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Optimizing Compound Epicyclic Gear Trains: Design, Load Analysis, and Results

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Abstract
In summary, epicycle gear trains have better planetary design efficiency, smaller size, less weight, and a greater torque capability.Technology that reduces transmission speeds via the use of planetary gears is small, powerful, and innovative. We take a look back at the structural analysis of linked planetary gear trains with three stages. In this study, we see how linked planetary gear trains' speed ratios, torques, efficiency, and power flow directions may be quickly and easily calculated. Efficiency in three stages found.Analyzed using ANSYS and 3D models created in CATIA.

INTRODUCTION

The gears of a planetary or epicyclic gear train revolve around a sun gear. In order to obtain a high reduction ratio in a compact and powerful package, epicyclical gearing systems are often used. The planetary gear train's unequal load-sharing capabilities are studied. These gear trains are the backbone of any mechanical power transmission system and see heavy use in transmission applications. Gear trains are very essential in every single industrial sector; when one breaks down, the whole system goes down with it. As a result, pinpointing the root reasons and optimizing for optimal performance is absolutely critical. Greater torque capacity, reduced weight, compact size, and enhanced planetary design efficiency are some of the benefits of epicyclic gear trains. The fact that it is 60% lighter and 50% smaller than a standard gearbox probably leads people to believe that it is not as sturdy. Minimizing strains in the gear system necessitates keeping loads to a minimum.

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EPICYCLIC GEAR TRAIN:

in the middle of both. Two gears, the sun gear and the planet gear, are rotated around each other by means of a carrier that is connected to their centers. Their pitch rings may roll without slipping because the planet and sun's gears mesh. An epicycloid curve is traced by a point on the planet gear's pitch circle. Here we have a simpler model where the sun gear is stationary and the planetary gears revolve around it. It is possible to construct an epicycle gear train so that the planet gear rolls inside the pitch circle of a stationary outer gear ring, also known as an annular gear. Here, a hypocycloid is the shape that a point on the planet's pitch circle traces. A planetary gear train is an epicycle gear train that incorporates a planet that engages a sun gear and a ring gear. This often involves driving the sun gear while fixing the ring gear.

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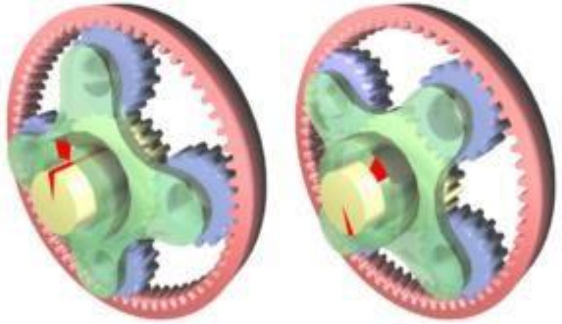
Fig: epicycle gear



Advantages Of An Epicyclic Gear:

- Envelope size (smaller than parallel shaft for samepower)
- Low weight
- Lower Pitch Line Velocity for comparable parallelshaft unit
- Coaxial Shafts (in line system) resulting in more compact installation
- low cost for entire train layout One of the most important considerations for an epicyclical gear is to assure uniform load distribution among the planets. This is made possible in a 3 or more planet arrangement.

DISADVANTAGES:

Include high bearing loads, constant lubrication requirements, inaccessibility, and design complexity. The efficiency loss in a planetary gear trains 3% per stage. The load in a planetary gear train is shared among multiple planets; therefore torque capability is greatly increased.

LITERATURE SURVEY

Ptolemy used spinning deferent and epicycles, which constitute epicyclic gear trains, to forecast the planetary movements in his work Almagest, written in the 2nd century AD. For the purpose of making precise predictions about the trajectories of the Sun, Moon, Mercury, Venus, Mars, Jupiter, and Saturn across the sky, it was imagined that each planet followed a path marked by a point on the planet gear of an epicyclic gear train. Epitrochoid describes this shape. In order to account for the moon's elasticity and even its precession of the ellipticity, the Antikythera Mechanism used epicyclic gearing about 80 BCE to alter the moon's exhibited location. One gear drove the other using a pin placed into a slot on the other, rather than meshed teeth, and the two gears were spun about slightly different centers. The driven gear would accelerate or decelerate with each rotation because the radius of driving changed as the slot drove the second gear.With the help of a steam engine and a "planet," a cogwheel attached to the connecting rod (which was itself attached to the beam), the sun and planet gear was able to transform the vertical motion of the beam into circular motion. In response to the beam's rotation, this'sun,' a second gear set to the driving shaft, spun around and around, producing rotational motion. When the sun and planet have an equal number of teeth, the arrangement's intriguing characteristic is that the drive shaft completes two rotations for each double stroke of the beam instead of one, which is in comparison to a simple crank. Because it is attached to the connecting rod, the planet gear cannot spin freely.Gear drives benefit from the small size and high load capacity of epicyclic gear stages. Numerous permutations of planetary gear configurations are possible. The practical gear ratio may vary from 3:1 to 9:1 for basic epicyclic planetary stages with a stationary ring gear. The range of viable gear ratios for comparable epicyclic planetary stages with compound planet gears is 8:1 to 30:1. While driving in one stage with common planet gears, a differential planetary gear arrangement may provide gear ratios of several hundred to one, and with compound planet gears, gear ratios of several thousand to one. A gear ratio greater than one hundred thousand to one may be used in a unique two-stage planetary design.

