# Modelling and Stress Analysis of Connecting Rod Using Fusion 360

**Riya Pal, Shweta Mitra, Rahul, and Neetu Kanaujia**

**Abstract** To ensure that any structure manufactured by the industry operates satisfactorily without breaking under the specified load requirements, it is extremely important to do stress analysis after designing a component as it will reduce a lot of time during design, by avoiding the redesign procedure due to structural verification during failure tests. Stress analysis plays an important role in today's era. In today's competitive market, every part that is manufactured requires proper designing and correct material selection because every part has to undergo various forms of stresses on applying load. Thus, through our research we have tried to demonstrate the importance of stress analysis on a connecting rod and the right material for the manufacturing of it. In this paper, we carried out with the structural static stress analysis of a connecting rod with different materials, using software called Autodesk Fusion 360. By doing this we were able to make a comparison among factors of safety, stress, strain and displacement with our selected materials.

**Keywords** Connecting rod · Fusion 360 · Stress analysis · Stainless steel

## 1 Introduction

The rod that joins the piston to the crankshaft to transfer combustion pressure or to transmit the tensile and compressive forces to the crank pin is known as a connecting rod. It mainly comprises a small end, a large end and an I-beam (shank), and the other parts like the bushing, bearing inserts, bolts and nuts and bearing cap. The small cease is supplied to deal with the piston pin, and the big cease is split into elements to hold the crank pin [1]. Connecting rod is of different types and shapes, but an I-shape connecting rod is preferred for lightness, low inertia force and can

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resist (or withstand) high gas pressure. The materials used for the connecting rod should be chosen wisely as it is one of the most severely stressed parts for many vehicles and engines (like IC engines). Its miles subjected to the force of gas stress and the inertia pressure of the reciprocating element. Thus, the material used for making connecting rod should be very lightweight and of very high fatigue strength (resistance) to reduce forces. The materials used for connecting rod varies from industry to industry depending on their different applications and uses. Common materials are medium carbon steels containing 0.35–0.45% carbon, alloy steels which include nickel–chromium or chromium-molybdenum steels, iron base sintered metal, spheroidized graphite cast iron (ductile), aluminium and titanium alloy (Ti-6Al-4V). There is always a high chance of facing failure in the connecting rod due to the high heat and pressure given to it. As a result, mostly it gets torn from the lock of the piston pin. The forces acting on the connecting rod are shear force (due to bending) and axial forces, that is compression force and tensile force.

## 2 Materials Used in Present Research

One of the key components of the engine is the connecting rod, which joins the piston to the crankshaft and transfers the piston's reciprocating action into the rotation of the crankshaft. The connecting rod needs to be sturdy enough to sustain the piston's forces during combustion. It experiences several tensile and compressive loads during the course of its lifespan. The selection of proper materials in the designing of the connecting rod is extremely important. Here in our paper, we have done a comparative study of a few materials and using them we did the stress and thermal analysis. Before using any particular material, the properties of that material should be focused on. Thus, given below is a small description of the physical, mechanical and chemical properties of the materials that we have used in designing the connecting rod (Table 1).

**Table 1** Properties of the material [2]

| Materials name | Density (kg/mm$^3$) | Modulus Young's (GPa) | Poisson's ratio | Strength yield (MPa) | Strength ultimate tensile (MPa) | Thermal conductivity (W/mm C) |
|---|---|---|---|---|---|---|
| Grey cast ASTM A48 grade 35, Iron | 7.395E−06 | 109.6 | 0.244 | 251.7 | 334 | 0.04804 |
| Aluminium 7075 | 2.81E−06 | 71.7 | 0.33 | 145 | 276 | 0.173 |
| Carbon steel (for pressure vessel) | 7.85E−06 | 200 | 0.29 | 350 | 420 | 0.0476 |
| Aluminium 6061 | 2.70E−06 | 68.90 | 0.33 | 275 | 310 | 0.167 |

## 3 Chemical Composition of Materials Used

### Iron, Grey Cast ASTM A48 Grade 35

This is a special grade of iron used to produce castings that require high tensile strength and hardness (Table 2).

