International Journal Of Engineering Research In Mechanical And Civil Engineering (IJERMCE) Volume 1, Issue 2,

Design and Development of Nano Composite Based Automotive Manual Transmission Shaft for LCVS

[1]T Rao Surtani, [2]Sathish Kumar .G
[1] post graduate student [2] M.E engineering design

Abstract*-- *The objective of the present work is to design an automotive manual transmission shaft for its better performance with the optimal weight. Increase in their inertia plays a major role in the more weight. Therefore it must be strong enough to bear the needs, whilst avoiding too much additional weight as that would. So here the work deals with the optimization are performed based on the design constraints such as natural frequency (resonant condition) and static strength which are subjected to torque. The local and Global Sensitivity analysis and optimization on the best among material is done to optimize the constraint in the aim to get minimum weight and stress. The numerical methods, used are genetic algorithm .The commercial FEA solvers are used for the numerical investigation. Finally the weight and stress optimized for different materials are compared with the PPT with CNT 0.05%. Hence results revealed that the PP with CNT 0.05 % has the better result than other which are considered.

Index Terms*—*automotive manual transmission shaft, design variables, genetic algorithm, CNTs

I. INTRODUCTION

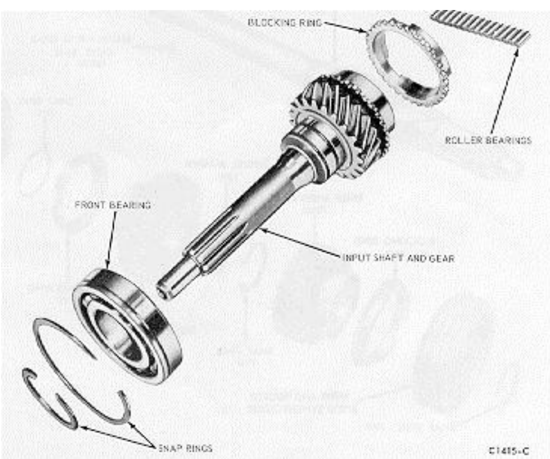

Fig 1.Input manual transmission shaft

As far above, to find those design variable there are certain different approaches are available. To make the design variable favorable for our approach, one must choose the algorithm which suits the best. So here comes the optimization technique which are used commonly everywhere, because it reduce the extra manufacturing cost of the particular component. There is different solution for optimization is there like graphical method, linear programming, and numerical method. So in response to this we are choosing numerical method. In that numerical genetic algorithm is preferred which is more suitable for as transmission shaft because of its complexity of solving procedure and also it provides more approximate solution for the transmission shaft, so it is chosen for our work [6], [7].

II. MATERIAL SELECTION

Different materials are being used in manual transmission shaft from an earlier time. The torque transmitting capacity will vary depend upon the material and on the corresponding design selection also. At the same time the natural frequency will vary for different material from this we come to know design variables also plays a major role in material selection.

This work mainly focuses on PP with CNT 0.05% material. Here PP with CNT 0.05% is compared with other material which is being currently used in industries. Because CNT reinforced polymers has more advantage when compared with the other material and it also provides good result which will be compared below further.

The most general shaft material which in use are, Low carbon, cold drawn or hot rolled steels such as ANSI 1020-1050 steels. Carburizing grades of ANSI 1020, 4320, 4820 and 8620 are also used. Cold drawn steel is usually used for diameter under about 3 inches. Here we use 4 material for our intent to show the comparable results, the four material are as follows,

Aluminium 7075-T6,
PP with cNT 0.05%
AISI 18Ni maraging steel annealed and,
Magnesium alloy AZ80A-T6.

Table I. Material properties

MATERIAL	Aluminum 7075-T6	PP with CNT	AISI 18Ni maraging steel annealed	Magnesium alloy AZ80A-T6
Density (g/cm^3)	2.80		8.0	1.80
Poisson`s Ratio	0.33		0.30	0.35
Tensile Strength (MPa)	510-572		660-965	250-340
Young`s Modulus (GPa)	72		183	45
Shear Modulus (GPa)	26.9		70	17
Bulk Modulus (GPa)	70		140	45

Above table show material properties of different materials. By using these material properties analysis are performed using finite element analysis software which are commercially available. The results of varies material are shown using FEA software`s.

