ISSN (e): 2250 – 3005 || Volume, 08 || Issue, 7|| July – 2018 ||
International Journal of Computational Engineering Research (IJCER)

Design and Analysis of Composite Drive Shaft Using ANSYS

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ABSTRACT:
Drive shaft is the main component of drive system of an automobile. It is the connection between the transmission and the rear axle of the car. Use of conventional steel drive shaft has many disadvantages such as low specific stiffness and strength. Two piece drive shaft increases the weight of drive shaft which is not desirable in today's market.
This project deals with optimization of drive shaft using ANSYS. Substitution of composite material over the conventional steel material for drive shaft has increasing the advantages of design due to its high specific stiffness, weight reduction and strength.
Many methods are available at present for the design optimization of structural systems and these methods based on mathematical programming techniques involving gradient search and direct search. These methods assume that the design variables are continuous. In practical structural engineering optimization, almost all the design variables are discrete. This is due to the availability of components in standard sizes and constraints due to construction and manufacturing practices. By using advanced composite materials, the weight of the drive shaft assembly can be tremendously reduced. This also allows the use of a single drive shaft (instead of a two piece drive shaft) for transmission of power to the differential parts of the assembly. Apart from being lightweight, the use of composites also ensures less noise and vibration.
Keywords: Shaft, ANSYS, composite material, engine, clutch, differential, rear wheel

I. INTRODUCTION:

OVER VEIW: A drive shaft, driveshaft, driving shaft, propeller shaft, or Cardan shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly. A driveshaft is the connection between the transmission and the rear axle of the car. As shown in Figure 1, power generated by the engine is transferred to the transmission via a clutch assembly. The transmission is linked to the driveshaft by a yoke and universal joint, or u-joint, assembly. The driveshaft transmits the power to the rear end through another yoke and u-joint assembly. The power is then transferred by the rig and pinion or rear differential to the rear wheels.

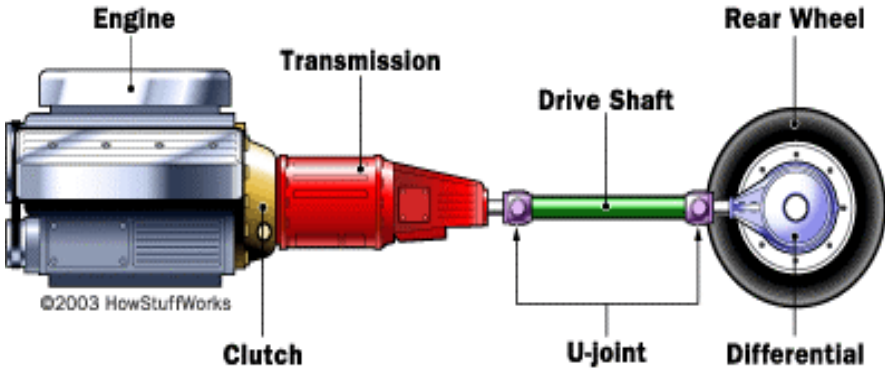

Figure 1.1: Vehicle Drive Train

The entire driveline of the car is composed of several components, each with rotating mass. The rule of thumb is that 17-22% of the power generated by the engine is lost to rotating mass of the drive train. The power is lost because it takes more energy to spin heavier parts. This energy loss can be reduced by decreasing the amount of rotating mass.

Light weight flywheels and transmission gears, aluminum and carbon-fiber drive shafts, riffle-drilled axels, and aluminum hubs are all examples of replacement or modified parts used to reduce the amount of rotating mass.

II. FUNCTIONS OF DRIVE SHAFTS

1. First, it must transmit torque from the transmission to the differential gear box.
2. During the operation, it is necessary to transmit maximum low-gear torque developed by the engine.
3. The drive shafts must also be capable of rotating at the very fast speeds required by the vehicle.
4. The drive shaft must also operate through constantly changing angles between the transmission, the differential and the axles. As the rear wheels roll over bumps in the road, the differential and axles move up and down. This movement changes the angle between the transmission and the differential.
5. The length of the drive shaft must also be capable of changing while transmitting torque. Length changes are caused by axle movement due to torque reaction, road deflections, braking loads and so on. A slip joint is used to compensate for this motion. The slip joint is usually made of an internal and external spline. It is located on the front end of the drive shaft and is connected to the transmission.

III. TYPES FO DRIVE SHAFTS

1. **Transmission shaft:** These shafts transmit power between the source and the machines absorbing power. The counter shafts, line shafts, overhead shafts and all factory shafts are transmission shafts. Since these shafts carry machine parts such as pulleys, gears etc., therefore they are subjected to bending moments in addition to twisting.

2. **Machine Shaft:** These shafts form an integral part of the machine itself. For example, the crankshaft is an integral part of I.C.engines slider-crank mechanism.
3. **Axle:** A shaft is called "an axle", if it is a stationary machine element and is used for the transmission of bending moment only. It simply acts as a support for rotating bodies.

Applications:
To support hoisting drum, a car wheel or a rope sheave.

