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CHAINLESS BICYCLE

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ABSTRACT: This project aims to develop a bicycle with a shaft-driven transmission system instead of the traditional chain drive. The use of a chainless transmission overcomes various disadvantages associated with the chain drive. In this system, two sets of bevel gears are incorporated at both ends of the shaft to create a new kind of transmission mechanism for bicycles, offering higher reliability and safety. In a shaft-driven bicycle, a large bevel gear replaces the chain ring found in conventional bikes. This gear meshes with another bevel gear mounted on the drive shaft. By utilizing bevel gears, the torque generated by pedaling can be effectively transferred at a 90-degree angle. Unlike the chain and sprocket method commonly used in two-wheelers, the shaft drive requires only periodic bicycle offers a novel transmission system that enhances reliability and safety while eliminating the need for a traditional chain drive.

I. INTRODUCTION

A shaft-driven bicycle is a bicycle that utilizes a drive shaft instead of a chain to transmit power from the pedals to the rear wheel. While shaft drives were introduced in the past, they were largely replaced by chain-driven bicycles due to the advantages offered by sprockets and derailleurs in providing a wide range of gear options. However, if roller bearings could be produced accurately and inexpensively through machinery, they could have significantly reduced the prevalence of chain drives. By employing a pinion drive shaft system, shaft-driven bikes eliminate eight points of chain sliding friction and replace them with just two points of higher-efficiency bearing rolling friction. In these bikes, a roller and pinion mechanism is used instead of the traditional chain ring found in conventional bicycles. The pinion meshes with a roller bearing located at the rear side of the shaft, allowing the drive torque from the pedals to be effectively redirected at a 90-degree angle. The drive shaft also incorporates another roller bearing near the rear wheel hub, which meshes with a pinion on the hub in the same position as the rear sprocket on a regular bike. This arrangement effectively cancels out the change in drive torque axis. In the automotive industry, drive shafts play a crucial role in transmitting power from the engine to the differential gear of rear-wheel-drive vehicles. Typically, drive shafts are manufactured in two pieces to increase their fundamental bending natural frequency. This is done because the bending natural frequency of a shaft is inversely proportional to the square of its length and proportional to the square root of its specific modulus. However, using a single-piece drive shaft is preferred to reduce weight and increase fuel efficiency. Titanium alloy is often chosen as the material for drive shafts due to its high strength and low density. Drive shafts need to be strong enough to withstand the torsion and shear stress generated by the difference between the input torque and the load, while avoiding excessive additional weight that would increase their inertia.

II. OBJECTIVES

Enhance Reliability: One of the primary goals is to improve the overall reliability of the bicycle by addressing common issues associated with chain-driven systems, such as chain breakage, slippage, and frequent maintenance requirements. The aim is to create a transmission system that offers greater durability and reduces the risk of component failure.

Increase Efficiency: Another objective is to enhance the efficiency of power transfer within the bicycle. By utilizing a chainless transmission mechanism, such as a shaft and bevel gear system, the aim is to minimize energy losses that occur in traditional chain and sprocket systems. This can result in improved power delivery from the pedals to the wheels.

Reduce Maintenance Needs: Minimizing the maintenance requirements of the bicycle is a crucial objective. By eliminating the need for regular cleaning, lubrication, and adjustments associated with chains and sprockets, a chainless bicycle can provide a lower- maintenance alternative, saving time and effort for the rider.

Enhance Durability: Increasing the bicycle's durability is an important objective. By implementing a robust and resilient chainless transmission system, wear and tear on components can be reduced, leading to a longer lifespan for the bicycle. This involves selecting durable materials and designing components that can withstand the stresses and demands of cycling.

Improve Safety: Safety is a significant concern, and the objective is to create a chainless bicycle that prioritizes rider safety. A reliable and secure transmission system can help prevent accidents caused by chain breakage or sudden loss of power transmission, ensuring a safer riding experience.

Expand Market Appeal: Introducing a chainless bicycle aims to target a specific market segment seeking advanced cycling technologies. The objective is to capture the interest of cycling enthusiasts, commuters, and individuals looking for a reliable and low- maintenance transportation option. By offering innovative features and addressing the limitations of traditional chain-driven bicycles, the chainless design can broaden the appeal of bicycles in the market.

