Indian Journal of Engineering & Materials Sciences
Vol. 28, June 2021, pp. 282-285

Fabrication and torsional strength evaluation of a glass fiber epoxy composite shaft

Vishal Jagadale[a,b*] & Surya Narayan Padhi[a]

[a]Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Guntur 522 502, India
[b]Department of Mechanical Engineering, MIT College of Railway Engineering & Research, Barshi 413 401, India

Received: 23 September 202; Accepted: 06 June 2021

Drive shaft plays a significant role in automotive power transmission. The weight of the drive shaft should be optimum to get better outcome. The selection of drive shaft is done based on the designed torsional strength. It means that torsional strength should be same irrespective of the material. In this present work the effort has been taken to evaluate the torsional strength of composite material drive shaft keeping the dimensions unaltered. Here drive shaft is manufactured using wire wound method. The materials chosen are glass fiber and epoxy as a main constituent. The efforts show the possible replacement of exiting drive shaft with composite one keeping all design parameters as constants.

Keywords: Classical lamination theory, Drive shaft, Hand layup, Mandrill manufacturing, Wire wound manufacturing

1 Introduction

The propeller shaft is a pilot shaft that connects the main transmission shaft to the actual axis differential. With universal joints, it transmits the power from the gear box to the rear axle. The shaft is often referred to as the drive tube. A shaft must be designed to meet the stringent automotive design requirements[1]. Results from some researchers clearly show that a single-piece propeller hybrid wave of fiber-reinforced composite and aluminum tubing can be designed with less weight than the steel shaft and a natural frequency above the shaft operating speed[2]. Substitution of standard drive shafts with steel components. AISI 8750 is used as a low alloy tool in this work. The design parameters have been optimized to minimize the drive shaft's weight. The optimization of the design also showed significant potential improvements in drive shaft performance[3]. The usage of composite material has led to a weight-saving measurement of 24-29% as opposed to the usual steel wave[4]. Single piece shaft can be implemented by using composite material. The power loss then decreases[5]. Nickel chromium steel SAE3145 has been designed for its suitability in terms of torsional strength, natural bending frequency and torsional buckling[6]. The shafts of the propeller need to be high enough, low sensitivity, heat-treated and wear resistant so that they sustain high bending and wear[7]. Conventional steel propeller shafts are usually made in two parts to increase the natural frequency of the fundamental bending. But three universal joints, an intermediate thrust bearing and a supporting support bracket are part of the two-piece steel driveshaft which increases the total weight of the vehicle[8]. Another advantage of composite material is that many of the composite material can be recycled and reused[9]. Improved Shear Deformation Theory (ISDT) can be used on laminated composite plate with mass variation through the cutout and additional mass for bi-axial buckling[10]. Fly ash can be added in order to decrease the heat transfer rate and to increase the mechanical bonding which can be observed through thermal testing and SEM analysis[11]. The propeller shaft is the very important part of a vehicle, the vehicle can move forward and reverse through the shaft. This shaft is known as a shaft for a propeller, the overall objective is to design and improve the weight of the light motor vehicle propeller shaft. Finite element model of representative volume element (RVE) of nano-composite can be generated using validated boundary conditions by which the axial elastic modulus can be estimated, which is found to be in close agreement with the experimental results[12]. To improve the cavitation performance hybrid composite marine propeller shaft can be preferred compared to its metallic counter-part[13] Advanced composite material propeller shaft can be used for Go-Kart[14]. Use of composite material drive shaft has gained great attention in case of racing cars.

*Corresponding author
(E-mail: vishjagadale@gmail.com)

2 Materials and Methods

2.1 Materials

On the basis of the values of the mechanical properties obtained from the tensile and shear measures, the best materials with ideal mechanical properties and necessary strength are chosen. A program is made in C++ for selecting the best content. The software results showed that 50% fiber content in composite showed optimum results and same is used for manufacturing. The material properties and variation of the materials can be studied by changing the percentage volume composition of the fiber to the resin, 50% fiber volume gives good results[15]. The detailed process of manufacturing is shown in Fig. 1. It shows manufacturing of composite material drive shaft along with manufacturing of mandrill needed for hollow construction.

2.2 Methods

2.2.1 Mandrill manufacturing

Mandrill is produced from the casting process with an outer diameter of 59 mm and a length of 600 mm with tapper as shown in Fig. 2. Tapper comes with decent surface finish thanks to simple removal of the propeller shaft. Cast iron is the material used for mandrill.

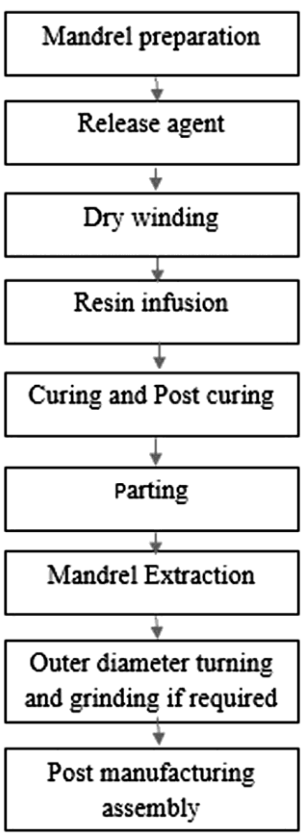

Fig. 1 — Steps used in manufacturing of filament wound product.

