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Comparative study of Stainless Steel and Aluminium Alloy for static structural analysis of quick release coupling used in the steering system

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ABSTRACT

The paper presents the design and analysis of Quick release coupling. Finite element analysis is used to evaluate the performance under severe turning of steering wheel conditions by comparing two materials. Aluminium Alloy and stainless-steel are used as quick release materials. DS SolidWorks 2020 and ANSYS 19.2 is used to design and carry out the analysis for determining the distribution of forces, variation of stresses and deformation across the quick release. Most reliable and efficient material of quick release coupling which are required in FSAE competitions is determined. A static structural analysis has been carried out using the axis symmetric finite elements. To get appropriate results the model is divided into discreate elements, so that the forces are applied effectively in each region.

Keywords— *Quick release coupling, Aluminium Alloy, Stainless steel, SolidWorks, Ansys*

1. INTRODUCTION

Quick releasing coupling can be used for the fast connection and disconnection of devices. These couplings are available both with and without mechanically unlock able non-return valve.

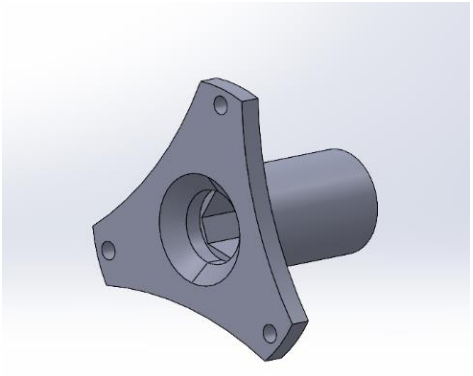
In this the lever and spring is in the base of the steering wheel, and a female receptacle on the end of the steering column. By pulling the lever towards the driver, the spring is pushed downwards, pushing the wheel forward while releasing the latch. Pulling the lever forward requires only one hand and can be done without having to reach behind the wheel.

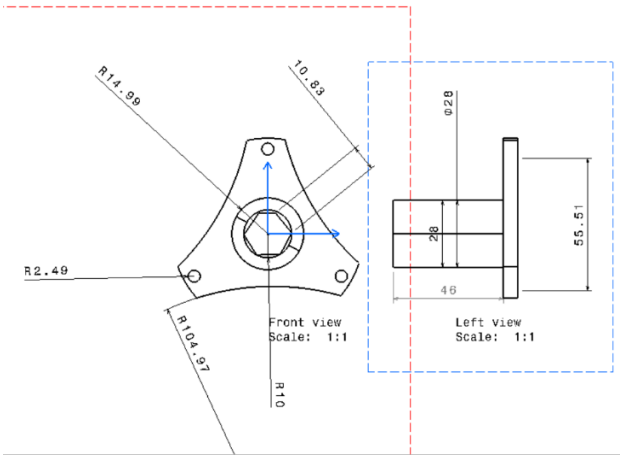
The hub allows the steering wheel to be removed from the steering shaft with the push of a button or the lifting of a collar. Used on racing and competition vehicles, the rapid-release steering wheel is used to aid a driver's entrance and exit from the tight confines of the racing cockpit as well as aid in the easy removal of an injured driver by safety personnel. Typically offered in one of two designs, a hexagonal or splined hub, the steering wheel is also offered in steel or lightweight aluminium for most three-bolt steering wheel mounting patterns

This increases the usability of the quick release. This also increases the complexity and weight of the release mechanism. The involuted spline design of the steering wheel quick release mechanism incorporates a master spline that allows both perfect orientation and alignment. It is designed such that the steering system does not have its excess weight on the car. This increases its durability.

It is used for safety of the driver during racing/driving. The quick release coupling is ejected immediately at the time of emergency during cornering or when the car is at high risk of engine failure or any other destruction during driving. These are essential components in connecting or disconnecting any mechanical lines.

2. DESIGN





3. METHODOLOGY

A replica model of the Quick Release was created in DS Solidworks 2020 software. We analysed its performance virtually in the CAD software.

1. Considering the calculations and dimensions of the quick release, a model was created.
2. Assignment of material was given.
3. Saving the file as a STEP file or IGES file using .stp and .igs file format.

