

A Review on a Composite Drive Shaft - An Advancement towards Future

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Abstract: Conveyance is the most consequential need in today's life. Sundry types of conveyances are now a day's utilized by us in our day to day life. Out of which some of the conveyances are rear-wheel drive. These conveyances require the propeller shaft to drive the conveyance. The propeller shaft transmits the potency from the engine to the rear wheels. In this paper, we are going to discuss the current research going on the propeller shaft. The propeller shaft is a very consequential component of the transmission system of the conveyance. The propeller shaft is responsible to transmit torque and rotary kineticism to the wheels. variety of designs of propeller shaft are utilized in conveyances nowadays. More and more research is going on the design of the propeller shaft abbreviate its weight and amend its performance. The main aim of this paper is to study the different designs of the propeller shaft and summarize the consummate research work in the field of the propeller shaft.

Index Terms - Propeller shaft, drive shaft, torque, transmission system, heavy vehicles.

I. INTRODUCTION

Conveyance is one of the most paramount desiderata for human beings. Variants of conveying systems are available nowadays. Out of which the road conveyance is utilized widely as it is most facile and most frugal[1]. For road convey sundry variants of conveyances are utilized some are for generally utilized by humans to peregrinate from one place to another, whereas other is utilized for the conveyance of goods and accommodations. Conveyances utilized for both the purport can be relegated into two different categories viz light obligation conveyance and heftily ponderous obligation conveyance. In which clumsily hefty-obligation conveyances are generally rear-wheel drive or all-wheel drive conveyance. In this conveyance, the engine is mostly mounted on the front side of the conveyance. Which requires some provision to transmit power from the engine to rear wheels. This can be done by utilizing using the propeller shaft. The propeller shaft is a component of the transmission system which transmit rotary kineticism of the engine to the rear wheels[2]. Transmission of puissance does not take place directly there is some modification made in the torque and power of the engine and then it is transmitted to the wheels. This work is done by the transmission system of a conveyance, where the propeller shaft is one of its components. The transmission system of conveyance varies according to the type of conveyance. Propeller shafts are mostly utilized in the rear-wheel-drive conveyance in which the engine is mounted on the front side or vice versa. It is rigid shafts which transmit torque and rotary kineticism to the differential gearbox[1].

The propeller shaft is additionally called a drive-shaft. Drive-shaft plays a most paramount role in power transmission in heftily ponderous obligation conveyances. The operation of the drive shaft is very intricate as it has to perpetually keep transmuted its angle between the transmission and axle. The substantial magnitude of puissance is to be transmitted by this shaft and it is additionally subjected to torsion and bending force hence the stiffness and vigor of a shaft should be very good. High-quality steel is mostly utilized for manufacturing this shaft[3]. Generally, most cars, vans, and minuscule trucks have propeller shafts within about 1.25m to 2m of length. These shafts are running at about 6000 rpm to 7000 rpm and their torque transmission capabilities should be more astronomically immense than 3000 Nm. To evade access amplitudes of vibrations, the fundamental natural frequency of these shafts should be more than the above range of 6000 rpm to 7000 rpm. Since the fundamental natural frequency of one-piece shafts composed of steel or aluminum is just at the lower limit of the above range, these shafts are made in two-pieces. Sometimes propeller shafts have supplemental middle bearing support. This is to increment shaft's fundamental natural frequency over the above range and thereby eschew access amplitudes of vibration. However, one-piece propeller shafts composed of fiber-reinforced composites can have more preponderant un-fortified length and higher fundamental natural frequency[4].

