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DESIGN AND ANALYSIS OF 4 WHEEL STEERING SYSTEM DESIGN

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Abstract: The most conventional steering arrangement is to turn the front wheels using a hand–operated steering wheel which is positioned in front of the driver, via the steering column, which may contain universal joints (which may also be part of the collapsible steering column design), to allow it to deviate somewhat from a straight line. In this thesis, to turn the rear wheels out of phase to the front wheels. In order to achieve this, a mechanism which consists of two bevel gears and intermediate shaft which transmit 100% torque as well turns rear wheels in out of phase was developed. The materials used for these analyses are Aluminium alloy, steel, and cast-iron materials. Static analysis to determine the deformation, stress of the steering system at different rotational velocities (220,250,300&400rad/s), modal analysis to determine the natural frequency and deformation for 5 mode shapes. 3D modelled by using the software Pro-Engineer and analysis done in ANSYS software.

Keywords: Steering, Gear, Velocity, ANSYS software

I.INTRODUCTION

Four-wheel steering is a strategy produced in car industry for the stunning turning of the vehicle and to acquire the manoeuvrability. In a conventional front wheel controlling arrangement the back tyres don't go into the bend and in this way look out for the sufficiency of the organising. In four wheels steering the back tyres turn with the front wheels in this way expanding the adaptability of the vehicle. The heading of organising the back tyres relative with the front wheels varies on the operating situations. At low-speed wheel progression is stated, so that back tyres are controlled the substitute way to that of front wheels. At fast, when managing adjustments are uncomplicated, the front fights back tyres turn a relative method. By altering the steering of the back tyres there is decrease in turning length of the vehicle, which is useful in leaving, low speed cornering and quick direction change. In city driving situations the vehicle with higher wheelbase and track width oversees concerns of turning as the space is restricted, an equal issue is looked in low speed cornering. Typically, clients pick the vehicle with bigger wheelbase and track width for their solace and deal with these challenges, thus to beat this difficulty a considered four-wheel planning can be achieved in the vehicle. Four wheels organising minimises the turning length of the vehicle, which is productive in bound space, in this assignment four-wheel steering is gotten for the existing vehicle and turning range is lowered without changing the segment of the vehicle. In four-wheel steering structure, back tyre additionally turns rather than basically follow the front wheel. As in four-wheel planning structure both front community and back focus moves according to the fundamental of the top of the vehicle. As in right now we have seen that the spots are pretty much nothing and there is less space on street where we need to drive the vehicle thusly on the off chance that we out and out consider it we need to get something which utilises less reach to turn and can without a truly striking stretch turn when turning of the vehicle is required. In this way, we believed that to shift two-wheel controlling steering over to four-wheel planning structure so we can vanquish the entirety of the troubles that are happening in two-wheel steering structure. Four-wheel controlling is new development identified with steering to moreover cultivate the organising structure in four-wheel autos.

This incredible planning structure enhances safety and response at high speeds while reducing the driver's organising commitment at low speeds by managing the steering characteristics of all four wheels.

It is important to have a vehicle that is easy to drive both in the city and on curving roads in order to have a favourable vehicle Vehicles may be driven safely on highways, remembering to switch to another lane if necessary.

Quick and responsive control steering allows for sensitive handling.

In order to overcome this problem, the vehicle can be fitted with a concept known as four-wheel steering.

II.LITERATURE SURVEY

1. Four-wheel steering system for Automobile

A Four-wheel steering system also known as Quadra steering system. In this paper, both front wheel and rear wheels can be steered according to speed other vehicle and space available for turning. Quadra steer gives full size vehicle greater ease while driving at low speed, improves stability, handling and control at higher speed. Production-built cars tend to under steer or, in few instances, overseer. If a car could automatically compensate for an under-steer overseer problem, the driver would enjoy nearly neutral steering under varying conditions. Four-wheel systems are a serious effort on the part of automotive design engineers to provide near-neutral steering. This system finds application in off-highway vehicles such as forklifts, agricultural and construction equipment mining machinery also in Heavy Motor Vehicles. It is also useful in passenger cars. It improves handling and helps the vehicle make tighter turns. This system is used to minimize the turning radius. KEYWORDS: Quadra, turning radius, cornering, pure

2. Four Wheel Steering System for Future

A Four-Wheel steering (4WS) System is also known as "Quadra Steering System". In this paper, both front as well as rear wheels can be steered according to speed of the vehicle and space available for turning. Quadra steer is system that gives full size vehicles greater ease while driving at low speed, and improves stability, handling and control at higher speed. Quadra steering system works in following three phases Negative phase, Neutral phase, Positive phase. It enables the car to be steered into tighter parking spaces. It makes the car more stable at speed (less body roll). It makes the car more efficient and stable on cornering, easier and safer lanes change when on motorways. The steering system allows the driver to guide the moving vehicle on the road and turn it right or left as desired. The main aim is that turning of the vehicle should not require greater efforts on the part of the driver. The Quadra steer steering system offers a 21% reduction in turning radius. So, if a vehicle is capable of making a U-turn in a 25-foot space, Quadra steer allows the driver to do it in about 20 feet.