2.2.2 Hand-layup

Hand layup process can be effectively used for duralumin with E-glass fiber hybrid composite where epoxy resin was used as a binder, thus a sandwich panel was prepared[13]. Classical lamination theory can be used for optimizing the lay-up sequence to exploit the bend-twist coupling[16]. To fabricate composite material powder metallurgy process can be effectively used[17]. The glass fibers and epoxy resins combined with hardener is mounted manually on the surface of the molding, *i.e.* the mandrill seen in Fig. 2. The glass fiber sheet is then prepared in 45° orientation. Note is taken to make sure that the solvent does not contain air bubbles, because it is used for fiber enhancement. For this purpose, tightened rollers are used to remove air bubbles and to ensure increased fiber wetting. Tata Sumo Tata Sumo Gold BS-III 2956 cc 4SP TCIC Engine variant is selected for the analysis. Below Fig. 3 shows the final fabricated shaft using hand layup manufacturing.

2.2.3 Testing

a) Introduction to torsion testing

For reduction in weight for hybrid vehicle composite material drive shaft manufactured using glass fiber can be used for desired tortional strength[18]. Taguchi method can be used for optimizing the number of experiments needed to get the desired outcome with minimum tests[19]. Torsion measures are commonly used to determine the elastic frame, resistance, shear framework, shear strength and other structural properties. The key distinction between the torsion test and the tensile test is that the force over the cross-section of the test specimen is not standardized. Components are often twisted in systems in certain fields of manufacturing activities such as drive shafts, axles and drills. In comparison, structural applications such as beams, coils, car

Fig. 2 — Mandrill.

Fig. 3 — Final Fabricated shaft.

bodies, fuselages for aircraft and boat hulls are arbitrarily bent. The materials used in this case should not only be strong enough but also torque resistant in operation.

Fig. 4 — Torsion testing machine.

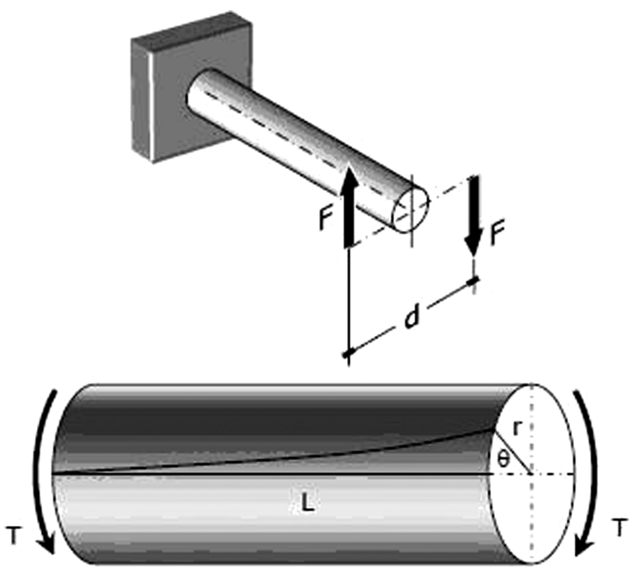

Fig. 5 — Torsion Twisting of Bar[6].

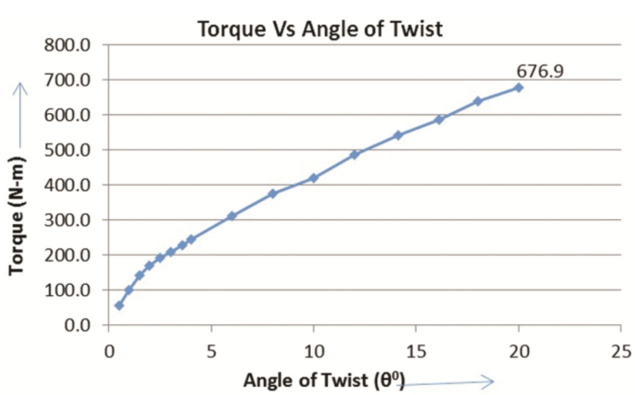

Fig. 6 — Torque vs. Angle of Twist graph obtained from torsion testing.

The torsion test is useful in the processing of delicate products such as machine stain. The method is often used to assess the device forge capability by means of torsion checks at high temperatures. Specifications of the machine used for the analysis are tabulated in Table 1.

The fabricated composite material drive shaft is mounted on a torsion testing machine which is shown in Fig. 4. The torsion test is conducted with the torque test by placing the specimen in the torsion testing system and then using the twisting moment before failure Fig. 5. Torque and rotational frequency are calculated and mapped as shown in the diagram. Higher torsional force is necessary in higher rotational degrees. The research specimens used are usually cylindrical, since the stress distribution through the rod segment is the easiest structure that is easy to quantify stresses. It is necessary to keep the angle of twist within the permissible limit for safety.

b) Experimental procedure

The first thing that was done in the lab was the measuring of the diameter of the specimen gauge section using calipers, and to record that value for later calculations. After that, it was necessary to draw a straight longitudinal line on the specimen so that the angle of twist of the specimen can be observed during the test.