III. STRATAGEM FOR DESIGN

A. Primary cad model

Here we are taking an initial model with specific dimension which is being used by the automotive industries now-a-days for the purpose of transmitting torque from engine to gear part without much in loss of transmission.
Some assumptions in primary design

a) The Input torque to shaft is a constant torque without variations and the shaft rotates in constant speed.
b) It has uniform annular cross section as hollow shaft has more Strength to weight ratio.
c) The shaft is balanced and the Mass Center coincides with Geometric center of shaft.
d) It obeys Hook's Law.
e) No fluid interaction like lubrication environment is not considered.
f) No vertical forces, hence no bending moments.

The transmission shaft is checked for its Torque carrying capacity, tensional deflection, Tensional Buckling capacity & Natural frequency. If Torque carrying capacity, T of the shaft which is nothing but Load factor x Input torque (Assume Load factor=1) &Ss is shear strength, t is the thickness of shaft, (do-di)/2

$$T = S_s \frac{\pi(d_0^4 - d_i^4)}{16td_0} \quad (1)$$

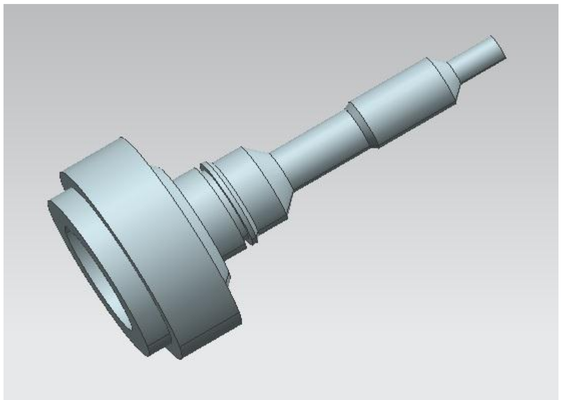

Fig 2. Primary design

B. Modified cad model design

An aspiration of this work is weight optimization to give better performance. After some thoughts on finalizing shaft diameters

$$d = \left(\frac{16n}{\pi}\left\{\frac{1}{S_e}\left[4(K_f M_a)^2 + 3(K_{fs}T_a)^2\right]^{1/2} + \frac{1}{S_{ut}}\left[4(K_f M_m)^2 + 3(K_{fs}T_m)^2\right]^{1/2}\right\}\right)^{1/3} \quad (2)$$

As per standard of ASME method of minimum diameter, B106.1M-1985 is

$$d = \sqrt[3]{\frac{32 Safety\ Factor}{\pi}\sqrt{(K_f \frac{M_a}{S_f})^2 + \frac{3}{4}(\frac{T_m}{S_y})^2}} \quad (3)$$

Where,

Ma, Mm, Ta, and Tm are alternating and mean bending moment as well as torques.

Sf or Se, Sy, Sut are shaft material`s endurance, yield and ultimate strengths.

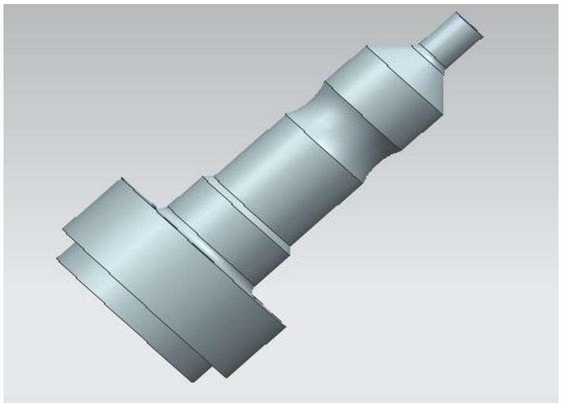

Fig 3. Modified design

Since this work proceeds with four material, now the cad model is analyzed using the FEA software which are commercially available to find the factor of safety, so that the optimization technique can be carried. To begin with the analysis the necessary condition are as

The transmission shaft is used at maximum input torque of 230 Nm at 4500 rpm from the engine and the engine have a maximum rpm of 7000. The Von-misses stress of the shaft should be less than 75% yield strength with a safety factor of 1.25.The forcing frequency from engine which is 7000 /60 = 116.67 hertz. The natural frequency of transmission shaft should be at least 10 times higher than this.