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### Aluminium 7075

Aluminium 7075 is widely used for making connecting rods and other industrial appliances [3] (Table 3).

### Carbon Steel (for Pressure Vessel)

In the recent years, the use of carbon steel has been constantly increasing in the construction industry. Carbon steel requires low investments, but all production capabilities can be achieved. Also, it is very easily available and rust-free usually, thus

**Table 2** Chemical composition of grey cast iron A48 grade 35

| Element | Range (wt%) |
|---|---|
| Sulphur | $\leq$ 0.16% |
| Manganese | 0.5–0.8% |
| Silicon | 1.7–2.4% |
| Nickel | 0.5–0.2% |
| Molybdenum | 0.5–0.15% |
| Chromium | 0.05–0.5% |
| Copper | 0.15–0.5% |
| Iron | 91–94% |
| Phosphorus | $\leq$ 0.12% |
| Carbon | 4.40–4.0% |

**Table 3** Chemical composition of Aluminium 7075

| Element | Range (wt%) |
|---|---|
| Aluminium | Balance |
| Titanium | 0.3% |
| Chromium | 0.15% |
| Silicon | 0.5% |
| Zinc | 5.5% |
| Iron | 0.5% |
| Magnesium | 3.0% |
| Copper | 1.5% |
| Manganese | 0.4% |

**Table 4** Chemical composition of carbon steel

| Element | Range (wt%) |
|---|---|
| Carbon | 0.10–0.22% |
| Manganese | 1–1.7% |
| Phosphorus | 0.04% |
| Sulphur | 0.03% |
| Silicon | 0.6% |
| Chromium | 0.4% |
| Nickel | 0.3% |
| Titanium | 0.03% |
| Molybdenum | 0.09% |
| Aluminium | 0.02% |
| Copper | 0.3% |

making it an excellent alloy for industrial application. Its chemical composition is as follows: [3] (Table 4).

**Aluminium 6061**

Usually utilized for the manufacturing of aircraft structures like aeroplane wings and fuselage. Aluminium 6061 has an excellent strength to weight ratio, making it very useful in the automobile as well as the aerospace industry. The demand for Aluminium 6061 alloy has been continuously increasing these days as they are crack resistant as well as corrosion-resistant [4] (Table 5).

**Table 5** Chemical composition of Aluminium 6061

| Element | Range (wt%) |
|---|---|
| Magnesium | 0.9% |
| Silicon | 0.62% |
| Iron | 0.33% |
| Copper | 0.28% |
| Chromium | 0.17% |
| Manganese | 0.06% |
| Zinc | 0.02% |
| Titanium | 0.02% |
| Aluminium | Balance |

