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Design and analysis of front axle using Solidworks simulation

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Abstract - *A. Front axle is one of the important parts in the vehicle which carries the weight of the vehicle, facilitates steering and absorbs shock due to irregular road condition. Front axle is designed to transmit the weight of the automobile from the spring of the front axle to front wheels so proper design of front axle is essential. This study describes the design and analysis of front axle. The front axle is deigned in CAD software and analyzed in Solidworks software We have studied the existing scenario of the front axle and analyzed the existing axle with different material using CAD software and Solidworkss simulation. We identified the problems in the axle and recommend the modifications. This front axle is analyzed for three different materials which are AISI 1010 steel, AISI 347 Annealed stainless steel, AISI 316L stainless steel. In this work the performance parameters such as stress, strain and displacement are measured by applying static load. The life cycle and strain value of the axle beam is analyzed.*

Key Words**: Front axle, Solidworks simulation, Modelling, Design improvement, Material optimization.**

1. INTRODUCTION

An auto industry is one of the important and key sectors of the Indian economy. The auto industry includes of automobile sector, auto components sector and includes commercial vehicles, passengers cars, multi-utility vehicles, two wheelers, three wheelers and related auto parts. The demands on the automobile designer increased and altered rapidly, first to meet system safety needs and later to reduce weight so as to satisfy fuel This Economy and vehicle performance requirement.

Engine location important to provide greater stability and safety at high speeds by lowering the centre of gravity of the road vehicles, the complete centre position of the axle is dropper. Front axle is subjected to both bending and shear stresses. In the static condition, the axle might be considered as beam supported vertically upward at the ends (at the centre of spring pads). Front wheels of the vehicles are mounted on front axles. Functions of font axle are listed below:

- It supports the weight of part of the vehicle.
- It facilitates steering.
- It absorbs shocks which are transmitted due to road surface irregularities.
- It absorbs torque applied on it due to braking vehicle.

1.1 Problem Definition

In the four wheel vehicle currently the front axle is subjected to non-uniform loading conditions and subjected to combination of stresses and because of that it is undergoing failure with respect to the desired durability. The front axle of the four wheel vehicle is always in the contact of water and the material used has the poor corrosion resistance. This can be reduced by surface protection methods such as paint.

Due to the irregularities on the road, the poor material selection and design the front axle undergoes failure and hence there is scope of improvisation in the front axle. Because of this reasons it is needed to develop CAD model of front axle and analyzing arm using Solidworkss simulation and testing the same under various non-uniform loading conditions with different material which we can achieve the desired durability.

1.2 Methodology

In this project the stress distribution will be carried out on the front axle by using Solidworkss simulation. For this, 3D modelling of front axle in Solidworkss is done by taking the actual dimensions of the axle. Performed static analysis in Solidworkss software and plot deflection, stresses. Design of front axle is changed by considering geometrical and material parameter to reduce stress and displacement. Best material chosen by comparing the present material and again analysis done with the material which have been chosen with the front axle.

2. CAD Modelling of front axel

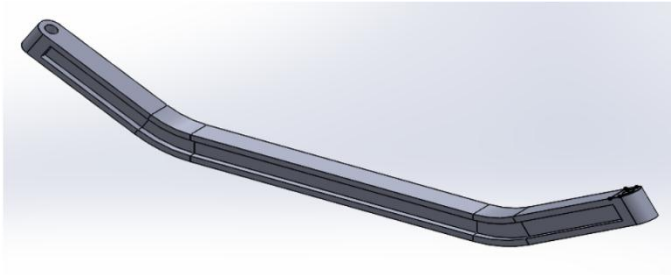


Fig. 3D Model of Front Axle

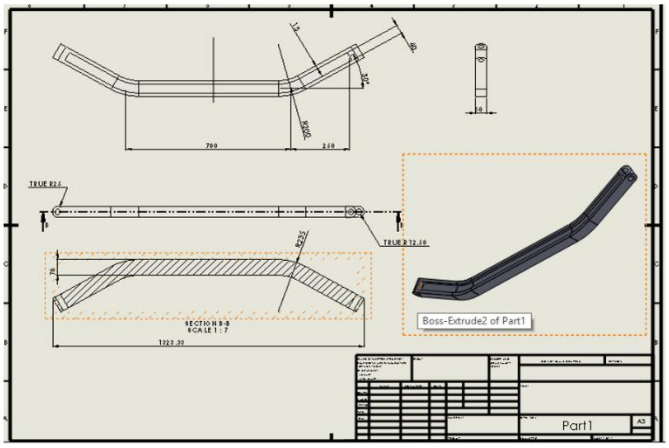


Fig. Drafting Model of Front Axle

2.1 Calculations for weight distribution on front axle

Kerb Weight:850 Kgs

The ratio of weight distribution is F/R:49/51

Weight acting on each front wheel

W=425Kg

Weight acting on individual front wheel is 212Kg. From research papers, Shock absorber and Coil absorbed 41% of front side load,