Keywords: Quadra, Negative phase, Neutral phase, Positive phase

3. WHEEL STEERING SYSTEMS

This paper is all about 4-wheel steering system rather than 2-wheel steering as in conventional vehicles running in INDIA. A 4-wheel steering is completely different from a 4-wheel drive (in which each wheel is given power rather than to 2 wheels). A 4-wheel steering system is superior to a 2-wheel steering system. It reduces the turning radius as well as the space required for turning. It also enables to change road lane while driving even at high speed. This paper is under research in a university of Egypt. In this project we want to develop an electric car with the wheel rotation up to 90º for the cause –the parking problem faced in metro cities. This car will be a special utility vehicle which can run on 2-wheel steering as well as on 4-wheel steering. Keywords: 2 Wheel steering system, 4 Wheel steering system, Turning radius

4. Convertible Four Wheels Steering with Three Mode

The most conventional and general steering arrangement is to turn the front wheels using a hand–operated steering wheel which is positioned in front of the Driver. The steering column, which contain a universal joint which is part of the collapsible steering column which is designed to allow it to deviate from a straight line according to the roadmap.

In CONVERTIBLE FOUR WHEEL STEERING WITH THREE MODE OPERATION three steering modes can be changed as needed which assists in parking at heavy traffic conditions, when negotiating areas where short turning radius is needed and in off road Driving. Key Words: Steering; Wheels, steering column; Universal joint.

5. Design and Simulation of 4 Wheel Steering Systems

In standard 2 Wheel Steering System, the rear set of wheels are always directed forward and do not play an active role in controlling the steering. While in 4 Wheel Steering System, the rear wheels do play an active role for steering, which can be guided at high as well as low speeds. Production cars are designed to under steer and rarely do they over steer. If a car could automatically compensate for an under steer/over steer problem, the driver would enjoy nearly neutral steering under varying operating conditions. Also, in situations like low-speed cornering, vehicle parking and driving in city conditions with heavy traffic in tight spaces, driving would be very difficult due to a sedan's larger wheelbase and track width. Hence there is a requirement of a mechanism which result in less turning radius. We have developed an innovative 4-wheel steering design to implement a mechanism that can serve the purpose of changing in-phase and counter-phase steering of rear wheels depending upon the conditions of turning and lane changing with respect to front wheels, thus enhancing the manoeuvrability of a sedan in accordance with its speed. Our 4 Wheel Steering System gives 64.4% reduction in turning circle radius of a sedan which is reduced from 5.394m to 1.92m, considering HONDA CIVIC as a standard car for our calculations, and steering ratio thereby obtained is 8.177:1 which gives much better manoeuvrability and control on the car even while driving at high speeds.

6. Development of Four-Wheel Steering System for A Car

Production cars are designed to under steer and rarely do they over steer. If a car could automatically compensate for an under steer/over steer problem, the driver would enjoy nearly neutral steering under varying operating conditions. Four-wheel steering is a serious effort on the part of automotive design engineers to provide near-neutral steering. Also, in situations like low-speed cornering, vehicle parking and driving in city conditions with heavy traffic in tight spaces, driving would be very difficult due to vehicle's larger wheelbase and track width. Hence there is a requirement of a mechanism which result in less turning radius and it can be achieved by implementing four-wheel steering mechanism instead of regular two-wheel steering. In this project Maruti Suzuki 800 is considered as a benchmark vehicle. The main aim of this project is to turn the rear wheels out of phase to the front wheels. In order to achieve this, a mechanism which consists of two bevel gears and intermediate shaft which transmit 100% torque as well turns rear wheels in out of phase was developed. The mechanism was modelled using CATIA and the motion simulation was done using ADAMS. A physical prototype was realised. The prototype was tested for its cornering ability through constant radius test and was found 50% reduction in turning radius and the vehicle was operated at low speed of 10 kmph.

III. CAD

Computer-aided design (CAD), also known as computer-aided design and drafting (CADD), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provide the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes. CADD output is often in the form of electronic files for print or machining operations. The development of CADD-based software is in direct correlation with the processes it seeks to economize; industry-based software (construction, manufacturing, etc.) typically uses vector-based (linear) environments whereas graphic-based software utilizes raster-based (pixelated) environments.

CADD environments often involve more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions.

CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) objects.

CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.

The design of geometric models for object shapes, in particular, is often called computer-aided geometric design (CAGD).

