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DESIGN AND ANALYSIS OF FOUR WHEEL STEERING SYSTEM

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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

3Dmodelled by using the software CATIA and analysis done in ANSYS software.

I. INTRODUCTION

Steering is the collection of components, linkages, etc. which allows any vehicle (car, motorcycle, bicycle) to follow the desired course. An exception is the case of rail transport by which rail tracks combined together with railroad switches (and also known as 'points' in British English) provide the steering function. The primary purpose of the steering system is to allow the driver to guide the vehicle.

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Part of car steering mechanism: tie rod, steering arm, king pin axis (using ball joints)

For other uses, see Four-wheel drive (disambiguation).

"Four by four" redirects here. For other uses, see Four by four (disambiguation).

The Jeep Wrangler is a 4WD vehicle with a transfer case to select low range or high range four-wheel drive

Four-wheel drive, 4×4 ("four by four"), and 4WD, is a form of drive train capable of providing power to all wheel ends of a two-axle vehicle simultaneously. It may be full-time, or on-demand, and is typically linked via a transfer case which provides an additional output drive-shaft, along with additional gear ranges.

A four-wheeled vehicle with power supplied to both axles may sometimes be described as "all-wheel drive" (AWD). However, "four-wheel drive" typically refers to a set of specific components and functions, and/or intended off-road application, which generally complies with modern use of the terminology.

Types of Steering System:

Conventional Steering System:

Four Wheel Steering Systems: In that steering system, only the front wheels are steered towards right or left According to the Requirement because of a rear their dead axle is present.

In that steering system, the all four wheels are to be steered according to the steer perform to drive towards left or right. Four-wheel steering, 4WS, also called rear-wheel steering or all-wheel steering, provides a means to actively steer the rear wheels during turning manoeuvres. It should not be confused with four-wheel drive in which all four wheels of a vehicle are powered. It improves handling and helps the vehicle make tighter turns. Production-built cars tend to under steer or, in few instances, over steer. If a car could automatically compensate for an under steer /over steer problem, the driver would enjoy nearly neutral steering under varying conditions. In most active four wheel steering system, the rear wheels are steered by a computer and actuators, the rear

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wheels generally cannot turn as far as the front wheels. Some systems including Delphi's Quadra steer and the system in Honda's Prelude line allow the rear wheels to be steered in the opposite direction as the front wheels during low speeds. This allows the vehicle to turn in a significantly smaller radius sometimes critical for large tucks or tractors and vehicles with trailers.

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. Other arrangements are sometimes found on different types of vehicles, for example, a tiller or rear–wheel steering. Tracked vehicles such as bulldozers and tanks usually employ differential steering — that is, the tracks are made to move at different speeds or even in opposite directions, using clutches and brakes, to bring about a change of course or direction.

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 is 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

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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 Modes

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.

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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 them 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.

III METHODOLOGY

Introduction to 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, provides 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 (pixilated) 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 modeling, 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

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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, spines and plotlines; 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, Create Solid Designer, Pro/Engineer Solid Edge, Solid Works, Unigraphics NX and VX CAD, CATIA V5.

3D Wireframe and Surface Modeling

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 Modeling

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 (Beep) solid modelling takes CSG images and links them together. Hybrid systems mix CSG and Beep to achieve desired designs

The main modules in CATIA

- Part Design
- Assembly
- Drawing

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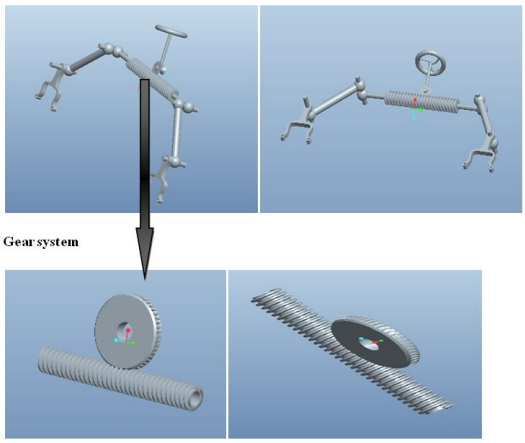
- Sheet Metal

3D MODAL OF FOUR WHEELER STEERING SYSTEM



IV ANALYSIS OF DESIGN

STATIC ANALYSIS OF FOUR WHEELER 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

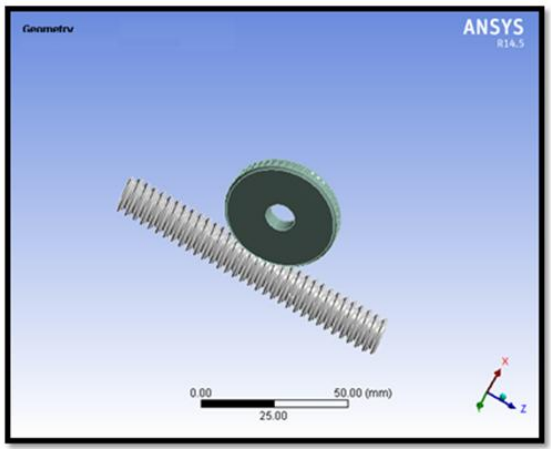
Young's modulus = 230 MPa

Poisson's ratio = 0.31

Used software for this project work bench

Open work bench in Ansys 14.5

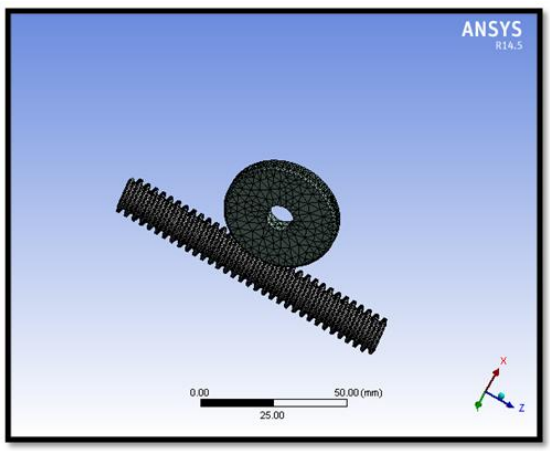
Select static structural>select geometry>import IGES model>OK