1. **Spindle:** A shaft is called "a spindle", if it is a short shaft that imparts motion either to a cutting tool or to a work-piece.
2. Drill press spindles-impart motion to cutting tool (i.e.) drill.
3. Lathe spindles-impart motion to work-piece.

Apart from, an axle and a spindle, shafts are used at so many places and almost everywhere wherever power transmission is required. Few of them are:

1. **Automobile Drive Shaft:** Transmits power from main gearbox to differential gear box.
2. **Ship Propeller Shaft:** Transmits power from gearbox to propeller attached on it.
3. **Helicopter Tail Rotor Shaft:** Transmits power to rail rotor fan.

This list has no end, since in every machine, gearboxes, and automobiles etc. Shafts are there to transmit power from one end to other.

DRIVE SHAFT ARRANGEMENTS IN A CAR MODEL

Conventional two-piece drive shaft arrangement for rear wheel vehicle driving system is shown in figure 3.2 below.

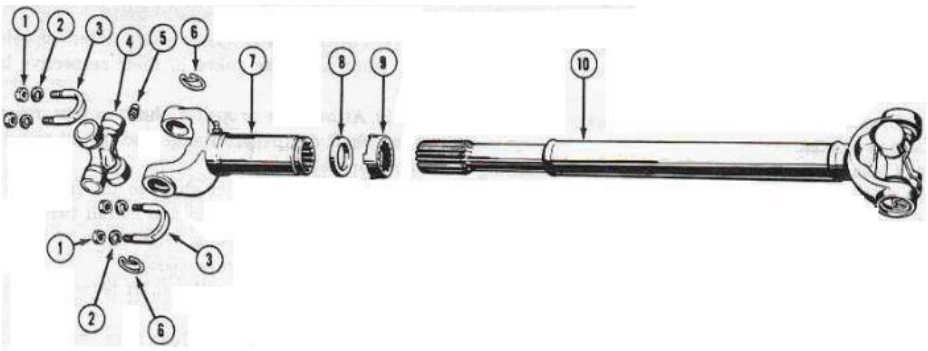

Figure 1.2. Driveshaft arrangement

PARTS OF DRIVE SHAFT IN A CAR MODEL:

Parts of drive shaft and universal joint are shown in fig.3.3.Parts of drive shaft and universal joints are

1. U-bolt nut 2. U-bolt washers 3. U-bolt
4. Universal joint journal 5. Lubrication fitting 6. Snap ring.
7. Universal joint sleeve yoke 8. Spline seal 9. Dust cap
10. Drive shaft tube

DEMERITS OF CONVENTIONOL DRIVE SHAFT

1. They have less specific modulus and strength.
2. Increased weight.
3. Conventional steel drive shafts are usually manufactured in two pieces to increase the fundamental bending natural frequency because the bending natural frequency of a shaft is inversely proportional to the square of beam length and proportional to the square root of specific modulus. Therefore the steel drive shaft is made in two sections connected by a support structure, bearings and U-joints and hence over all weight of assembly will be more.
4. Its corrosion resistance is less as compared with composite materials.
5. Steel drive shafts have less damping capacity.

IV. RESULTS AND DISCUSSIONS

The replacement of conventional drive shaft results in reduction in weight of automobile are discussed below.. The finite element analysis is used in this work to predict the deformation of shaft. A one-piece composite drive shaft for rear wheel drive automobile was designed optimally for E-Glass/ Epoxy, High Strength Carbon/Epoxy composites with the objective of minimization of weight of the shaft which is subjected to the constraints such as stress, deformation and frequency.

MATERIALS	DEFORMATION (m)	EQ-STRESS (N/m)	FREQUENCY (HZ)	WEIGHT (Kg)	COST (Rs)
STEEL	3483.5	1.5587E6	4.1627E-4	13.75	1650
E/GLASS EPOXY	903.62	4.1018E5	8.1733E-4	3.62	470
HS CARBON EPOXY	722.89	3.2814E5	9.138E-4	2.89	1220

V. CONCLUSION

The E-Glass/ Epoxy, High Strength Carbon/Epoxy composite drive shafts have been designed to replace the steel drive shaft of an automobile.

A one-piece composite drive shaft for rear wheel drive automobile has been designed for E-Glass/ Epoxy, High Strength Carbon/Epoxy with the objective of minimization of weight of the shaft which was subjected to the constraints such as torque transmission and natural bending frequency.

The usage of composite materials has resulted in considerable amount of weight saving in the range of 78% to 73% when compared to conventional steel drive shaft. Taking into account the weight saving, deformation, shear stress induced and resultant frequency it is evident that composite has the most encouraging properties to act as replacement to steel. This was achieved by reducing the weight of the drive shaft with the use of composite materials.

By using advanced composite materials, the weight of the drive shaft assembly can be tremendously reduced. This also allows the use of a single drive shaft (instead of a two piece drive shaft) for transmission of power to the differential parts of the assembly. Apart from being lightweight, the use of composites also ensures less noise and vibration.

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Mahesh Kumar Sah" Design and Analysis of Composite Drive Shaft Using ANSYS., International Journal of Computational Engineering Research (IJCER), vol. 8, no. 7, 2018, pp. 64-66.