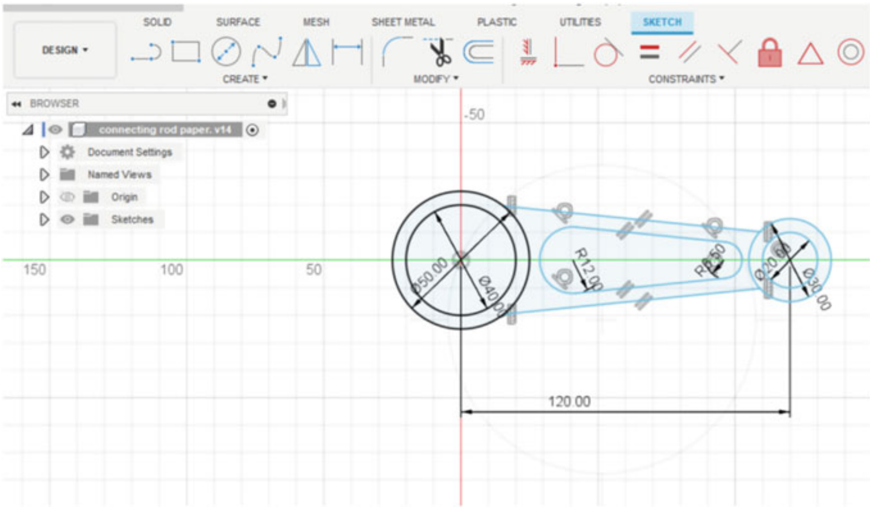


**Fig. 1** Sketch of a connecting rod using Autodesk Fusion 360

## 4 Design of Connecting Rod

Fusion 360 is a software that has been introduced by Autodesk as a design platform that allows cloud collaboration and sharing. Fusion 360 is a flawless design that helps in solving technical challenges of cross-platform data sharing, enables effective cross-regional cooperation, presents a top-level view of collaboration, and breaks down the obstacles among art and production, in addition to obstacles between design and processing [5]. To design the connecting rod, some steps are involved which is briefly described below.

Step 1: Make a sketch of the required small end and the big end using proper dimensions as shown in Fig. 1. The length of the connecting tool can be set by using the dimension tool [6, 7].

Step 2: First we have extruded the small end and the bigger end by 25 mm. Next is to extrude the connecting rod portion by 23 mm, keeping the direction symmetric. The screenshot has been attached in Fig. 2 [8].

## 5 Modelling and Analysis

In our paper, we performed the modelling and analysis of the connecting rod using Fusion 360. After designing the connecting rod in the 'design' section of Fusion 360, we have moved to the 'Simulation' section of Fusion 360 for the simulation part (Analysis) which is our next step. After entering the 'Simulation' section, we

