Structural Analysis of Chassis using AISI 4130 and AA 7068

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Abstract. The chassis frame is the backbone of a vehicle to safely carry the maximum load for all the designed operating conditions. This paper describes the design and analysis of vehicle chassis using different materials for different cross sections. The main objective of this attempt is to reduce the self-weight of the chassis. In this work a truck chassis is taken for modeling and analysis. Two different alloy materials of steel and aluminium are considered for three different cross sections namely I, C and regular box type. SOLIDWORKS and ANSYS software are used for modeling and analysis of this work respectively.

Keywords: Chassis Design, Weight Reduction, Alloy Materials, Modeling and Analysis

1 Introduction
Automotive chassis is a skeletal frame on which various mechanical parts like engine, axle assemblies, brakes, steering and various other parts are bolted. The chassis is considered to be the most significant component of an automobile. It provides strength and flexibility to the automobile. Steel alloy AISI 4130 is the most commonly used material in the production of automotive chassis. In this work AA 7068[1-6] (aluminium alloy) is used as a replacement material for the chassis, even though the young’s modulus of AISI 4130 is significantly higher than that of AA 7068, still it is taken for this work because of its cost reduction and weight reduction properties, which has similar physical properties to AISI 4130[7-13]. Three different cross sections namely I, C and Box type are analysed with these two materials in order to find the best suitable replacement for AISI 4130 in the aspects of strength, weight reduction and cost. For this work Eicher E2 truck’s ladder chassis[14-23] is taken to find the equivalent stress and total deformation of the chassis. The total load applied on the chassis for analysis is 112270 N[15]. For modeling of the chassis SOLIDWORKS 2020 is used and for the purpose of analysing ANSYS R2 is used.
2. Properties of Materials

The AA 7068 [1-6] is one of the strongest aluminium alloys with a yield strength of 590 MPa, poisson ratio of 0.23, young’s modulus of 73.1 MPa, Ultimate strength of 641 MPa and density of 2.85 g/cm$^3$, used as a replacement for AISI 4130 [7-13] steel alloy with a yield strength of 460 MPa, poisson ratio of 0.29 young’s modulus of 205 MPa, ultimate strength of 560 MPa and density of 7.85 g/cm$^3$. From the physical properties of these materials it is clearly understood that the density of AA 7068 is very low which will help in weight reduction.

| Properties              | Materials  |
|-------------------------|------------|
|                         | AA 7068    | AISI 4130 |
| Young’s modulus(MPa)    | 73.1       | 205       |
| Poisson ratio           | 0.23       | 0.29      |
| Density (g/cm$^3$)      | 2.85       | 7.85      |
| Yield strength (MPa)    | 590        | 460       |
| Ultimate strength (MPa)| 641        | 560       |

Table1. Physical Properties of AA 7068 and AISI 4130

3. Modeling and Analysis

3.1 Modeling

The ladder chassis of truck (Eicher E2) is modeled in solid works 2020 for the different cross sections namely I, C and box type are shown in the below figures.

Figure 1: Modeling of I section
The above figure 1 shows the modeling of chassis using I cross section in solidworks, the dimensions of the model is given for reference.

![Figure 1: Modeling of I Type Cross section](image1)

The above figure 2 shows the modeling of chassis using box type cross section in solidworks, the dimensions of the model is given for reference.

![Figure 2: Modeling of Box Type Cross section](image2)

The above figure 3 shows the modeling of chassis using C cross section in solidworks, the dimensions of the model is given for reference.

![Figure 3: Modeling of C Type Cross section](image3)

### 3.2 Analysis.
For the purpose of analysing the models, Ansys R2 is used, the solidworks file is imported into ansys in IGS format. Equivalent stress and total deformation is calculated for three different cross sections (I, C and Box type) using two different materials (AISI 4130 and AA 7068) to find the best material and cross section for the truck chassis. Second and fourth beam of the chassis is fixed and a load of 112270 N is applied on the chassis for analysis. For the purpose of analysis the load is considered to be static.
Figure 4: Fixed support

Figure 4 shows the fixed support of the chassis during analysis.

Figure 5: Load applied

Figure 5 shows where the load is applied on the chassis during analysis.

4. Result and Discussion

The result on analysing the chassis for different materials in different cross sections is given below.

Figure 6: Deformation of AA 7068 – I section
The figure 6 shows the total deformation of chassis when the force is applied for AA 7068 in I cross section, the maximum deformation obtained is 5.0554 mm.

![Figure 6: Total deformation of AA 7068 I cross section](image)

**Figure 7**: Equivalent stress (von-mises) of AA 7068 – I section

The figure 7 shows the stress deformation of chassis when the force is applied for AA 7068 in I cross section, the maximum stress value obtaines is 45.544 MPa.