Literature Review

The propeller shaft is the most consequential part of the conveyance transmission system. It is utilized in rear-wheel or all-wheel drive conveyance. As it is mostly utilized in heftily ponderous conveyances there is a desideratum to truncate the weight of it which will result in overall weight abbreviation of the conveyance. Hence to do so lots of research is being done on optimization of the propeller shaft. Amim Altaf Baig[2] has experimentally analyzed the failure of propeller shaft in Heftily ponderous Motor Conveyances. In this research work, they have utilized the single material and optimized the diameter of the shaft for the same material. It is kenneled that stress concentration increases in minuscule diameter section hence according to this the genuine optimization was performed. During analysis, the shaft was subjected to tensional stress and bending stress in coalesced. It is additionally subjected to fatigue loading and withal during cornering there stress concentration of the propeller shaft increases. Considering all the types of loading verbally expressed the analysis of drive shaft was carried out. Analysis results showed that the drive shaft can sustain for a longer time with the optimized diameter shaft. Salaisivabalan T[1] has researched on the utilization of composite material for making a propeller shaft. As the weight of the conveyance is of major concern as it directly affects the fuel efficiency of the conveyance, hence it is consequential to minimize the overall weight of the conveyance. As the propeller shaft is rigid shaft its weight is more if it is manufactured utilizing steel or aluminum. Hence to truncate its weight utilization of composite is studied in this research work. In this project, they have designed a propeller shaft of Maruthi Omni to minimize its dimension by utilizing composites in lieu of steel. Carbon / Epoxy and Glass / Epoxy composite are utilized for the design. Analysis results of