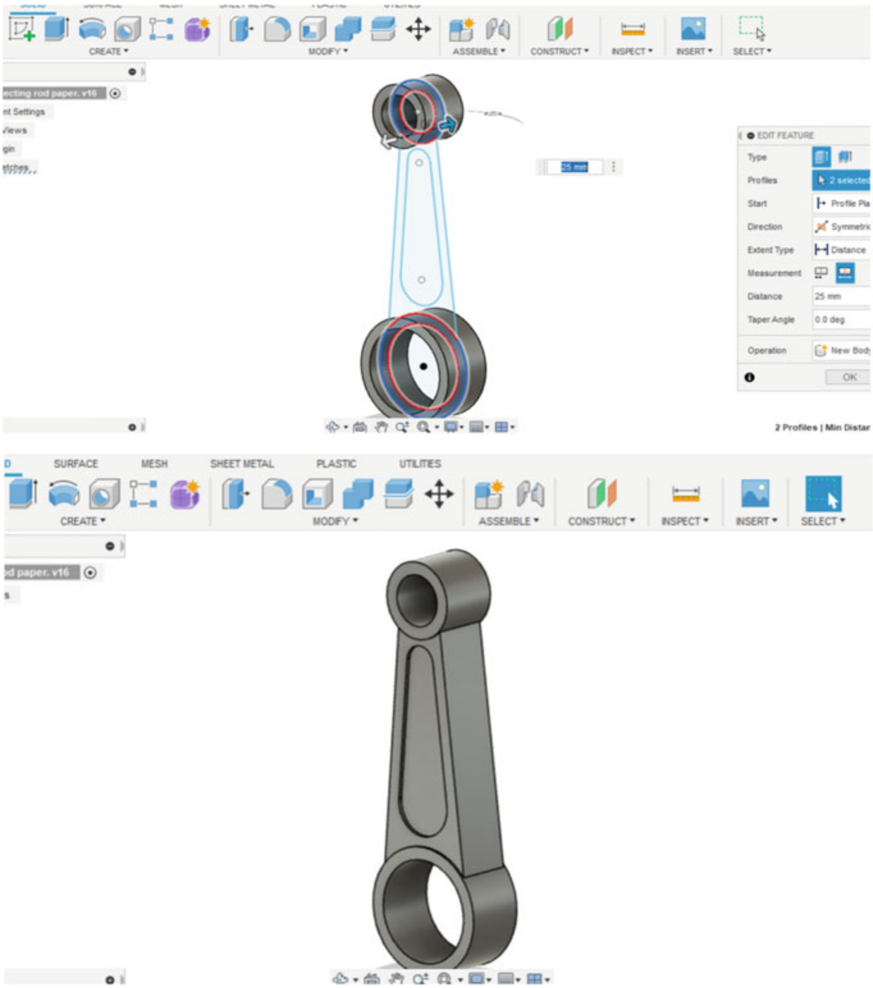


**Fig. 2** Design of connecting rod

will select 'Static Stress' for the stress analysis of the connecting rod. Four different materials are taken that is Grey cast iron of grade 35, Aluminium 7075, Aluminium 6061 and carbon steel. Each of these four materials is undergone the following boundary conditions.

Boundary Conditions:

1. Load: A load of 5000 N (5 kN) is applied at the crank side, i.e. the larger end of the connecting rod at tensile condition.
2. Constraints: A fixed support is provided to the inner portion of the small end (piston side) of the connecting rod.

After when the boundary conditions (as shown in Fig. 3) are applied and checking all the prerequisites (needed conditions), we will move to the 'solve simulation study'. After the completion of the simulation study, we get the following result of four different materials in terms of factor of safety (FOS), stress, deformation (displacement) and strain (as shown in Figs. 4, 5, 6, 7 and Tables 6, 7, 8, 9).