III. LITERATURE SURVEY

- The project titled "Fabrication Of Chainless Bicycle" conducted by Soundar R., Pravin Kumar M., Sivanantha Selvan C., SundraMoorthy M., and Vinoth Kumar S. aims to overcome the limitations associated with conventional bicycle chain drive systems. These limitations include the need for precise mounting and alignment for proper functionality and the risk of chain dropping due to misalignment. To address these issues, the project proposes the use of a shaft drive system. The project involves the design and fabrication of a bicycle with a shaft drive mechanism. Specifically, it utilizes two spiral bevel gears at the pedal side and two straight bevel gears at the rear wheel side. The drive shaft is equipped with two gears, one spiral bevel pinion at the pedal end and one straight bevel pinion at the rear wheel end. By employing bevel gears, the axis of the drive torque from the pedals can be redirected by 90 degrees. The bevel gear at the rear end of the drive shaft meshes with a bevel gear in the rear wheel hub, similar to the position of the flywheel unit in a traditional bicycle. This arrangement effectively cancels out the initial change in drive torque axis.
- The research article titled "Design and Fabrication of Chainless Bicycle" authored by K. Nagendra Reddy, N. Phanindra Kumar, P. V. Goutham Kumar, V. Bala Sankara Rao, and Manoj Kumar Roy, and published in the International Journal for Modern Trends in Science and Technology, examines the characteristics and benefits of two drive mechanisms: chain drive and shaft drive. The chain drive has played a significant role in the development of modern bicycles, providing improved balance and stability by positioning the cyclist between the two wheels. However, in recent years, shaft-driven bicycles have emerged as a gradually influential alternative in the bike industry. Both drive mechanisms offer distinct advantages and comparable efficiency. After a thorough evaluation of the two options, the researchers selected the conventional shaft drive for their project due to its superior cost- effectiveness and flexibility, which align better with the research objectives. The shaft drive system utilizes a shaft instead of a chain to transmit power from the rider's legs to the wheels. Gears are typically enclosed within a housing that connects to the main shaft.
- The research article titled "CHAINLESS BICYCLE SYSTEM" by Tripti Shrivastava and Dr. Pratesh Jayaswal, published in the International Research Journal of Modernization in Engineering Technology and Science, presents a novel setup called the Chainless Bicycle System (CBS) that allows bicycles to run without chains. The CBS utilizes a shaft-driven concept, replacing traditional chains with a drive shaft for power transmission from the pedals to the wheels. The decision to construct a bicycle using the shaft- driven system was influenced by the advancements in internal gear technology, which offers various advantages.

The system incorporates bevel gears, a shaft rod, and two additional bevel gears along with the hub assembly. When the rider pushes the pedals, the bevel gears at the front end rotate the shaft rod. At the rear end of the rotating shaft, another bevel gear meshes with a bevel gear on the rear hub, transferring power to the rear wheel of the bicycle. The CBS is designed to be fully enclosed, resulting in reduced maintenance requirements. Periodic lubrication through a grease gun is necessary to ensure optimal performance. The Chainless Bicycle System offers improved comfort and efficiency in power transmission from the rider's feet to the rear wheel. Additionally, it eliminates the risk of accidental damage to the rider's footwear and clothing, as well as injuries caused by chain bites.

- “Propose and Manufacture of Chainless Bicycle” by Amit kumar Singh, Arvind Yadav, Vinay Kumar Chaurasiya, Ankit Yadav, Niteesh Kumar Mishra, IJES, Volume 7 Issue No.6A chainless bicycle that uses a driven shaft instead of a chain to transmit power from the pedals to the wheel. Shaft drives were introduced over a century ago, but were mostly supplanted by chain-driven bicycles due to the gear ranges available with sprockets and derailleur. Recently, due to achievements in internal gear technology, a small number of modern shaft-driven bicycles have been introduced. The shaft drive only needs time to time lubrication using grease or any other lubricant to keep the gears working quiet and smooth. This “chainless” drive system provides smooth, quite and efficient transfer of energy.

V. METHODOLOGY

The chainless bicycle is a ground-breaking design that eliminates the need for a traditional chain and derailleur system, offering several advantages over conventional bicycles. The methodology employed in creating a chainless bicycle involves the integration of a direct-drive system, such as a shaft drive or a belt drive, which enables the direct transfer of power from the rider's pedalling motion to the rear wheel. This innovative approach eradicates the challenges associated with chains, such as high maintenance demands, potential chain slippage, and the risk of clothing or skin getting caught. To achieve this, a specially designed bottom bracket is incorporated into the chainless bicycle, housing the direct-drive mechanism. This mechanism is connected to the crankset, where the rider applies force while pedalling. The power is then transmitted to the rear wheel through a drive shaft or durable belt. This direct-drive system ensures efficient power transfer, resulting in minimal energy loss compared to traditional chain-driven bicycles. The manufacturing process of a chainless bicycle requires precise engineering and meticulous alignment of components to ensure optimal performance. Lightweight alloys or carbon fiber, advanced materials known for their strength and reduced weight, are often utilized to enhance efficiency. Rigorous testing and prototyping are conducted to guarantee durability, smooth operation, and compatibility with various riding conditions. The methodology behind the chainless bicycle aims to enhance reliability, reduce maintenance, and provide an improved overall riding experience. By eliminating the chain, riders can enjoy a quieter and cleaner cycling experience, while also benefiting from lower maintenance requirements and increased durability offered by the direct-drive system. This innovative approach revolutionizes the traditional bicycle design, offering a more efficient and enjoyable mode of transportation.

