Bending Stress Analysis of Rear Axle of Maruti-800 Car

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Abstract

An axle is central shaft for a rotating wheel or gear. On wheeled vehicles, the axle may be fixed to the wheels, rotating with them, or fixed to its surroundings, with the wheels rotating around the axle. In any case, axle is one of the most important part of a vehicle.

Present work deals with the rear axle of Maruti-800 car. This particular vehicle is front wheel drive vehicle and its rear axle plays vital role in motion transmission, load distribution and stability. The design of axle was done taking total weight of vehicle as load and value of maximum bending stress was calculated.

In the later stage, computer model of the rear axle was developed using Solid Works. The stress analysis was done in ANSYS. The value of maximum bending stress was derived.

This procedure was repeated for three different cross sections of axle; 1. Circular 2. Square and 3. I-section. The results were then compared to find out which cross section of the axle gives desirable results.

Keywords: basics of fem, need of FEA in turbo machines, problem definition & present work, boundary conditions, analysis results, discussion on results, conclusion.

Basics of FEM

The finite element method has become a powerful tool for the numerical solution of a wide range of engineering problems. Applications range from deformation and stress analysis of automotive, aircraft, building, and bridge structures to field analysis of heat flux, fluid flow, magnetic flux, seepage, and other flow problems. With the advances in computer technology and CAD systems, complex problems can be modeled with relative ease. An approximate solution for the partial difference equation can be developed for each of descretized elements. The finite element method is endowed with three basic features that account for its superiority over other competing methods: Geometrically complex domain of the problem is represented as a function of geometrically simple sub domains called "finite elements". Over each finite element the approximation, functions are derived using the basic idea that any continuous function can be represented by a linear combination of algebraic polynomials. Algebraic relations among the undetermined co efficient (i.e. nodal values) are obtained by satisfying the governing equation often in a weighted integral sense over each element. A three dimensional body occupying a volume 'V' and having a surface "S" is shown in Fig 1.Points in the body are located by x, y, z co ordinates. The boundary is constrained on some region where displacement is specified. On part of the boundary, distributed force per unit area T, also called traction is applied. Under the force, body deforms The deformation of a point $X = [x, y, z]^T$ is given by three components of its displacements:

$$U = [u, v, w]^T$$

Where u = displacement in x- direction
v = displacement in y- direction
w = displacement in z- direction

In the same manner i.e. in terms of the transpose of the matrix formed by the components of respective physical quantity other physical quantities can be written. Now if we consider equilibrium of this body then

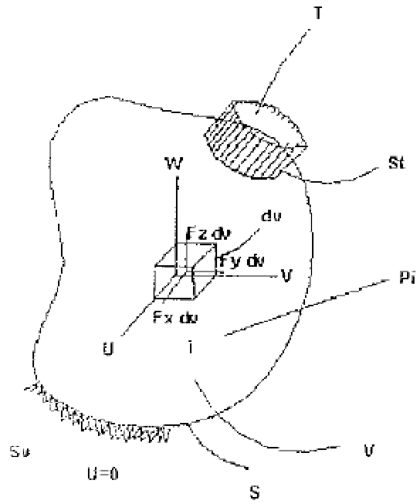


Figure 1: Three Dimensional Body.

$\Sigma F_x = 0$, $\Sigma F_y = 0$ and $\Sigma F_z = 0$. Also $dV = dx \cdot dy \cdot dz$

Therefore, we get the equilibrium equations

$$\frac{\partial \sigma x}{\partial x} + \frac{\partial \tau xy}{\partial y} + \frac{\partial \tau xz}{\partial z} + fx = 0$$

$$\frac{\partial \sigma_y}{\partial y} + \frac{\partial \tau xy}{\partial y} + \frac{\partial \tau_{yz}}{\partial z} + fy = 0$$

$$\frac{\partial \sigma z}{\partial z} + \frac{\partial \tau yz}{\partial y} + \frac{\partial \tau_{xz}}{\partial z} + fz = 0$$

The stresses are related to strain, which, in turn, are related to displacements. This leads to requiring solution of second-order partial differential equations.

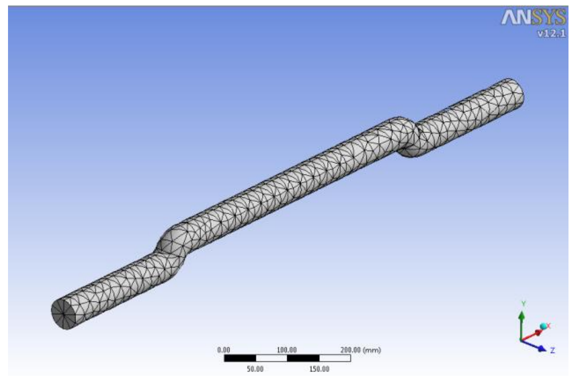
Problem Definition & Present Work

The present work includes the simulation (stress analysis) of rear axle subjected to load, equal to vehicle weight. The stress analysis was carried out using advanced computational fluid dynamic tool i.e. *ANSYS*. The analysis was done for three different cross sections.

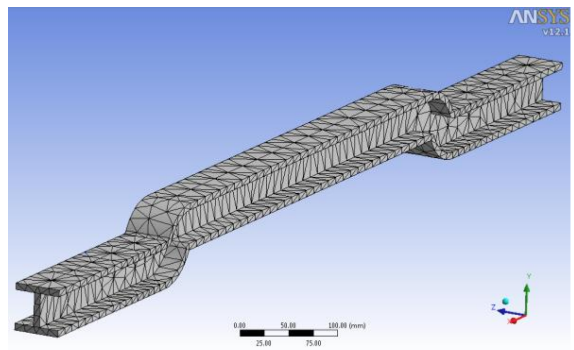
Modelling and Meshing

The geometry is drafted based on the dimensions of geometric design parameters. The axle is 3-dimensionally modeled then meshed properly to divide it into elements and nodes.