![Figure 7: Equivalent stress (von-mises) of AA 7068 I section](image)

**Figure 8**: Deformation of AISI 4130 – I section

The figure 8 shows the total deformation of chassis when the force is applied for AISI 4130 in I cross section, the maximum deformation obtained is 1.8076 mm.

![Figure 8: Deformation of AISI 4130 I section](image)

**Figure 9**: Equivalent stress (von-mises) of AISI 4130 – I section

The figure 9 shows the stress deformation of chassis when the force is applied for AISI 4130 in I cross section, the maximum stress value obtaines is 45.544 MPa.
The figure 9 shows the stress distribution of chassis when the force is applied for AISI 4130 in I cross section, the maximum stress value obtained is 45.06 MPa.

**Figure 10:** Deformation of AA 7068– Box type cross section

The figure 10 shows the total deformation of chassis when the force is applied for AA 7068 in box type cross section, the maximum deformation obtained is 4.15 mm.

**Figure 11:** Equivalent stress (von-mises) of AA 7068 – Box type cross section

The figure 11 shows the stress distribution of chassis when the force is applied for AA 7068 in box type cross section, the maximum stress value obtained is 35.601 MPa.

**Figure 12:** Deformation of AISI 4130– Box type cross section
The figure 12 shows the total deformation of chassis when the force is applied for AISI 4130 in Box type cross section, the maximum deformation obtained is 1.4807 mm.

**Figure 13:** Equivalent stress (von-mises) of AISI 4130 – Box type cross section

The figure 13 shows the stress distribution of chassis when the force is applied for AISI 4130 in Box type cross section, the maximum stress value obtained is 35.458 MPa

**Figure 14:** Deformation of AA 7068 – C section

The figure 14 shows the total deformation of chassis when the force is applied for AA 7068 in C cross section, the maximum deformation obtained is 8.9515 mm.

**Figure 15:** Equivalent stress (von-mises) of AA 7068 – C section

The figure 15 shows the stress distribution of chassis when the force is applied for AA 7068 in C cross section, the maximum stress value obtained is 102.45 MPa.
The figure 16 shows the total deformation of chassis when the force is applied for AISI 4130 in C cross section, the maximum deformation obtained is 3.1999 mm.

The figure 17 shows the stress distribution of chassis when the force is applied for AISI 4130 in C cross section, the stress value obtained is 102 MPa.

By doing analysis in ansys the following results of total deformation, equivalent stress and weight of the chassis is obtained.

By doing analysis in ansys the following results of total deformation, equivalent stress and weight of the chassis is obtained.
Table 2: Total deformation of chassis (mm)

| Cross sections | Materials  |
|----------------|------------|
|                | AISI 4130  | AA 7068   |
| I section      | 1.8076     | 5.0554    |
| Box type       | 1.4807     | 4.15      |
| C section      | 3.1999     | 8.9515    |

The table 2 and figure 18 shows the total deformation of the chassis in three different cross sections in both materials. From the graph it is clear that the steel alloy (AISI 4130) has lower deformation rate when compared to aluminium alloy. The box type cross section in aluminium alloy has lower deformation when compared to other cross sections in aluminium alloy.

Figure 19: Equivalent stress – von mises

Table 3: Equivalent stress – von mises (MPa)

| Cross sections | Materials  |
|----------------|------------|
|                | AISI 4130  | AA 7068   |
| I section      | 45.06      | 45.544    |
| Box type       | 35.458     | 35.601    |
| C section      | 102        | 102.45    |
The table 3 and figure 19 shows the equivalent stress – von mises on the chassis for different cross section in both materials, it is visible that the steel alloy (AISI 4130) has lower stress distribution when compared to AA 7068, but there is no significant difference.

Figure 20: Weight of the chassis(kg)

| Cross sections | Materials      |                 |
|----------------|----------------|-----------------|
|                | AISI 4130      | AA 7068         |
| I section      | 10477.08       | 3804.9          |
| Box type       | 14121.49       | 5126.8          |
| C section      | 5320.45        | 1931.58         |

The figure 20 and table 4 shows the weight of the chassis, it is noticed that there is more than 50% weight reduction in AA 7068 (aluminium alloy) when compared to AISI 4130.

Conclusion

This paper explains about the design and analysis of chassis using different materials in different cross sections. It is proven that the AA 7068 has higher deformation when compared to AISI 4130, but still AA 7068 can be considered as a suitable replacement for steel alloy (AISI 4130) because it provides us with more than 50% of weight reduction, which will increase the efficiency of the vehicle considerably. Aluminum alloy (AA 7068) with box type cross section can be used as a replacement because it has less deformation (4.15mm) when compared to other cross sections in AA 7068, greater moment of inertia and it will be helpful in wire harness to organise the cables.
Future Scope
In this work, only the static load is taken into consideration and the load is considered to be uniformly distributed. For future works dynamic load can be taken into consideration and varying load distribution must be taken for analysis.

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