Therefore,

Load on axle = Front side load X Load absorbs by shock absorber/100

=212Kg X 41% /100

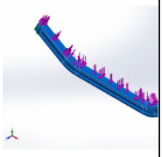
Therefore, Load on axle=38Kg

P=38 X 9.81

=375 N

3. Simulation of Existing Front Axle Model (AISI 1020)

3.1Material properties

Model Reference	Properties		Components
	Name: Model type: Default failure criterion: Yield strength: Tensile strength: Elastic modulus: Poisson's ratio: Mass density: Shear modulus: Thermal expansion coefficient:	**AISI 1020** **Linear Elastic Isotropic** **Max von Mises Stress** **3.51571e+008 N/m^2** **4.20507e+008 N/m^2** **2e+011 N/m^2** **0.29** **7900 kg/m^3** **7.7e+010 N/m^2** **1.5e-005 /Kelvin**	**Solid Body 1(Boss-Extrude2) (FRONT AXLE MODEL)**

3.2Mesh information details

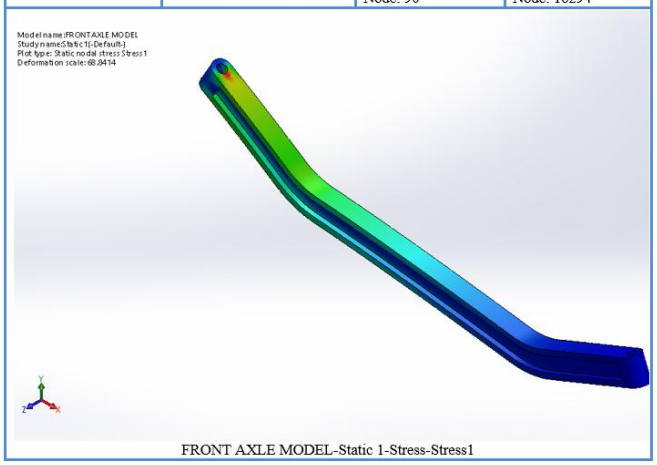
Total Nodes	16519
Total Elements	9364
Maximum Aspect Ratio	3.3941
% of elements with Aspect Ratio < 3	99.9
% of elements with Aspect Ratio > 10	0
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:01

3.3 Study results

1.Von mises stress

The Von Mises Stress at load 375N is obtained in following table

Name	Type	Min	Max
Stress1	VON: von Mises Stress	729.871 N/m^2 Node: 90	38.6860 N/m^2 Node: 16294



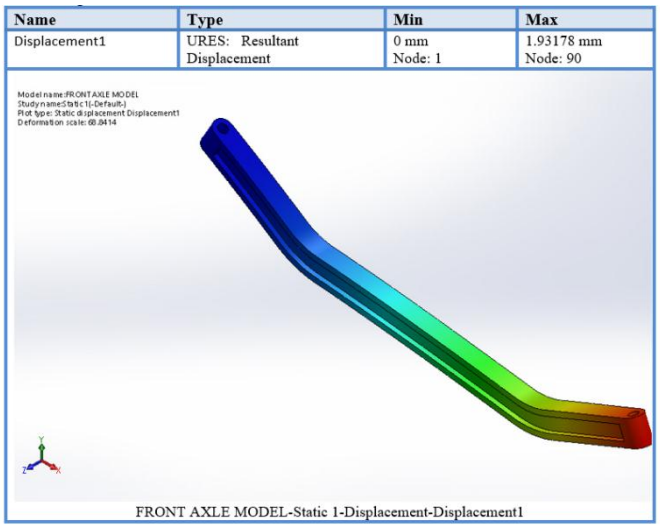
FRONT AXLE MODEL-Static 1-Stress-Stress1

The static stress analysis by selecting Existing Front Axle AISI1020 material is shown in above diagram. Maximum. stress is obtained 38.68 N/mm^2 (MPa). The obtained stress value is huge which causes failure of Existing Front Axle at applied load.

