



“DESIGN AND FABRICATION OF SHAFT DRIVEN MECHANISM FOR MOPED”

¹Tejesh S, ²Amith Kumar S N, ³ H S Manjunath, ⁴ Chandan R,

¹²³⁴ Assistant Professor

¹²³⁴ Department of Mechanical Engineering

¹²³⁴ Dr. Ambedkar Institute of Technology, Bangalore, India.

Abstract: A shaft-driven vehicle transfers power from the engine to the wheels via a solid shaft. Unlike chain or belt-driven vehicles, which transfer power through flexible components, shaft-driven vehicles use a stiff, spinning shaft. A shaft-driven vehicle has multiple components that function together. The engine provides power, which is then transferred to the transmission system. The transmission system directs power to the back differential via a sequence of gears or a gearbox. The rear differential is a mechanism that distributes power between the two rear wheels. It is made up of a series of gears and shafts that allow the wheels to rotate at various rates, especially during cornering. The power from the transmission system is sent to the rear differential via the solid shaft. A shaft-driven vehicle has the advantage of being both durable and sturdy. The solid shaft avoids the requirement for routine maintenance and adjustments that are required in chain or belt-driven systems. It also enhances power transfer and overall performance. To summarize, shaft-driven vehicles provide various benefits and probable future advances in the automobile industry. For many years, motorcycles and automobiles have used a shaft drive system to transmit power. However, developments in technology and shifting market demands are opening up new possibilities for the future of shaft-driven vehicles.

Key words: Shaft, Differential, Gear box, Transmission

I. INTRODUCTION

A shaft-driven bike is one that does not have a chain and instead transfers power from the engine to the wheels via a drive shaft. Shaft drives were developed over a century ago, but were mostly replaced by chain-driven bikes due to the increased gear ranges available with sprockets and derailleurs. Recent developments in internal gear technology have resulted in the introduction of a small number of modern shaft-driven bikes. Shaft-driven bikes have a large bevel gear where a conventional bike would have its chain ring. This meshes with another bevel gear mounted on the drive shaft. The use of bevel gears allows the axis of the drive torque from the engine to be turned through 90°. The drive shaft then has another bevel gear near the rear wheel hub which meshes with a bevel gear on the hub where the rear sprocket would be on a conventional bike, and cancelling out the first drive torque change of axis.

The 90° change of the drive plane that occurs at the bottom bracket and again at the rear hub requires the use of bevel gears. Bevel gears are the most efficient way of turning drives 90° as compared to worm gears or crossed helical gears. The drive shaft is often mated to a hub gear which is an internal gear system housed inside the rear hub.

A shaft-driven vehicle is a type of vehicle that utilizes a driveshaft to transmit power from the engine to the wheels. Unlike chain-driven or belt-driven vehicles, which rely on a flexible connection between the engine and the wheels, shaft-driven vehicles employ a solid metal shaft to transfer torque and rotational force.

The concept of a shaft-driven vehicle can be traced back to the early days of automotive engineering. In the late 19th and early 20th centuries, many automobiles were designed with shaft-driven systems due to their reliability and efficiency. The shaft, typically made of steel or aluminum, is connected to the engine's output shaft at one end and the differential at the other end. The differential, in turn, transfers power to the wheels, allowing the vehicle to move forward.

One of the primary advantages of shaft-driven vehicles is their robustness and durability. The solid shaft design is less prone to wear and tear compared to chain or belt systems, which can stretch, loosen, or break over time. This makes shaft-driven vehicles particularly suitable for heavy-duty applications, such as trucks and larger passenger vehicles. The solid connection also results in more direct power transfer, minimizing power losses and maximizing overall efficiency.

The current work is mainly emphasizing on the design of power transmission mechanism using shaft and bevel gear.

II POWER TRANSMISSION

2.1 Design calculation and Comparison of the power transmission efficiency of three mechanisms.

Data:

Input power (P_{in}): 1000 W

Speed of rotation (N): 100 rpm

Gear drive efficiency (η_{gear}): 87.37 %

Chain drive efficiency (η_{chain}): 84.30 %

Belt drive efficiency (η_{belt}): 82 %

Design Calculation:

Gear Drive:

To calculate the power transmitted in a gear drive, the formula:

$$P_{\text{transmitted}} = P_{\text{in}} * \eta_{\text{gear}}$$

$$P_{\text{transmitted}} = 1000 * 0.87$$

$$P_{\text{transmitted}} = 870 \text{ W}$$

Chain Drive:

For a chain drive:

$$P_{\text{transmitted}} = P_{\text{in}} * \eta_{\text{chain}}$$

$$P_{\text{transmitted}} = 1000 * 0.84$$

$$P_{\text{transmitted}} = 840 \text{ W}$$

Belt Drive:

In a belt drive

$$P_{\text{transmitted}} = P_{\text{in}} * \eta_{\text{belt}}$$

$$P_{\text{transmitted}} = 1000 * 0.82$$

$$P_{\text{transmitted}} = 820 \text{ W}$$

Based on the design calculations, the power transmitted in the gear drive is 9.8 kW, while the chain drive and belt drive transmit 9.5 kW and 9 kW, respectively. This indicates that the gear drive outperforms both the chain drive and belt drive in terms of power transmission efficiency.

The higher power transmission efficiency of the gear drive is due to its direct meshing of teeth, which minimizes energy losses. Gear drives are known for their high efficiency and ability to transmit large amounts of power accurately. They are commonly used in applications where power transmission efficiency is crucial, such as automotive transmissions, heavy machinery, and industrial equipment.

III DESIGN OF SHAFT AND BEVEL GEAR

3.1 DESIGN CALCULATION OF SHAFT

Material used for shaft = Mild steel

Diameter of shaft (d) = 0.075 m

Length of shaft (L) = 0.39 m

Length of crank (l) = 0.175 m Speed of gear = 100 rpm

$$T = (\text{body mass of the rider}) \times (g) \times (\text{length of crank}) = 60 \times 9.81 \times 0.175 \text{ T} = 103 \text{ N-m}$$

$$\text{Power (P)} = 2\pi NT / 60$$

$$P = 2\pi \times 100 \times 103 / 60 = 1078.06 \text{ watts}$$

$$J = \pi d^4 / 32 = \pi \times 0.075^4 / 32 = 3.104 \times 10^{-6} \text{ m}^4$$

$$\text{Shear stress } (\tau) = TR / J = 103 \times 0.0375 / 3.104 \times 10^{-6} = 1244362.11 \text{ N/m}^2$$

$$I = \pi d^4 / 64 = \pi \times 0.075^4 / 64 = 1.552 \times 10^{-6} \text{ m}^4$$

$$\text{Bending moment, M} = EI / R = 2.06 \times 10^{11} \times 1.552 \times 10^{-6} / 0.0375 = 8.5 \times 10^6 \text{ N-m}$$

$$\text{Rate of twist} = T / GJ = 103 / (0.84 \times 10^{11} \times 3.104 \times 10^{-6}) = 0.000395 \text{ rad / m}$$

$$\Theta = TL / GJ = \text{Rate of twist} \times \text{Length of shaft} = 0.000395 \times 0.39 = 0.0100540 \text{ rad}$$

3.2 DESIGN CALCULATION OF BEVEL GEAR

Outer diameter = $d_2 = 60 \text{ mm}$

Inner diameter = $d_1 = 40 \text{ mm}$

RPM = $n_1 = 3000 \text{ rpm}$

Number of teeth on pinion: - 16

$P = N = 6 \text{ kW}$

$$i = n_1 / n_2 = z_1 / z_2 = d_1 / d_2$$

$$i = d_1 / d_2 = 60 / 40 = 1.5$$

$$n_2 = n_1 / i = 3000 / 1.5 = 2000 \text{ rpm}$$

$$\text{Pitch angle of pinion} = \tan^{-1}(1/i) = \tan^{-1}(1/1.5) = 33.69$$

$$\text{Pitch angle of gear} = \tan^{-1}(i) = \tan^{-1}(1.5) = 56.30$$

$$\text{Formative number of teeth in a straight teeth bevel pinion} = Z_{v1} = Z_1 / \cos \delta_1 = 16 / \cos 33.69 = 19.22$$

$$\text{Formative number of teeth in a straight teeth bevel gear} = Z_{v2} = Z_2 / \cos \delta_2 = 23 / \cos 56.30 = 41.453$$

$$\text{Lewis form factor for 20 degree full depth involute system} = y = 0.154 - (0.912 / Z_v)$$

$$\text{Form factor for pinion} = y_1 = 0.154 - (0.912 / Z_{v1}) = 0.154 - (0.912 / 19.22) = 0.1065$$

$$\text{Form factor for gear} = y_2 = 0.154 - (0.912 / Z_{v2}) = 0.154 - (0.912 / 41.453) = 0.1319$$