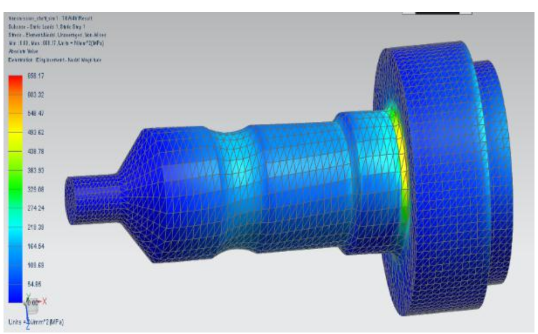

Fig 4. (a) Static strength check for PP with CNT 0.05%

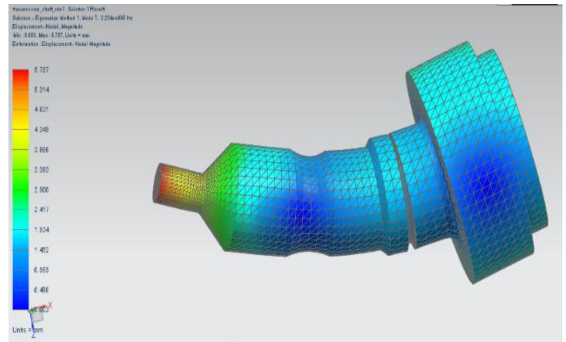

Fig 4. (b) Shows the natural frequency for PP with CNT 0.05% 7th normal mode shape

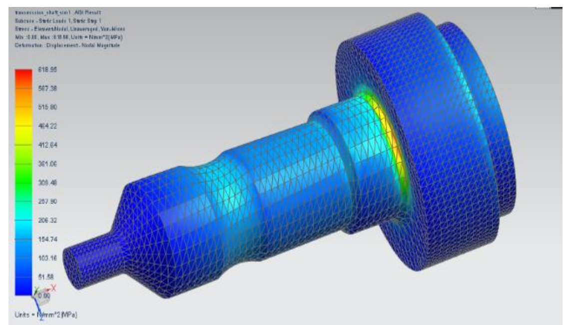

Fig 5. (a) Static strength check for AISI 28i steel managing

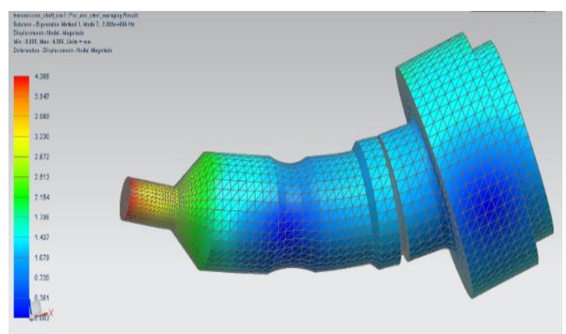

Fig 5. (b) Shows the natural frequency for AISI 28i steel managing at 7th normal mode shape