2.Resultant displacement

The Resultant Displacement on existing Front Axle at load 375N is obtained in following table.

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 1	1.93178 mm Node: 90

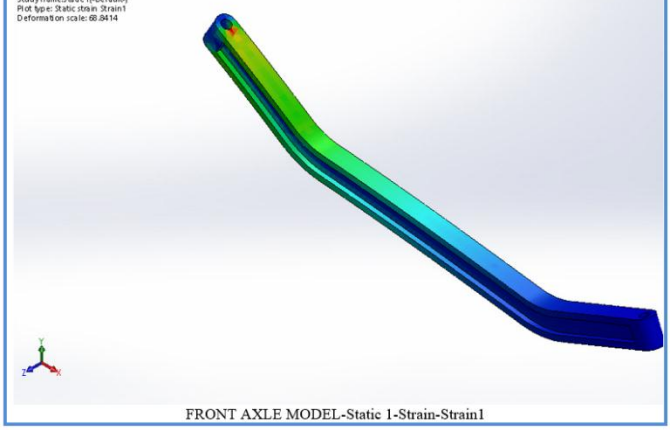


FRONT AXLE MODEL-Static 1-Displacement-Displacement1

The Displacement at load 375N is obtained by selecting Existing Front Axle AISI1020 material is 1.93mm i.e 2mm mm which is more at given load.

3.Equivalent strain

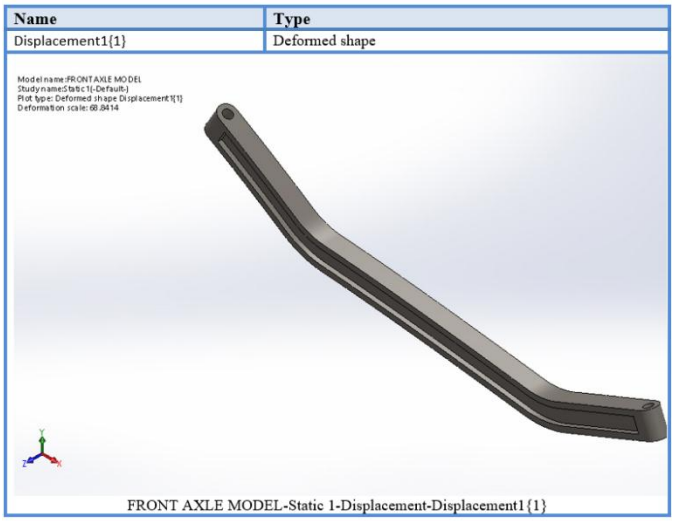
Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	5.19728e-009 Element: 8779	0.000154786 Element: 42



FRONT AXLE MODEL-Static 1-Strain-Strain1

4.Deformed shape

Name	Type
Displacement1{1}	Deformed shape



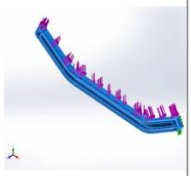
FRONT AXLE MODEL-Static 1-Displacement-Displacement1{1}

4. Simulation of Modified Front Axle Model (AISI 1010 steel)

The existing Front Axle is not safe under non uniform loading due to its geometry and no proper material used. Therefore it is subjected to combination of stresses and undergoing failure w.r.t. desired durability. We have done design optimization and material optimization.

CAD model of Modified Front Axle is created in Solidworkss software. The handle is developed in sheetmetal feature. Following are the modified Front Axle results

4.1 Material properties

Model Reference	Properties	Components
	Name: AISI 1010 Steel, hot rolled bar Model type: Linear Elastic Isotropic Default failure criterion: Max von Mises Stress Yield strength: 1.8e+008 N/m^2 Tensile strength: 3.25e+008 N/m^2 Elastic modulus: 2e+011 N/m^2 Poisson's ratio: 0.29 Mass density: 7870 kg/m^3 Shear modulus: 8e+010 N/m^2 Thermal expansion coefficient: 1.22e-005 /Kelvin	Solid Body 1(Fillet2) (FRONT AXLE MODEL)