$$\text{The material for both pinion and gear is cast-steel heat treated} = \sigma_1 = \sigma_2 = 191.925 \text{ N/mm}^2$$

$$F_t = 895.31 \text{ N}$$

$$\text{Available stress} = (\sigma_{01} * C_v)_{\text{all}} = 34.71 \text{ N/mm}^2$$

$$\text{Induced stress} = \sigma_{\text{ind}} = (\sigma_{01} C_v)_{\text{ind}} = 28.30 \text{ N/mm}^2$$

$$\sigma_{\text{all}} > \sigma_{\text{ind}}, \text{ Design is safe}$$

$$F_d = 1040.26 \text{ N}$$

Brinell Hardness number for pinion = 200BHN

Brinell Hardness number for gear = 150BHN

IV. MODELLING AND ANALYSIS OF SHAFT AND BEVEL GEAR

4.1 Modelling and Analysis of drive shaft



Figure 4.1: CATIA design of 3D drive shaft

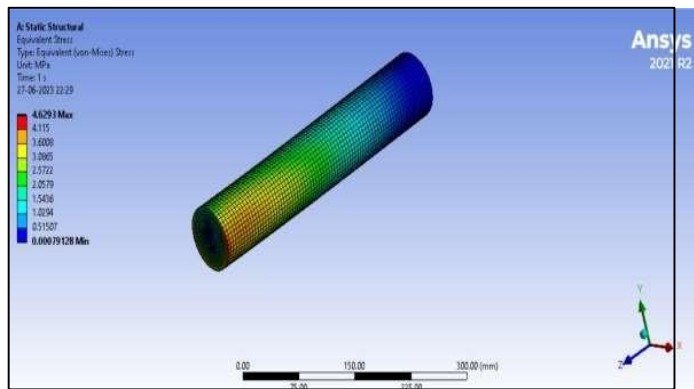


Figure 4.2: Equivalent Stress Analysis of drive shaft using ANSYS

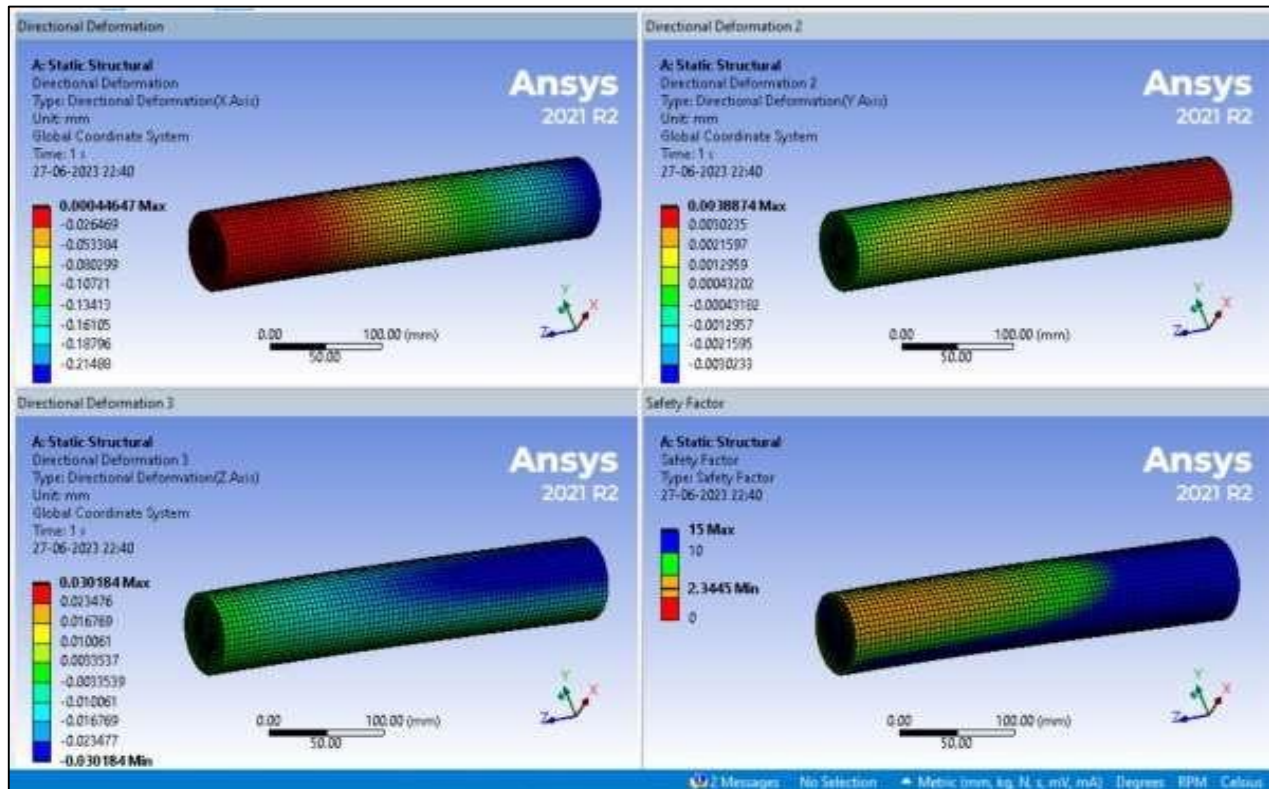


Figure 4.3: Directional Deformation and Safety factor Analysis of drive shaft using ANSYS

The analysis of a drive shaft using ANSYS software involves a comprehensive evaluation of its structural performance and behavior under various loading conditions. ANSYS, a powerful engineering simulation tool, enables engineers to simulate and study the drive shaft's response to forces, torques, vibrations, and other external factors.