Current computer-aided design software packages range from 2D vector-based drafting systems to 3D solid and surface modelers. Modern CAD packages can also frequently allow rotations in three dimensions, allowing viewing of a designed object from any desired angle, even from the inside looking out. Some CAD software is capable of dynamic mathematic modelling, in which case it may be marketed as CADD — computer-aided design and drafting.

CAD is used in the design of tools and machinery and in the drafting and design of all types of buildings, from small residential types (houses) to the largest commercial and industrial structures (hospitals and factories).

CAD is mainly used for detailed engineering of 3D models and/or 2D drawings of physical components, but it is also used throughout the engineering process from conceptual design and layout of products, through strength and dynamic analysis of assemblies to definition of manufacturing methods of components. It can also be used to design objects.

CAD has become an especially important technology within the scope of computer-aided technologies, with benefits such as lower product development costs and a greatly shortened design cycle. CAD enables designers to lay out and develop work on screen, print it out and save it for future editing, saving time on their drawings.

Types of CAD Software

2D CAD

Two-dimensional, or 2D, CAD is used to create flat drawings of products and structures. Objects created in 2D CAD are made up of lines, circles, ovals, slots and curves. 2D CAD programs usually include a library of geometric images; the ability to create Bezier curves, splines and polylines; the ability to define hatching patterns; and the ability to provide a bill of materials generation. Among the most popular 2D CAD programs are AutoCAD, CAD key, CADDS 5, and Medusa.

3D CAD

Three-dimensional (3D) CAD programs come in a wide variety of types, intended for different applications and levels of detail. Overall, 3D CAD programs create a realistic model of what the design object will look like, allowing designers to solve potential problems earlier and with lower production costs. Some 3D CAD programs include Autodesk Inventor, Cocreate Solid Designer, Pro/Engineer Solid Edge, SolidWorks, Unigraphics NX and VX CAD, CATIA V5.

3D Wireframe and Surface Modelling

CAD programs that feature 3D wireframe and surface modelling create a skeleton-like inner structure of the object being modelled. A surface is added on later. These types of CAD models are difficult to translate into other software and are therefore rarely used anymore.

Solid Modelling

Solid modelling in general is useful because the program is often able to calculate the dimensions of the object it is creating. Many sub-types of this exist. Constructive Solid Geometry (CSG) CAD uses the same basic logic as 2D CAD, that is, it uses prepared solid geometric objects to create an object. However, these types of CAD software often cannot be adjusted once they are created. Boundary Representation (Brep) solid modelling takes CSG images and links them together. Hybrid systems mix CSG and Brep to achieve desired designs

INTRODUCTION TO PRO/ENGINEER

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

Customer requirements may change and time pressures may continue to mount, but your product design needs remain the same - regardless of your project's scope, you need the powerful, easy-to-use, affordable solution that Pro/ENGINEER provides.

Pro/ENGINEER Wildfire Benefits:

•Unsurpassed geometry creation capabilities allow superior product differentiation and manufacturability

•Fully integrated applications allow you to develop everything from concept to manufacturing within one application

•Automatic propagation of design changes to all downstream deliverables allows you to design with confidence

•Complete virtual simulation capabilities enable you to improve product performance and exceed product quality goals

•Automated generation of associative tooling design, assembly instructions, and machine code allow for maximum production efficiency

Pro ENGINEER can be packaged in different versions to suit your needs, from Pro/ENGINEER Foundation XE, to Advanced XE Package and Enterprise XE Package, Pro/ENGINEER Foundation XE Package brings together a broad base of functionality. From robust part modelling to advanced surfacing, powerful assembly modelling and simulation, your needs will be met with this scale able solution. Flex3C and Flex Advantage Build on this base offering extended functionality of you're choosing.