Total Nodes	27773
Total Elements	16098
Maximum Aspect Ratio	14.325
% of elements with Aspect Ratio < 3	76.4
% of elements with Aspect Ratio > 10	0.118
% of distorted elements(Jacobian)	0
Time to complete mesh(hh;mm;ss):	00:00:05

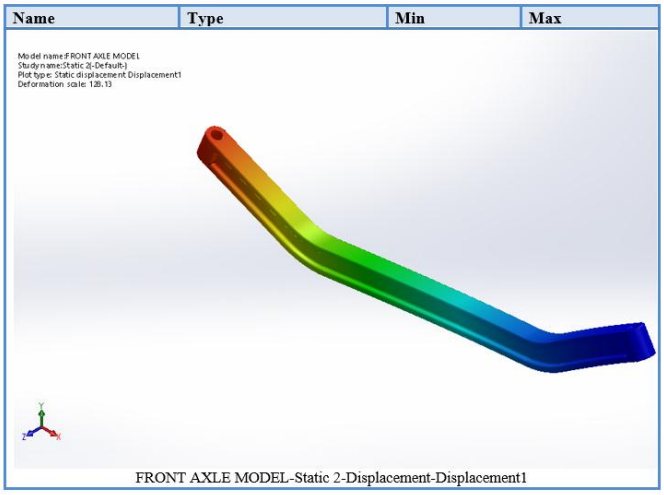
Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.000215863 N/mm^2 (MPa) Node: 27643	30.4131 N/mm^2 (MPa) Node: 27201

The static stress analysis by selecting AISI 1010 Steel material is shown in above diagram. Maximum stress is obtained is 30.4131 N/mm^2 (MPa). Here it is found that design optimization and material optimization there is considerable reduction in stress.

4.2 Resultant displacement

The Resultant Displacement on Modified Front Axle at load 375 N is obtained in following table.

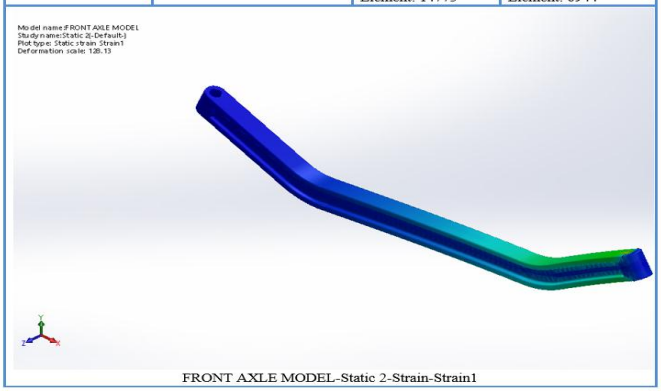
Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 63	1.03603 mm Node: 27643



The Displacement at load 375N is obtained by selecting Modified Front Axle by use of AISI 1010 Steel material is 0.6533 mm which is less at given load. Here it is found that design optimization and material optimization there is considerable reduction in displacement i.e. less displacement of Axle under non uniform load.

4.3 Equivalent strain

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	8.38378e-010 Element: 14773	0.000120188 Element: 6944



FRONT AXLE MODEL-Static 2-Strain-Strain1

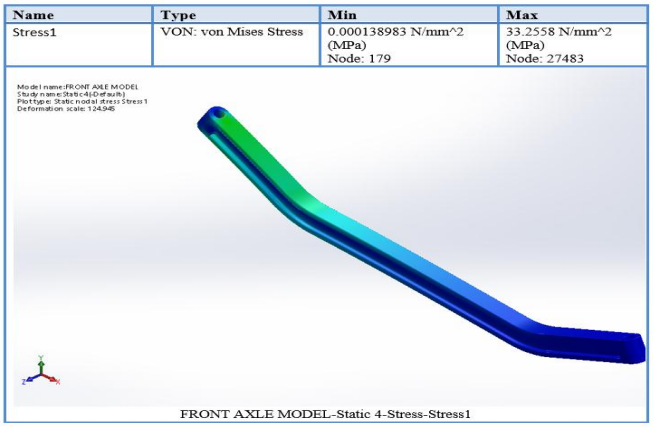
After modification it is found that there is considerable reduction in strain value at non uniform Maximum Equivalent Strain at load 375N is obtained by selecting Existing Handle AISI 1010 Steel material load. The maximum equivalent strain value is 0.000120188.