1. Grey cast iron (ASTM A48 Grade 35)
2. Aluminium 7075
3. Aluminium 6061
4. Carbon steel (for pressure vessel)

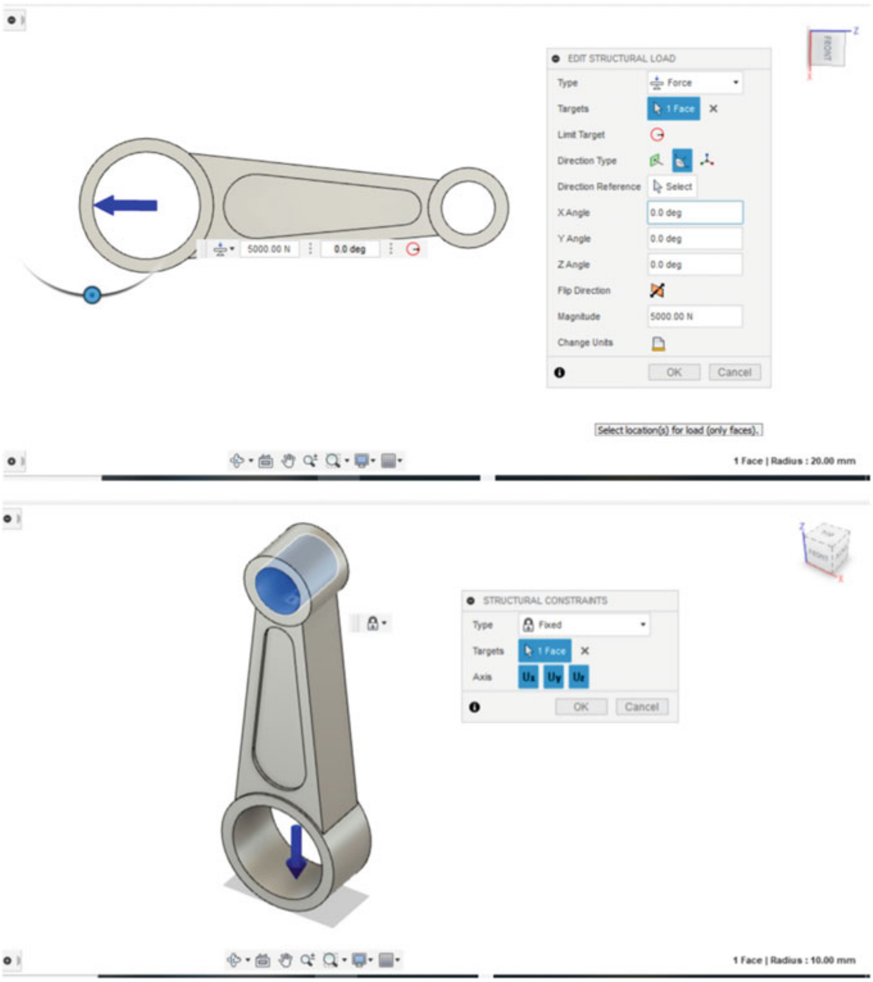


**Fig. 3** Boundary conditions (load and constraints)

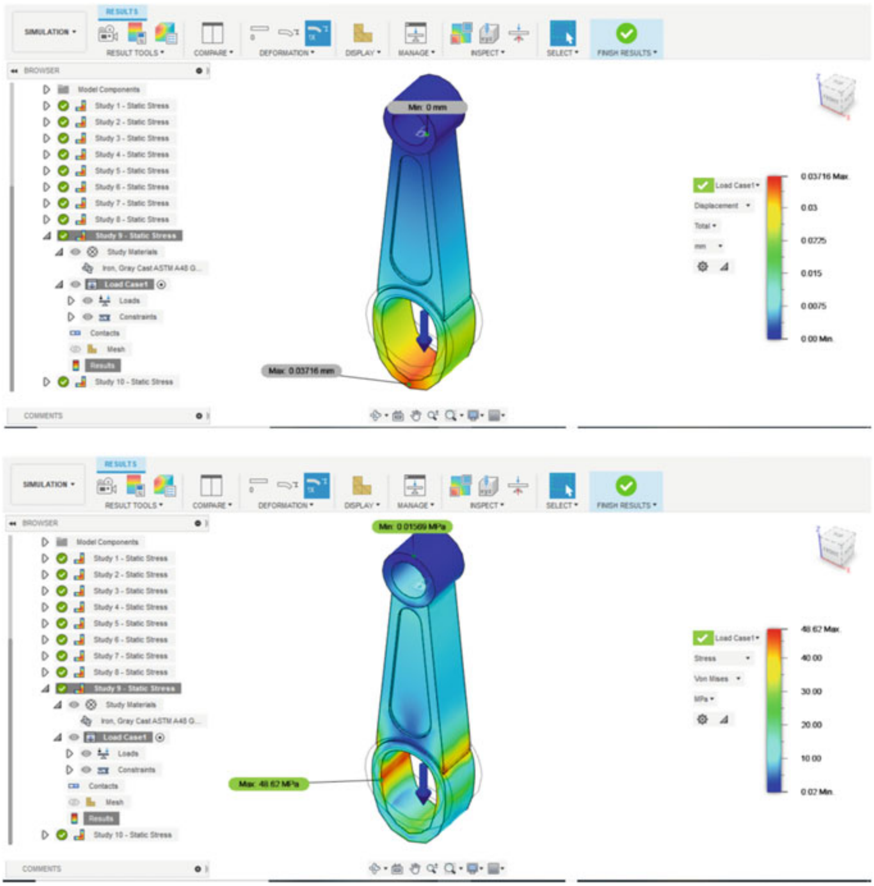


**Fig. 4** Displacement and stress analysis of grey cast iron

# 6 Results and Discussion

We have done the stress analysis of a connecting rod and obtained the result. And from the analysis, we found that our design is safe for materials that we have chosen which are grey cast iron, Aluminium 7075, Aluminium 6061 and carbon steel since the values of factor of safety of each material that we have used lie within a range of 3–6. A comparison has been drawn between all the materials based on the result obtained. The result is shown in Table 10 and Fig. 8.

