

# Fatigue Analysis of Automotive Door Hinge to Avoid Sagging of Doors

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## ABSTRACT

Door hinges allow your car or truck's doors to open and close, and they also hold them to the vehicle. They are located where the door attaches to the frame. There are two hinges for each door, an upper one and a lower one. The problem of a sagging car door is more than just a mere annoyance; if door sag is ignored over time, it can cause other issues that will ultimately cost even more to repair. To minimize the failure of door hinge, the stress induced in it must be studied. A hinge is subjected to continuous loading and unloading. This may cause fatigue failure of the door hinge. The review of previous publications enable to conclude that components with complex geometry as door hinge require a more extensive investigation in view of the fact that a very few articles have been published so far regarding stress analysis of this door hinge.

**KEY WORDS:** Door Hinge, Fatigue failure, FEM, stress analysis

## 1. INTRODUCTION

Door hinges allow car or truck's doors to open and close and also hold door in closed position to the vehicle. They are located where the door attaches to the frame. There are two hinges for each door, an upper hinge and a lower hinge. Inside the hinge there is a circular pin that allows the hinge to swivel around pin axis. Car door latches and hinges are door retention components. Hinge is an assembly of components connected to the body of the vehicle and door, linked to each other and capable of rotating around the same axis. Now a days two positioned latch system is provided for the car locking. First is fully latched position and other is secondary latched position. A sagging or misaligned car door is certainly a nuisance. After all, it can take multiple tries to get it to close properly, which can be time-consuming when you're in a hurry to get to work or make an appointment on time. It also increases the likelihood of property theft – both of your vehicle and its contents – because there is a higher possibility of accidentally leaving your car or truck unattended with an open door you thought you closed. A misaligned car door is also a safety issue in that it may pop open while your car is in motion.

The problem of a sagging car door is more than just a mere annoyance; if door sag is ignored over time, it can cause other issues that will ultimately cost even more to repair. Here are the most common causes misaligned striker and latch: If the door sag isn't too noticeable, the culprit may be simply that the striker and latch aren't quite lined up properly. This is a relatively easy fix, often caused by repeatedly slamming the door too hard, requiring some small adjustments to the fitting in between the striker and latch that a qualified mechanic can do in little time.

Worn hinge pins and bushings: If your car door sags more dramatically (i.e. is visible to the naked eye), it's likely the hinge pins and bushings are worn or damaged, which can be caused by frequently slamming it shut or simply from wear and tear from the elements. This repair is a little more intensive, usually requiring removing the door entirely, replacing the problem parts, and rehanging the door in correct alignment.

Weather stripping needs to be replaced: Sometimes our eyes deceive us and make a door appear to sag when there's really just a general misalignment that makes it difficult to shut. In this case, it is possible the problem lies in old weather stripping in need of replacement. This is something that can occur just with the passage of time and exposure to various weather conditions. Some images of Door Hinge are as follows:



Fig1. Door Hinge

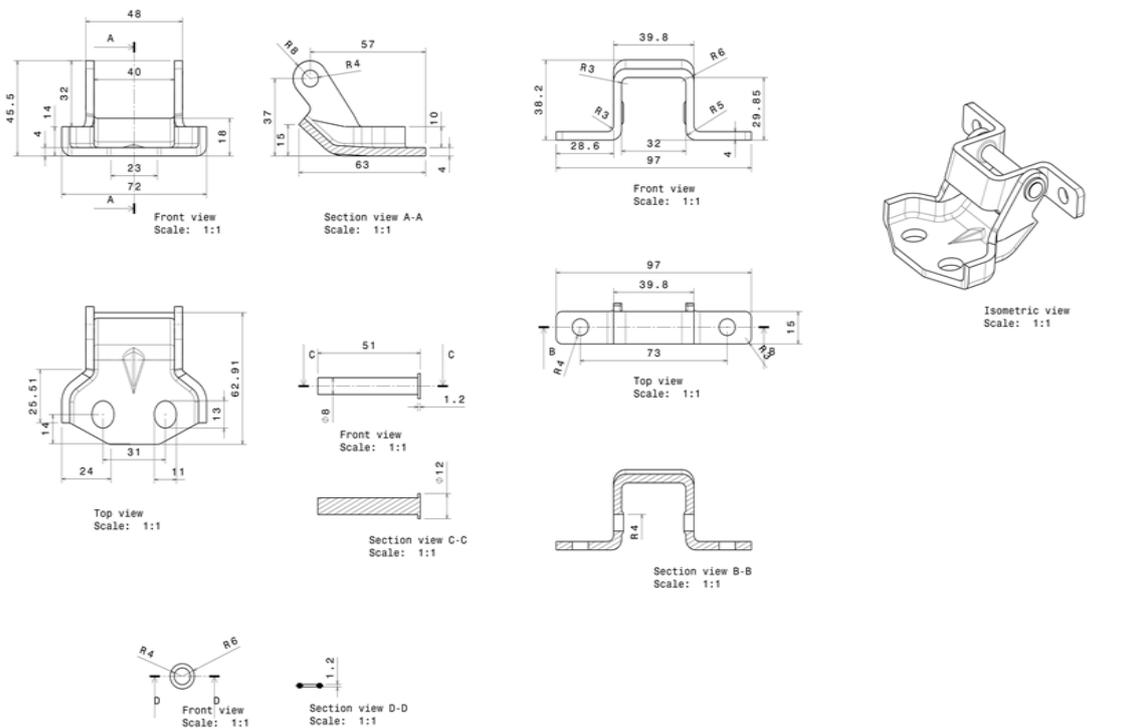
## 2. Problem Statement

Hinge is an assembly of components connected to the door and body of the vehicle, linked to each other and capable of rotating around the same axis. Due to repetitive loading door hinge get may failure. The working and design (always very tricky) of Door Hinge. During the actual working condition, the maximum load is transferred from Vehicle structure as well as repeated opening and closing of Door. Hinge which creates possibility of fatigue failure in Door Hinge.

### 3. FE Analysis

Due to severe working conditions, Door Hinge is subject to high loads. The Door Hinge must work reliably under unpredictable working conditions. Poor strength properties of the Door Hinge limit the life expectancy. In our project, we are going to work over Door Hinge of Alto 800. By reverse engineering dimensions of the Door Hinge are found out. 3D modeling will be done in CatiaV5. Meshing, static and fatigue analysis will be carried out in HYPERMESH and ANSYS respectively. Stress, deformation and fatigue life will be the output of analysis. Once we get the results from numerical solutions, we make a prototype of the Door Hinge and carryout experimental testing on it.