4.4 Deformed shape

5. Simulation of Modified Front Axle Model (AISI 347 annealed stainless steel)

5.1 Static stress

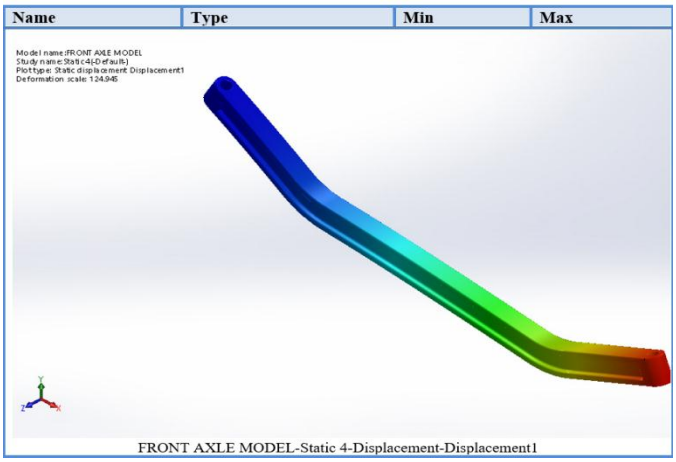
Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.000138983 N/mm^2 (MPa) Node: 179	33.2558 N/mm^2 (MPa) Node: 27483



FRONT AXLE MODEL-Static 4-Stress-Stress1

5.2 Displacement

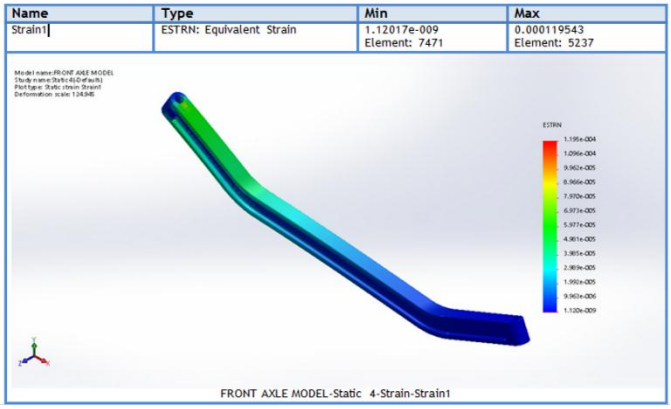
Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 37	1.06245 mm Node: 27578



FRONT AXLE MODEL-Static 4-Displacement-Displacement1

5.3 Equivalent strain

Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	1.12017e-009 Element: 7471	0.000119543 Element: 5237



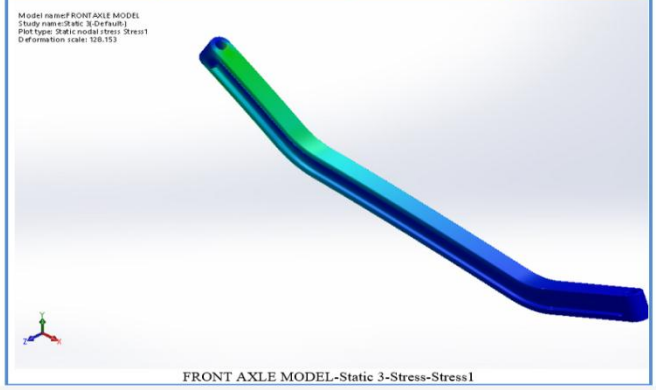
FRONT AXLE MODEL-Static 4-Strain-Strain1

5.4 Displacement

6. Simulation of Front Axle Model (AISI 316L,stainless steel)

6.1 Static stress

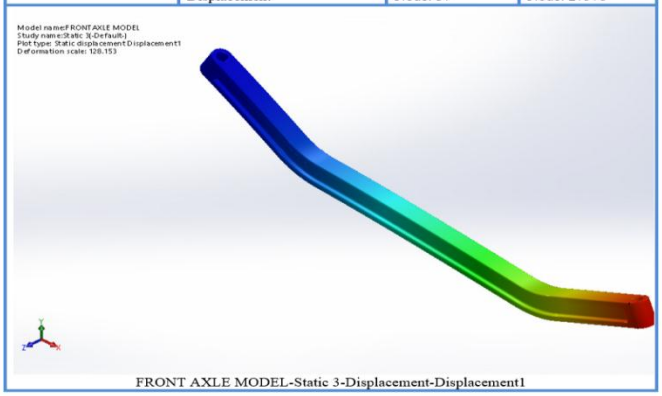
Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.000143313 N/mm^2 (MPa) Node: 179	33.2554 N/mm^2 (MPa) Node: 27483



