Material Selection of Knuckle using Static Analysis Method Under Statically Applied Gross Weight of GO-KART

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Abstract : Steering knuckle is one of the most important component of vehicle which is connected to the stub axle and chassis of the vehicle. It continuously undergoes the static and dynamic loading condition. The report explains about the objectives and assumptions made in designing of a GO-Kart knuckle with best suitable material. The design is chosen such that the knuckle is easy to fabricate in every possible way. SolidWorks has been used for the CAD modeling of above said GO-KART knuckle and static analysis is completed in ANSYS workbench by fixing the knuckle and applying normal reaction in upward direction due to gross weight of the kart. This report documents the process and methodology of selecting the strong and suitable material for knuckle out of three available materials we have i.e. Mild Steel, Stainless Steel & Heat treated Steel. One after another three possible cases of all the available materials of knuckle will be analyzed under the statically applied gross weight of the car and finally strong and safe material for the knuckle shall be selected.

Keywords— Knuckle, GO-KART, Stub axle, Mild Steel, Stainless Steel, Heat treated Steel.

I. INTRODUCTION

A. Background

This report contains project work dependent on analyzing and selecting a material for steering knuckle of Go-kart. As we are probably aware, Go-kart is not a commercial vehicle. Therefore, its knuckle does not have constrained dimension and material for it. There are various material in market, but we will be focusing on Mild Steel, Stainless Steel, Heat treated Steel. This issues can be unraveled by analyzing the candidate material.In this project we are selecting a material for knuckle by comparing the result from candidate material.

B. Problem Identification

- The shape, size and material of the knuckle depend upon the weight of the kart due to vertical loading directly act on it and the lateral force from the stub-axel.
- There are various material available in the market which have their own distinct physical as well chemical properties.
- If proper shape, size and material is not selected it may affect the performance of the kart as well as increase the inventory cost.

C. Title Justification and Purpose

As all the load of vehicle whether the load is static or dynamic is transferred from the tire to the axel connected to knuckle and finally on the chassis making the steering knuckle an important part to be analyzed. There are numerous materials available in the market having different properties and use for different purpose. Due to which it really becomes difficult to choose the best material suitable for the knuckle. Wrong selection of material can lead to bad performance of the knuckle and it can fail increasing the maintenance cost and inventory cost.

To fabricate a knuckle which is strong and flexible enough to take the load of the kart with the passenger. As the title implies "Material Selection of Knuckle using Static Analysis Method Under Statically Applied Gross Weight of GO-KART". It becomes optimal to compare knuckle made of different materials. It can be done applying the gross weight of the kart on the knuckle under static condition.

D. Objective

- Material selection out of three available materials i.e. Mild Steel, Stainless Steel, Heat treated Steel.
- To maximize the knuckle performance under loading condition
- To minimize the maintenance cost and inventory cost.

II. THEORY

Go-kart is a simple four-wheeled vehicle which does not have any suspension, differential [1] and power steering. It has two type of engine category, a light engine which may be of 125cc and a heavy engine which can be up to 250cc.The engine used can be a two stroke or a four stroke single cylinder engine. Go-kart which is used for sport is a single seated kart and has a bucket seat and for amusement purpose may have a single or a double seat.

Steering knuckle usually used in Go-kart has C-cross-section and is connected with the chassis of the kart and the other end to the stub-axel as shown in "Fig 1". The stub-axel is connected to knuckle by the help of king pin. The use of the knuckle is to give support to the stub-axel so that the stub-axel can convert the liner motion from the tie rod into angular motion of the stub-axel [1]. As all the load of vehicle whether the load is static or dynamic is transferred from the tire to the axel connected to knuckle and finally on the chassis making the steering knuckle an important part to be analyzed.