this design showed that Carbon / Epoxy material is exhibiting better results. R. Harimaheswaran[5] has researched the design and optimization of the drive shaft of the conveyance. In this work, they have superseded a conventional drive shaft with the alloy steel shaft. As we know high stiffness and vigor of the material can be benign, utilization of alloy steel is done in this project. AISI 8750 is utilized in this work for designing the shaft. The objective of this work was to abbreviate the weight of the drive shaft with the avail of alloy steel material. In this design, it was visually examined that the design showed ameliorated results as compared to the conventional shaft results. Abbreviation in the overall weight of the shaft was optically canvassed. In most of the conveyances, a two-piece driveshaft is utilized due to its stiffness and vigor circumscriptions. Hence most of the research work is being carried out on the utilization of composites instead of conventional material and thereby making the drive shaft in a single piece. V. Jose Ananth Vino[3] has experimentally designed the one-piece composite drive shaft which can supersede the two-piece conventional driveshaft. In most of the conveyances which are long due to material circumscriptions, a two-piece driveshaft is utilized, which makes the design intricate. Hence in this research work, an incipient composite material drive shaft is designed which is a single piece. E-glass / Epoxy, high vigor carbon/epoxy, and high modulus carbon/epoxy composites are habituated to design a single piece drive shaft in this work. The design parameters were optimized to minimize the weight of the composite driveshaft. The design optimization showed the ameliorated results in the performance of the drive shaft. The main concept of this project is to minimize the weight of the automotive drive shaft with the utilization of composite material. CAD design of the drive shaft was analyzed in an FEA software. The results showed that there was 28% weight minimization in the design as compared to a conventional shaft. The single-piece shaft was withal working better as compared to a two-piece conventional driveshaft. Hence the conventional two-piece driveshaft was prosperously superseded by the single-piece composite driveshaft. S. Balakrishnan[4] has experimentally researched on the composite drive shaft analysis. Most of the research is going on in the field of Material science. Different materials are being developed to supersede the conventional materials which we are utilizing day by day. In this research work, the composite material drive shaft is designed to supersede the conventional steel shaft. Composites have many advantages over steel such as stiffness and vigor of composites is more. In this paper, they have studied and analyzed the composite drive shaft design. A split type propeller shaft is designed and analyzed in FEA software. Utilizing the FEA results of one design the other designs are made by transmuting the geometrical parameter and materials of the shaft. In the analysis process, different boundary conditions are applied and accordingly, the designs are tested for the application. From the analysis results of sundry designs, the optimum design out of those is culled. The cull of the optimum design is done by comparing the tabulated FEA results. From these results, we can limpidly identify the best-suited design for the application. Out of the different materials utilized the E-glass showed the optimum results. Predicated on this, the E Glass composite material can be suggested as a material for supersession. B. China Brahmaiah[6] has research on the composite drive shaft for rear-wheel drive conveyance. The driveshaft is tubular in design which rotates with the frequency of engine output. Driveshaft must transmit both high power as well as low power as transmitted by the engine. Due to fluctuating loading of the torque drive shaft may fail during operation thereby resulting in the breakdown of the conveyance. Currently, in long rear-wheel drive conveyances, a two-piece driveshaft is utilized which increases the overall weight of the shafts. Hence in this research work, an endeavor is being made to truncate the weight of this two-piece drive shaft by transmuting the material of the drive shaft. The design of the composite drive shaft was analyzed for static and dynamic loading conditions and accordingly, the results were obtained. Different geometrical designs as well as different composites were analyzed in this project. Determinately it was concluded that the composites of carbon and epoxy are congruous for the application. Many of the lightweight conveyances withal use drive shaft for power transmission purport. Lightweight conveyances are generally having engines on the front side of the conveyance, to ameliorate the puissance transmission in these conveyances they are made the rear-wheel drive. In such conveyances, a single rigid drive shaft is utilized for power transmission to the rear wheels. Deepti kushwaha[7] has researched on the drive shaft of the lightweight conveyances. Present time the main issue of the automobile industry are weight minimization. The weight abbreviation of the drive shaft can have a certain role in the general weight minimization of the conveyance and is a highly desirable goal. This can be achieved by utilizing composite material instead of utilizing steel. The advanced composite materials such as graphite, carbon, Kevlar, and Glass with congruous resins are widely utilized because of their high categorical vigor and high categorical modulus. Due to these sustainable properties, these materials can prosperously supersede the conventional materials thereby truncating the weight of the component. In this project work, the lightweight conveyance conventional drive shaft is superseded by the composite drive shaft which is lighter in weight. Design with varying geometrical parameters and composite materials is tested in this work. FEA results of the design showed that the composites not only minimize weight but additionally the overall dimension of the shaft. M. Arun[8] has experimented on the laminated aluminum epoxy composite drive shaft in the light obligation conveyances. In this research work, the conventional two-piece driveshaft is superseded by the single-piece aluminum E glass/epoxy composite driveshaft. The shaft is required to have some of the rudimentary properties such as torsional vigor, torsional buckling, and bending natural frequency. The composite of aluminum and E glass/epoxy has all the rudimentary requisites. In this work, the static torsional capability of the shaft was tested for four different designs. The analysis results showed that the maximum static torsion increases with the incrementation in layers of composite. The weight truncation of up to 42 % was optically canvassed as compared to a conventional steel shaft. The bending natural frequency of the composite shaft is higher than the steel shaft. Hence it was optically canvassed that the composite drive shaft is best to abbreviate the weight of the conventional shaft. In all the above research work we studied that the composites play a major role in weight minimization of the propeller shaft. Hence we can verbalize that the composites are the future of material science. Gourav Gupta[9] has reviewed the application of composite materials in the future. Materials are the most consequential parameter in any kind of machinery or structure. In which composites are the upcoming materials which have very high vigor to weight ratio as compared to conventional metals and non-metals. Composites are facile to fabricate and are very cost efficacious. In modern applications, the composites can be used very efficaciously and with an advantage of low cost and high vigor. Now a day's utilization of composites is being done for sundry applications such as aerospace, automobiles, electronic contrivances, sports goods, etc. In this research work, they have studied the sundry applications of composites, which are now a day's becoming a future trend. Shivanand[10] has experimented on the utilization of composite materials for making the propeller shaft of a two-seater aircraft. In this study, the analysis of different composites is performed that can be utilized for maximum loading applications such as aircraft propeller shaft. They have designed a laminated composite propeller shaft for a two-seater aircraft. In this work, the classical laminated theory is utilized for modeling a propeller shaft. After analysis of this shaft, it was optically canvassed that the composite of low carbon steel, epoxy, S glass, and T700 fibers is the best composite for this application. The overall summary of the literature survey is shown in table 1.

Table 1. Summarised literature review

Sr.No.	Author	Experiment Performed
1	A.A. Baig[2]	Performed the failure mode analysis of drive shaft at high speed.
2	Salaisivabalan T[1]	Experimentally designed the drive shaft utilizing composite material to reduce the weight of the vehicle.
3	R. Harimahaswaran[5]	Research on the optimization of the propeller shaft using alloy steel material.
4	V.Jose Ananth Vino[3]	Design of one piece drive shaft to replace the conventional two piece drive shaft. One piece drive shaft of composite is designed to improve the performance of the heavy vehicle.
5	S.Balakrishnan[4]	Research on the use of composite drive shaft to replace the conventional steel drive shaft.
6	B.China Brahmaiah[6]	Designing of single piece hollow drive shaft of composite material is done to reduce the overall weight of the vehicle.
7	Deepti kushwaha[7]	Experimentally worked on the use of composite drive shaft in the light weight vehicles. Thereby reducing the weight of the vehicle and improving the performance of the light duty vehicle.
8	M. Arun[8]	Research on the use of Aluminium and E-glass/epoxy composite for designing the drive shaft of the vehicle.
9	G. Gupta[9]	Researched on the application of the composite materials in the field of engineering and science.
10	Shivanand[10]	Experimentally analysed the propeller shaft made of composite laminates for two seater aircraft.