FRONT AXLE MODEL-Static 3-Stress-Stress1

6.2 Resultant displacement

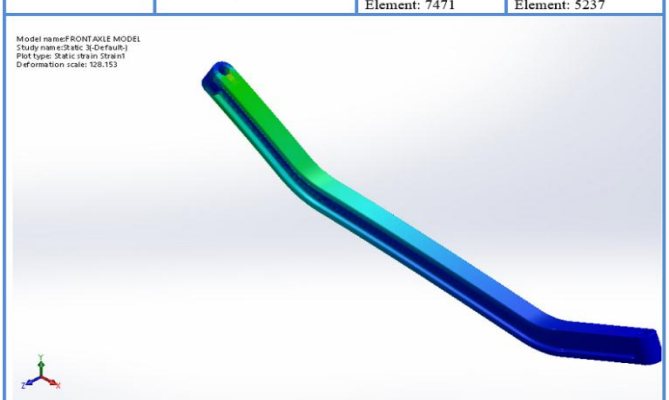
Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0 mm Node: 37	1.03585 mm Node: 27578



FRONT AXLE MODEL-Static 3-Displacement-Displacement1

6.3 Equivalent strain

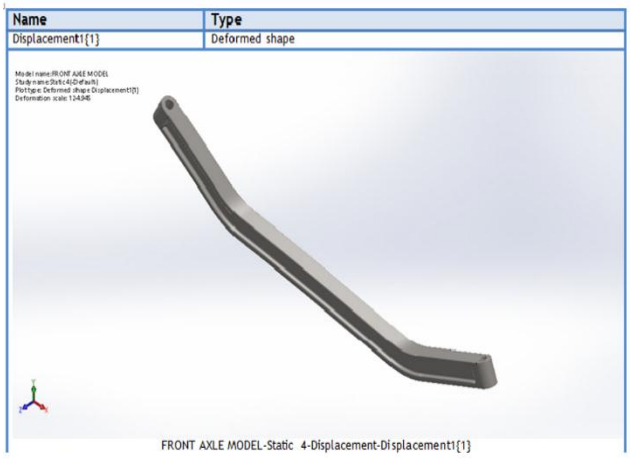
Name	Type	Min	Max
Strain1	ESTRN: Equivalent Strain	1.08829e-009 Element: 7471	0.000116159 Element: 5237



FRONT AXLE MODEL-Static 3-Strain-Strain1

6.4 Deformed shape

Name	Type
Displacement1{1}	Deformed shape



FRONT AXLE MODEL-Static 4-Displacement-Displacement1{1}

3. CONCLUSIONS

1. Existing Front Axle is subjected to non-uniform loading conditions and subjected to combination of stresses and hence undergoing failure w.r.t. desired durability. CAD model of Existing Front Axle is created by selecting AISI 1020 steel and results represented in point number 1. In existing Front Axle model Maximum stress is obtained 38.68 (MPa). The Resultant Displacement is 2mm which is more at given load therefore more deformation of model. The Strain value is obtained by selecting Existing Handle AISI1020 steel material is more 0.0001547. Cost per kilogram of Cast carbon Steel is 85/- which is less but rusting problem.

2. Some design modifications and material optimization have done. The optimization results Stress, displacement, strain and cost are represented in point number 2, 3 and 4, which gives satisfactory results.

From the results it is concluded that the results obtained with new design is best than previous or existing design. So from results it is concluded that the best material used for Front Axle amongst three is AISI 1010 Steel.

Sr. No	Material	Stress	Displacement	Strain	Cost per Kg
1	AISI1020	38.686 N/mm^2 (MPa)	2 mm	0.000154786	150/-
2	**AISI 1010 Steel**	**30.4131 N/mm^2 (MPa)**	**1.03 mm**	**0.000120188**	**115/-**
3	AISI 347 Annealed Stainless Steel	33.25 N/mm^2 (MPa)	1.06 mm	0.000119	200/-
4	AISI 316L stainless steel	33.25 N/mm^2 (MPa)	1.02	0.000116159	175/-

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