The main modules are

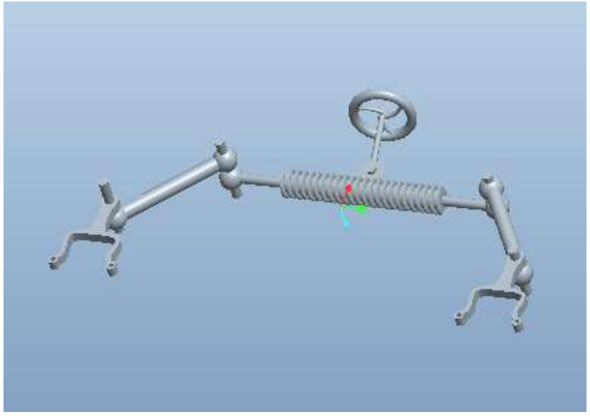
Part Design

Assembly

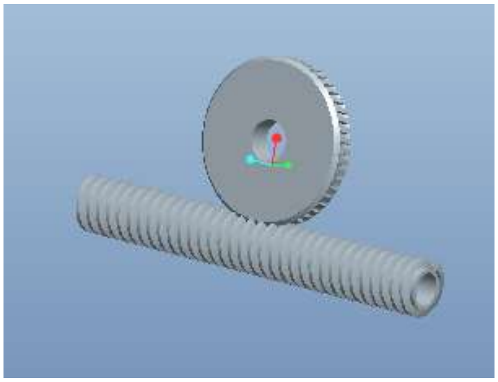
Drawing

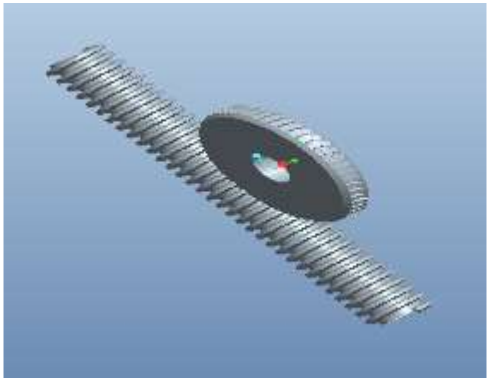
Sheet Metal

3D MODAL OF FOUR-WHEELER STEERING SYSTEM



Gear system





IV. 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 behaviour 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 analyse by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

ANSYS is the standard FEA teaching tool within the Mechanical Engineering Department at many colleges. ANSYS is also used in Civil and Electrical Engineering, as well as the Physics and Chemistry departments.

ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping.

With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of a design on the whole behaviour of the product, be it electromagnetic, thermal, mechanical etc.

Steps involved in ANSYS

In general, a finite element solution can be broken into the following these
categories.
1. Pre-processing module: Defining the problem
The major steps in pre-processing are given below
- defining key points /lines/areas/volumes
- define element type and material /geometric /properties
- mesh lines/areas/volumes/are required

The amount of detail required will depend on the dimensionality of the analysis (i.e., 1D, 2D, axis, symmetric)
2. Solution processor module: assigning the loads, constraints and solving. Here we specify the loads (point or pressure), constraints (translation, rotational) and finally solve the resulting set of equations.
3. Post processing module: further processing and viewing of results
In this stage we can see:
List of nodal displacement
Elements forces and moments

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Deflection plots
Stress contour diagrams

Thermal

ANSYS is capable of both steady state and transient analysis of any solid with thermal boundary conditions. Steady-state thermal analyses calculate the effects of steady thermal loads on a system or component. Users often perform a steady-state analysis before doing a transient thermal analysis, to help establish initial conditions. A steady-state analysis also can be the last step of a transient thermal analysis; performed after all transient effects have diminished. ANSYS can be used to determine temperatures, thermal gradients, heat flow rates, and heat fluxes in an object that are caused by thermal loads that do not vary over time. Such loads include the following:

- Convection
- Radiation
- Heat flow rates
- Heat fluxes (heat flow per unit area)
- Heat generation rates (heat flow per unit volume)
- Constant temperature boundaries

A steady-state thermal analysis may be either linear, with constant material properties; or nonlinear, with material properties that depend on temperature. The thermal properties of most material vary with temperature. This temperature dependency being appreciable, the analysis becomes nonlinear. Radiation boundary conditions also make the analysis nonlinear. Transient calculations are time dependent and ANSYS can both solve distributions as well as create video for time incremental displays of models.

