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Rigid PVC Propeller Shaft for Automobiles

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Abstract: **An automobile drive shaft is made up of rigid PVC material. It is done in order to reduce the weight of the drive shaft in an automotive transmission system transmission. Some major objectives/advantages of this invention are as follows:**

- **Reduction in body weight and thus increase in power to weight ratio.**
- **Transfer same torque using lighter material.**
- **To present an alternative material for drive shaft.**

Keywords: **Propeller Shaft, Drive Shaft, Rigid PVC, Automobile, Transmission System, Power – Weight Ratio, Hollow shaft, Torque, Speed, Vibrations, Whirling, etc.**

I. INTRODUCTION

The article relates to a propeller shaft for automobiles, and more particularly, it relates to a hollow light weight rigid PVC propeller shaft for automobiles capable of excellent damping of vibrations and reduced weight.

II. DETAILED DESCRIPTION

A. Background of the invention:

Propeller shaft, sometimes called a carden shaft connects gearbox to the final drive gears of the vehicle through universal joint and serves as drive shaft. A universal joint allows the drive to be transmitted through a variable angle. The drive system is an arrangement for transmitting the driving thrust from the road wheels to the vehicle body. The final drive is the transmission system between propeller shaft and differential.

The output of a transmission in an automobile is transmitted via propeller shaft to a differential gear. In order to have good bending and twisting durability, the propeller shaft is made up of metal pipe, generally forged steel. Even the light propeller shaft of the metal pipe, if long, must be divided by two (three joint systems) or by three (four joint system) in consideration of critical speed. In this case, the number of joints and number of parts and number of assembling steps increases, resulting in higher cost. The weight of the metal pipe is also one of the important issues which increase the power to weight ratio. Also squeaking is another concern due to increased vibrations.

Accordingly, there exists a need to provide a propeller shaft which overcomes abovementioned drawbacks.

B. Objectives of the invention:

An object of the present invention is to provide a light weight hollow rigid PVC propeller shaft which provides excellent damping of vibrations.

Another object of the present invention is reduction in body weight which increases the power to weight ratio.

Yet another object of the present invention is transferring same torque using lighter material.

Further object of the present invention is reduction in overall cost due to reduction in number of divisions and joints.

Still further object of the present invention is to ensure less squeaking due to reduced vibrations.

One more object of the present invention is to provide an alternative material for drive shaft.