3 Results and Discussion

A 250 mm long specimen was used to measure the torque capabilities of the composite drive shaft, which had been shortened to be mounted on the torque tester. Figure 6 The angle diagram for torque distortions of the shaft shows up to 676.9 N-m at maximum torque. Readings were taken at fixed time interval of 5 sec.

The torsion test was carried out at Shreyas Enterprises, Warje-Malwadi, Pune. In the torsion test we get the results listed in Table 2.

Table 1 — Specification of torque testing machine

Particular	Capacity
Maximum torque	1500 Nm
Maximum Angle of twist	20 degrees
Maximum length of specimen can occupy	250mm
Make of machine	Shreyas Enterprises, Pune
Type of machine	Digital
Input method	Manual

Table 2 — Torque applied and angle of twist

Applied torque (N-m)	Angle of twist (Degrees)
56.9	0.5
101.0	1.0
143.2	1.5
168.7	2.0
191.3	2.5
209.9	3.0
228.6	3.6
246.2	4.0
312.0	6.0
375.7	8.0
418.9	10.0
485.6	12.0
540.5	14.1
585.7	16.1
637.7	18
676.9	20

4 Conclusion

The following conclusions are drawn from the present work:

i. Drive shaft can be manufactured using hand layup method with optimum accuracy, but to increase the accuracy, advancement in manufacturing processes is desirable.
ii. For same torsional strength single piece drive shaft can effectively replace the two-piece drive shaft.
iii. A one–piece composite material drive shaft for real wheel drive automobile has been designed optimally by using classical lamination theory with the objective of minimization of weight of the shaft which was subjected to the constraints such as natural bending frequency.
iv. The maximum torque of 676.9 N-m is sustained by the shaft for 20-degree angle of twist.

References

1 Vino V J, & Hussain J H, *Int J Innov Res Sci Eng Technol*, 4(8) (2015) 2666.
2 Gubran H B H, & Gupta K, *J Vib Eng Technol*, 2(1) (2014) 35.
3 Harimaheswaran R, Jeyakumar N, Satheeshkumar R, & Viswabharathy P, *Int J Emerg Tech in Eng Res*, 5(4) (2017) 314.
4 Rao A S, Poornima L, Kumar K S, & Subrahmanyam B V, *Int J Sci Res*, 7(1) (2018) 211.
5 Nizam S S, Thoufeek A, Vyshak O R, Hallaj J, & Mathews T, *Int Res J Eng Technol*, 6 (5) (2019) 5069.
6 Mhaske S P, & Doshi N P, *Int J Res Appl Sci Eng Technol*, 4 (2016) 2321.
7 Raikwar A K, Jain P, & Raikwar R, *Int J Eng Dev Res*, 4(4) (2016) 39.
8 Shinde S, *Int Eng Res J*, 7 (2017) 1046
9 Mali S S, & Patil S S, *Int J Eng Res Tech*, 7(7) (2018) 368.
10 Chaubey A, Kumar A, Kwiatkowski B, Barnat-Hunek D, & Widomski M K, *Mat (Basel)*, 12(11) (2019) 1750.
11 Kushnoore S, Atgur V, Kanigalpula P K C, Kamitkar N, & Shetty P, *J Mech Eng Sci*, 13(3) (2019) 5588.
12 Jalan S K, Rao B N, Narayana Murty S V S, & Gopalakrishnan S, *Trans Indian Inst Met*, 72 (2019) 951.
13 Ashok P, Jamaleswara K P, & Premkumar P S, *J Adv Res Dyn Control Syst*, 9(14) (2017) 1823.
14 Bala Subramanyam P N V, Rao B N, Naga H O, & Pavan Sai Kumar M, *Int J Mech Prod Eng Res Dev*, 9(2) (2019) 769.
15 Vijaya Kumar T, Ali A, Gunasekhar B, Rajasekhar Reddy K, & Mustafa M, *Int J Innov Res Sci Eng*, 8(7) (2019) 2046
16 Chintalapudi B T, Gonuguntla C B, Pothuri M, Kant J, Pathan A, & Pittala R K, *Int J Mech Eng Tech*, 8(5) (2017) 425.
17 Kumar G A, Surya S, Naidu G S, Phanindra G, & Gangaraju Y, *Int J Mech Eng Tech*, 8(12) (2017) 1083.
18 Teja N S, Anvesh B Y, Mahesh Ch, Kiran D S, & Harsha D S, *Int J Mech Eng Tech*, 8(5) (2017) 237.
19 Rao K S, Kumar M P, Prasad S S, Teja B S, & Chandh Y V S, *Int J Mech Eng Tech*, 8(4) (2017) 223.