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Design and analysis of hexagonal drive shaft in all-terrain vehicles

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ABSTRACT

In this paper deals with the hexagonal drive shaft for torque transmission from differential to the wheels is a prime factor of driveshaft. The shaft was designed and analyzed for its use in an all-terrain vehicles (ATV) to give high lateral motion and high suspension travel. The entire design of the shaft was done theoretically by using CREO software then import into ANSYS R 14.5 and made analysis on Von mises stress, fatigue, thermal and etc. this shaft used in an all-terrain vehicle was seen to be strength, robust and effective when compared with the other types of shafts.

Keywords: All-Terrain Vehicle (ATV), Hexagonal Shaft, Von Misses Stress Theory

INTRODUCTION

A drive shaft is the half shaft is a piece of an automobile which takes power from the differential and delivers to the wheels. A drive shaft has to be strong enough to absorb the torque of the engine and lightweight to reduce the overall weight of the vehicle. A drive shaft should be in perfect balanced and spin equal to the torque coming out of the engine and the transmission for the smooth drive performance. Several types of drive shaft are used in automotive industry such as,

- CV jointed half shaft
- Universal jointed half shaft

In CV jointed half shaft in extreme condition the angular motion is arrested and bottom out of the driveshaft happened due to insufficient lateral travel and angular motion in bump and droop condition. For this universal jointed half shaft is used in universal jointed telescopic half shaft the required angular motion is achieved by universal joint and lateral travel achieved by plunger. In existing telescopic half shaft made up of splined

plunger. It increase the cost of the manufacturing and time for manufacturing. For this hexagonal telescopic half shaft is designed to get good results

All-terrain vehicle (ATV), also known as a quad, quad bike, three-wheeler, or four-wheeler, or RZR is defined by the American National Standards Institute (ANSI) as a vehicle that travels on low-pressure tires, with a seat that is straddled by the operator, along with handlebars for steering control. As the name implies, it is designed to handle a wider variety of terrain than most other vehicles. Although it is a street-legal vehicle in some countries, it is not street-legal within most states and provinces of Australia, the United States or Canada. To be able to drive off the pavement, off-road vehicles need several characteristics: They need to have a low ground pressure, so as not to sink into soft ground, they need ground clearance to not get hung up on obstacles, and they need to keep their wheels or tracks on the ground so as not to lose traction. Wheeled vehicles accomplish this by having a suitable balance of large or additional tires combined with tall and

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flexible suspension. Tracked vehicles accomplish this by having wide tracks and a flexible suspension on the road wheels. The choice of wheels versus tracks is one of cost and suitability. A tracked drive train is more expensive to produce and maintain. Wheeled drive trains are cheaper and give a higher top speed. The tracked drive train has greater off-road capability.

Most off-road vehicles are fitted with especially low gearing. This allows the operator to make the most of the engine's available power while moving slowly through challenging terrain. An internal combustion engine coupled to a normal gearbox often has an output speed too high. The vehicle often has one of two things, either a very low ("granny") first gear (like the all-wheel drive Volkswagen Transporter versions) or an additional gearbox in line with the first, called a reduction drive. Some vehicles, like the BV 206 in the picture on the right, also have torque converters to further reduce the gearing.

LITERATURE SURVEY

The lot of the information can be collected from the various literatures and journals which can clearly tell that what are all the failures occurs and what are all the things to do while analysis the procedures and what are all the analysis has to be done. The failure of drive shaft and summarized the causes of failures of FWD drive shaft and analyzes the premature failure in drive shaft. Some common failures are manufacturing, design, maintenance, raw material and the user originated faults [1].