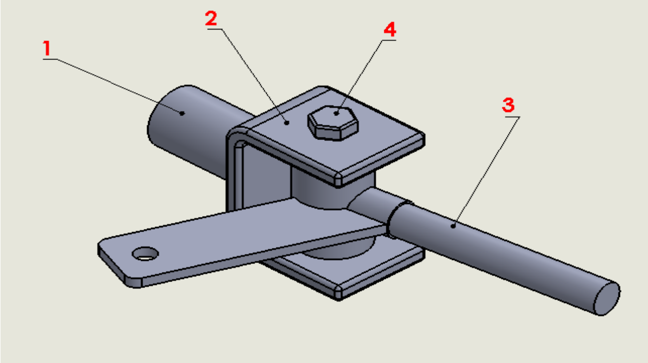

Fig 1: Knuckle Stub-axel assembly

1. Chassis member
2. Steering knuckle
3. Stub-axel
4. King pin

A. Knuckle Material

- Mild Steel
  Mild steel is very strong due to the low amount of carbon it contains. In material science, strength is a complicated term. Mild steel has a high resistance to breakage. Mild steel, as opposed to higher carbon steel, is quite malleable, even when cold.
- Stainless Steel
  Stainless Steel is a metal alloy, made up of steel mixed with elements such as chromium, nickel, molybdenum, silicon, aluminium and carbon. Iron mixed with carbon to produce steel is the main component of stainless steel.
- Heat treated Steel
  Heat treated steel is a type of low, medium to hard plain carbon steel that has undergone heat treatment, quenching and further reheating. Components made of hardened steel have a hard exterior casing and a robust core.

B. Proposed Methodology

The study is divided into three parts. First part will be pre-processing, the knuckle will be designed in Solid Works2014 according to requriment of size of stub-axel and keeping its dimension constant for all the three material which will be tested for. The second part will be processing, by keeping the modal dimension constant one after another material will be selected and apropriate mesh type, element sizing and load will be applied in ANSYS WORKBENCH 19.1. Third part is post processing part, in which result obtain for all the three material will be compared and approriate material will be selected.
Several methodologies are used to design by certain define process. As discussed in introduction, diffferent material will be used for the given desing. To resolve the problem which are observerd with the help, a new method is proposed to resolve all the discussed problems. The following chart shows the step which are followed. As shown in figure 2.

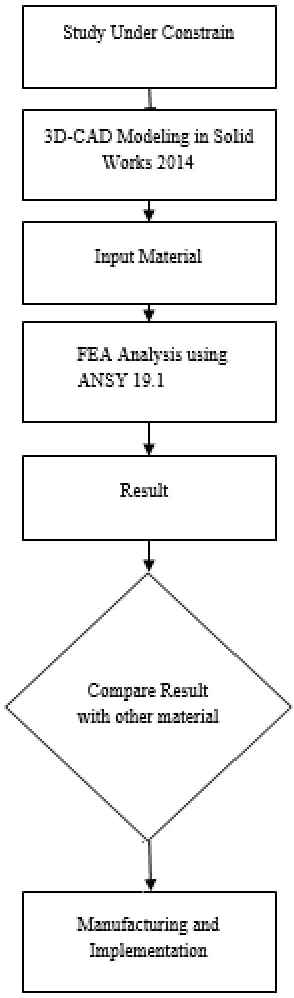

Fig 2:Flow chart

C. Measurement

Table 1

Thickness	8mm
Width	48mm
Height	70mm

Table1: Dimension of knuckle

D. Standard

Table 2

Properties				
Quantity	**Value**			
Material	*Mild steel*	*Stainless Steel*	*Heat Treated Steel*	*Units*
Density	7850	7900	7850	Kg/m^3
Ultimate Tensile Strength	460	546	440	MPa
Yield Strength	250	243	329	MPa
Young's Modulus	210	198	210	GPa
Poisson ratio	0.3	0.27	0.29	-

Table 2: Properties of material

III. RESEARCH

A. Modeling

3D-CAD model of knuckle was made in Solid Works 2014. It consists of Stub-axel mounting and chassis mounting. Knuckle design depends upon Stub-axel geometry.