VI. CALCULATIONS

Calculation Of Drive-Shaft

Let us assume, the mass of rider= 75 kg

1. Shaft's Inner Diameter (d_i) = 22mm = 0.022m
2. Shaft's Outer Diameter (d_o) = 24mm = 0.024m
3. Length of Shaft (L) = 300mm = 0.300m
4. Transmitted Torque (T) = Cyclist's Mass * g * Length of Shaft = 75 * 9.81 * 0.300 = 220.725 Nm = 220725 N.mm
5. Polar moment of inertia (J) = $\pi (d_o^4 - d_i^4)/32 = \pi (0.024)^4 - (0.022)^4 / 32$
 $= \pi (9.752 \times 10^{-8}) / 32$

$$= (3.063681156 \cdot 10^{-7}) / 32$$

$$= 9.574 \cdot 10^{-9} \text{ m}^4$$

6. Power (P) = $2\pi NT / 60 = 2\pi \cdot 100 \cdot 220.725 / 60 = 2311.4267 \text{ W}$

7. Shear Stress (τ) = $T_p / J = (220.725) (7800) / 574 \cdot 10^{-9} = 1.798 \cdot 10^{14} \text{ N/ m}^2$

8. Maximum Shear Stress (τ_{max}) = $TR_o / J = (220.725) (0.012) / 9.574 \cdot 10^{-9} = 27.6655 \cdot 10^7 \text{ N/ m}^2$

Gear Set Calculation

Module is the term or says unit used to show the size of gears. It is equal to the ratio of the reference diameter of the gear to the total number of teeth. It is shown by 'm' & the unit of size.

Module (m) = Gear reference diameter/ no. of teeth present on the gear Or, $m = d/z$