Propeller Shafts and its types

A propeller shaft is a rigid shaft that transmits torque and power from the engine to the rear wheels of the conveyance. It is additionally called a Cardan shaft or driving shaft is associated with a mechanical component that is utilized for rotational purport transmitting torque and rotation and subjected to torsional or shear stress. The propeller shafts must be vigorous enough, low notch sensitivity factor, having heat-treated, and high wear-resistant property so that it can sustain high bending and torsional load. There are variants of drive shaft utilized in automotive industries which are verbally expressed as follows:

- One piece drive shaft
- Two piece drive shaft
- Slip in tube drive shaft

The slip-in-tube drive shaft is an incipiently designed propeller shaft that ameliorates Crash safety. It can be compressed to absorb energy in the event of a crash, so is additionally kened as a collapsible driveshaft.

Conventional drive shaft which is currently utilized in automobiles is shown in the figure 1[11].



Figure 1. Drive shaft

Design Parameters of Propeller Shaft

Designing of propeller shaft depend on various parameters[11], which are discussed as follows:

- Torsional Strength: as drive shaft is acted up on by torsional loading while operation its torsional strength must be high.
- Toughness and Hardness: toughness and hardness of the drive shaft must be high to resist bending and buckling during operation.
- Dynamic Balancing: whirling of shaft may occur during high speed of rotation, hence the balancing of shaft is most important.
- Type of shaft: generally there are two type of shaft used in now a day's wiz solid and hollow. According to the type of shaft the diameter of shaft must be selected, because diameter of shaft also affects the overall strength of the shaft[7].

Drive Shaft Materials

The conventional drive shaft is composed of steel or alloy steel. This type of drive shafts is very cumbersome hefty which generally increases the overall weight of the conveyance and has lots of circumscriptions. Some of the demerits of the conventional steel shaft are listed below:

- Fuel consumption of a vehicle is more due to excess weight of drive shaft.
- Less corrosion and fatigue resistance.
- Stiffness and strength of steel is less.
- In two piece drive shaft, two universal joints are used, which reduce the overall power transmission of shaft.
- Overall efficiency of the vehicle is reduces.

Due to which nowadays the conventional shafts are being superseded by the composite material drive shafts. The composite material is an incipient kind of material that is composed due to the cumulation of two or more metals or non-metals is kened as composite materials. Generally, composite materials are lighter and more vigorous than conventional metals. There are many types of composite materials like carbon epoxy, glass epoxy, Kevlar, etc., now a day's utilized for sundry applications[1]. The driveshaft is one of the applications in which composites are now a day's utilized. Sundry advantages of composite material drive shaft over conventional steel shaft are listed below:

- Fuel consumption reduces as the overall weight of the vehicle is reduced.
- More corrosion and fatigue resistance.
- It has more strength and stiffness.
- As single piece drive shaft is used the overall power transmission of shaft is more.
- Efficiency of the vehicle increases.

Conclusion

In this research paper, we have studied different composite materials utilized for making the propeller shaft. From the literature survey of the sundry researches, it is visually examined that the composites of variants can be utilized for designing a one-piece driveshaft instead of a two-piece conventional shaft. Composite shafts result in overall weight abbreviation of the conveyance thereby amending the efficiency of the conveyance. Its torsional vigor and stiffness are more as compared to a conventional steel shaft, which provides better results even with the more diminutive diameter shaft. Composites corrosion and fatigue resistance is withal more which increases the life of the composite shaft. After summarizing all the results we can conclude that the composite drive shaft can prosperously supersede the conventional drive shafts.

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