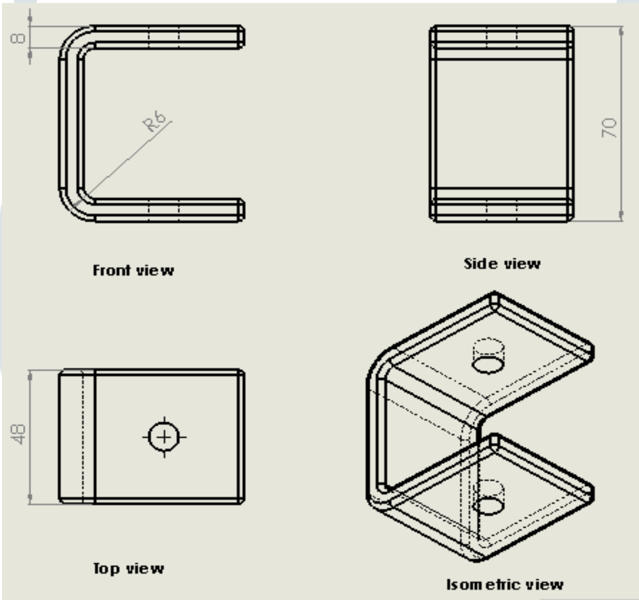

Fig 3: 3D-CAD model of knuckle

B. Calculation

- Static condition

This type of load is acted on the vehicle when the vehicle is not in motion. When the vehicle sits statically on level ground, the load equations simplify considerably. The sine is zero and the cosine is one, and the variables Rhx• Rhz• ax, and D A are zero. Thus. It is given by following equation [6]

$$W_{fs} = W\left(\frac{c}{L}\right) \quad (1)$$

$$W_{rs} = W\left(\frac{b}{L}\right) \quad (2)$$

Where,

W_{fs} = Weight acting on front wheel

W_{rs} = Weight acting on rear wheel

c = Distance from C.G of vehicle to rear wheel

b = Distance from C.G of vehicle to front wheel

L = Wheel base

- Assumption

Wheel base =1040mm [7]
Gross weight of kart=160kg
Weight distribution=43 percent at front and 57 percent at rear wheel of 160 kg
By theoretical calculation C.G location was calculated to be 447.2mm from rear wheel
Weight on front wheel

From equation 1

$$W_{fs} = 160\left(\frac{447.2}{1040}\right)$$

$$W_{fs} = 68.8\ kg$$

Force = 68.8*9.81
Force = 674.928/2
Force = 337.464 N

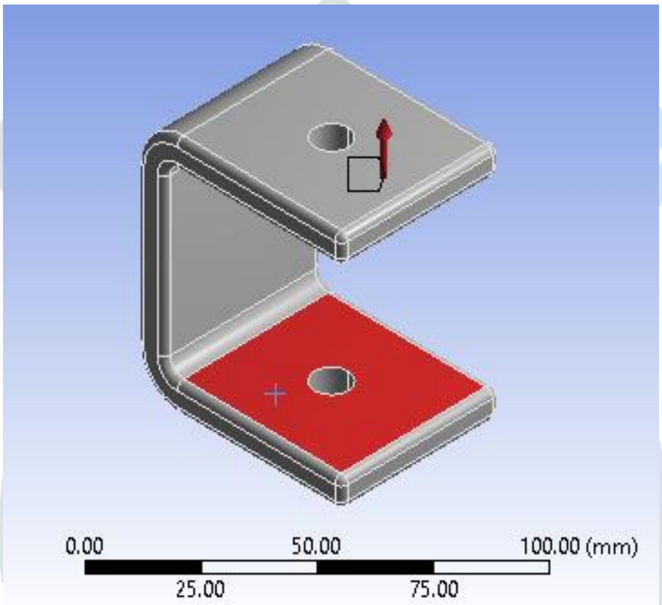

Fig 4: Direction and place where load is acting

C. Mesh Setup and Analysis

Candidate material is selected one after another then the geometry is imported. Knuckle is constrained and load of 337.464 N is applied in positive Y direction after selecting suitable mesh which is hex dominant type and element size. ANSYS WORKBENCH 19.1 is used to analysis the component. Mesh model is shown in “Fig 5”.

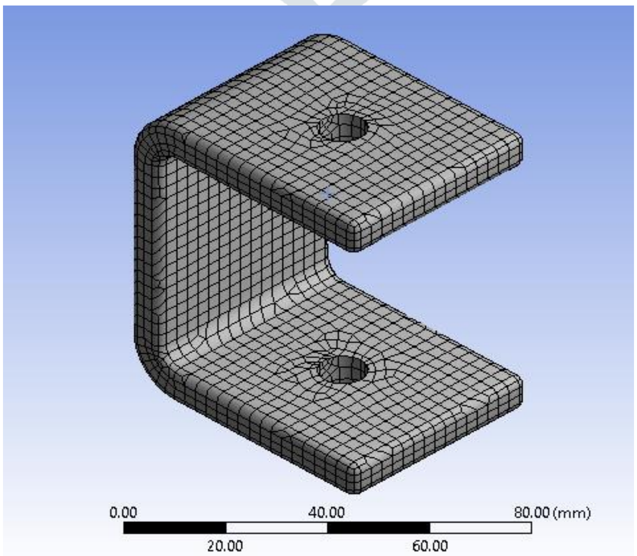

Fig 5: Mesh quality

Table 3

No of Nodes	21991
No of element	5496
Element size	3mm

Table 3: Quality of mesh

The analysis result for different material candidate are shown in figures which are given below.

