Static and modal analysis of engine cover for different thermoplastic materials - A Finite Element (FE) study

Vinayak Honnutagi
Department of Mechanical Engineering, SVERI's College of Engineering Pandharpur

INTRODUCTION

Today's ever increasing demand for newer, lighter materials with higher strength, greater stiffness, and better reliability has led to wide research on development of thermo plastic materials. These materials offer a combination of strength and modulus that are either comparable to or better than many traditional materials such as metals. Because of their low specific gravities, the strength-to-weight ratios as well as specific modulus make these materials more superior to those of metallic materials. Thermoplastics have been extensively used in automotive applications for the last few decades and are most visibly seen in automobile bumpers and interiors.

Recently it has been seen engineering plastics are used in critical components on the vehicle itself as well as into safety critical components such as brakes, steering and air bag systems. The driving force behind this trend has been the growing confidence of automotive engineers in the capabilities of thermoplastics and engineering plastics. Engineering plastics have performed very well in each new demanding application. This raised awareness about plastic materials successfully.

SIGNIFICANCE OF PROPOSED WORK

The introductions of plastics to replace the traditional materials in the vehicle industry do not only reduce product cost but also reduce production cost. Plastics are modern synthetic materials. Plastics are oil and gas based, and consumes less our oil and gas reserves. The superior properties of plastics such as hygienic (clean or free from disease causing microorganisms) barrier properties, light weight, and durability contribute significantly to our health and quality of life.

In the present work an attempt has been made to analyze the different composite materials for engine cover of Mahindra Scorpio vehicle with respect to static and modal analysis. Initially the engine cover model is prepared in catia software with actual dimensions. Analysis of engine cover model is done in ANSYS by importing the CATIA software model for 5 different materials viz Polypropylene with glass fiber, Nylon with glass fiber, Poly vinyl chloride(PVC) ,High density polyethylene(HDPE), Polybutylene terephthalate(PBT) and results for existing material poly propylene are studied. The objective of present work is to suggest the best material for Mahindra Scorpio vehicle engine cover by comparing obtained results with present material. The various parameters of interest are natural frequency, total deformation and equivalent stress.

Based on results obtained with the study of above parameters ideal material for engine cover is suggested.

The major objectives are outlined as follows:-

- Preparation of CAD model of engine cover using CATIA software.

- Carrying out static analysis and modal analysis using ANSYS for 5 different Materials viz Polypropylene with glass fiber, Nylon with glass fiber, Poly vinyl Chloride, High density polyethylene, Polybutylene terephthalate and to compare The obtained results with existing material.
- To obtain the mechanical properties viz equivalent stress, total deformation and Modal frequencies of engine cover for different materials.
- To compare the various parameters of interest and draw conclusion.

STATIC STRUCTURAL ANALYSIS

Table 3.2 Material properties

Material	E (GPa)	Poission's ratio	Density (g/cm^3)	Yield Stress (MPa)
Glass reinforced pp	3.553	0.40	1.12	40
Glass reinforced nylon	7.5	0.40	1.4	48
PVC	1.5	0.42	1.4	53
HDPE	0.7	0.42	0.95	25
PBT	5	0.41	1.31	50
PP	0.9	0.40	0.89	35

Results and discussion

The variations of equivalent stresses for different material are found to be almost equal and they are ranging from 1.642 to 2.54MPa. The developed stresses are well within the limits (Compared to yield Stress). At this level of analysis the optimization is not possible. The constraint is that the minimum thickness to be taken is 3mm. But, unlike stresses the deformations are not same for different materials when analysis is done using self-weight. The deformation is found to be maximum for HDPE material and minimum is found to be for Glass reinforced PP. This clearly indicates that such variation is attributed to different values of Young's modulus and Poission's ratio. At this moment with static analysis using self-weight as a parameter, Glass Reinforced PP is an alternate material to present existing material (PP) for the engine cover.