The part is now analysed in the Analysis software. Here we are using the Ansys 19.2 version.

1. We first open the Ansys workbench and select the static structural analysis option
2. Material is assigned using the engineering data option. Structural steel being the default material we change it by selecting the stainless steel and aluminium alloy material from General Material category.
3. Geometry is imported
4. Meshing is done using different meshing options, respective of the orientation
5. In static structural, we have applied pressure, fixed support, and rotational velocity.
6. In the solution, we solved the geometry for total deformation, equivalent stress, and safety factor.

4. MATERIALS

4.1 Aluminium Alloy

Grey Cast Iron is an alloy of Carbon and Iron. With addition of Small amounts of Silicon, Phosphorus, Manganese and Sulfur. It has high compressive strength and is highly resistant to deformation. It can be remould into complex structures and low cost. It is one of the most widely used alloys.

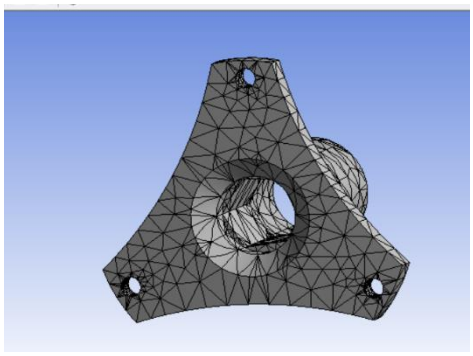
4.2 Stainless steel

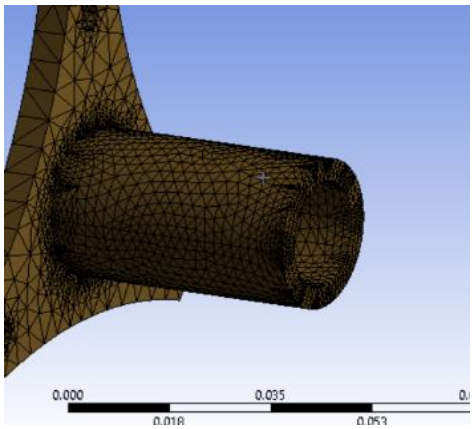
Stainless steel is selected primarily for their heat resistant and corrosion properties. All stainless steels contain principally iron and a minimum of 10.5% chromium. At this level, chromium reacts with oxygen and moisture in the environment to form a protective, adherent, and coherent, oxide film that envelops the entire surface of the material. The passive layer on stainless steels exhibits a truly remarkable property: when damaged (e.g., abraded), its self-repairs as chromium in the steel reacts rapidly with oxygen and moisture in the environment to reform the oxide layer.

Material	Stainless steel	Aluminium alloy
Density	7750 kg/m³	2770 kg/m³
Young's modulus	1.93e+11 Pa	7.1e+10 Pa
Thermal conductivity	15.1 W/m·°C	148.62 W/m·°C
Specific heat	480 J/kg·°C	875 J/kg·°C
Tensile yield strength	2.07e+08 Pa	2.8e+08 Pa
Tensile ultimate strength	5.86e+08 Pa	3.1e+08 Pa

5. MESHING

Meshing is basically division of the model into discreate fragments. It helps in identifying the forces, deformation, various physical and thermal properties acting on a particular area of the part. It serves accuracy, convergence, and speed of the solution. All these factors depend on type of mesh we apply on the model. More accurate the mesh is on area more accurate will be the solution. And we will get more précised values as results. The type of mesh considered here is tetrahedron mesh on the front face where the moment is applied, and the shaft is refined. Refinement increases accuracy of the solution.