C. ***Brief description of the drawing:***

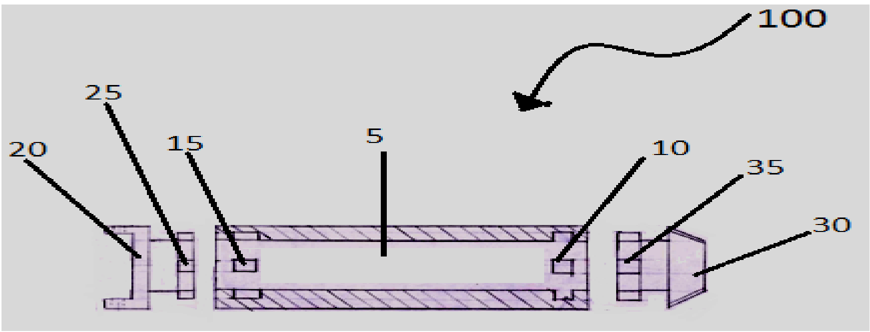

Figure 1

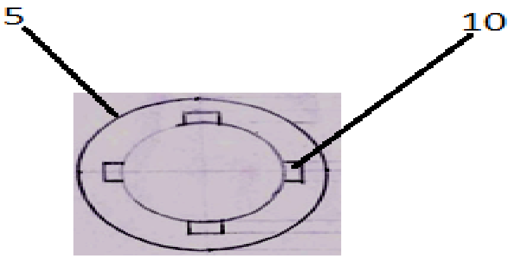

Figure 2

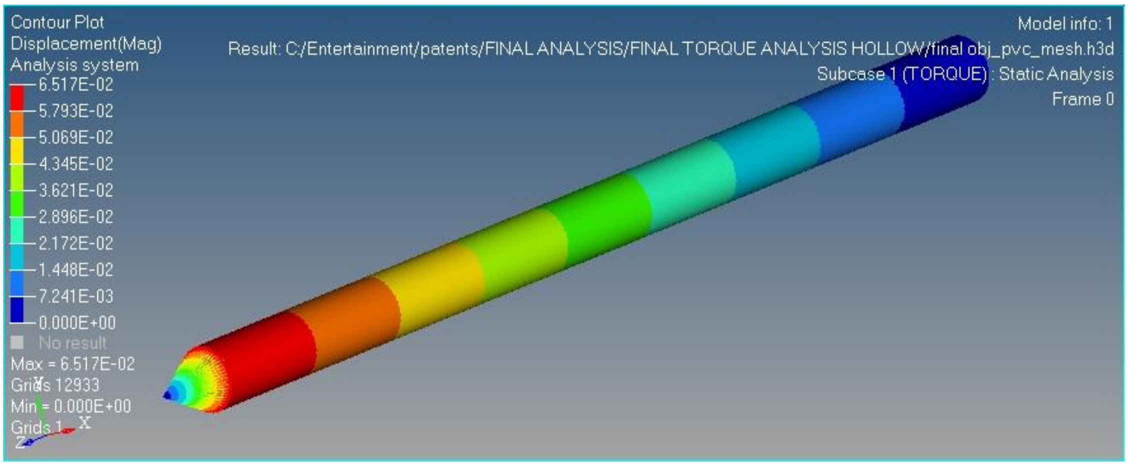

Figure 3

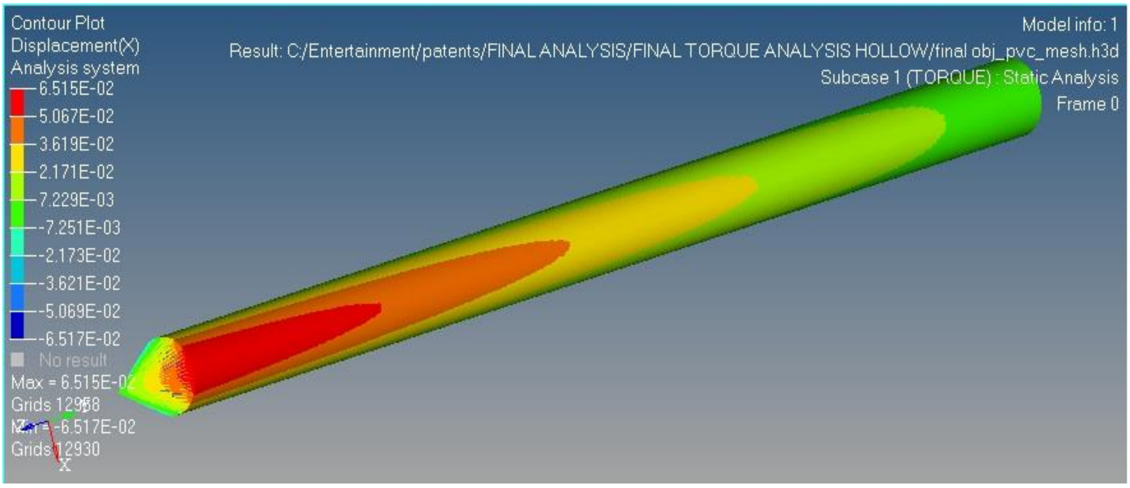

Figure 4

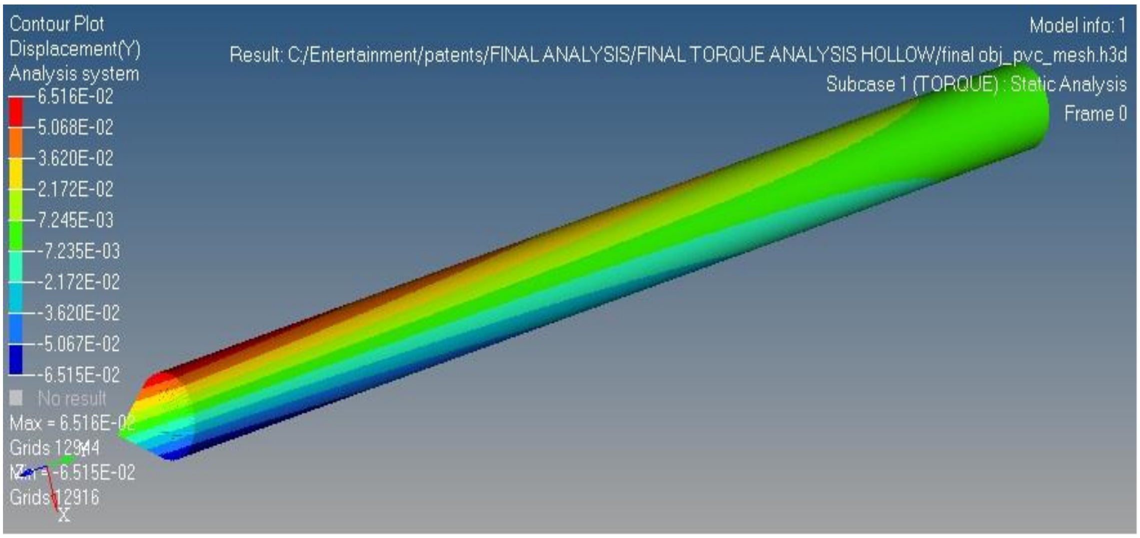

Figure 5

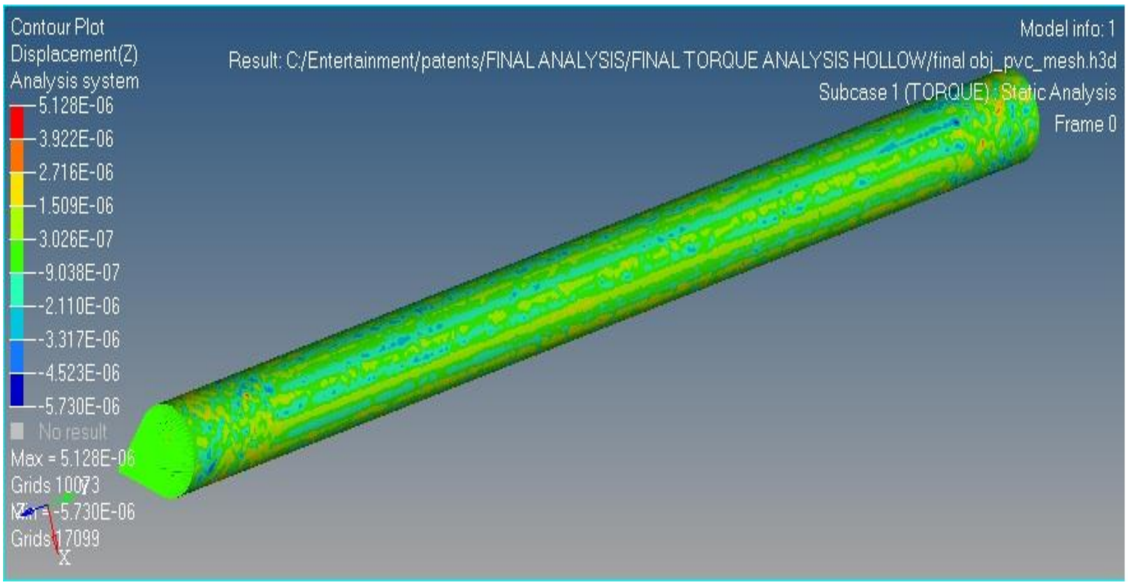

Figure 6

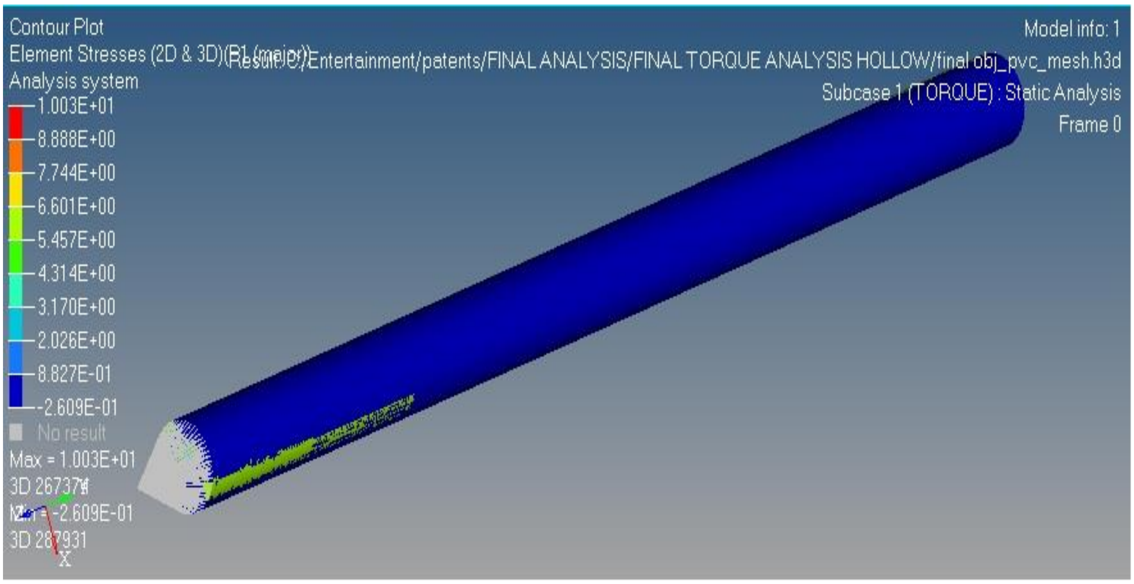

Figure 7

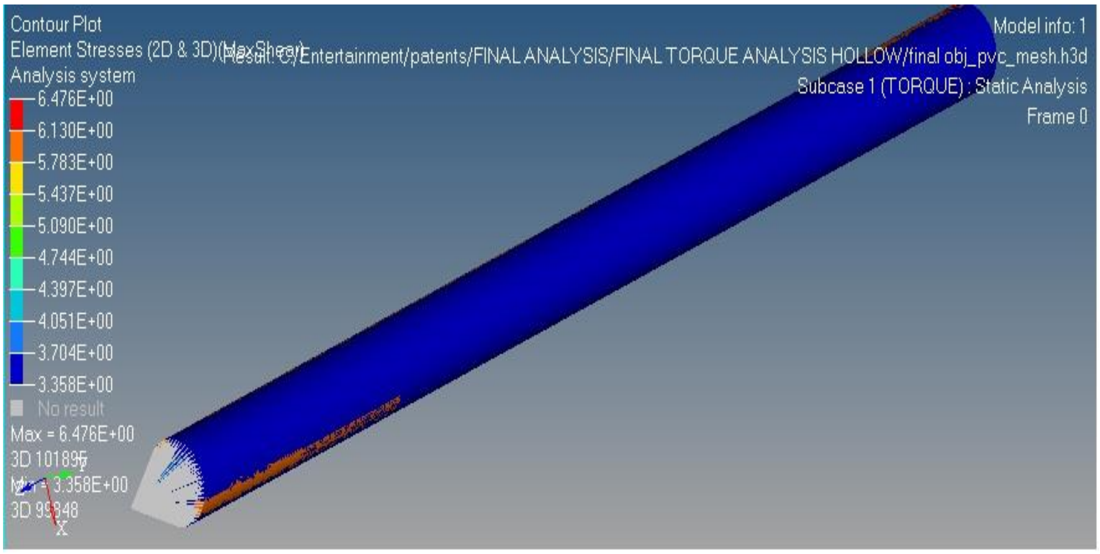

Figure 8

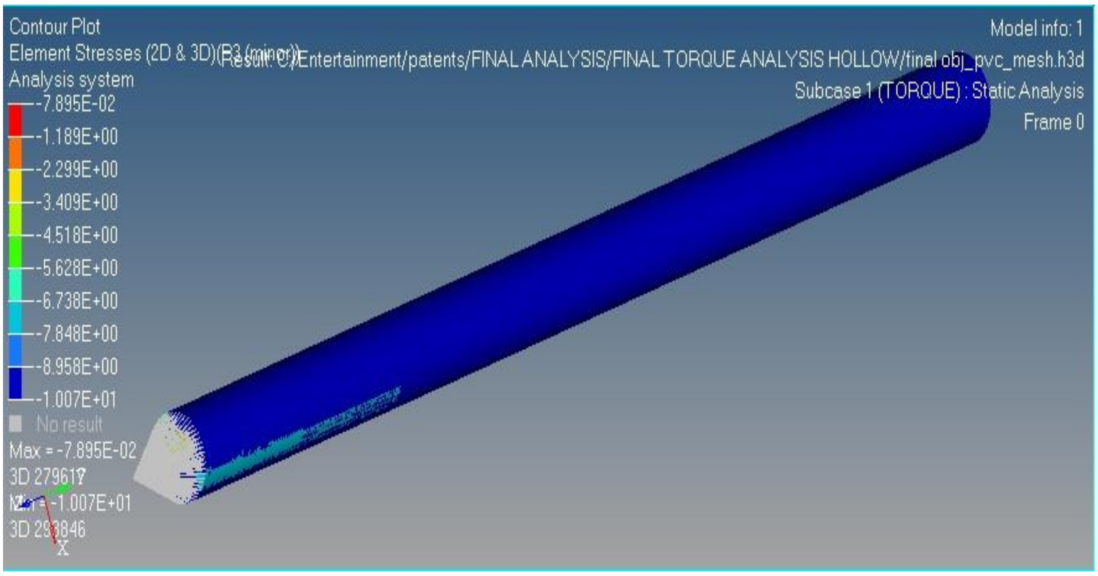

Figure 9

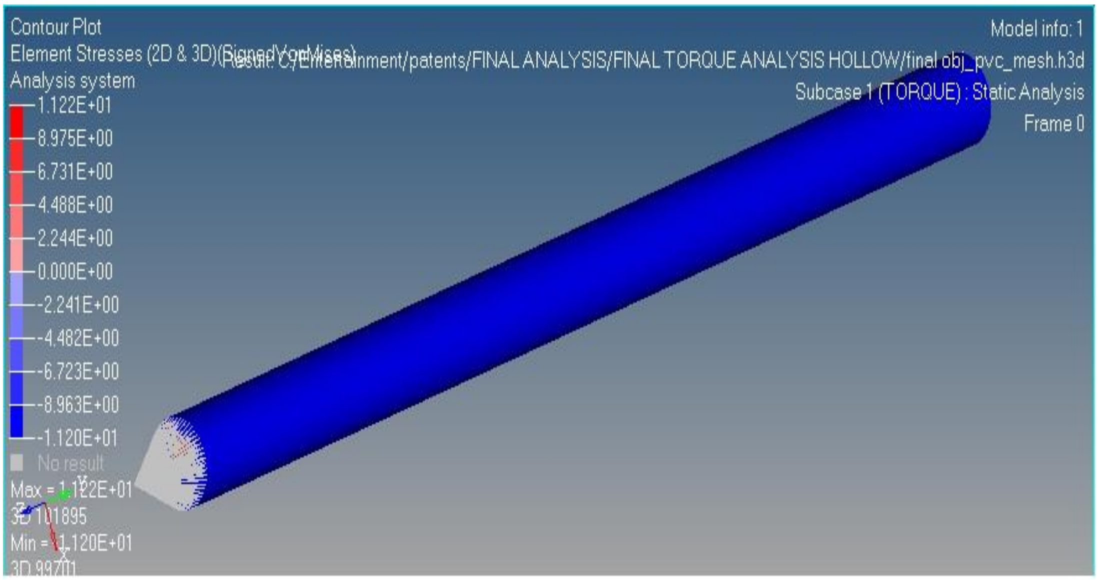

