Finite Element Analysis of Carburetor
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Abstract:
A carburetor is a device that blends air and fuel for an internal combustion engine. The carburetor works on Bernoulli’s principle. The faster air moves, the lower its static pressure, and the higher its dynamic pressure. The throttle (accelerator) linkage does not directly control the flow of liquid fuel. Instead, it actuates carburetor mechanisms which meter the flow of air being pulled into the engine. The speed of this flow, and therefore its pressure, determines the amount of fuel drawn into the airstream. When carburetors are used in aircraft with piston engines, special designs and features are needed to prevent fuel starvation during inverted flight. Later engines used an early form of fuel injection known as a pressure carburetor. In this study Carburetor was designed in UNIGRAPHICS software. Static analysis of carburetor was done using ANSYS APDL software. Static analysis was done on carburetor for different materials (i.e. Aluminum, Zinc, and Cast Iron). From static analysis, we check the deflections for different materials and also check whether all materials have Von misses Stresses less than their yield strengths to consider Factor of safety which is suitable for carburetor.

Keywords: FEM, FEA, Static Analysis, Nodes, Elements, Yield Strength, Deflection, Stress.

I. INTRODUCTION

Finite Element Modeling (FEM) and Finite Element Analysis (FEA) are two most popular mechanical engineering applications offered by existing CAE systems. This is attributed to the fact that the FEM is perhaps the most popular numerical technique for solving engineering problems. The method is general enough to handle any complex shape of geometry (problem domain), any material properties, any boundary conditions and any loading conditions. The generality of the FEM fits the analysis requirements of today’s complex engineering systems and designs where closed form solutions are governing equilibrium equations are not available. In addition it is an efficient design tool by which designers can perform parametric design studying various cases (different shapes, material loads etc.) analyzing them and choosing the optimum design. The FEM is numerical analysis technique for obtaining approximate solutions to wide variety of engineering problems. The method originated in the aerospace industry as a tool to study stresses in complicated airframe structures. It grew out of what was called the matrix analysis method used in aircraft design. The method has gained popularity among both researchers and practitioners and after so many developments codes are developed for wide variety of problems.

II. STRUCTURAL ANALYSIS OF CARBURETOR

Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behavior of structures. The subjects of structural analysis are engineering artifacts whose integrity is judged largely based upon their ability to withstand loads; they commonly include buildings, bridges, aircraft, and ships. Structural analysis incorporates the fields of mechanics and dynamics as well as the many failure theories. From a theoretical perspective the primary goal of structural analysis is the computation of deformations, internal forces, and stresses. In practice, structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it.

III. METHODS OF PERFORMING STRUCTURAL ANALYSIS

To perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure. Advanced structural analysis may examine dynamic response, stability and non-linear behavior.

DESCRIPTION:

ANSYS is a Finite Element Analysis (FEA) code widely used in the Computer Aided Engineering (CAE) field. ANSYS software allow to construct computer models of structures, machine components or systems, apply operating loads and other design criteria and study physical responses, such as stress levels, temperature distributions, pressure, etc. The ANSYS program has a variety of design analysis applications, ranging from automobiles to such highly sophisticated systems as aircraft, nuclear reactor containment buildings and bridges. There are 250+ elements derived for various applications in ANSYS. In the present application shell, beam and mass elements that have structural static and dynamic analysis capabilities were considered.

IV. FINITE ELEMENT MODELING

3D model of the Carburetor was developed in UNIGRAPHICS. The model was then converted into a parasonid to import into ANSYS. A Finite Element model was developed with solid elements. The elements that are used for idealizing the Carburetor were described below. A detailed Finite Element model was built with solid elements to idealize all the components of the Carburetor. Static and Modal
analysis were carried out to find the natural frequencies. Changes were also implemented to shift the fundamental natural frequency. The elements that are used for idealizing the Carburetor are solid 92. The description of each element is given below.

Element Type Used:
Element type: Solid92
No. of nodes: 10
Degrees of freedom: 3 (UX, UY, UZ)

Solid92:
The element is defined by ten nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. SOLID92 has quadratic displacement behavior and is well suited to model irregular meshes.

V. CASE-I: STATIC ANALYSIS OF CARBURETOR FOR ALUMINUM MATERIAL

Static analysis is used to determine the displacements, stresses, strains and forces in structures or components caused by loads that do not induce significant inertia and damping effects.

Objective:
To Objective of this analysis is to check the High stressed locations and deflections on the Carburetor for the applied pressure loads.

Material properties of Aluminum:
Young’s modulus = 70GPa
Density = 2800 kg/m3
Yield strength = 276 MPa

Boundary conditions:
1. Both sides of carburetor are fixed in all DOF.
2. A Pressure load of 0.98 applied on Carburetor.

The boundary conditions and loading applied for static analysis are shown below.
From the analysis, it is observed that the maximum deformation 0.001mm and Von Mises stress 7.71MPa observed on Carburetor. The yield strength of the material (Aluminum) used for Carburetor is 276 MPa. The FOS at most of the locations is 276/7.71 = 35. According to the Von Mises Stress Theory, the Von Mises stress of Carburetor is less than the yield strength of the material. Hence the design of Carburetor is safe for the above operating loading conditions.