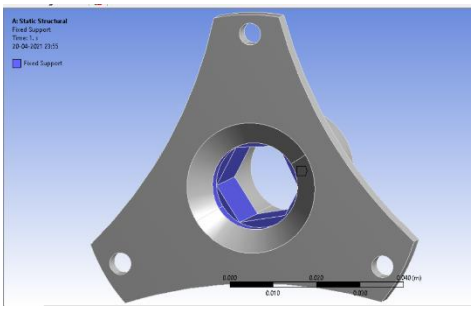
Element Order	Linear
Transition	Fast
Span Angle Center	Fine
Initial Size Seed	Assembly
Bounding Box Diagonal	0.42769 m
Average Surface Area	7.308e-004 m²
Minimum Edge Length	6.0402e-006 m
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Nodes	61529
Elements	220278
Method	Tetrahedron

6. ELEMENTS OF THE STATIC STRUCTURAL ANALYSIS

Three types of elements such as fixed support, moment and force has been applied to the model. These factors come into consideration when forces are applied on the steering wheel.

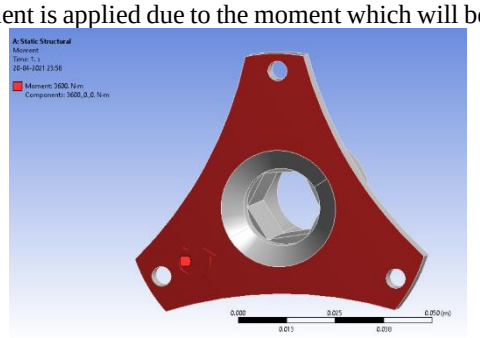
(a) Fixed Support

There is fixed support which is applied on the inner part of the coupling which is assembled to the shaft of the bearing shaft.



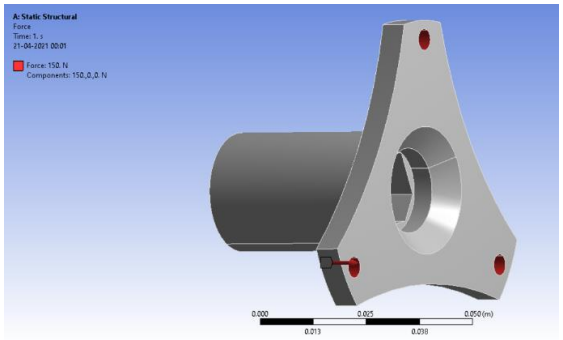
(b) Moment

The Moment is applied due to the moment which will be applied.



(c) Force

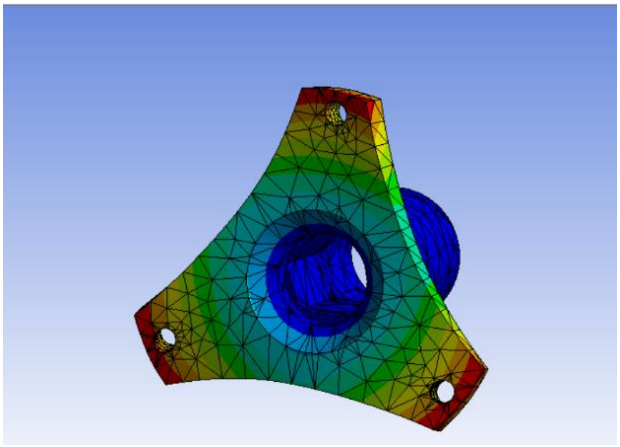
As the wheel moves the brake disc which is aligned to the hub also moves hence it retains a rotational velocity along its axis.



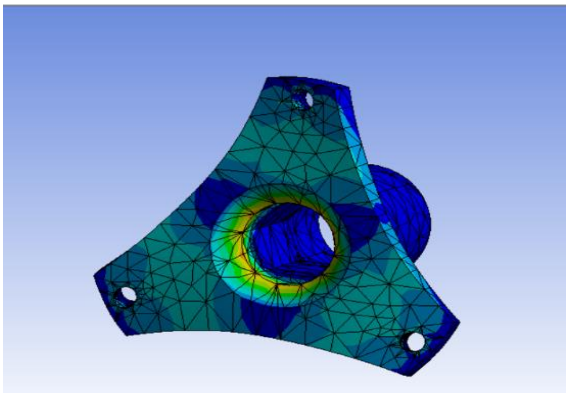
7. SOLUTION

Due to various elements applied on the quick release, it tends towards the total deformation, stress is applied of stainless steel and Aluminium alloy material, respectively.