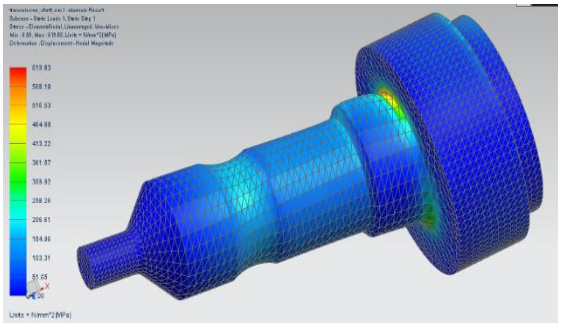

Fig 6. (a) Static strength for Aluminium 7075

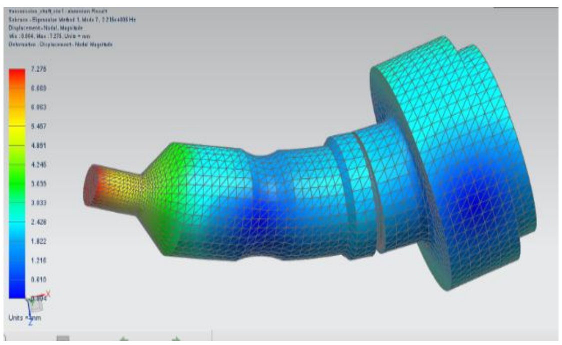

Fig 6. (b) Natural frequency for Aluminium 7075at 7th normal mode shape

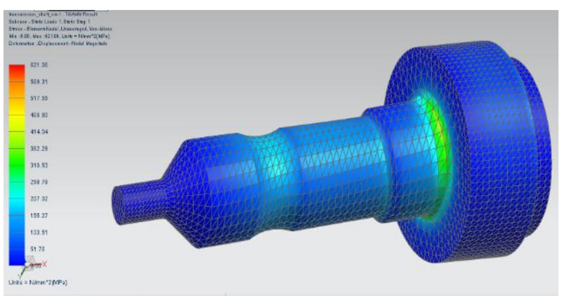

Fig 7. (a) Static strength for Magnesium AZ80

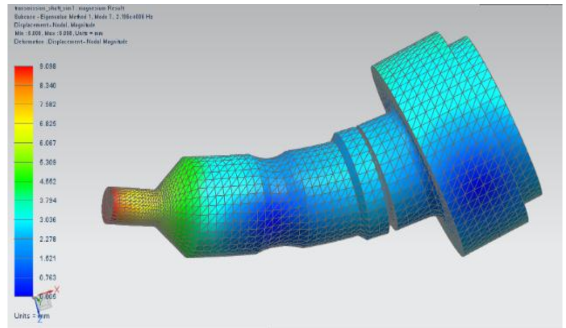

Fig 7. (b) Natural frequency of Magnesium AZ80 at 7th normal mode shape

Now comparing all the material factor of safety

Table II: factor of safety and natural frequency

Material	Factor of safety	Frequency (hertz)
PP with CNT 0.05%	1.77	222400
AISI 28i steel maraging	1.55	209300
Aluminium 7075	0.922	221500
Magnesium AZ80	0.55	219500

Though AISI 28i steel managing shows increase in factor of safety compared to all, AISI 28i managing steel is 1.81 times weigh more than PP with CNT 0.05%. From the values of frequency listed in table for different material The Natural frequencies of transmission shaft with different materials are very higher than the forcing frequency of engine, 116.67 Hz. If u closely observe the titanium alloy is having more natural frequency than the other materials natural frequency. So PP with CNT 0.05% is considered.

IV. Sensitivity analysis and optimization

Sensitivity analysis & optimization on the best among materials is done to optimize a feature in an aim to minimize weight and stress in transmission shaft. Sensitivity studies are used to determine whether a certain characteristic or property of the model is sensitive to a change in a design parameter. Specifically, the system calculates the changes in a model's measures (such as stress and displacement) when a parameter varied over a specified range.

There are many optimization technique are available, but in that here numerical method is considered.

International Journal Of Engineering Research In Mechanical And Civil Engineering (IJERMCE) Volume 1, Issue 2,

One among numerical method is, Genetic algorithm usage. (GA)

Genetic algorithms (GA) belong to the class of stochastic search optimization methods, such as the simulated annealing method. These algorithms also belong to a class of methods known as evolutionary methods or nature-inspired methods. The algorithms are very general and can be applied to all kinds of problems—discrete, continuous, and non-differentiable. In addition, the methods determine global optimum solutions as opposed to the local solutions determined by a derivative based optimization algorithm. The methods are easy to use and program since they do not require the use of gradients of cost or constraint functions [8], [9].