V. STATIC ANALYSIS OF FOURWHEELER STEERING SYSTEM

USED MATERIALS

STEEL, ALUMINUM ALLOY AND CAST IRON

MATERIAL PROPERTIES

STEEL

Density = 7.89g/cc

Young's modulus = 205000MPa

Poisson's ratio = 0.29

ALUMINUM ALLOY

Density = 2.7g/cc

Young's modulus = 68900MPa

Poisson's ratio = 0.3

CAST IRON

Density = 7.81g/cc

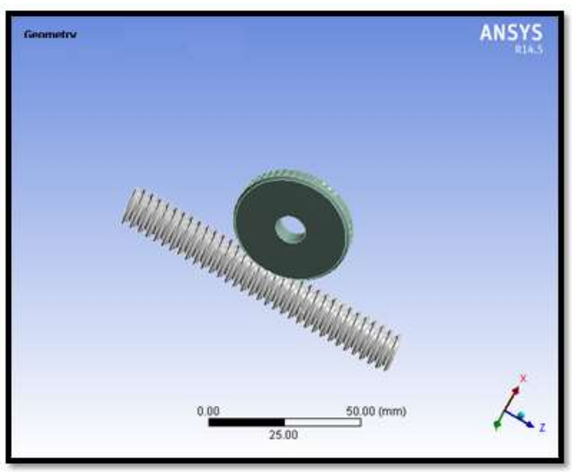
Young's modulus = 230 MPa

Poisson's ratio = 0.31

Used software for this project work bench

Open work bench in Ansys 14.5

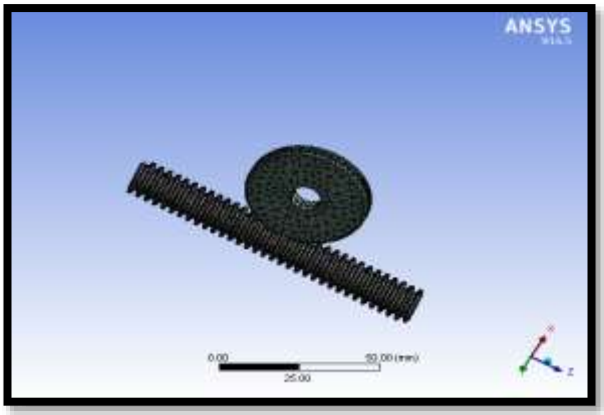
Select static structural>select geometry>import IGES model>OK



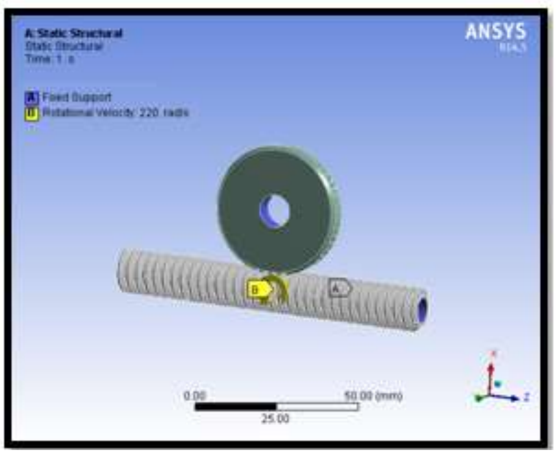
Click on model>select EDIT

Select model >apply materials to all the objects (different materials also)

Mesh> generate mesh>ok



Static structural A5>insert>select. displacement>select fixed areas>ok >Select pressure>select pressure areas> enter pressure >Select rotational velocity>select axis>enter speed value



Solution A6>insert>total deformation>right click on total deformation>select evaluate all results

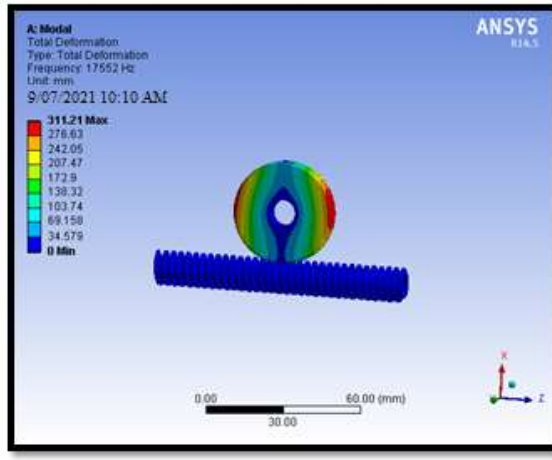
Insert>stress>equivalent (von misses)>right click on equivalent >select evaluate all results

Insert>strain>equivalent (von misses)>right click on equivalent >select evaluate all results

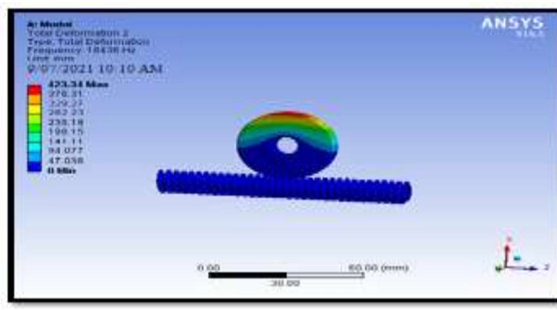
MODAL ANALYSIS OF FOUR-WHEELER STEERING SYSTEM