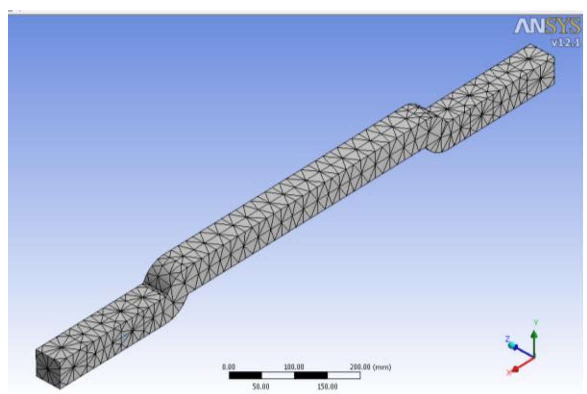
Finite element model was generated using free meshed 4 nodes quadratic tetrahedral element due to their flexibility in curved and complex shapes, which has three degrees of freedom per node i.e. translation in x, y, z directions were used. Quality checks and mesh optimization for elements were also performed taking into consideration of aspect ratio, distortion, stretch. Geometric models of axle were developed in three different cross sections. The digital images of models are given below;



(a)



(b)

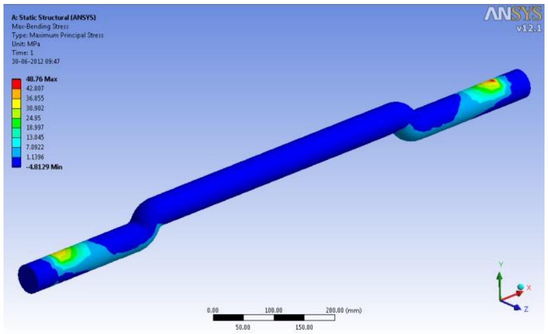


(c)

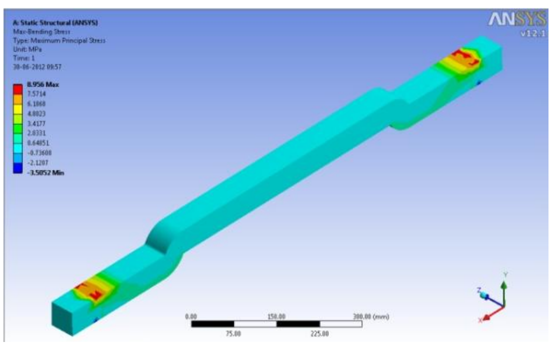
Figure 2 (a) (b) and (c): Fe Model of circular, I-section and Square with Meshing

Analysis Result

The results obtained are presented in the form of counter maps and profiles of radial elongation, mechanical stresses on blade surface for the rotor blade of axial flow impulse turbine.



(a)



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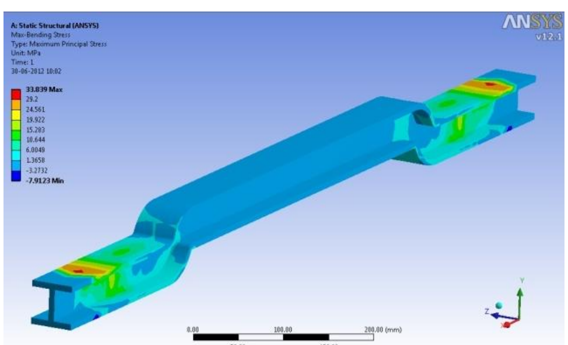
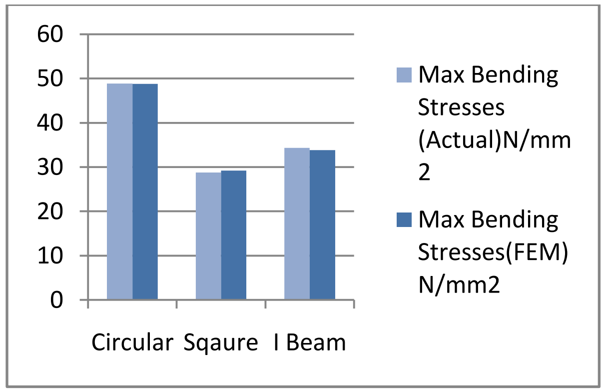


(c)

Figure 3(a) (b) and (c),**:** Bending Stress Analysis Results on all three axles.

Table 1: Values of Maximum Bending Stress obtained from simulation and calculated from design procedure.

C/S	Max Bending Stresses(FEM) N/mm2	Max Bending Stresses (Actual)N/mm2
Circular	48.76	48.8923
Square	29.2	28.8
I Beam	33.839	34.3059



Graph 1: Values of Maximum Bending Stress achieved by FEM and calculated for actual case; for three different cross sections.

Conclusion

From post processing results on graphics screen & graphs shown above, results are discussed as bellows:

1. The values of the maximum bending stress induced in the axle are almost same; in each three cases; for the manual design and for the simulation. Which suggest that we can rely on the softwares for this kind of analysis work.
2. The value of maximum bending stress is highest in case of circular (actual) cross section as compared to the square and I-section. This is because the circular shape has less cross sectional area. The square shape has more cross sectional area compared to other two shapes, which helps square axle against bending and hence the value of bending stress is minimum for square cross section. But on the other hand,

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square cross section will require more material for manufacturing.

3. Looking at the values of bending stresses induced in I-section, we can see that the values are higher than the square cross section but compared to circular cross section, they are considerably less. I-section has less cross sectional area compared to square and circular shape. Which means I-section will need less material for manufacturing. So, we can conclude that while manufacturing axle, one can prefer I-section over circular or square shaped axle.

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