### 4. 2D Drafting Of Door Hinge



All Dimensions are in mm

Fig2. Door Hinge Drafting

### 5. CAD Model Door Hinge

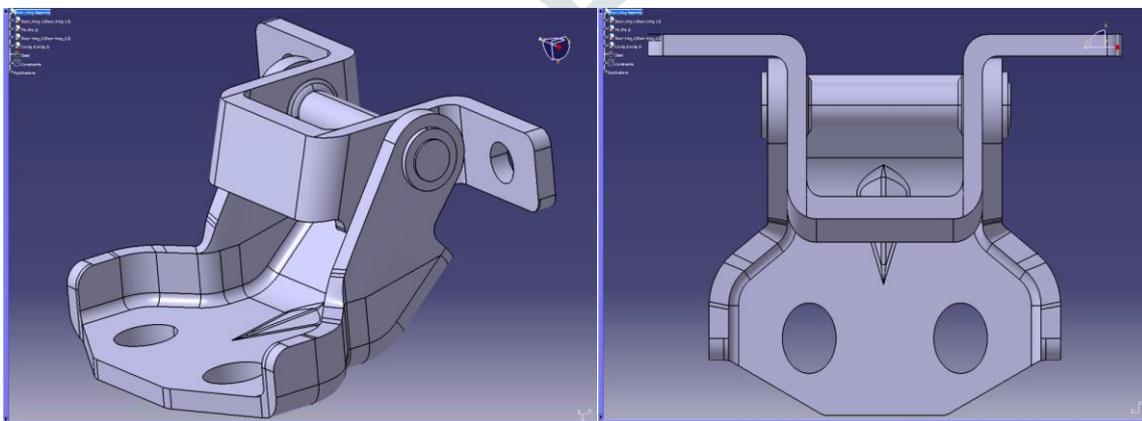


Fig 3: Door Hinge image 1

Fig 4: Door Hinge image 2

## 6. Mesh Generation

### 6.1 Meshing

Initially the IGS file is imported to the meshing software like Hypermesh. The CAD data of the Door Hinge is imported and the surfaces were created and meshed. As all the dimensions of Door Hinge are comparable the element for meshing the Door Hinge is solid 45 (3D Mesh Element Type).

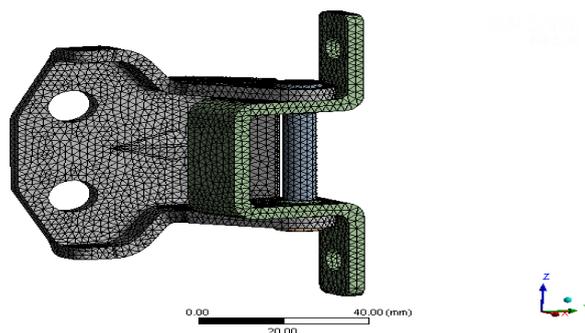


Fig.5: Meshed Door Hinge in Hypermesh (Tetrahedral – Solid 45 – 3D Mesh)

### 6.2 Meshing Details:

Element Type	Solid 45 (3D element)
Number of Nodes	99187
Number of Elements	54004

**Table1. Details of Meshing**

In meshing we divide these components into finite numbers. Dividing helps us to carry out calculations on the meshed part.

## 7. Static Structural Analysis

The Finite Element Method is a numerical approximation method, in which the complex structure is divided into number of small parts that is pieces and these small parts are called as finite elements. These small elements are connected to each other by means of small points called as nodes. As the finite element method uses matrix algebra to solve the simultaneous equations, so it is also known as structural analysis and it's becoming primary analysis tool for designers and analysts.

The three basic FEA process are

- a) Preprocessing phase
- b) Processing or solution phase
- c) Post processing phase

A static structural analysis is the analysis displacements, stresses, strains and forces on structure or a component due to load application. The structures response and loads are assumed to vary slowly with respect to time. There are various types of loading that can be applied in this analysis which are externally applied forces and pressures, and temperatures.

• **Material properties:** The values of young's modulus, poissons ratio, density, and yield strength for Door Hinge are taken from material library of the FEA PACKAGE.

Property	Value
Young's modulus, E	2.110 <sup>9</sup> Mpa
Poisson's Ratio ,ν	0.2
Density, ρ	7.9 x 10 <sup>-9</sup> tonne/mm <sup>3</sup>

**Table 2. Material properties**

To perform the FEA of the Existing Door Hinge, continuum (Door Hinge) is discretized into finite number of elements through meshing process and then boundary conditions are applied to the system. Loads are Transverse Load of 910N and longitudinal load of 1140N.