Global sensitivity studies serve three primary purposes:

To help understand how a measurable quantity is affected as a parameter varies through its range.

To help eliminate unimportant parameters from an upcoming optimization.

To determine a good initial value for a parameter in an optimization.

The Transmission shaft which uses favourable material among four, PP with CNT 0.05% is subjected to optimization analysis.

i. Design problem: Optimization of transmission shaft.

ii. Design objective: Minimize Von misses stress.

iii. Design constraint: Weight of the shaft

iv. Design variables: Dimensions of Ball end groove and fillets in shaft.

v. Optimization type: Altair Hyper opt.

So accordingly the optimization are carried out and the result from the excel sheet is provided below.

Optimization History						
Based on Altair HyperOpt						
Design Objective Function Results						
Minimum Von Mises Stress [N/mm^2(MPa)]	0	1	2	3	4	5
	658.1666	623.3578	611.8184	609.5584	606.8607	620.5093
Design Variable Results						
Name	0	1	2	3	4	5
Ball end groove dia	33	31.8	33	33	33	33
Ball end groove shaft dia	31.53811	31.53811	32.73811	31.53811	31.53811	33
Fillet 2	2.7	2.7	2.7	2.82	2.7	2.7
Fillet 1	2.7	2.7	2.7	2.7	2.82	2.7
Design Constraint Results						
	0	1	2	3	4	5
Weight						
Upper Limit = 4.500000 [N]	4.834428	4.8354	4.834428	4.835088	4.834449	4.834428