Figure 10

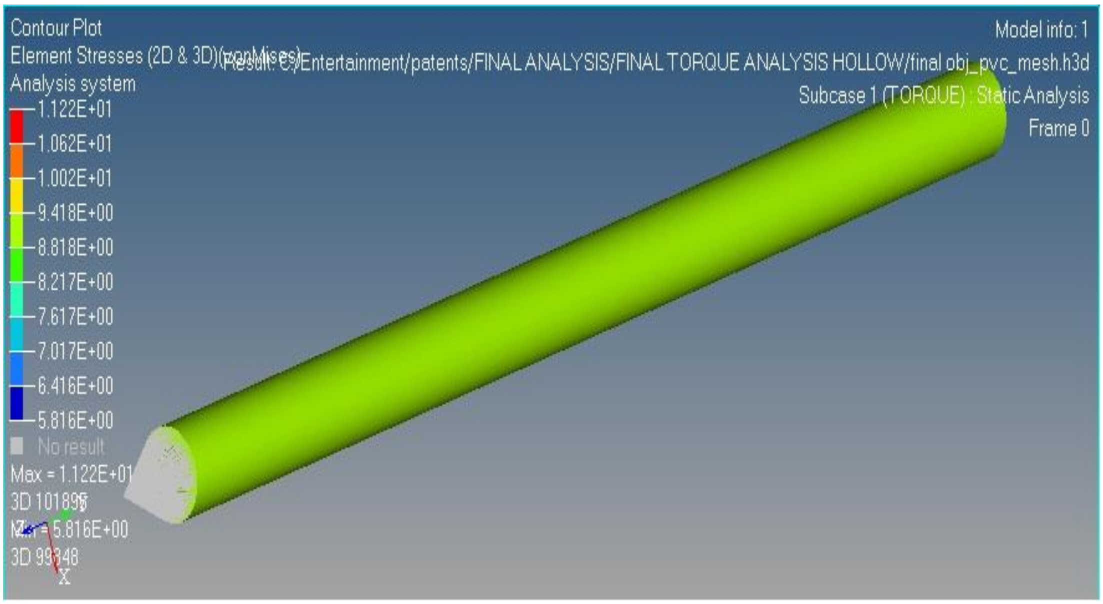

Figure 11

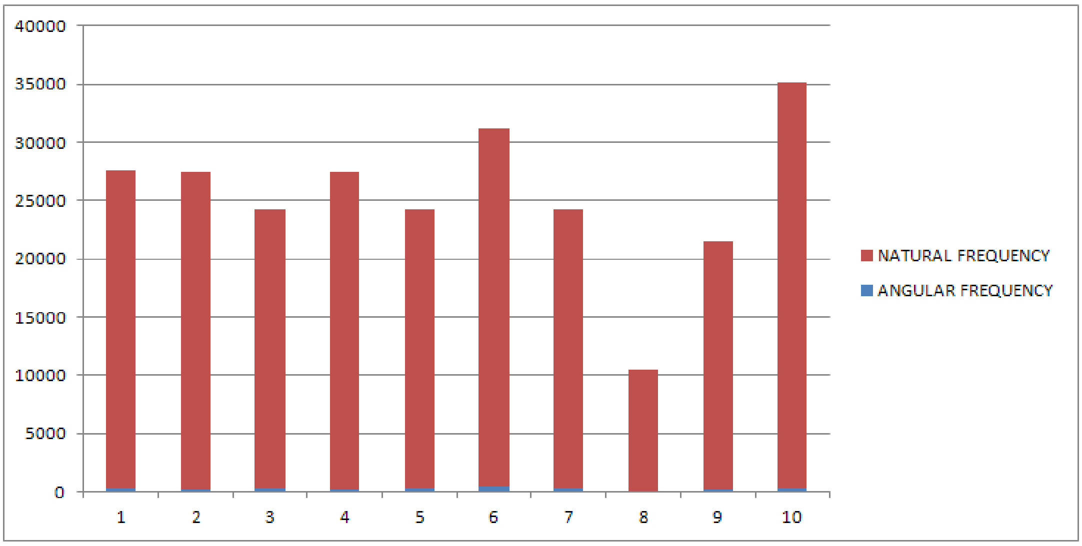

Figure 12

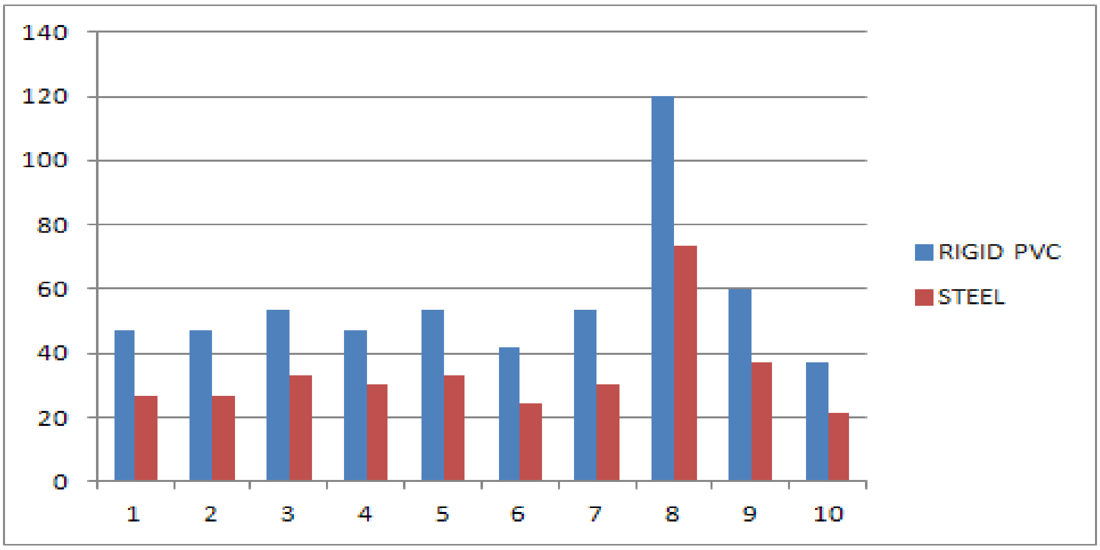

Figure 13

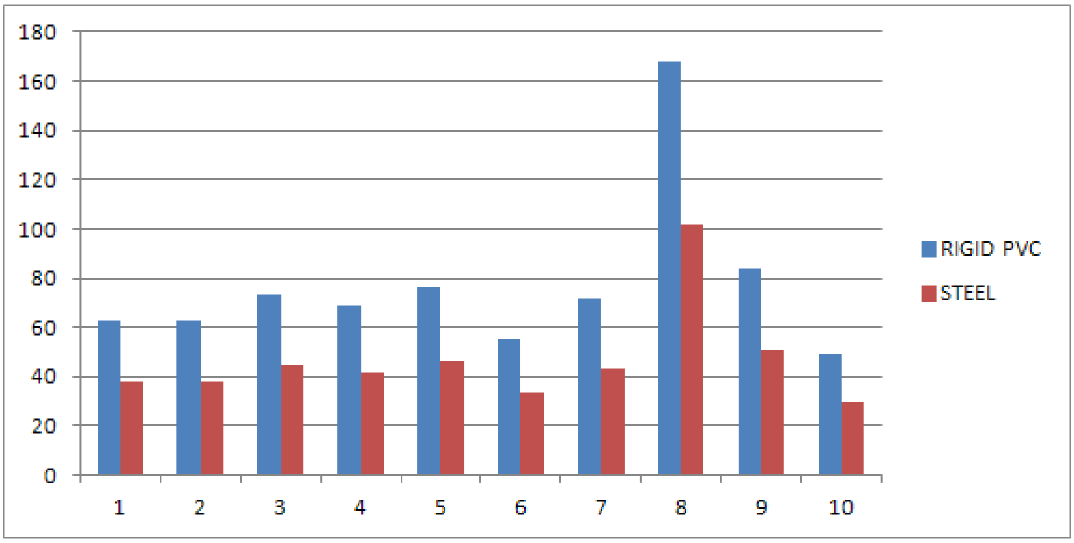

Figure 14

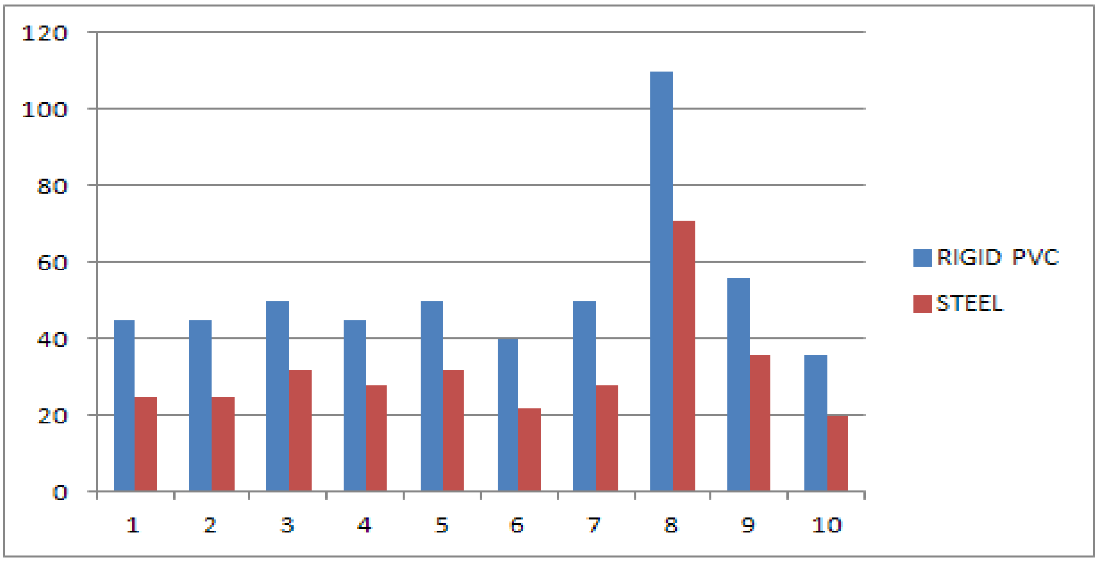

Figure 15

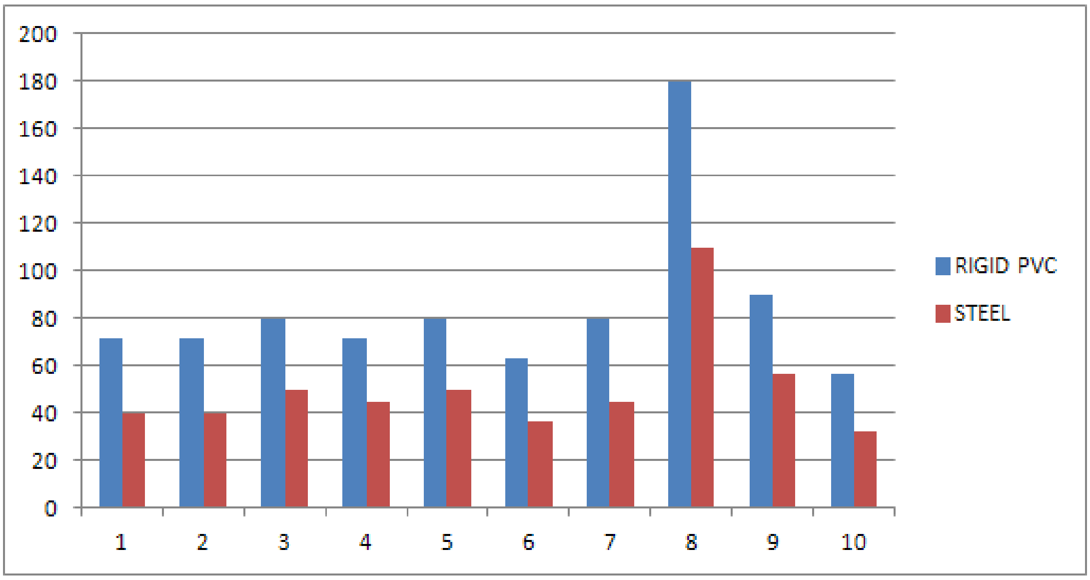

Figure 16

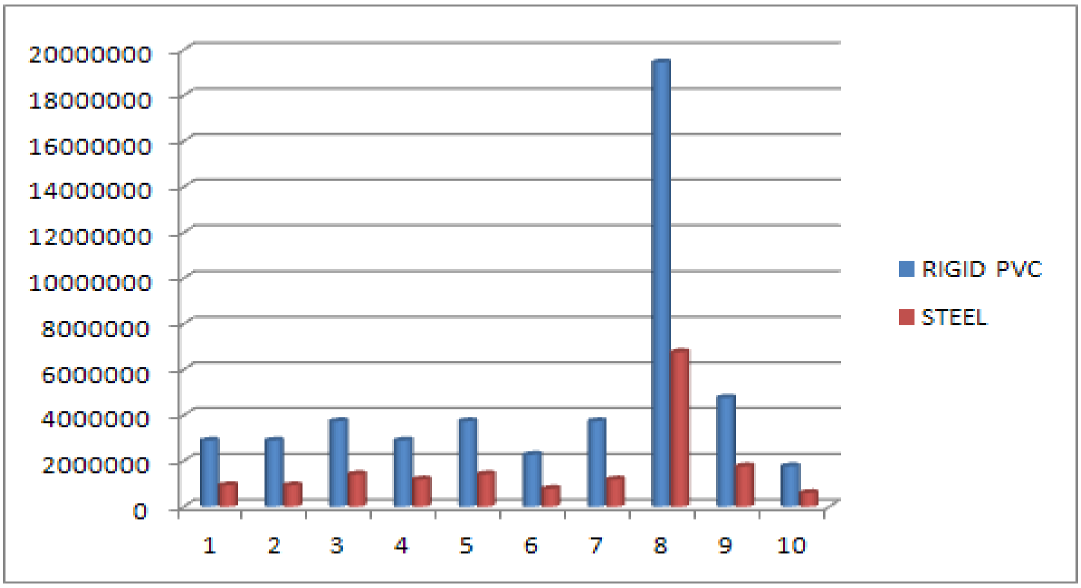

Figure 17

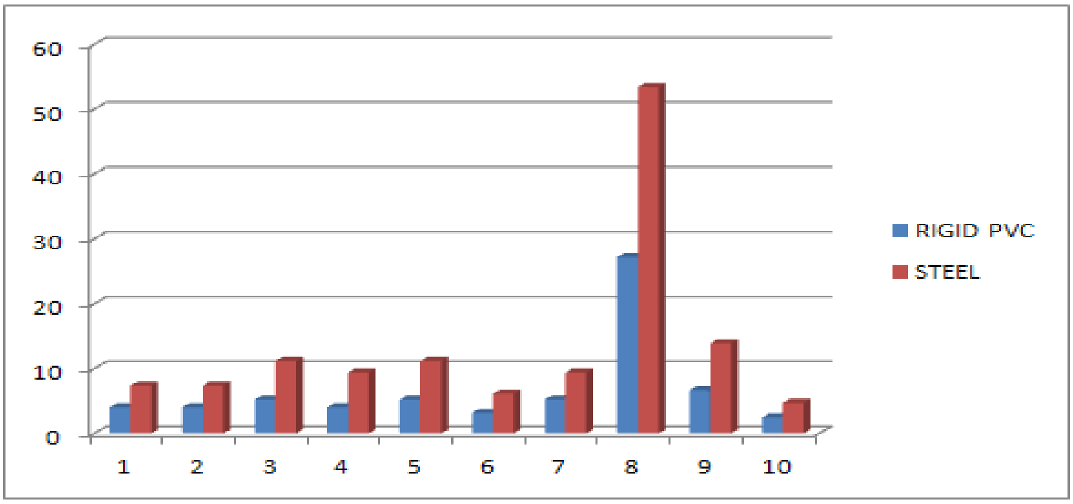

Figure 18

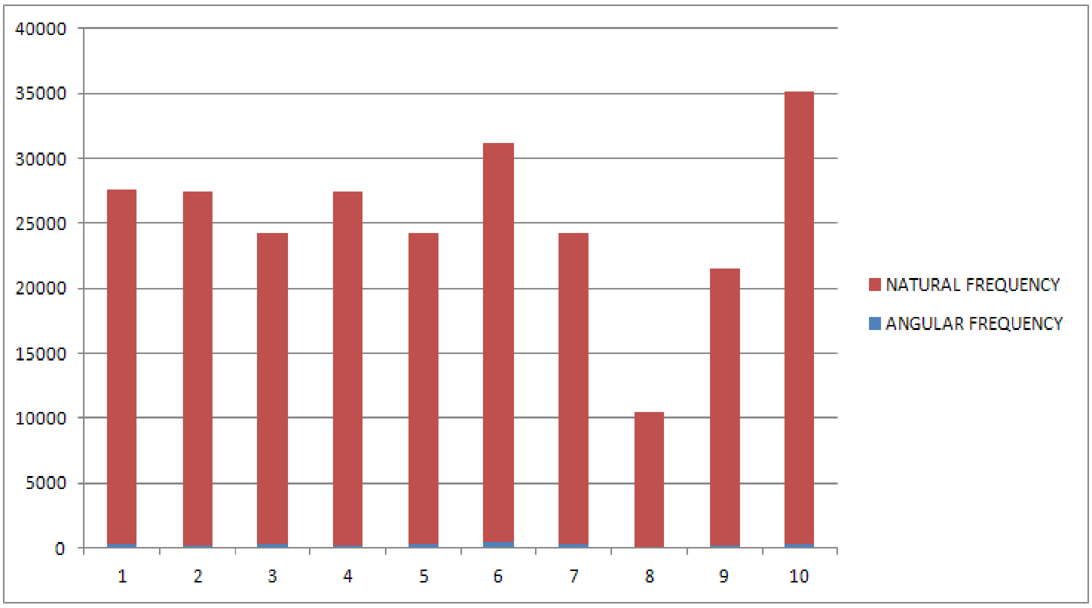

Figure 19

Figure 1 shows a side exploded view of the coupling of a propeller shaft assembly, in accordance with the present invention;

Figure 2 shows a front view of a propeller shaft, in accordance with the present invention;

Figure 3 shows an output analysis in terms of Magnitude of net displacement having values from 0 mm to 0.006517 mm, in accordance with the present invention;

Figure 4 shows an output analysis in terms of Magnitude of displacement in X-axis having values from 0.006517 mm to 0.006515 mm, in accordance with the present invention;

Figure 5 shows an output analysis in terms of Magnitude of displacement in Y-axis having values from minimum -0.006515 mm to 0.006516 mm, in accordance with the present invention;

Figure 6 shows an output analysis in terms of Magnitude of displacement in Z-axis having values from 0.00000573 mm to 0.000005128 mm, in accordance with the present invention;

Figure 7 shows an output analysis in terms of Magnitude of Stresses generated about Major Principle Plane having values from -0.02609 N to a 10.03 N, in accordance with the present invention;