MATERIAL- STEEL

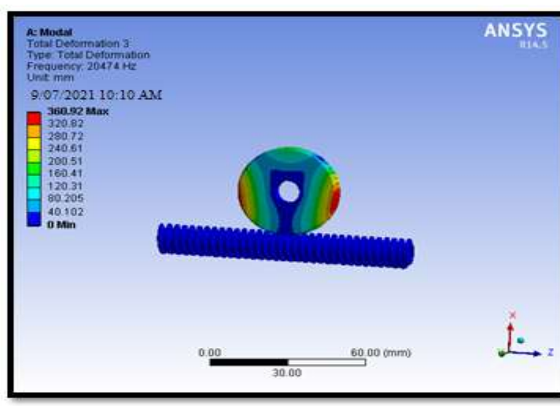
1st mode shape deformation



2nd mode shape deformation



3rd mode shape deformation



4rth mode shape deformation

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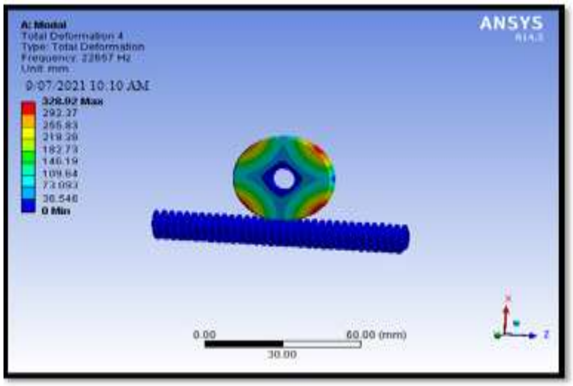
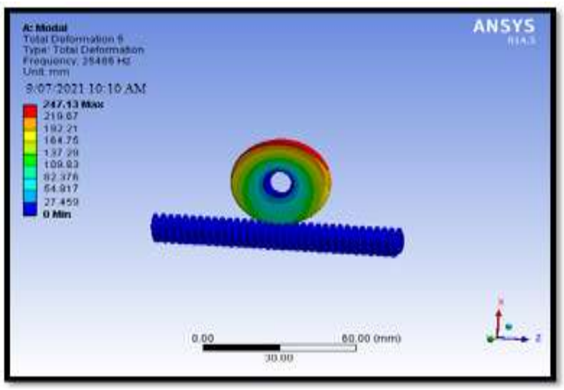
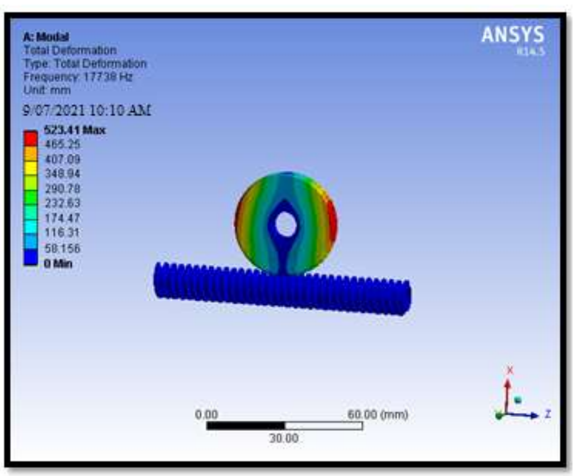