VI. CASE: 2 STATIC ANALYSIS OF CARBURETOR FOR CAST IRON MATERIAL

MATERIAL PROPERTIES:

All the components of the Carburetor are made using cast iron

Cast Iron Mechanical Properties:

- Young’s modulus = 82 GPa
- Yield Strength = 240 Mpa
- Density = 7200 kg/m3
Boundary conditions:

- Both sides of carburetor are fixed in all DOF.
- A Pressure load of 0.98 applied on Carburetor.

The boundary conditions and loading applied for static analysis are shown below.

![Boundary conditions applied on carburetor for static analysis](image1.png)

**DEFLECTIONS:**

- **Figure 15.** Deflection in X-direction for static analysis
- **Figure 16.** Deflection in Y-direction for static analysis
- **Figure 17.** Deflection in Z-direction for static analysis

**STRESSES:**

- **Figure 19.** Stresses developed in carburetor in X-direction
- **Figure 20.** Stresses developed in carburetor in Y-direction
- **Figure 21.** Stresses developed in carburetor in Z-direction

![Stress analysis](image2.png)
From the analysis, it is observed that the maximum deformation 0.001 mm and Von Mises stress 7.71 MPa observed on Carburetor. The yield strength of the material (Cast Iron) used for Carburetor is 240 MPa. The FOS at most of the locations is 240/7.71 = 31. According to the Von Mises Stress Theory, the Von Mises stress of Carburetor is less than the yield strength of the material.

VII. CASE-3: STATIC ANALYSIS OF CARBURETOR FOR ZINC MATERIAL

MATERIAL PROPERTIES:

Zinc Mechanical Properties:
Young’s modulus = 108 GPa
Yield Strength = 246 Mpa
Density = 7130 kg/m³
STRESSES:

FIGURE 29. STRESSES DEVELOPED IN CARBURETOR IN X-DIRECTION

FIGURE 30. STRESSES DEVELOPED IN CARBURETOR IN Y-DIRECTION

FIGURE 31. STRESSES DEVELOPED IN CARBURETOR IN Z-DIRECTION

FIGURE 32. VON MISSES STRESS DEVELOPED FOR STATIC ANALYSIS OF CARBURETOR

From the analysis, it is observed that the maximum deformation 0.0009mm and Von Mises stress 7.74MPa observed on Carburetor. The yield strength of the material (Zinc) used for Carburetor is 246 MPa. The FOS at most of the locations is 246/7.74 = 31. According to the Von Misses Stress Theory, the Von Misses stress of Carburetor is less than the yield strength of the material.

VIII. COMPARISON OF DEFLECTIONS AND STRESSES OF CARBURETOR FOR DIFFERENT MATERIALS

<table>
<thead>
<tr>
<th>S.N o</th>
<th>MATERIALS</th>
<th>DEFLECTION (mm)</th>
<th>STRESS (MPa)</th>
<th>FACTOR OF SAFETY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aluminum</td>
<td>0.001</td>
<td>7.71</td>
<td>35</td>
</tr>
<tr>
<td>2</td>
<td>Zinc</td>
<td>0.0009</td>
<td>7.74</td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>Cast Iron</td>
<td>0.001</td>
<td>7.71</td>
<td>31</td>
</tr>
</tbody>
</table>

IX. GRAPHS:

GRAPH-1: COMPARISON OF DEFLECTION OF CARBURETOR FOR DIFFERENT MATERIALS

GRAPH SHOWS COMPARISON OF DEFLECTION VALUES OF CARBURETOR FOR DIFFERENT MATERIALS

GRAPH-2: COMPARISON OF STRESS VALUES OF CARBURETOR FOR DIFFERENT MATERIALS

GRAPH SHOWS COMPARISON OF STRESS VALUES OF CARBURETOR FOR DIFFERENT MATERIALS

GRAPH-3: COMPARISON OF FACTOR OF SAFETY OF CARBURETOR FOR DIFFERENT MATERIALS

GRAPH SHOWS COMPARISON OF FACTOR OF SAFETY OF CARBURETOR FOR DIFFERENT MATERIALS
X. Results

Carburetor was studied for static analysis. In static analysis carburetor was studied for different materials (i.e. Aluminum, Zinc, and Cast Iron).

Table 2: Static Analysis of Carburetor for Different Materials (i.e., Aluminium, Zinc & Iron):

<table>
<thead>
<tr>
<th>S. No</th>
<th>MATERIALS</th>
<th>DEFLECTION (mm)</th>
<th>STRESS (MPa)</th>
<th>FACTOR OF SAFETY</th>
</tr>
</thead>
<tbody>
<tr>
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XI. Conclusion

Carburetor was developed in UNIGRAPHICS software. Static analysis of carburetor was done using ANSYS software. Static analysis was done on carburetor for different materials (i.e. Aluminum, Zinc, and Cast Iron). From static analysis, all materials have Von misses less than their yield strengths. So, all the materials are suitable for carburetor but, by considering Factor of safety, Aluminum has high Factor of safety value than Zinc and Cast Iron materials. Hence, it was concluded that Aluminum is best suitable material for carburetor.

XII. References


