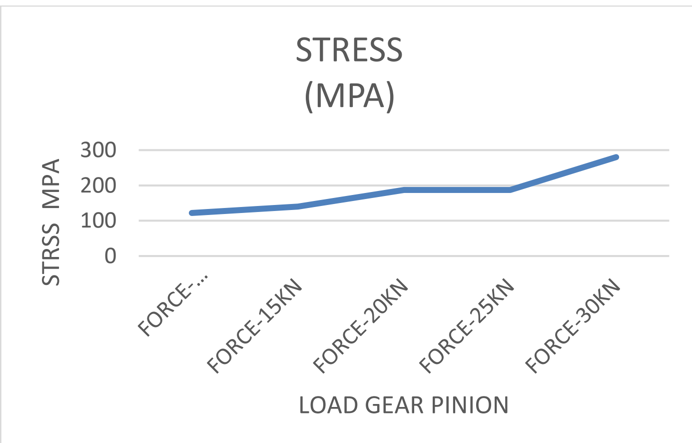
SNO.	LOAD ON PINION	DEFORMATION (MM)	STRAIN (MM/MM)	STRESS (MPA)
1	FORCE-13015N	4.70E-03	7.06E-04	122
2	FORCE-15KN	5.40E-03	8.10E-04	140.47
3	FORCE-20KN	7.20E-02	1.00E-03	187.02
4	FORCE-25KN	0.07	1.00E-03	187.02
5	FORCE-30KN	0.1	1.60E-03	280.11



Graph: Deformation vs Load On Gear Teeth



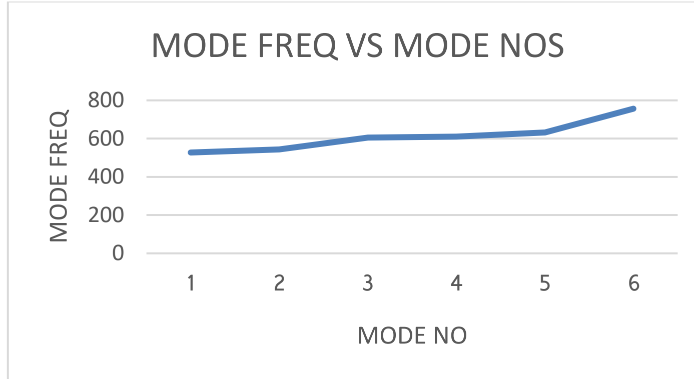
Graph: Deformation vs Load On Gear Pinion



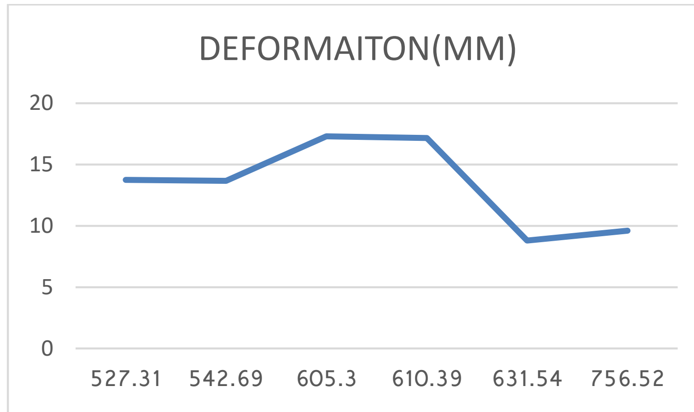
Graph: Stress vs Load On Gear Pinion

6.2 DYNAMIC ANALYSIS:

MODE NO	MODE FRQ	DEFORMAITON(MM)
1	527.31	13.74
2	542.69	13.66
3	605.3	17.3
4	610.39	17.17
5	631.54	8.8
6	756.52	9.6



Graph: Mode Frequency vs Mode No



Graph: Deformation

7. CONCLUSION:

Helical Gear dynamic simulation and optimization of FEA considering actual misalignments are rarely discussed in the literature. In this study, multi-objective optimization was first performed to determine the optimum tip relief modification parameters of a highspeed Helical gear pair.Dynamic characteristics of the original design and optimum design Helical gear pair were also simulated and compared. A dynamic model of the Helical gear system was used to calculate. Subsequently, the RMS values of the acceleration at various rotational speeds and meshing frequencies were computed for comparison. According to the Static and dynamic analysis results. With Load on pinion has applied 13k, 15k,20k, 25k and 30K Newtons. By our desing load bearing capacity increase by load 30K N, Maximum stress is 281MPA load of 30KN with stand as per our design Helical Gear train.Dynamic Model with stand frequency and deformation are plot having high stability.

7.References:

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