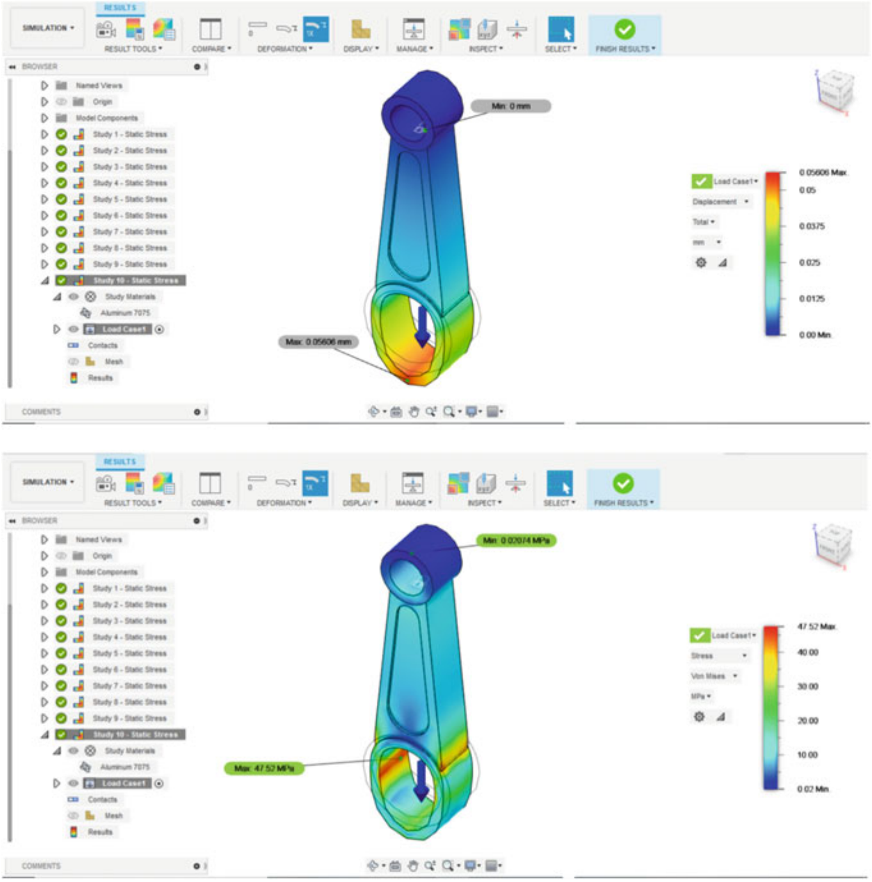


**Fig. 5** Displacement and stress analysis of Aluminium 7075

## 7 Conclusions

1. We have compared different possible materials that are used for making connecting rods with the help of analysis (by applying a force in tensile conditions) using Fusion 360 and observed that grey cast iron, Aluminium 6061, Aluminium 7075, carbon steel and some other materials (which is not shown in this paper) like stainless steel is safe and can be used for further analysis and work.
2. On the other hand, materials like Titanium 6Al-4 V, Steel AISI 4340 350A QT and Ductile Iron (SG Cast Iron), who's factor of safety (FOS), is coming out of range (15) for the same design with the same dimensions which is not safe for working and for any industrial purpose.