Figure 8 shows an output analysis in terms of Magnitude of Maximum Shear Stress generated having values from 3.358 N to 6.476 N, in accordance with the present invention;

Figure 9 shows an output analysis in terms of Magnitude of Maximum Shear Stress generated having values from – 10.07 N to -0.0789 N, in accordance with the present invention;

Figure 10 shows a graph of an output analysis in terms of Magnitude of Maximum Shear Stress generated having values from -11.20 N to 11.22 N, in accordance with the present invention;

Figure 11 shows a graph of an output analysis in terms of Magnitude of Maximum Shear Stress generated having values from 5.816 N to 11.22 N, in accordance with the present invention;

Figure 12 shows a graph of the relative shaft whirling for 10 vehicles, in accordance with the present invention;

Figure 13 shows a graph of the relative inside diameters of hollow shaft for 10 vehicles, in accordance with the present invention;

Figure 14 shows a graph of the relative outside diameters of hollow shaft for 10 vehicles, in accordance with the present invention;

Figure 15 shows a graph of the relative standard inside diameters of hollow shaft for 10 vehicles, in accordance with the present invention;

Figure 16 shows the graph of the relative standard outside diameters of hollow shaft for 10 vehicles, in accordance with the present invention;

Figure 17 shows the graph of the relative shaft Volume of hollow shaft for 10 vehicles, in accordance with the present invention;

Figure 18 shows the graph of the relative shaft Masses of hollow shaft for 10 vehicles, in accordance with the present invention; and

Figure 19 shows the graph of the relative shaft whirling of hollow shaft for 10 vehicles, in accordance with the present invention.

D. Detailed description of the invention:

The foregoing objects of the present invention are accomplished and the problems and shortcomings associated with the prior art, techniques and approaches are overcome by the present invention as described below in the preferred embodiments.

The working of propeller shaft is although independent on material but reduction or losses in energy and power do vary from material to material. In the transmission assembly, after the power from engine to clutch finally reaches gearbox. In the gearbox, this power is manipulated according to the driving conditions. This varied power is transferred to the differential assembly using a propeller shaft. The rotational motion of propeller shaft is the medium of transfer of torque. Due to this rotational motion, this shaft is subjected to twisting and hence, it must be designed accordingly. Accordingly, the present invention provides a hollow light weight rigid PVC propeller shaft for automobiles when used the power output remains the same with a difference in size and reduction in weight, vibrations, noise, etc.

Refereeing now to figures 1 and 2 which shows a side exploded view of the coupling of a propeller shaft assembly (100) and a front view of a propeller shaft respectively. The propeller shaft assembly (100) comprises a propeller shaft (5), a plurality of key slots (10) at one end of the propeller shaft (5), a plurality of key slots (15) at the other end of the propeller shaft (5), a U-joint (20), a plurality of keys (25), a bevel pinion (30), and a plurality of keys (35).

More specifically, the propeller shaft (5) is a hollow pipe made up of rigid Polyvinyl Chloride (hereinafter referred as 'PVC') material. There is provided a plurality of key slots (10) at one end of the propeller shaft (5) and a plurality of key slots (15) at the other end of the propeller shaft (5). The U-joint (20) is shown which includes a plurality of keys (25). Further, the bevel pinion (30) is shown which includes a plurality of keys (35). Both the U-joint (20) and the bevel pinion (30) are made up of steel as per the standards and final drive ratio respectively. The melting point of the PVC is very less as compare to the steel and therefore both the ends of the propeller shaft (5) are melted and manufactured by casting in shape of shaft on the surface of the U-joint (20) and the bevel pinion (30). In an embodiment, the design of the ends of the propeller shaft (5) may change according to the locking arrangement with the other parts and serve the purpose of mating with them respectively. The plurality of key slots (10) and plurality of key slots (15) are capable of providing a firm locking arrangement by interfacing with the plurality of keys (25) and plurality of keys (35) on the U-joint (20) and the bevel pinion (30) respectively.

E. Design of Hollow Propeller Shaft:

The design procedure of hollow propeller shaft is as follows:

Since propeller shaft is required to transfer power, so the torque transferred corresponding to the speed is given by:

$$P = 2\pi NT/60$$

Therefore,

$$=> T = 60P/2\pi N$$

Here,

P = Power in KW

N = Speed in revolution per minute

T = Torque transferring in Nm.

Now, since the difference in diameters due to the effect of bending due to self-weight and without its consideration were negligible hence, neglecting the effect of bending due to self-weight.

By Torsion Equation-

$$=> T = \frac{\pi}{16}\left[\tau(d_o{}^3 - d_i^3)\right]$$

$$k = \frac{d_0}{d_i} = 1.5$$

$$=> T = \frac{\pi}{16}\left[\tau(1.5d_i^3 - d_i^3)\right]$$

$$=> T = \frac{\pi}{16}\left[\tau(0.5d_i^3)\right]$$

$$=> d_i = \left[\frac{16T}{\pi\tau}\right]^{\frac{1}{3}}$$

Here, the value of τ is not the actual value of shear stress but a ratio of actual shear stress to the factor of safety.

For convention material "commercial steel":

Actual Shear stress, τ = 41 MPa

Factor of Safety, FOS =1

Density, ρ= 7900Kg/m^3

Poisson's ratio, ν = 0.30

Elastic modulus, E = 2.1 x 10^5 MPa

For RIGID PVC:

Actual Shear stress, τ= 9240 Psi = 63.707 MPa

Factor of Safety, FOS =7

Density, ρ = 1400 Kg/m^3

Poisson's ratio, ν= 0.42

Elasticity modulus, E = 3.2 GPa

F. Analysis:

In order to maintain the quality and standard of the PVC propeller shaft, it is subjected to various tests which are as follows:

1. Torque Analysis

When the propeller shaft transfers motion from gearbox to the differential assembly it is subjected to an applied torque. Due to this Torque, the shaft is under the influence of certain mechanical parameters like Displacement and Various Stresses.

Refereeing now to figure 3, it shows an output of analysis in terms of Magnitude of net displacement. Its Value varies from a minimum 0 mm to a maximum of 0.006517 mm. The segments shown with different colours signify various values of displacement, from Blue colour indicating Minimum displacement to Red colour indicating Maximum Displacement.

Refereeing now to figure 4, it shows an output of analysis in terms of Magnitude of displacement in x-axis. Its Value varies from a minimum -0.006517 mm to a maximum of 0.006515 mm. The segments shown with different colour signify various values of displacement, from Blue colour indicating Minimum displacement to Red colour indicating Maximum Displacement.

Refereeing now to figure 5, it shows output of analysis in terms of Magnitude of displacement in Y-axis. Its Value varies from a minimum -0.006515 mm to a maximum of 0.006516 mm. The segments shown with different colour signify various values of displacement, from Blue colour indicating Minimum displacement to Red colour indicating Maximum Displacement.

Refereeing now to figure 6, it shows an output of analysis in terms of Magnitude of displacement in Z-axis. Its Value varies from a minimum -0.00000573 mm to a maximum of 0.000005128 mm. The segments shown with different colour signify various values of displacement, from Blue colour indicating Minimum displacement to Red colour indicating Maximum Displacement.

Refereeing now to figure 7, it shows an output of analysis in terms of Magnitude of Stresses generated about Major Principle Plane. Its Value varies from a minimum -0.02609 N to a maximum of 10.03 N. These values are safe for the material. The segments shown with different colour signify various values of displacement, from Blue colour indicating Minimum displacement to Red colour indicating Maximum Displacement.

Refereeing now to figure 8, it shows an output of analysis in terms of Magnitude of Maximum Shear Stress generated. Its Value varies from a minimum 3.358 N to a maximum of 6.476 N. These values are safe for the material. The segments shown with different colour signify various values of displacement, from Blue colour indicating Minimum displacement to Red colour indicating Maximum Displacement.