Let, Module (m) = 4

Pressure Angle (α) = 20

degree On Pinion, no. of Teeth (Z_p) = 19

On Gear, no. of Teeth (Z_g) = 40

Gear ratio = $Z_g / Z_p = 40 / 19 = 2.1$ Pitch Circle

Diameter (D) = $m \cdot Z$

Pinion pitch circle diameter (D_p) = $4 \cdot 19 = 76 \text{ mm}$

Gear Pitch Circle Diameter (D_g) = $4 \cdot 40 = 160 \text{ mm}$,

Addendum (h_a) = module (m) = 4 mm

Dedendum (h_d) = $1.25m = 1.25 \cdot 4 = 5 \text{ mm}$

Clearance (c) = $0.25 m = 0.25 \cdot 4 = 1 \text{ mm}$

Working depth (h_w) = $2 \cdot m = 2 \cdot 4 = 8 \text{ mm}$

Whole depth (h) = $2.25m = 2.25 \cdot 4 = 9 \text{ mm}$

Thickness of Tooth (s) = $1.5708m = 1.5708 \cdot 4 = 6.28 \text{ mm}$

Tooth Space = $1.5708m = 1.5708 \cdot 4 = 6.28 \text{ mm}$

Fillet Radius = $0.4m = 0.4 \cdot 4 = 1.6 \text{ mm}$

VII. CAD

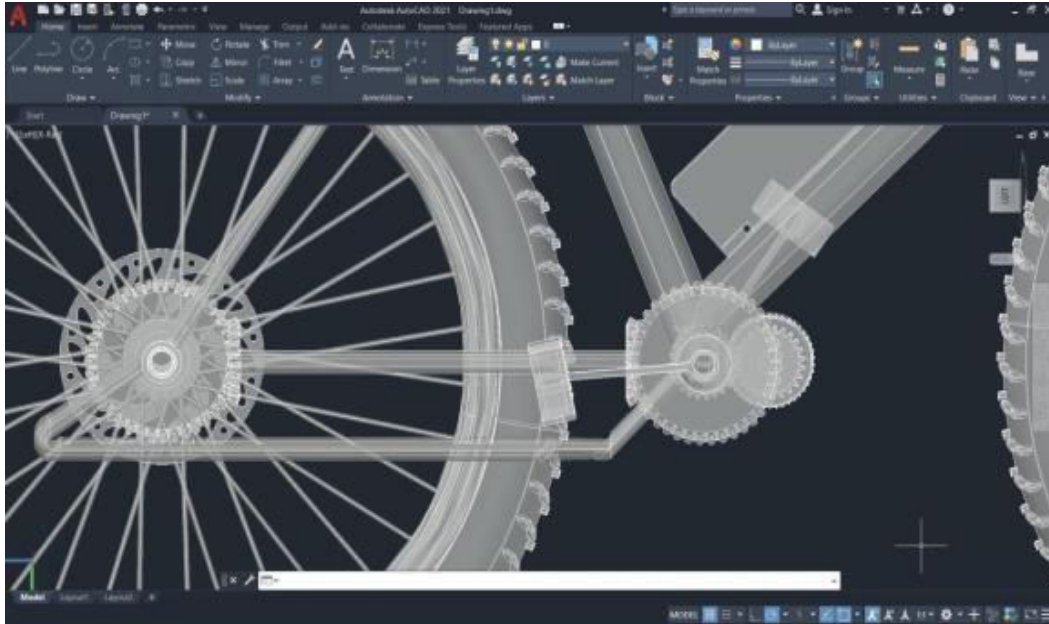
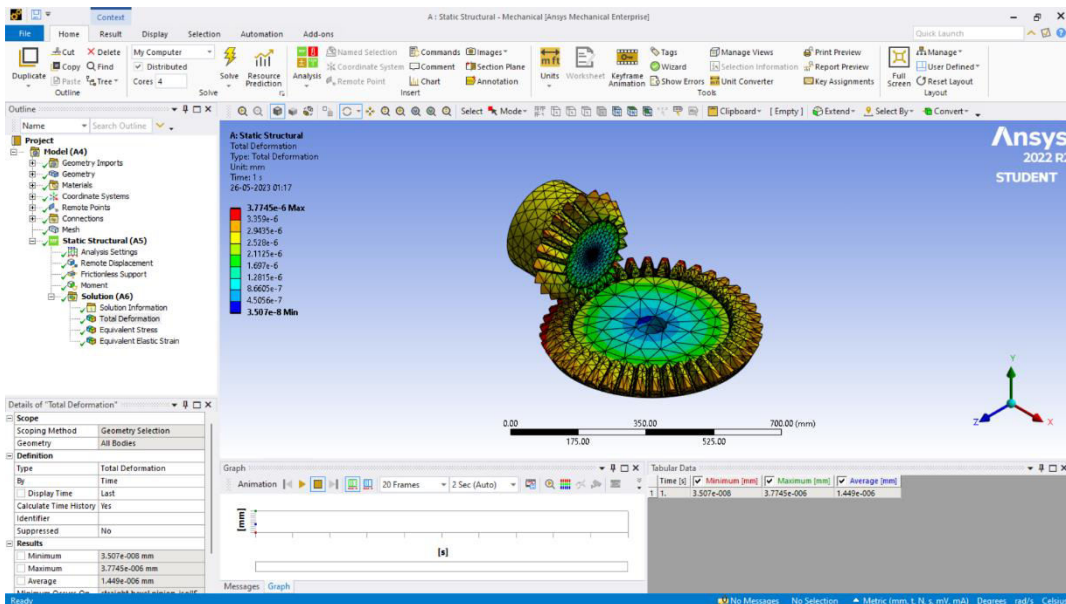


Figure 1: CAD Model

VIII. ANSYS FOR GEARS



IX. WORKING MODEL



Figure 3: Working model

X. CONCLUSION

In conclusion, the chainless bicycle represents a groundbreaking and potentially game-changing innovation in the realm of cycling. By eliminating the conventional chain and adopting alternative propulsion systems, chainless bicycles offer numerous advantages and effectively tackle the limitations associated with traditional chain-driven bikes.

One of the key benefits of chainless bicycles is the significant reduction in maintenance requirements. With the absence of a chain, cyclists are no longer burdened with the regular tasks of cleaning, lubricating, and adjusting the chain tension. This streamlines the maintenance process and allows riders to enjoy a more convenient and hassle-free cycling experience, where their focus can solely be on the joy of riding.

Furthermore, chainless bicycles often provide a smoother and quieter ride compared to their chain driven counterparts. The elimination of the chain removes the common sources of noise and vibrations, resulting in a more serene and comfortable cycling experience. This not only enhances the overall enjoyment of the ride but also contributes to a more pleasant environment for both the cyclist and those around them.

Additionally, chainless bicycles offer improved efficiency and power transfer. Alternative propulsion systems such as belt drives, shaft drives, or electric motors are capable of transmitting power more effectively, minimizing energy loss and maximizing the conversion of pedaling effort into forward motion. This can lead to enhanced speed, acceleration, and overall performance, offering a compelling advantage for both recreational and professional cyclists.

Moreover, the absence of a chain in chainless bicycles often results in increased durability and resistance to external factors such as dirt, grime, and adverse weather conditions. The drivetrain components, being better protected without an exposed chain, are less prone to damage, thereby extending the lifespan of the bicycle.

While chainless bicycles do have certain limitations, such as the potential for higher manufacturing and maintenance costs, as well as limited availability of specialized components, their advantages far outweigh these drawbacks. The chainless bicycle represents a significant step forward in cycling technology, and as further advancements are made, we can expect even more improvements and innovations in this exciting field.



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