4.2 Analysis of bevel gear

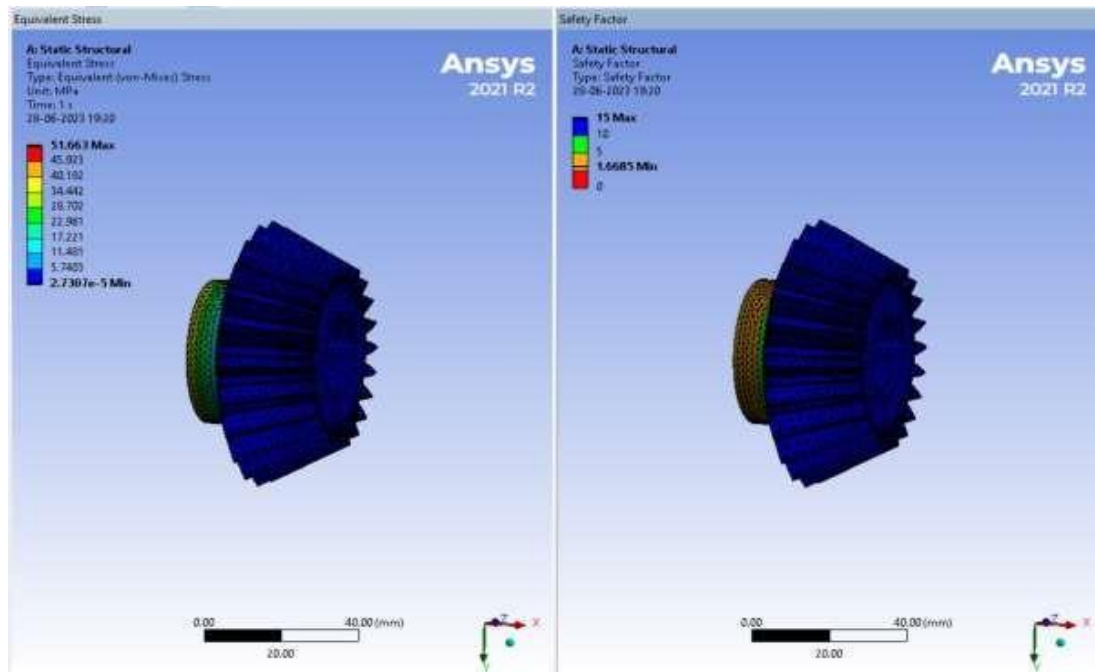


Figure 4.4: Stress and Safety factor Analysis of bevel gear using ANSYS

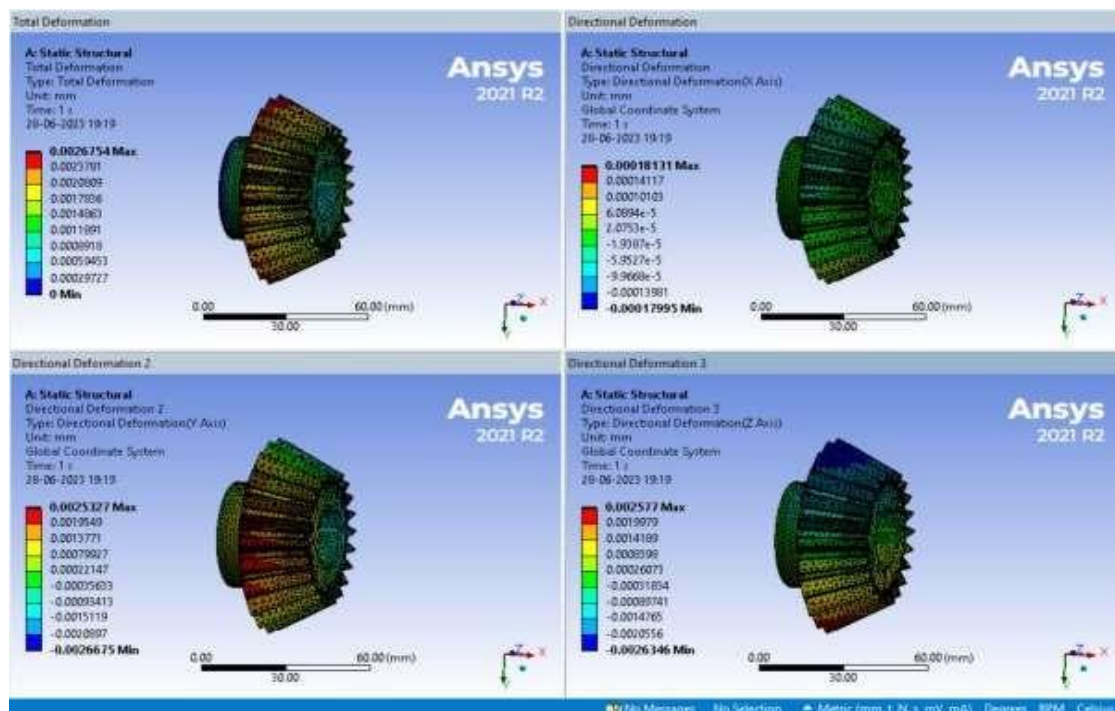


Figure 4.5: Total and Directional Deformation of bevel gear using ANSYS

V RESULTS

5.1 Comparison of parameters of shaft drive and chain drive table

Table 01: Parameters of shaft drive and chain drive

Parameters	Shaft drive	Chain drive
Torque	103 Nm	137 Nm
Input speed	100 rpm	400 rpm
Output speed	144 rpm	544 rpm
Minimum velocity	0.6386 m/s	0.6534 m/s
Maximum velocity	1.0267 m/s	0.7986 m/s
Velocity ratio	0.3636	0.4091

Efficiency	87.37%	84.30%
Input power	1078.06 W	1978.97 W
Output power	1552.41 W	4837.5 W
Tangential driving force	3108.65 N	3028.72 N
Centrifugal force	373.26 N	383.14 N

Parameters of Shaft Drive:

Polar moment of inertia (J) = $3.104 \times 10^{-6} \text{ m}^4$

Shear stress (τ) = 1244362.11 N/ m^2

Bending moment (M) = $8.5 \times 10^6 \text{ N-m}$

Angle of twist (θ) = 5.795°

Diameter of shaft= 0.075 m

In conclusion, the shaft drive system offers higher efficiency compared to the chain drive system. Shaft drives minimize energy loss through friction and bending, resulting in more power being transmitted to the wheels. The absence of chain slippage or stretching ensures consistent power delivery, enhancing overall efficiency.

Table 02: Trouble Detected with Shaft Drive Causes and remedies of shaft drive

Problem	Caused by	Remedy by
More torque required	Large gear ratio	reduce gear ratio
Noise	Insufficient lubrication	Provide sufficient lubrication
Gear slip at rear side	more initial load on pedal	Precise alignment of gear
Gear pitch circle not coincides	Vibrations	Precise alignment of gear
Jamming of gears	Foreign dust particles	Provide casing



Figure 5.1: Final fabricated model

VI. CONCLUSION

The presented work deals with design optimization i.e converting rotary motion in linear motion with aid of two bevel gears. The obtained results and discussions highlight the significant advantages of shaft-driven vehicles, including power delivery efficiency, stability, and durability. While there are certain challenges, such as weight and complexity, these can be addressed through continued research and development efforts. Overall, shaft-driven vehicles offer a promising drivetrain solution for various applications, and further advancements in technology can unlock their full potential in the automotive industry

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