Splined hexagonal axles that feature a unique slip joint design in the main shaft that allows the axles to extend and compress slightly during suspension travel to help relieve added stress to the axle joints and to help prevent the axle from pulling from the differential. In this study, a hexagonal half-shaft was designed and analyzed for its use in an all-terrain vehicle (ATV). The entire design of half-shaft was done theoretically by using maximum principal shear stress theory and maximum shear stress theory. In their paper the torsional vibrations of the drive shaft of the mechanisms having variable inertia characteristics are studied by modeling the shaft as a continuous

element. As a result of the continuous element modeling, a non-linear boundary value problem is obtained. The non-linear problem is linearized by a suitable transformation and the forced response of the shaft is examined [2].

Surface analysis topology in dry machining of EN-8 steel which is widely used material for general-purpose axles, shafts, gears, bolts and studs. Regression models are developed for Ra, Rq, and Rz parameters of surface topology which are very significant parameters from contact stiffness, fatigue strength and surface wear point of view. [3]. The procedure and methodology of the design and analysis of half shaft. The conventional shaft is usually over designed so team makes the common shaft to reduce the weight and rotational inertia. The main criteria consider in the analysis included high performance, reliability and serviceability weight and cost [4].

The different methodology used their application and limitation by various authors. The objective of present work is to study the various methodologies used for the shaft failure analysis and to choose best methodology suitable for the failure analysis of shaft used in gear box which is mounted on the overhead crane to prevent repetitive failure [5].

A drive shaft machined from steel that was carbo-nitrided, quenched and tempered but it ruptured at an early stage of its use. Both sides of the shaft are delivered for an investigation in order to discover the cause of the rupture. Scanning electron microscope revealed an inter crystalline fracture in the carbo nitride region of the shaft [6].

Automobiles drive shaft is used for the transmission of motion from the engine to the differential. An automotive propeller shaft, or drive shaft, transmits power from the engine to differential gears of rear wheel-driving vehicle [7].

Design and develop the new technology from the conventional ground-wheeled vehicles usually have poor traffic ability, low efficiency, a large amount of energy consumption and possible failure when driving on soft terrain. To solve this problem, this paper presents a new design of transformable wheels for use in an amphibious all-terrain vehicle [8].

The physically, misalignment causes speed variation of the driven shaft, which in turn excites

elastic twist dynamics of the driven shaft. If the driven shaft is carrying a significant torsional inertia load, the speed variation and elastic twist dynamics induce a dynamic torque load at the U-joint. The dynamic torque load, in addition to any static load torque, generates lateral moments at the U-joint which excite lateral shaft motion resulting in dynamic misalignment [9].

In the present scenario weight of an automobile, Vehicle is a major issue. Many composite materials are used now a day in order to overcome this issue. In this paper, Drive shafts made of SM45C Steel is compared with the Kevlar composite shaft. The Strength and Efficiency of the composite drive shaft is also tested. For this, CATIA v5 is used software for the 3D modeling and ANSYS is used for the analysis. In the present scenario weight of an automobile, Vehicle is a major issue [10].

The hybrid shaft consists of aluminum tube wound outside by E-glass and carbon fibers/epoxy composite. The finite element method has been used to analyze the hybrid shaft under static torsion. ANSYS finite element software was used to perform the numerical analysis for the hybrid shaft [11].

PROBLEM IDENTIFICATION

The major issues such as, due to over damping of the suspension the drive shaft drives out

of the gear box because of the maximum angle of 17° deg in power transmission. Dust accumulated between the spurs and splines due to the higher range of suspension travel. Vehicle weight increases due to the weight of the drive shaft or around 3 kg's and it can withstand only the maximum torque up to 500Nm.

SELECTION OF MATERIALS

En8 material selection

Material selection is the prime factor in designing. For half shaft application the material should have better hardness, fatigue strength and toughness. There are several materials are available for telescopic half shaft. Some materials consider for hexagonal half shaft are, EN 353, EN 24, EN8. This material are readily available in market. While considering EN 353 it is a common material for auto mobile gears and shaft which has better wear resistance. But it required post heat treatment like as case hardening. It is poor in welding properties. While considering EN 24 material it also has high fatigue strength but it has weldment brittleness properties which lead to cracks in half shaft which it is not suitable for this application. Table 1 shows the property values of this material.