- **Mild Steel**

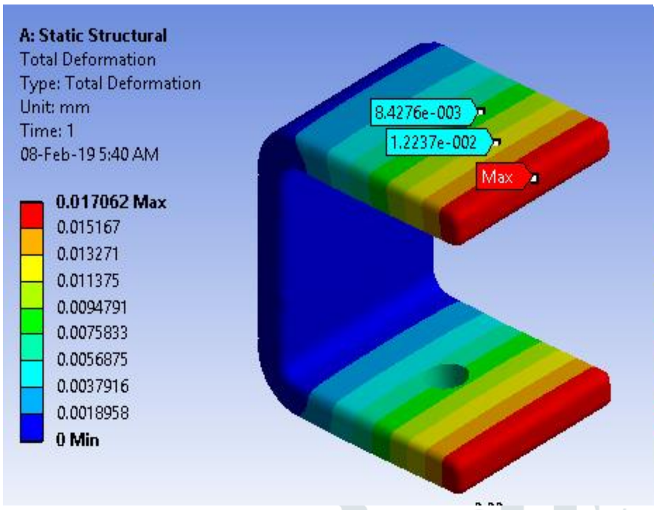

Fig 6: Total deformation

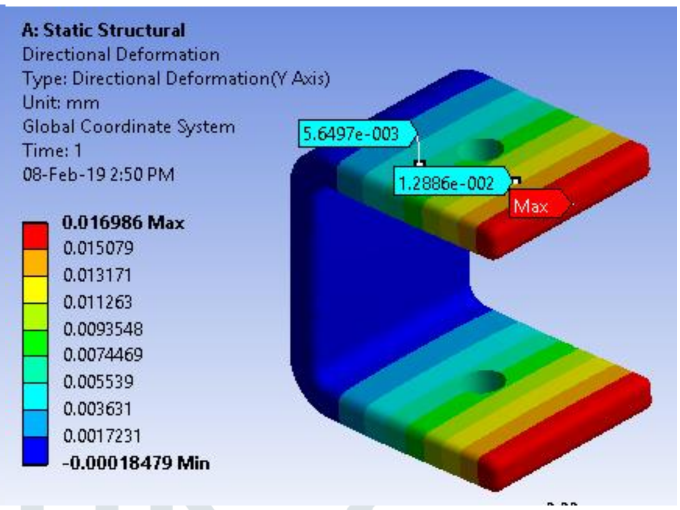

Fig 7: Directional deformation

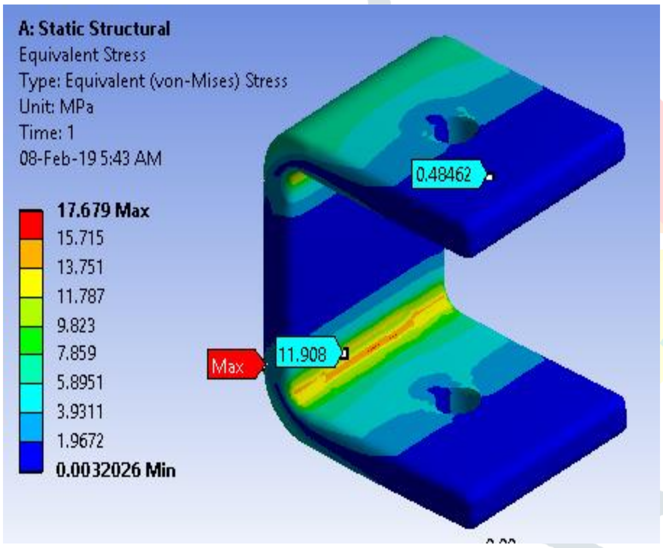

Fig 8: Equivalent (von-Mises) stress

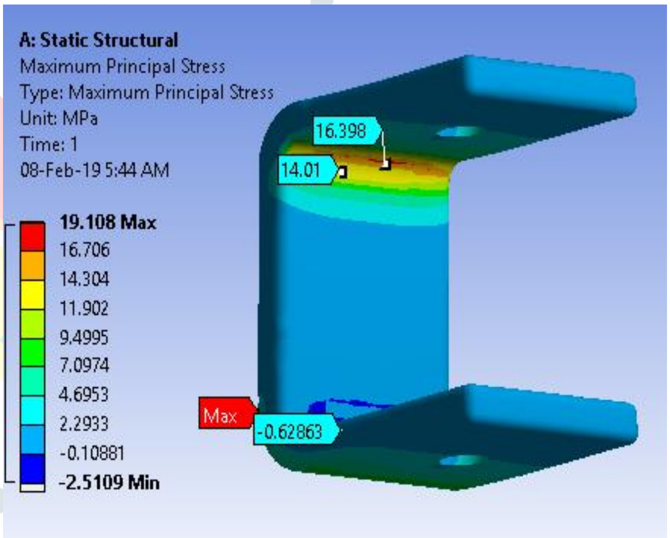

Fig 9: Maximum principal stress

- **Stainless Steel**

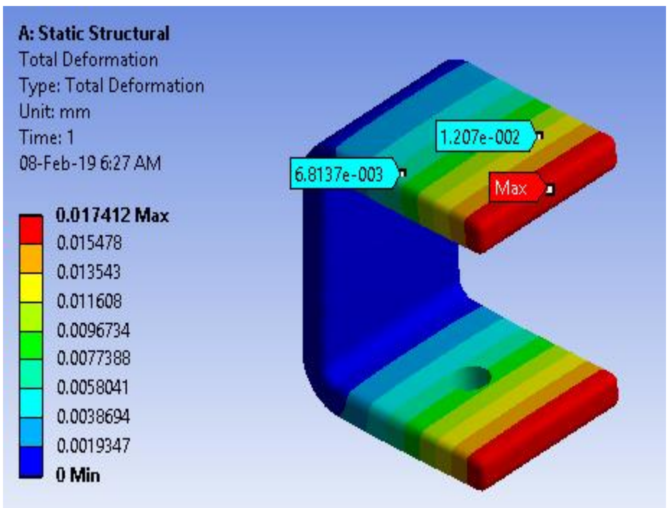

Fig 10: Total deformation

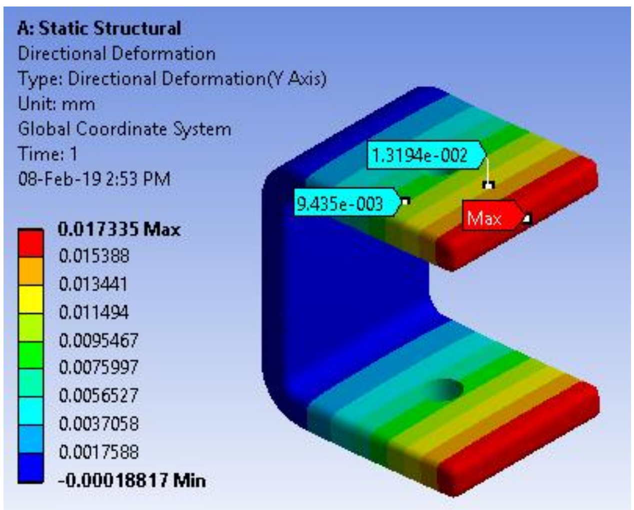

Fig 11: Directional deformation

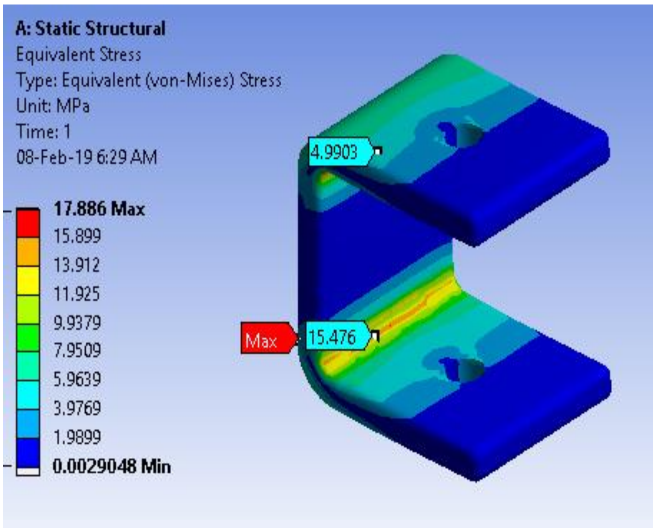

Fig 12: Equivalent (von-mises) stress

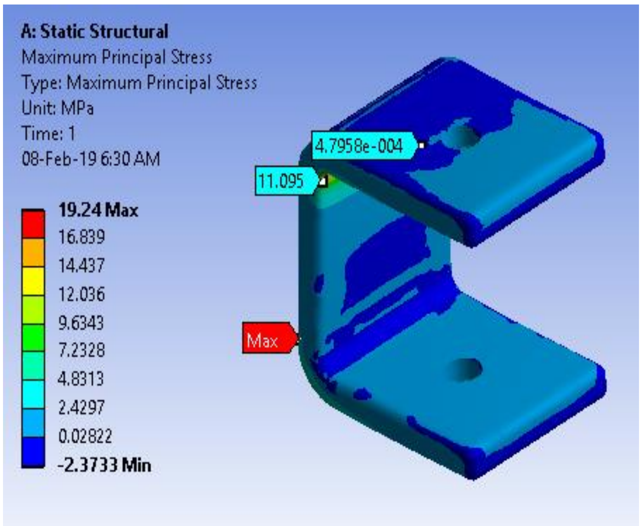

Fig 13: Maximum principal stress

- **Heat treated steel**

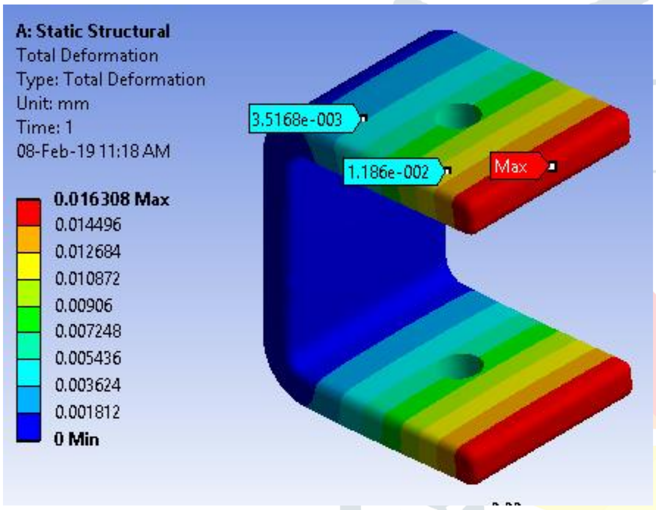

Fig 14: Total deformation

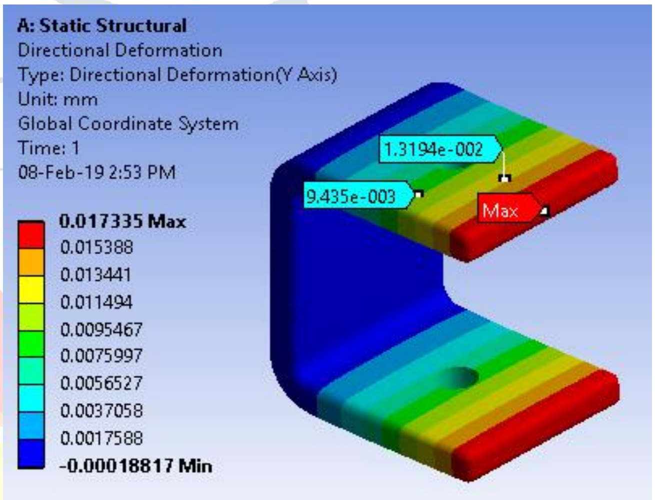

Fig 15: Directional deformation

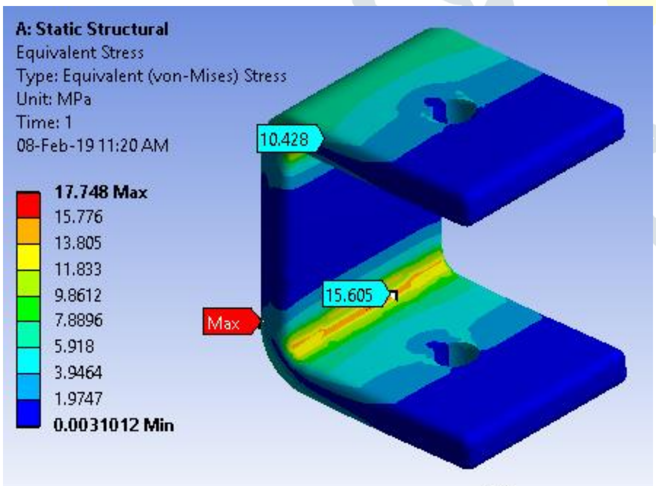

Fig 16: Equivalent (von-mises) stress

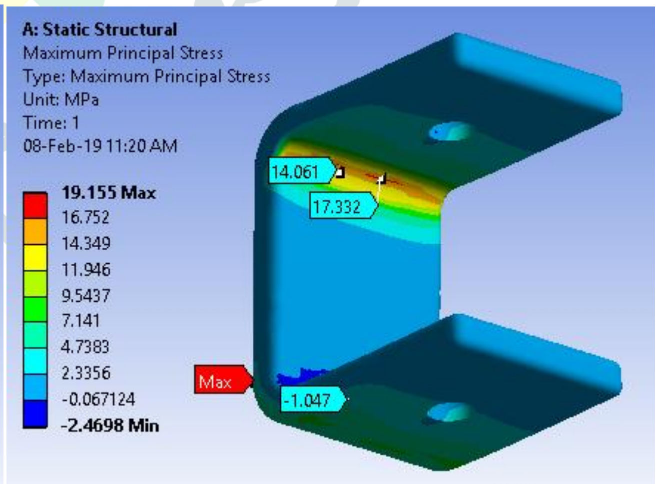

Fig 17: Maximum principal stress

IV. RESULT