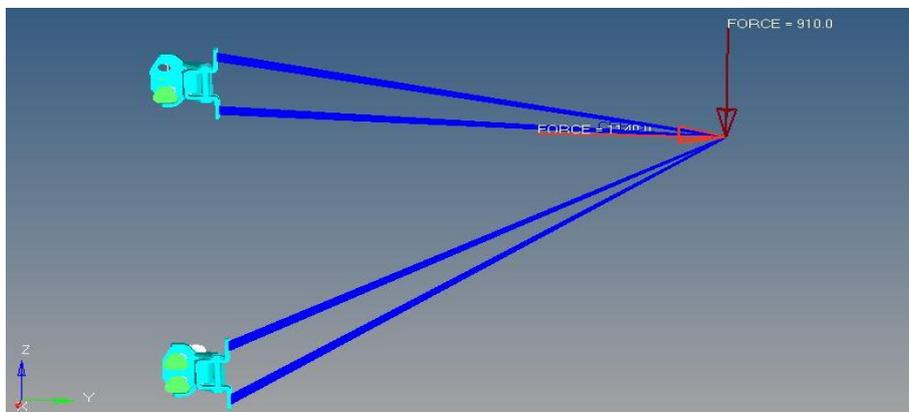


Fig6. Meshed model with boundary conditions.

## 8. RESULT

### 8.1 Result for Stress:

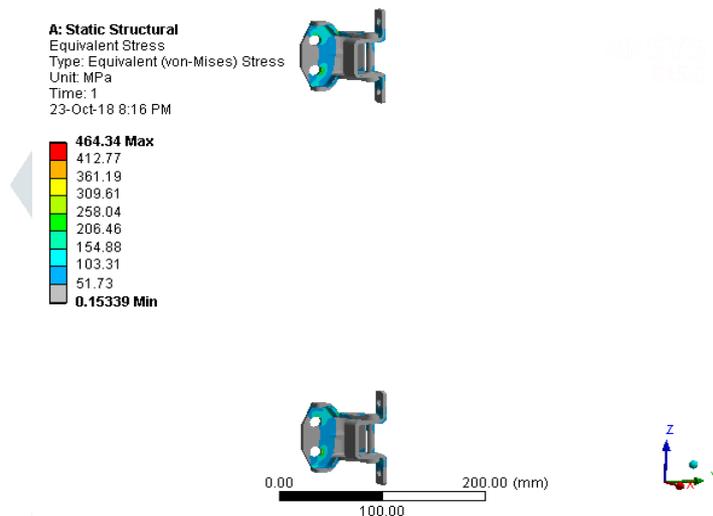


Fig7: von-mises stress for Door Hinge

Maximum Stress of of **464 Mpa** is observed

### 8.2 Result for Deflection:

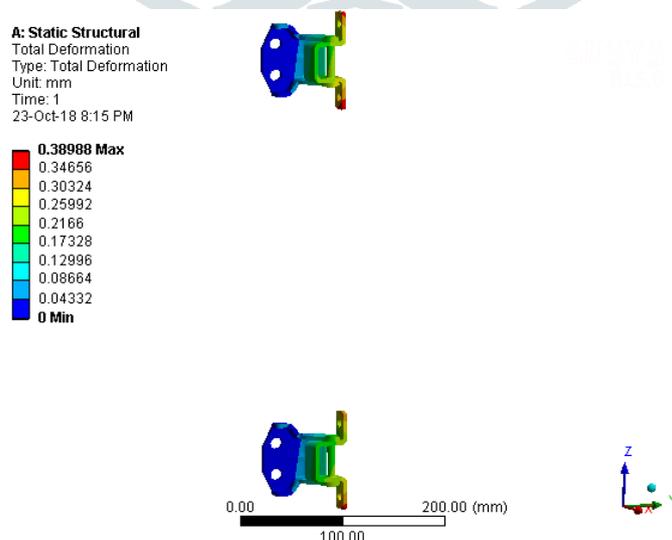


Fig8: Displacement result for Door Hinge

From fig., it can be seen that the deformation is **0.38 mm**,

## 9. CONCLUSION

In this study, an Automotive Hinge is designed by 3D and analyzed by using FEA. After the static analysis of Door Hinge model, we got the results in terms of stresses and deflection. Von mises stress and deflection are 464.34 MPA and 0.38988mm respectively. And this analysis also indicates the maximum stress concentration area.

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