MODAL ANALYSIS

The objective of the present work is to estimate the natural frequencies and mode shapes of engine cover using different materials of interest. The details of the material used in the analysis are given in Table 4.1. The obtained mode shapes and frequencies are used to compare with the present existing material (PP) of the engine cover.

Table 4.1 Material properties

Material	E,(GPa)	Poission's ratio	Density(g/cm^3)
Glass reinforced pp	3.553	0.40	1.12
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Results and discussion

Table 4.3 Mode shape frequencies

Material	Mode 1(Hz)	Mode 2(Hz)	Mode 3(Hz)	Specific Modulus
HDPE	7.6881	11.823	24.342	0.00074
PP	8.9734	13.794	28.48	0.00101
PVC	9.2707	14.257	29.353	0.00107
PBT	17.464	26.852	55.365	0.00382
Glass Reinforced PP	15.893	24.431	50.444	0.0317
Glass Reinforced nylon	20.73	31.88	65.636	0.0536

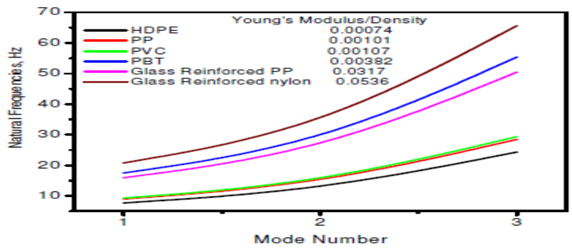

Figure 4.4 clearly indicates that the natural frequencies are dependent on the specific modulus. Similar kind of variation is found in the work of Patil and Barjibhe [2013]. As specific modulus increases natural frequencies also increase and vice versa. This is in accordance with the work of Bondok, [2013]. The nature of variation is found to be same in all materials. The lowest natural frequency is found in HDPE and the highest is in Glass Reinforced nylon. The only material having lesser natural frequency is HDPE as compared to existing material of engine cover. The suitability of the material for the engine cover with reference to frequencies cannot be clearly indicated at this juncture unless further investigation is made. This kind of analysis helps practicing design engineers to safety design critical engine components. The present investigation also indicates that there is a need for a further experimentation for estimation of strength and frequencies. Future research on this area needs to be focused in these directions.

CONCLUDING REMARKS AND FUTURE SCOPE

In this chapter, the major conclusions listed at the end of chapter 3 to chapter 4 have been reviewed. In addition, the major findings of this investigation have been outlined and the experiences acquired from this work have been used to indicate some guidelines for future research. In the present work engine cover of Mahindra Scorpio has been modeled in CATIA software. Mesh is generated using ANSYS software with solid tetrahedron four node elements. Five different materials are used for the analysis. The static analysis clearly shows that minimum total deformation was found in Glass reinforced PP material and was lower than existing PP material. Hence it is better material as far as deformation is concerned. The deformation is found to be higher for HDPE material. It clearly infers that it is better to avoid HDPE material if deformation produced in engine cover is major design criterion. In order to study the vibrational behavior Modal analysis was carried out.

The results have been presented for comparative study of different materials and comparing with existing PP material. The mode shape frequencies are found to be very less for HDPE material as compared to existing material. Hence the use of HDPE is better option for engine cover as far as modal analysis concerned. Finite element analysis results indicated that the natural frequency increases as the specific modulus increases. These natural frequencies and mode shapes gives designer/engineers an idea of how the design will respond to different types of dynamic loads. This allows to designer/engineer to change the design to avoid resonant vibrations or to vibrate at a specified frequency. Also helps in calculating solution controls (time steps, etc.) for other dynamic analyses. The suitability of material cannot be decided at this juncture.

An investigation of this kind requiring extensive FEA is naturally limited in a restrained time axis to probe several features of scientific interest in depth. It is considered that future work in this area of research should attempt to quantify other factors and experimental work. Fillet areas near the boss, where bolts are tightened, were found structurally critical. For complete structural analysis, fatigue life analysis of engine cover would be necessary to predict critical area.

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