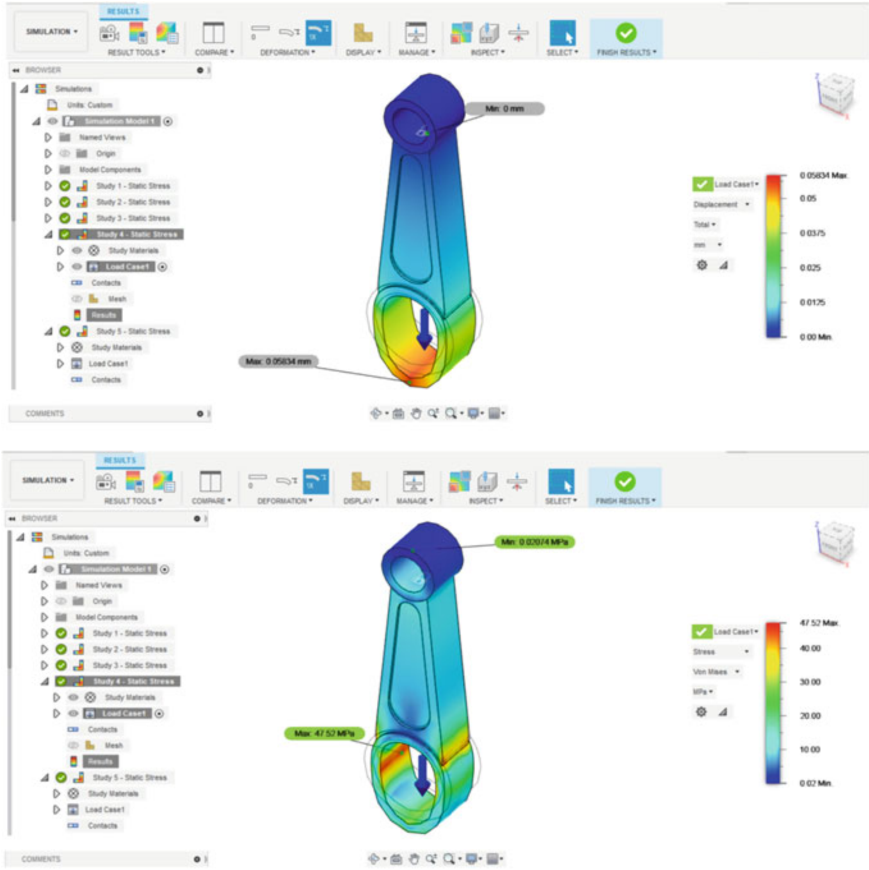


**Fig. 6** Displacement and stress analysis of Aluminium 6061

3. From our analysis, we get, that grey cast iron can endure maximum stress in comparison to the other selected materials. In terms of factor of safety (FOS), Aluminium 7075 is better as it has the least FOS value among other materials.