A. Observation Table

Material	Total deformation	Directional deformation	Maximum von-mesis stress	Maximum principle stress
Mild steel	0.017062 mm	0.016986 mm	17.679 MPa	19.108 MPa
Stainless Steel	0.017412 mm	0.017335 mm	17.886 MPa	19.24 MPa
Heat treated Steel	0.016308 mm	0.017335 mm	17.748 MPa	19.155 MPa

Table 4: Result of all the three material

B. Findings and new learning

Steering knuckle model with three candidate material i.e. Mild Steel, Stainless Steel, Heat treated Steel were analyzed. Result are shown in table 4.

All the three material were compared with each other and we found that Mild Steel and Heat treated steel had approximately equal reading under same loading condition.

Thus we decide to go with Mild Steel, as it is easily available, easy to work with and cheap in cost compared to Stainless Steel and Heated treated steel.

V. CONCLUSION

The steering knuckle was modeled using Solid Works2014 and was analyzed in ANSYS WORKBENCH 19.1. By studying under constrain and following the methodology we were successfully able to analysis and compare all the three material taken into consideration i.e. Mild Steel, Stainless Steel and Heat treated steel and select the optimum material for knuckle which is mild steel.

This report also shows the area where Stress concentration is maximum due to static loading condition.

VI. FUTURE SCOPE

- Optimization of knuckle dimension can reduce the weight and material resource and even can improve performance of kart.
- New and better methodology can be developed for the analysis and refinement of mesh can be done.
- Analysis considering dynamic condition can be done to check for failure in dynamic loading condition.

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REFERENCES

[1] Avinash Barve,Vivek Gurve,Gaurao Tapre,Arvind Totey, "Detailed Design calculation & Analysis of Go-Kart Vehicle," JETIR,ISSN2349-5162 ,2018

[2] B.Babu, M. Prabhu, P.Dharmaraj, R.Sampath, "Stress analysis on steering knuckle of the automobile steering system," vol:3., Issue3,ISSN:2319-1163, March 2014, pISSN:2321-7308.

[3] Sanjay Yadav, Ravi Kumar Mishra, Varish Ansari, Shyam Bihari lal, "Design and Analysis of Steering Knuckle component,"ISSN:2278-0181, vol 5, Issue 04,April 2016.

[4] J.Adamczyk, A. Grajcar, "Heat treatment and mechanical properties of low carbon steel with dual phase microstructure,"Journal of Achivement in Materials and Manufacturing , vol 22, Issue 1, May 2007 .

[5] Swapnil R. Nimbhorkar, B.D. Deshmukh "Effect of case hardening treatment on the structure and properties of automobile,"International Journal of Modern Engineering Research (IJMER), vol 3, Issue 2,March-April 2013, pp637-641.

[6] Thomas D. Gillespie, Fundamentals of Vehicle Dynamics Society of Automotive Engineers Inc. Publication.

[7] ISK-FMSCI technical regulation

[8] www.softschools.com

[9] https;//science.com//properties-hardened steel-6301296.html