Table 1: EN8 Material Properties

PARAMETERS	VALUES
Density	7.85 g/cm ³
Hardness	201 HBN
Tensile strength	550 MPa
Yield strength	280 MPa
Izod value	15 t.lb

Designing of universal joint

The universal joint is a critical component to design in 3D software, CREO. There are many types of universal joints are available in market

they are Cardan A type, Cardan B type, Cardan C type and Thomson type. Among these types Thomson type is more critical to design, Cardan A type and Cardan C type are simple to design and fabricate.

- On usage the corners of octagonal shafts get degraded which results in slippage during power transmission.

Analysis of hexagonal shaft

The hexagonal shaft design has been completed after that made an analysis based on the below parameters in the ANSYS R14.5 software.

Table 2: Various parameters used in Analysis of universal joint

Parameters	Values
Mesh size	0.75mm
No of elements	267543
No of nodes	175038
Theory for static structural	von mises theory
Theory for fatigue	Gerber

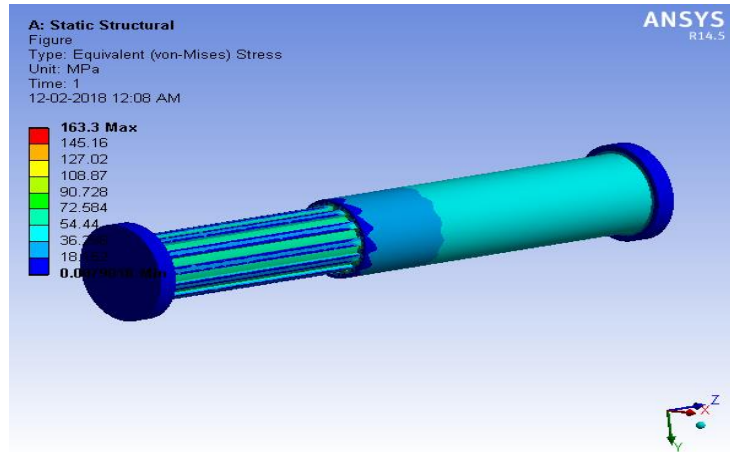


Figure 3: Stress analysis of circular drive shaft

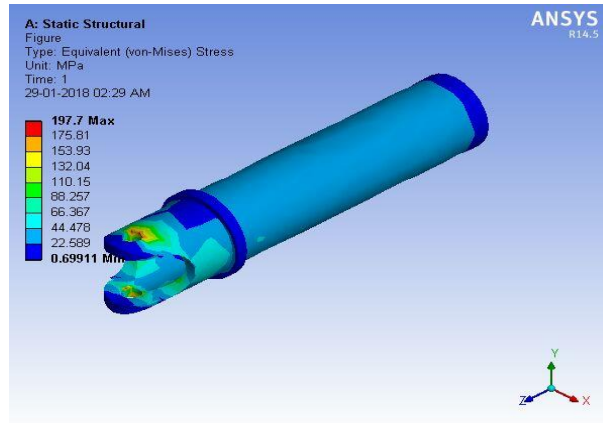


Figure 4: Stress analysis of hexagonal drive shaft

Hence based on the analysis hexagonal drive shaft have the higher stress level 197.7 N/mm^2 when compared with the existing circular shaft.

CONCLUSION

The hexagonal half shaft gives the better withstanding capacity to driveshaft at critical angular transmission of power from differential to wheels compared with usual circular half shaft. This shaft can be used in off road vehicles where loading conditions to shaft are too high and anonymously varies proved by the analyzing software ANSYS R14.

This shaft is employed in vehicles that needed higher suspension, better angular transmission and lateral motion. Increasing number of off-road vehicles requests for higher suspension with increased lateral motion. This project helps in accommodate the requested conditions by providing better angular transmission along with increased lateral motion. Thus it has good scope in future

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