Refereeing now to figure 9, it shows an output of analysis in terms of Magnitude of Maximum Shear Stress generated. Its Value varies from a minimum – 10.07 N to a maximum of -0.0789 N. These values are safe for the material. The segments shown with different colour signify various values of displacement, from Blue colour indicating Minimum displacement to Red colour indicating Maximum Displacement.

Refereeing now to figure 10, it shows an output of analysis in terms of Magnitude of Maximum Shear Stress generated. Its Value varies from a minimum -11.20 N to a maximum of 11.22 N. These values are safe for the material. The segments shown with different colour signify various values of displacement, from Blue colour indicating Minimum displacement to Red colour indicating Maximum Displacement.

Refereeing now to figure 11, it shows an output of analysis in terms of Magnitude of Maximum Shear Stress generated. Its Value varies from a minimum 5.816 N to a maximum of 11.22 N. These values are safe for the material. The segments shown with different colour signify various values of displacement, from Blue colour indicating Minimum displacement to Red colour indicating Maximum Displacement.

2. *Vibrations:*

To and Fro motion of a body about a mean position is called Vibration.

Major Causes of Vibrations:

- Unbalanced Centrifugal Forces
- Misalignment
- Looseness / Play
- Dry Friction B/w mating Surfaces
- External Excitation.

Now, since the material Rigid PVC is a polymer and has a property of excellent vibrational damping thus the effect of vibrations are negligible unless the speed of rotations are thrice the current speed(s).

3. *Whirling Analysis*

A rotating shaft tends to bow out with large amplitude at a certain speed of rotation. This phenomenon is known as whirling of shafts. The speed at which the shaft tends to vibrate violently in the transverse direction is termed as Critical/Whirling/Whipping Speed

It is denoted by ω_n.

$$\omega_n = \sqrt{\frac{k_t}{m}}$$

Here,

k_t = Stiffness of Shaft material.

m = Mass of Shaft.

$$\omega \;\square\; \omega_n$$

If the shaft has a rotational speed of N rpm, then frequency of rotation may be given as

$\omega = 2\pi N/60$

The procedure of whirling analysis remains the same for both hollow and solid shafts. The condition of whirling is given as

$$\omega \geq \omega_n$$

Results in the below Table No. 1 show that $\omega \ll \omega_n$. Thus NO WHIRLING occurs.

Table No. 1

WHIRLING ANALYSIS						
Sr. No.	**Stiffness(N/m)**	**Mass(kg)**	**RPM**	**ω**	**ωn**	
1	3000000000.00	4.0458436	2880	301.5928947	27230.5294	NO Whirling
2	3000000000.00	4.0458436	2400	251.3274123	27230.5294	NO Whirling
3	3000000000.00	5.2316942	2880	301.5928947	23946.3568	NO Whirling
4	3000000000.00	4.0458436	2400	251.3274123	27230.5294	NO Whirling
5	3000000000.00	5.2316942	2500	261.7993878	23946.3568	NO Whirling
6	3000000000.00	3.1779189	3800	397.9350695	30724.8112	NO Whirling
7	3000000000.00	5.2316942	2500	261.7993878	23946.3568	NO Whirling
8	3000000000.00	27.231639	220	23.03834613	10495.9979	NO Whirling
9	3000000000.00	6.6590078	2200	230.3834613	21225.3992	NO Whirling
10	3000000000.00	2.4682865	3200	335.1032164	34862.8464	NO Whirling

Refereeing now to figure 12, it shows the relative shaft whirling for the 10 vehicles. On the X-axis the Vehicle no. is shown, whereas the Y-axis indicates the value of Frequency of shaft in PER SEC. It is observed that value of angular frequency of vibration is always very much less than its natural frequency. Thus NO WHIRLING occurs.

Refereeing now to figure 13, it shows the relative inside diameters of hollow shaft for 10 vehicles. On the X-axis the Vehicle no. is shown, whereas the Y-axis indicates the value of inside diameter of shaft in mm. It is observed that value of diameter for hollow shaft for Rigid PVC is always more than that of steel.

Refereeing now to figure 14, it shows the graph of the relative outside diameters of hollow shaft for 10 vehicles. On the X-axis the Vehicle no. is shown, whereas the Y-axis indicates the value of outside diameter of shaft in mm. It is observed that value of diameter for hollow shaft for Rigid PVC is always more than that of steel.

Refereeing now to figure 15, it shows the graph of the relative standard inside diameters of hollow shaft for 10 vehicles. On the X-axis the Vehicle no. is shown, whereas the Y-axis indicates the value of standard inside diameter of shaft in mm. It is observed that value of standard diameter for hollow shaft for Rigid PVC is always more than that of steel.

Refereeing now to figure 16, it shows the graph of the relative standard outside diameters of hollow shaft for 10 vehicles. On the X-axis the Vehicle no. is shown, whereas the Y-axis indicates the value of standard outside diameter of shaft in mm. It is observed that value of standard diameter for hollow shaft for Rigid PVC is always more than that of steel.

Refereeing now to figure 17, it shows the graph of the relative shaft Volume for 10 vehicles. On the X-axis the Vehicle no. is shown, whereas the Y-axis indicates the value of Volume of hollow shaft in cubic mm. It is observed that value of Volume for hollow shaft for Rigid PVC is always more than that of steel.

Refereeing now to figure 18, it shows the graph of the relative shaft Masses for 10 vehicles. On the X-axis the Vehicle no. is shown, whereas the Y-axis indicates the value of Mass of shaft in kg. It is observed that value of Mass for hollow shaft for Rigid PVC is always less than that of steel.

Relative data output for some commercial vehicles:

1. The data is based on the above mentioned expressions.
2. The calculations are based on the given data of 10 different vehicles.
3. The length of propeller shaft for every vehicle is assumed constant for simplicity.

Table no. 2

SR. NO	VEHICLE NAME	MAX. POWER (kW)	SPEED (rpm)
-	-	-	-
1	Eicher 20.16	108	2880
2	Ashok Leyland BOSS 1112 LE	89.48	2400
3	Ashok Leyland ULE CNG BS4	172	2880
4	Ashok Leyland Cheetah BS3 IL MECH	118	2400
5	Ashok Leyland ULE DIESEL BS4	165	2500
6	Force Traveller Ambulance	95	3800
7	Eicher Terra25	136.75	2500
8	Eicher Pro 6031	156.597	220
9	Mahindra Traco 40	193	2200
10	Mahindra CRDe Engine LCV	58.5	3200

Table No. 3

Sr. No.	Vehicle Name	Density(kg/mm3)	
		RIGID PVC	STEEL
1	Eicher 20.16	0.0000014	0.0000079
2	Ashok Leyland BOSS 1112 LE	0.0000014	0.0000079
3	Ashok Leyland ULE CNG BS4	0.0000014	0.0000079
4	Ashok Leyland Cheetah BS3 IL MECH	0.0000014	0.0000079
5	Ashok Leyland ULE DIESEL BS4	0.0000014	0.0000079
6	Force Traveller Ambulance	0.0000014	0.0000079
7	Eicher Terra25	0.0000014	0.0000079
8	Eicher Pro 6031	0.0000014	0.0000079
9	Mahindra Traco 40	0.0000014	0.0000079
10	Mahindra CRDe Engine LCV	0.0000014	0.0000079

Table No. 4

Sr. No.	Vehicle Name	Length(mm)
1	Eicher 20.16	1220
2	Ashok Leyland BOSS 1112 LE	1220
3	Ashok Leyland ULE CNG BS4	1220
4	Ashok Leyland Cheetah BS3 IL MECH	1220
5	Ashok Leyland ULE DIESEL BS4	1220
6	Force Traveller Ambulance	1220
7	Eicher Terra25	1220
8	Eicher Pro 6031	1220
9	Mahindra Traco 40	1220
10	Mahindra CRDe Engine LCV	1220