INTRODUCTION TO CAD

Making, tweaking, analyzing, or optimizing a design with the use of computer systems (or workstations) is known as computer-aided design (CAD). Improved design quality, faster design iteration, clearer communication via documentation, and a production database are all outcomes of using computer-aided design (CAD) software. Electronic files for printing, machining, and other industrial processes are common formats for CAD output. Additional abbreviations include "CADD" (for "computer-aided design and drafting").

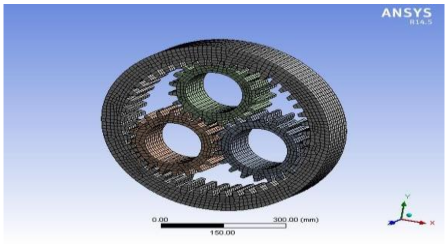
The term for its use in the design of electrical systems is EDA, or electronic design automation. When making a technical drawing using software, mechanical design automation (MDA) or computer-aided drafting (CAD) are terms used in the mechanical design field.

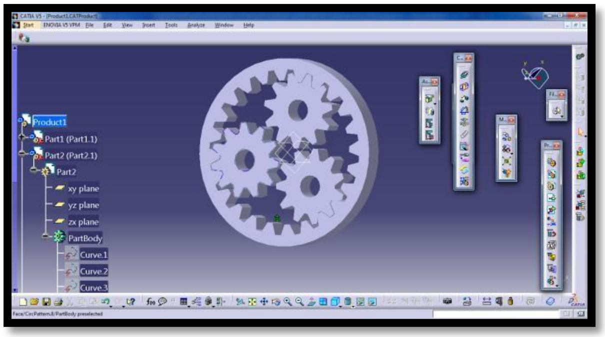
INTRODUCTION TO CATIA

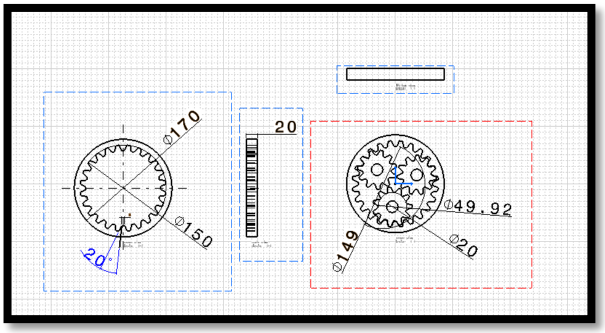
French software firm Dassault Systems created a multi-platform software suite called CATIA, which stands for computer assisted three-dimensional interactive application. It includes tools for CAD, CAM, CAE, PLM, and 3D.

In 1977, French aviation firm Avions Marcel Dassault—then a client of the CADAM software—started developing CATIA internally to build their Mirage fighter plane. The aerospace, automotive, and shipbuilding sectors were among the latest to embrace it.

Epicyclical gear assembly model





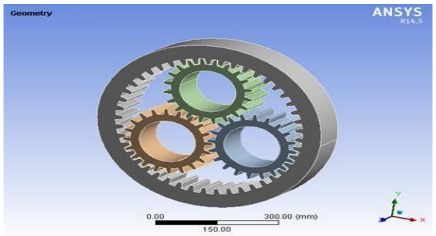


INTRODUCTION TO FEA

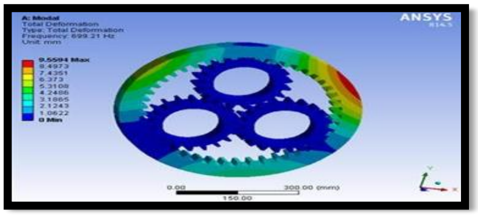
When faced with a scientific or technical challenge, finite element analysis might help you find a rough solution. For issues without a precise, mathematically-expressible solution, it is the tool of choice. That is why it is more of a numerical approach than an analytical one. These kinds of approaches are necessary in engineering since analytical techniques fall short when faced with complex, real-world situations. If we want to know what's occurring with a car's suspension system as we corner, we can utilize engineering strength of materials or mathematical theory of elasticity to compute analytically the stresses and strains in a bent beam, but these methods won't help much.

STATIC ANALYSIS OF EPICYCLICAL GEAR TRAINS

Imported model



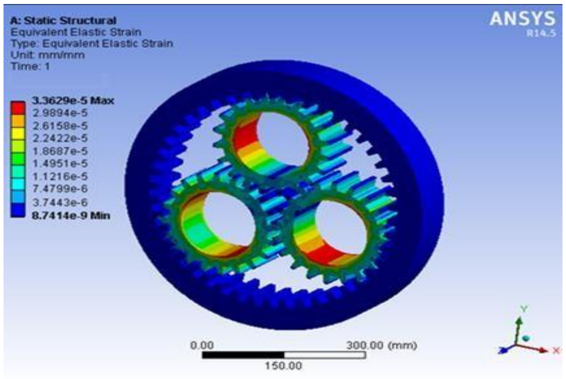
Meshed model



Boundary conditions

MODE SHAPE 1

MODE SHAPE 2



MODE SHAPE 3

CONCLUSION

The use of planetary gears to decrease transmission speeds is a novel, compact, and powerful piece of technology. A three-stage connected planetary gear train's structural analysis is reviewed. Speed ratios, torques, efficiency, and power flow directions of connected planetary gear trains may be readily and swiftly computed in this research. Determined to be efficient in three steps. For analysis, we utilize ANSYS, and for 3D modeling, we use CATIA.The static study revealed that when the rotational velocity increases, the stress values also increase. The stress values of steel are greater than those of cast iron.

According to the modal analysis, the deformation values of cast iron are greater than those of steel.Therefore, cast iron is the material of choice for epicyclical gear trains.

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