7.1 Stainless steel

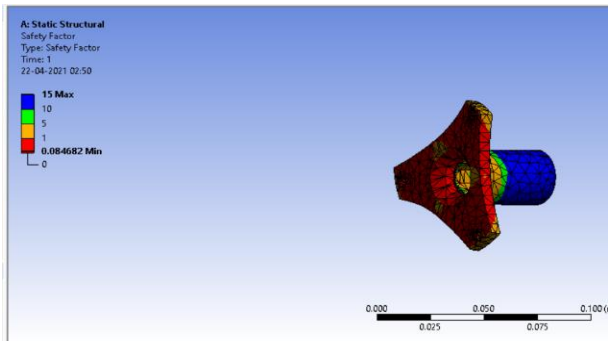


Total deformation



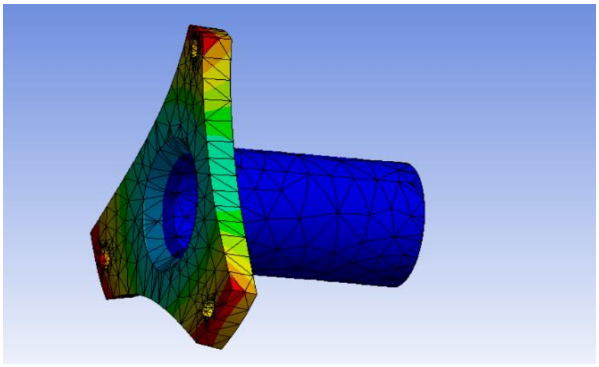
Equivalent stress

	Total deformation	Equivalent stress
Minimum	0. m	15.519 Pa
Maximum	1.0297e-003 m	2.4402e+009Pa
Average	3.7729e-004 m	3.326e+008 Pa

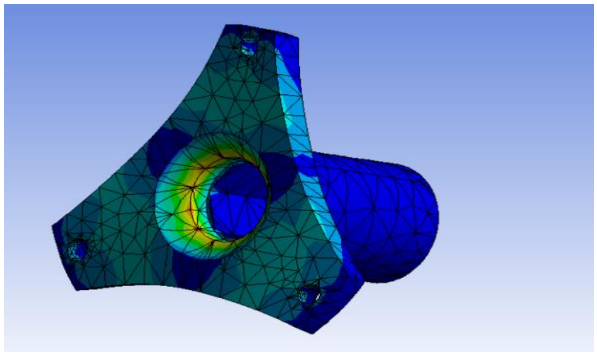


Safety factor

7.2 Aluminium alloy

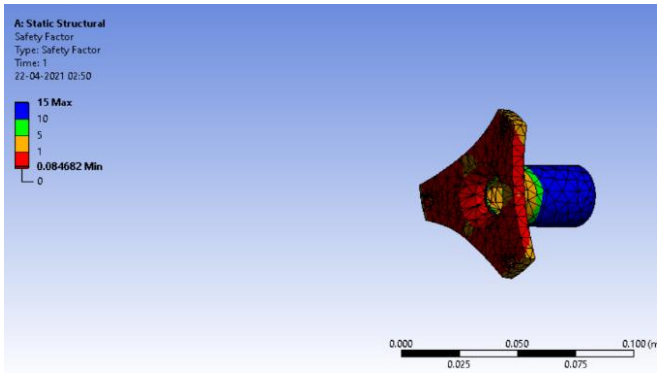


Total deformation



Equivalent stress

	Total deformation	Equivalent stress
Minimum	0. m	15.567 Pa
Maximum	3.7432e-004 m	2.4444e+009 Pa
Average	1.37e-004 m	3.3277e+008 Pa



Safety factor

8. CONCLUSIONS

Aluminium quick connect couplings are lightweight and resist corrosion. Aluminium fittings are generally more affordable than other metal quick-connect couplings, but are more susceptible to scratches

Stainless steel quick connect fittings are in high demand due to their resilience and durability when exposed to and handling caustic chemicals and other potentially corrosive fluids, oils, and gases. If you are looking for the best in pressure ratings, high temperature functionality and corrosion resistance, look to stainless steel quick connect fittings.

9. ACKNOWLEDGEMENT

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10. REFERENCES

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