Table No. 5

	Vehicle Name	Shear Strength (N/mm2)	
		RIGID PVC	STEEL
1	Eicher 20.16	63.707	41
2	Ashok Leyland BOSS 1112 LE	63.707	41
3	Ashok Leyland ULE CNG BS4	63.707	41
4	Ashok Leyland Cheetah BS3 IL MECH	63.707	41
5	Ashok Leyland ULE DIESEL BS4	63.707	41
6	Force Traveller Ambulance	63.707	41
7	Eicher Terra25	63.707	41
8	Eicher Pro 6031	63.707	41
9	Mahindra Traco 40	63.707	41
10	Mahindra CRDe Engine LCV	63.707	41

Table No. 6

Sr. No.	Vehicle Name	Torque (N-mm)
1	Eicher 20.16	358098.622
2	Ashok Leyland BOSS 1112 LE	356029.6077
3	Ashok Leyland ULE CNG BS4	570305.2127
4	Ashok Leyland Cheetah BS3 IL MECH	469507.0821
5	Ashok Leyland ULE DIESEL BS4	630253.5746
6	Force Traveller Ambulance	238732.4146
7	Eicher Terra25	522346.5232
8	Eicher Pro 6031	6797232.715
9	Mahindra Traco 40	837733.7459
10	Mahindra CRDe Engine LCV	174573.0782

Table No. 7

Sr. No.	Vehicle Name	Stiffness (K)	
		RIGID PVC	STEEL
1	Eicher 20.16	0.666666667	0.666666667
2	Ashok Leyland BOSS 1112 LE	0.666666667	0.666666667
3	Ashok Leyland ULE CNG BS4	0.666666667	0.666666667
4	Ashok Leyland Cheetah BS3 IL MECH	0.666666667	0.666666667
5	Ashok Leyland ULE DIESEL BS4	0.666666667	0.666666667
6	Force Traveller Ambulance	0.666666667	0.666666667
7	Eicher Terra25	0.666666667	0.666666667
8	Eicher Pro 6031	0.666666667	0.666666667
9	Mahindra Traco 40	0.666666667	0.666666667
10	Mahindra CRDe Engine LCV	0.666666667	0.666666667

Table No. 8

Sr. No.	Vehicle Name	Factor of Safety	
		RIGID PVC	STEEL
1	Eicher 20.16	7	1
2	Ashok Leyland BOSS 1112 LE	7	1
3	Ashok Leyland ULE CNG BS4	7	1
4	Ashok Leyland Cheetah BS3 IL MECH	7	1
5	Ashok Leyland ULE DIESEL BS4	7	1
6	Force Traveller Ambulance	7	1
7	Eicher Terra25	7	1
8	Eicher Pro 6031	7	1
9	Mahindra Traco 40	7	1
10	Mahindra CRDe Engine LCV	7	1

Table No. 9

Sr. No.	Vehicle Name	Max. Permisibble Strength	
		RIGID PVC	STEEL
1	Eicher 20.16	9.101	41
2	Ashok Leyland BOSS 1112 LE	9.101	41
3	Ashok Leyland ULE CNG BS4	9.101	41
4	Ashok Leyland Cheetah BS3 IL MECH	9.101	41
5	Ashok Leyland ULE DIESEL BS4	9.101	41
6	Force Traveller Ambulance	9.101	41
7	Eicher Terra25	9.101	41
8	Eicher Pro 6031	9.101	41
9	Mahindra Traco 40	9.101	41
10	Mahindra CRDe Engine LCV	9.101	41

Table No. 10

Sr. No.	Vehicle Name	Outside Diameter		Standard Outside Diameter	
		RIGID PVC	STEEL	RIGID PVC	STEEL
1	Eicher 20.16	62.97262095	38.12883376	71	40
2	Ashok Leyland BOSS 1112 LE	62.85110601	38.05525856	71	40
3	Ashok Leyland ULE CNG BS4	73.53938603	44.52682741	80	50
4	Ashok Leyland Cheetah BS3 IL MECH	68.92312101	41.73175871	71	45
5	Ashok Leyland ULE DIESEL BS4	76.03075885	46.0353106	80	50
6	Force Traveller Ambulance	55.01165147	33.30860431	63	36
7	Eicher Terra25	71.41735944	43.24197698	80	45
8	Eicher Pro 6031	167.9815557	101.7099291	180	110
9	Mahindra Traco 40	83.59613963	50.61601792	90	56
10	Mahindra CRDe Engine LCV	49.56137072	30.00855351	56	32

Table No. 11

Sr. No.	Vehicle Name	Inside Diameter		Standard Inside Diameter	
		RIGID PVC	STEEL	RIGID PVC	STEEL
1	Eicher 20.16	47.33333333	26.66666667	45	25
2	Ashok Leyland BOSS 1112 LE	47.33333333	26.66666667	45	25
3	Ashok Leyland ULE CNG BS4	53.33333333	33.33333333	50	32
4	Ashok Leyland Cheetah BS3 IL MECH	47.33333333	30	45	28
5	Ashok Leyland ULE DIESEL BS4	53.33333333	33.33333333	50	32
6	Force Traveller Ambulance	42	24	40	22
7	Eicher Terra25	53.33333333	30	50	28
8	Eicher Pro 6031	120	73.33333333	110	71
9	Mahindra Traco 40	60	37.33333333	56	36
10	Mahindra CRDe Engine LCV	37.33333333	21.33333333	36	20

Table No. 12

Sr. No.	Vehicle Name	Volume (mm3)	
		RIGID PVC	STEEL
1	Eicher 20.16	2889888.25	934231.1154
2	Ashok Leyland BOSS 1112 LE	2889888.25	934231.1154
3	Ashok Leyland ULE CNG BS4	3736924.461	1414282.181
4	Ashok Leyland Cheetah BS3 IL MECH	2889888.25	1189108.527
5	Ashok Leyland ULE DIESEL BS4	3736924.461	1414282.181
6	Force Traveller Ambulance	2269942.064	778046.8366
7	Eicher Terra25	3736924.461	1189108.527
8	Eicher Pro 6031	19451170.91	6763833.275
9	Mahindra Traco 40	4756434.109	1763061.797
10	Mahindra CRDe Engine LCV	1763061.797	597907.9138

Table No. 13

Sr. No.	Vehicle Name	Mass	
		RIGID PVC	STEEL
1	Eicher 20.16	4.04584355	7.380425811
2	Ashok Leyland BOSS 1112 LE	4.04584355	7.380425811
3	Ashok Leyland ULE CNG BS4	5.231694246	11.17282923
4	Ashok Leyland Cheetah BS3 IL MECH	4.04584355	9.393957366
5	Ashok Leyland ULE DIESEL BS4	5.231694246	11.17282923
6	Force Traveller Ambulance	3.177918889	6.146570009
7	Eicher Terra25	5.231694246	9.393957366
8	Eicher Pro 6031	27.23163928	53.43428287
9	Mahindra Traco 40	6.659007753	13.9281882
10	Mahindra CRDe Engine LCV	2.468286516	4.723472519

These are the Sample calculation of 10 Rear Wheel Drive Vehicles. These vehicles have specific values of Power and Speed. On basis of these values, the corresponding values of Torque and Diameter (Inner and Outer) have been calculated using the procedure mentioned in the propeller shaft report under the heading Design of Hollow propeller shaft.

III. CONCLUSION

Usage of this material for the mentioned purpose leads to the following advantages:

- Reduction in body weight and thus increase in power to weight ratio.
- Transfer same torque using lighter material.
- An alternative material for drive shaft.
- Excellent damping of Vibrations.
- Reduction in overall cost due to reduction in no. of divisions and joints.
- Less squeaking due to reduced vibrations.

REFERENCES

The references of the article were cited from the following:

[1] A Textbook of Machine Design by R.S. Khurmi & J.K. Gupta ,S.Chand Publication

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[3] Indian Patent (Pending) – 2149/MUM/2015