5th mode shape deformation

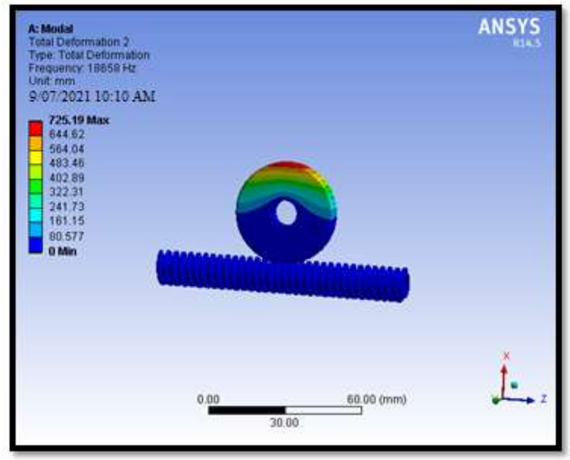


MATERIAL- ALUMINUM ALLOY

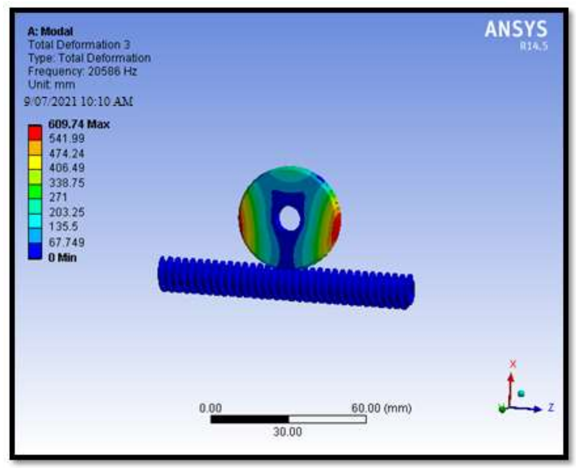
1st mode shape deformation



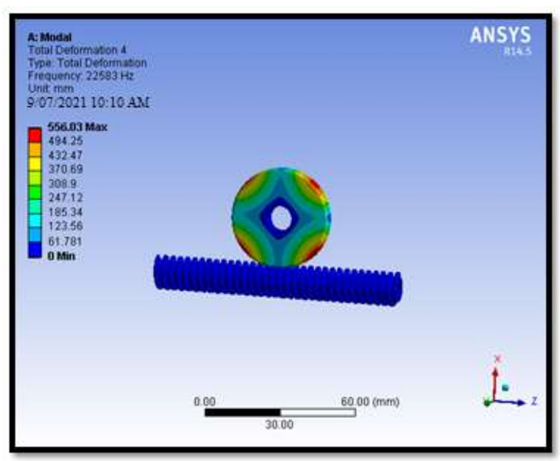
2nd mode shape deformation



3rd mode shape deformation



4rth mode shape deformation



5th mode shape deformation

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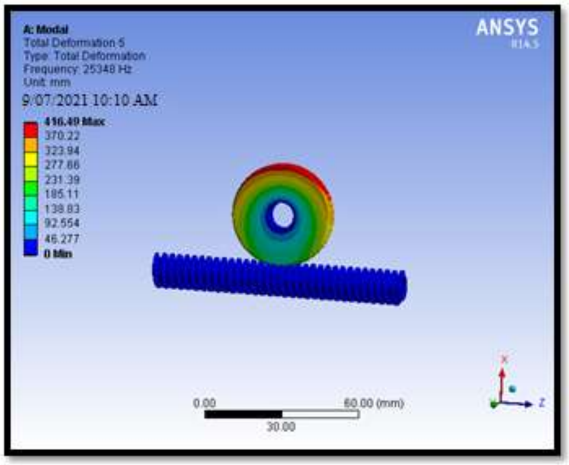
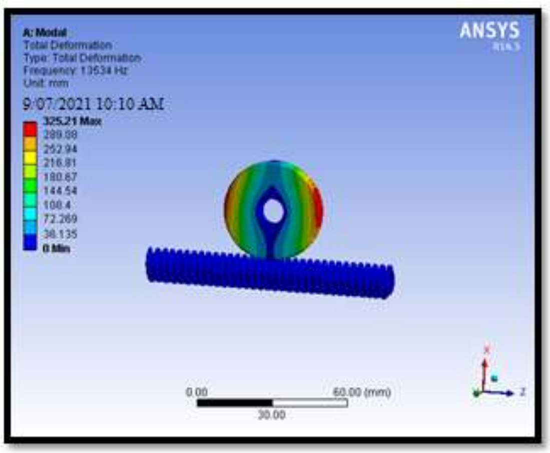
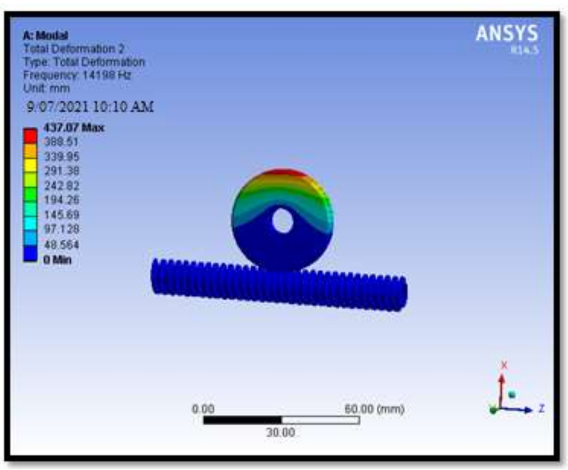


MATERIAL- CAST IRON

1st mode shape deformation



2nd mode shape deformation



STATIC ANALYSIS RESULT TABLE

material	Rotational velocity(rad/s)	Deformation(mm)	Stress (MPa)	strain
steel	220	2.2348e-5	0.93905	4.9445e-6
	250	2.8858e-5	1.2126	6.3849e-6
	300	4.1556e-5	1.7402	9.194e-6
	400	7.3877e-5	3.1043	1.6345e-5
Aluminium alloy	220	2.2538e-5	0.33689	4.9978e-6
	250	2.9104e-5	0.43504	6.4537e-6
	300	4.1909e-5	0.62646	9.293e-6
	400	7.4505e-5	1.1137	1.6522e-5
Cast iron	220	3.6893e-5	0.85185	8.1545e-6
	250	4.7641e-5	1.11	1.053e-5
	300	6.8603e-5	1.584	1.5163e-5
	400	0.00012196	2.816	2.6957e-5

MODAL ANALYSIS RESULT TABLE

material	Mode shapes	Deformation(mm)	Frequency (Hz)
steel	Mode 1	311.21	17552
	Mode 2	423.31	18436
	Mode 3	360.92	20474
	Mode 4	328.92	22657
	Mode 5	247.13	25485
Aluminiu	Mode	523.41	17738