Fig 8. Optimized history

The graph corresponding to that are

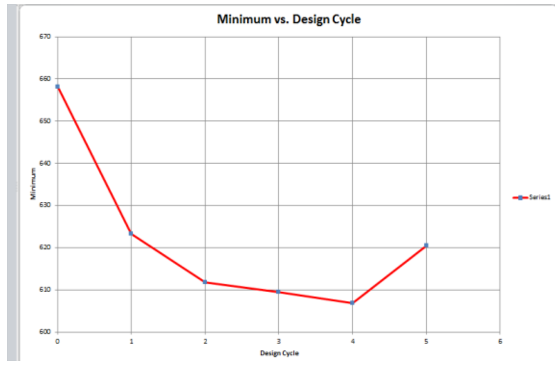

Fig 9. Minimum vs design cycle

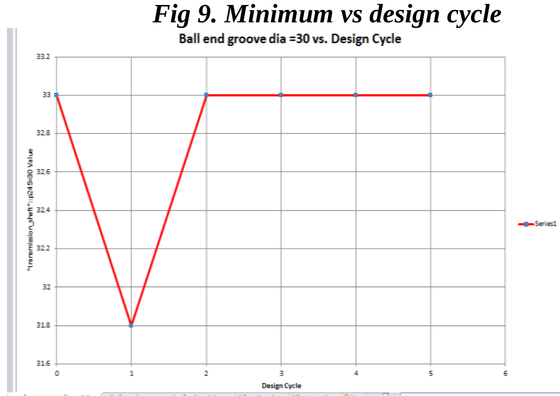

Fig 10. Ball end groove diameter=30 vs design cycle

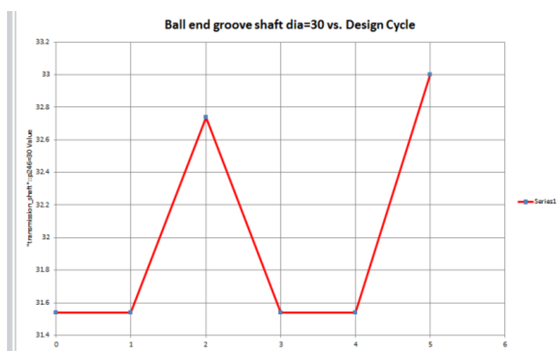

Fig 11. Ball end groove shaft diameter=30 vs design cycle

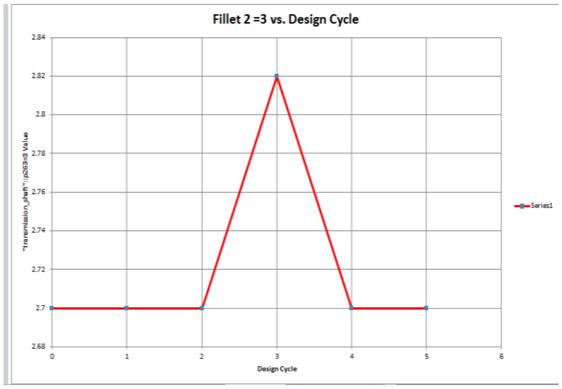

Fig 12. Fillet 2=3 vs design cycle

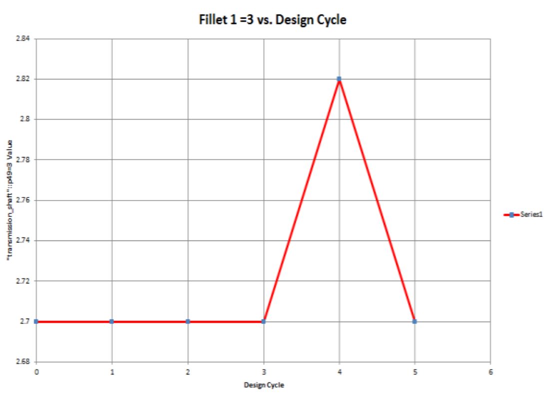

Fig 13. Fillet 1=3 vs design cycle

V. Results

The design and development of Nano composite based manual transmission shaft pp with CNT 0.05 is completed

REFERENCES

[1] Brajendra Mishra, "Review of Extraction, Processing, Properties, and Applications of Reactive Metals", Brajendra Mishra, wiley, 1999.

[2] http://www.rsgear.com/blog/2011/5/23/understanding-and-analyzing-manual-transmission-failures.aspx.

[3] M. R. Khoshravan, A. Paykani,"Design of a composite drive shaft and its coupling for automotive application"Vol. 10, December 2012, Department of Mechanical Engineering, Parand Branch, Islamic Azad University ,Parand, Iran.

[4] M. A. Badie, A. Mahdi, A.R. Abutalib, E. J. Abdullah, R. Yonus, "Automotive composite drive shafts: investication of the design variable effects" department of mechanical engineering, university putra Malaysia, 43400, serdang, delangor, malaysia.

[5] M. Y. Wang, R. Manoj and W. Zhao, " Gear rattle modelling and analysis for automotive manual transmissions"Department of mechanical engineering university of Maryland, college park ,MD 2074,USA ,D09499©IMechE 2001.

[6] T. Rangaswamy, S. Vijayarangan, R. A. Chandrashekar, T. K. Venkatesh and K. Anantharaman," optimal design and analysis of automotive composite drive shaft" International Symposium of Research Students on Materials Science and Engineering December 2002-04 Chennai India Department of Metallurgical and Materials Engineering Indian Institute of Technology Madras.

[7] Anup A. Bijagare, P.G. Mehar and V.N. Mujbalie,"Design optimization & Analysis of drive shaft" VSRD International journal of mechanical, Automobile & production engineering,VSRD –MAP, Vol.2(6),2012,210-215, Research Scholar, Assistant Professor, Department of Mechanical Engineering, K.D.K. College of Engineering, Nagpur, Maharashtra, INDIA.

[8] D. E. Goldberg, "Genetic algorithm in search optimization and machine learning", Reading MA, Addison-Wesley, 1989

[9] S. V. Gopals Krishna, B. V. subrahmanyam, and R. Srivnivasulu, "Finite element analysis and optimization of automotive composite drive shaft" Asst.professor, Sir C R Reddy college of engineering, eluru, Andhra Pradesh.