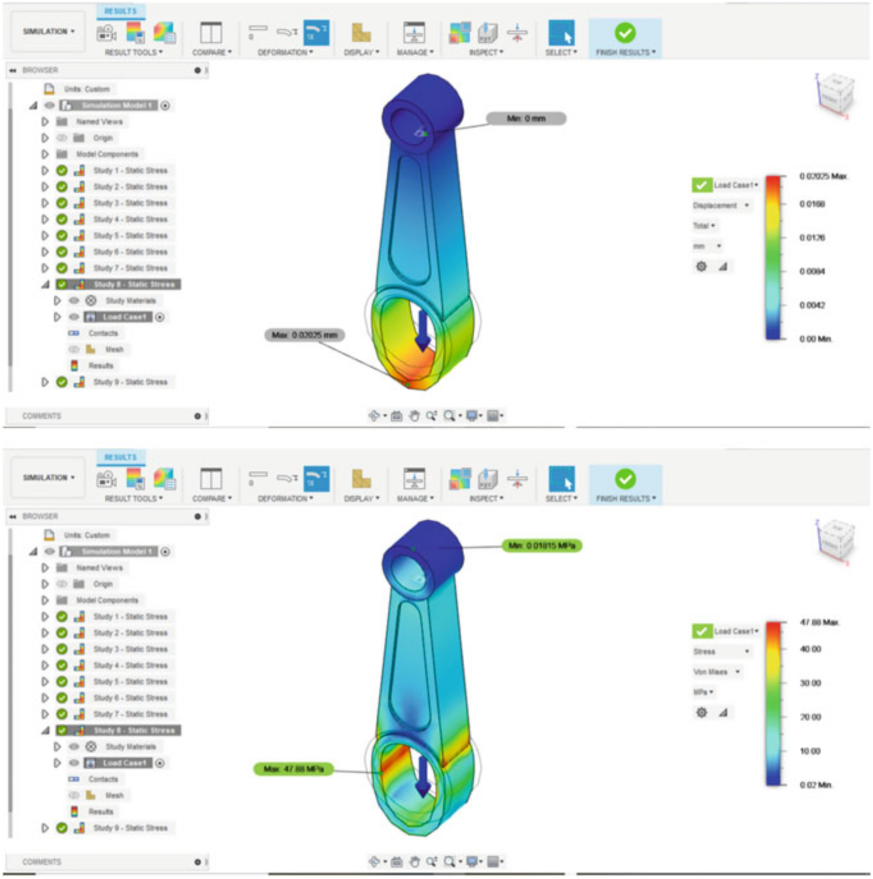

**Fig. 7** Displacement and stress analysis of carbon steel

**Table 6** Result table for Grey cast iron

| FOS | Max. stress (MPa) | Max. displacement (mm) | Strain | Design |
|---|---|---|---|---|
| 5.177 | 48.62 | 0.03716 | 0.0004769 | Safe |

**Table 7** Result table for Aluminium 7075

| FOS | Max. stress (MPa) | Max. displacement (mm) | Strain | Design |
|---|---|---|---|---|
| 3.051 | 47.52 | 0.05606 | 0.0007541 | Safe |

**Table 8** Result table for Aluminium 6061

| FOS | Max. stress (MPa) | Max. displacement (mm) | Strain | Design |
|---|---|---|---|---|
| 5.787 | 47.52 | 0.05834 | 0.000785 | Safe |

**Table 9** Result table for carbon steel

| FOS | Max. stress (MPa) | Max. displacement (mm) | Strain | Design |
|---|---|---|---|---|
| 5.472 | 47.88 | 0.02025 | 0.000266 | Safe |

**Table 10** Compassion between different materials

| Material | FOS | Max. stress (MPa) | Max. displacement (mm) | Strain | Design |
|---|---|---|---|---|---|
| Grey cast iron | 5.177 | 48.62 | 0.03716 | 0.0004769 | Safe |
| Aluminium 7075 | 3.051 | 47.52 | 0.05606 | 0.0007541 | Safe |
| Aluminium 6061 | 5.787 | 47.52 | 0.05834 | 0.000785 | Safe |
| Carbon steel | 5.472 | 47.88 | 0.02025 | 0.000266 | Safe |

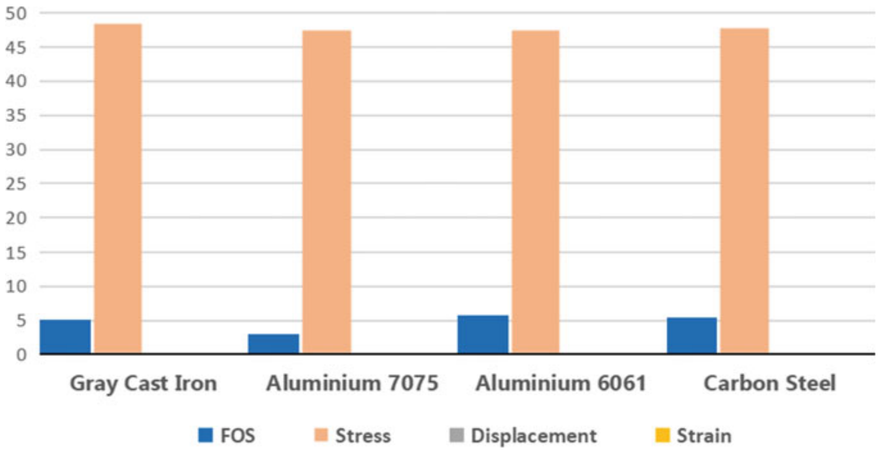


**Fig. 8** Compassion between different materials

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