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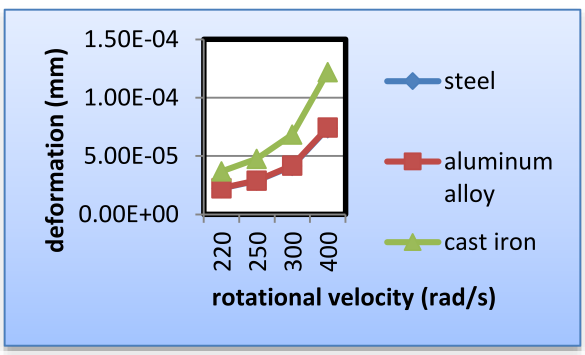
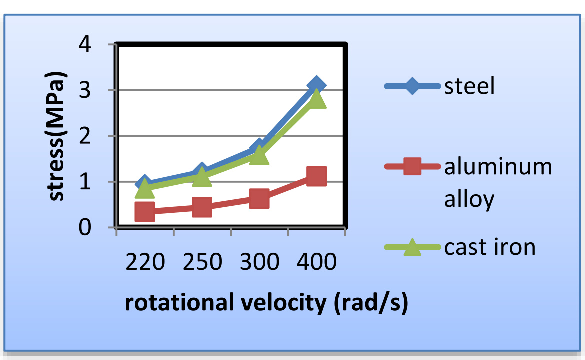
m alloy	**1**		
	Mode 2	725.19	18658
	Mode 3	609.74	20586
	Mode 4	556.03	22583
	Mode 5	416.49	25348
Cast iron	**Mode 1**	325.21	13534
	Mode 2	437.07	14198
	Mode 3	375.56	15842
	Mode 4	342.6	17625
	Mode 5	257.86	19850

GRAPHS

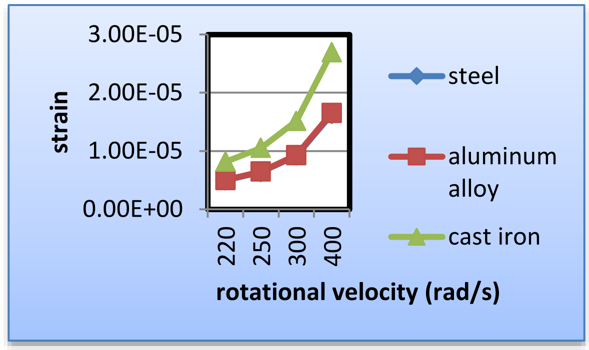
DEFORMATION PLOT



STRESS PLOT

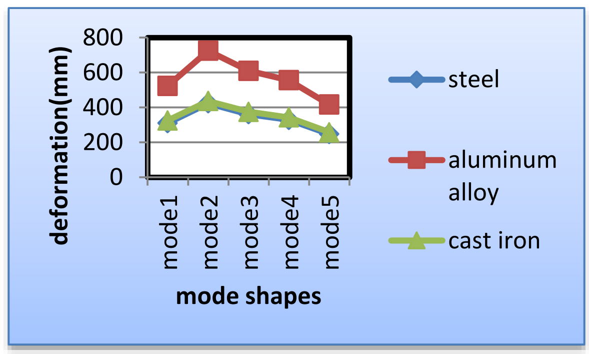


STRAIN PLOT

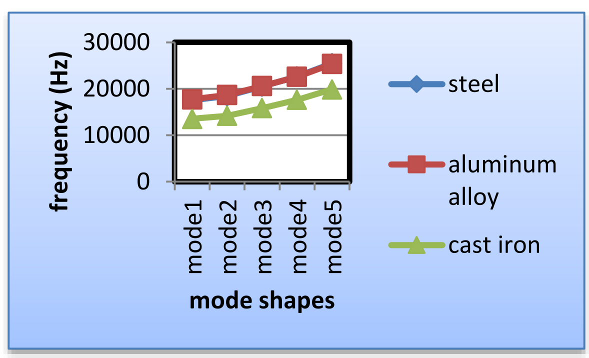


MODAL ANALYSIS

DEFORMATION PLOT



FREQUENCY PLOT



CONCLUSION

In this thesis, to turn the rear wheels out of phase to the front wheels. In order to achieve this, a mechanism which consists of two bevel gears and intermediate shaft which transmit 100% torque as well turns rear wheels in out of phase was developed.

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The materials used for these analyses are Aluminium alloy, steel, and cast-iron materials. Static analysis to determine the deformation, stress of the steering system at different rotational velocities (220,250,300&400rad/s), modal analysis to determine the natural frequency and deformation for 5 mode shapes. 3D modelled by using the software Pro-Engineer and analysis done in ANSYS software. By observing the static analysis, the stress values are increases by increasing the rotational velocity. Less stress values for aluminium alloy compare with steel and cast iron. By observing the modal analysis, the deformation values more for aluminium alloy. So, it can be concluded the aluminium alloy material is better material for steering mechanism system.

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