Click on model>select EDIT

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

Mesh> generate mesh>ok



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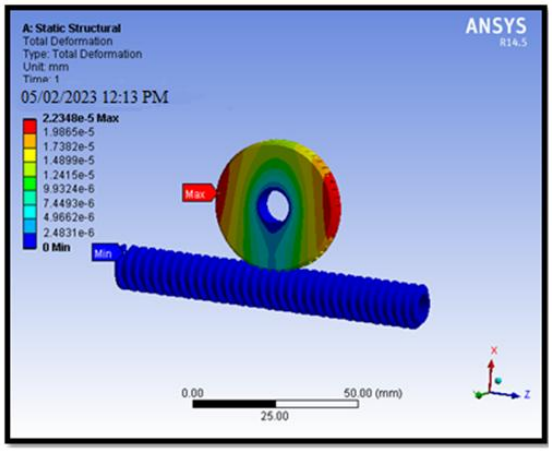
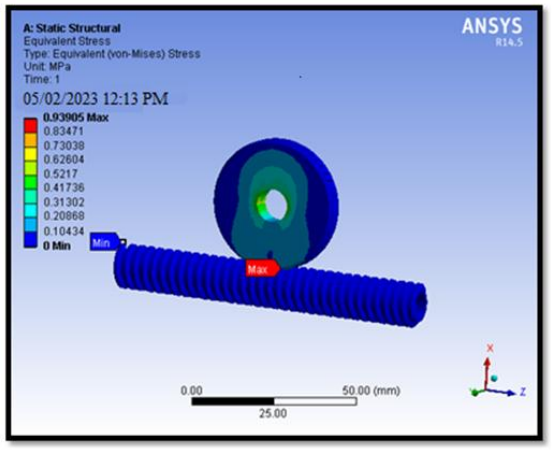
ROTATIONAL VELOCITY 220rad/s

MATERIAL- STEEL

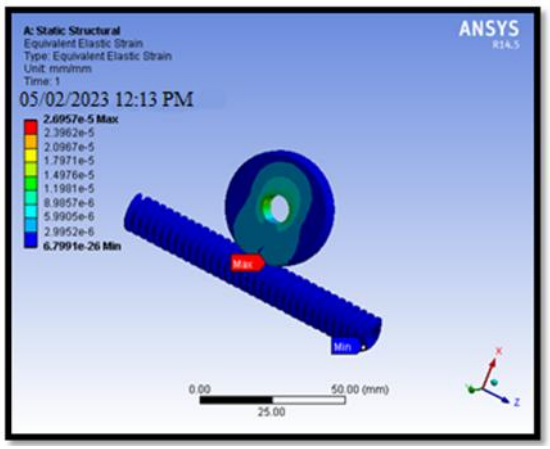
DEFORMATION



STRESS

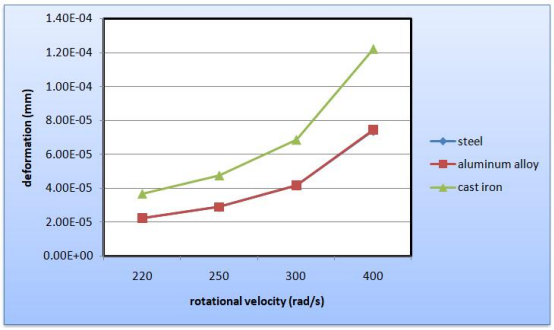


STRAIN

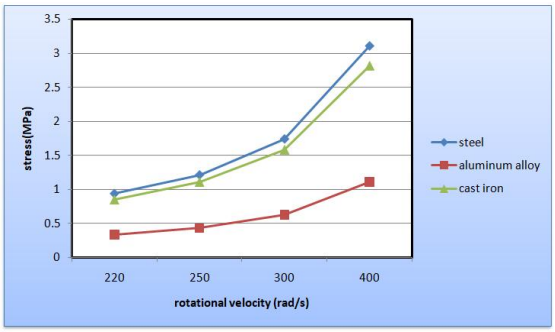


GRAPHS

DEFORMATION PLOT



STRESS PLOT



V RESULT AND DISCUSSION

STATICANALYSIS 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
Aluminum 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

VI 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.

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. 3Dmodelled 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.

VII SCOPE FOR FUTURE WORK

Having studied how 4WS has an effect on the vehicle's stability and driver manoeuvrability, we now look at what the future will present us with. The successful implementation of 4 Wheel Steering using mechanical linkages & single actuator will result in the development of a vehicle with maximum driver manoeuvrability, uncompressed static stability, front and rear tracking, vehicular stability at high speed lane changing, smaller turning radius and improved parking assistance. Furthermore, the following system does not limit itself to the benchmark used in this project, but can be implemented over a wide range of automobiles, typically from hatchbacks to trucks. This coupled with an overhead cost just shy of Rs. 15,000 provides one of the most economical steering systems for improved manoeuvrability and drivers" ease of access. With concepts such as "ZERO TURN" drive as used in „Tata Pixel" and "360o Turning" used in „Jeep Hurricane", when added to this system, it will further improve manoeuvrability and drivers ease of access.

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