iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 Issue: I Month of publication: January 2022

DOI: https://doi.org/10.22214/ijraset.2022.40054

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue I Jan 2022- Available at www.ijraset.com

Design, Analysis and Simulation of Halo System

Rohit Jadhav
Undergraduate from University of wolverhampton

Abstract: The Federation Internationale de L'Autobile (FIA) has been working on improving safety of drivers in open wheel racing series. Numerous incidents caused serious impacts on drivers' lives. The car-to-car collision, car to environment collision and injuries due to flying debris are common threats to these drivers. In 2016 the introduction of Halo surrounding the cockpit was appreciated by the FIA. The following study includes the design and analysis of this Halo system using FEA. The designing is carried out using Onshape 3D modelling software and its dynamic, static and modal analysis is done with the help of Simscale software. The results showed the values under permissible levels.
Keywords: Halo system, F1 Racing Halo, Crash analysis, Simulation of Halo, Head Protection in F1 race, Drivers safety system.

I. INTRODUCTION

Safety is paramount in motorsports. For years' motorsport has had serious incidents affecting the drivers. The FIA had no choice but to strive to minimize the risk of drivers' lives. The engineers came up with a solution with the Halo concept. It got its name from its resemblance to angel's Halo. Halo safety system protects the driver's head from external injuries. Without a halo, the driver's head is exposed to external flying debris which could be fatal in some incidents.
Halo is designed for open-wheel racing series vehicles. It is a curved bar placed around the driver's cockpit. It is connected to the vehicle frame via three points.

There are three parts of Halo,
1) the front middle section called as 'V transition',
2) the tube around the cockpit and
3) rear mounts. The design provides the teams 20 mm area of freedom for other modifications. The tests of the halo design were carried out in 2016 and 2017 and the FIA made it mandatory on every vehicle from the open-wheel racing series in 2018.

The tests of FIA for Halo consists of three types –
a) collision between two vehicles,
b) contact between a vehicle and the surrounding environment, and
c) collisions with vehicles and debris.

A test known as the chassis homologation test is carried out by applying loads from different positions on Halo. In the test, a 116kN of force is applied on top of the Halo and expected to withstand the force for at least 5 seconds. It must withstand longitudinal forces of 46kN and 83kN on the front. aside lateral force of 93kN is applied. The Halo has to withstand 125kN of force from above for 5 seconds without failure of any components and also from the side it should withstand the same. The Halo is made from Titanium and weighs around 7 kg. Unlike manufacturing the vehicle parts and other components by the teams, Halo is chosen by the FIA to be manufactured by three external manufacturers, which are CC Autosport, SS Tube Technology, and V system. Adding Halo adds different challenges for teams such as weight challenge, aerodynamic challenge, structural challenge, etc. In the studies of FIA, it was found that the addition of a halo would protect the driver 17% of the time than 0% without a halo.
The material used for the manufacturing of Halo under the regulations of FIA is Ti6Al4V Grade 5, a Titanium alloy. This material is used in aerospace engineering due to its high strength and stiffness yet low-density characteristics. The material has excellent corrosion resistance and is heat treatable in sections up to 25mm. The mechanical properties of this material are given below in the tabular form.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue I Jan 2022- Available at www.ijraset.com

II. BACKGROUND INFORMATION

The FIA reviewed three basic scenarios over the course of its development: collision between two cars, impact between the vehicle and the atmosphere (e.g. barriers), and car and debris collisions. Halo-system tests have demonstrated that the chance of driver injuries will dramatically be reduced. In certain situations, when testing for several previously existing injuries, the device was able to prevent a helmet from contacting the shield. The FIA reviewed three basic scenarios over the course of its development: collision between two cars, impact between the vehicle and the atmosphere (e.g. barriers), and car and debris collisions.

Figure 1 (How halo save driver's head during crash)

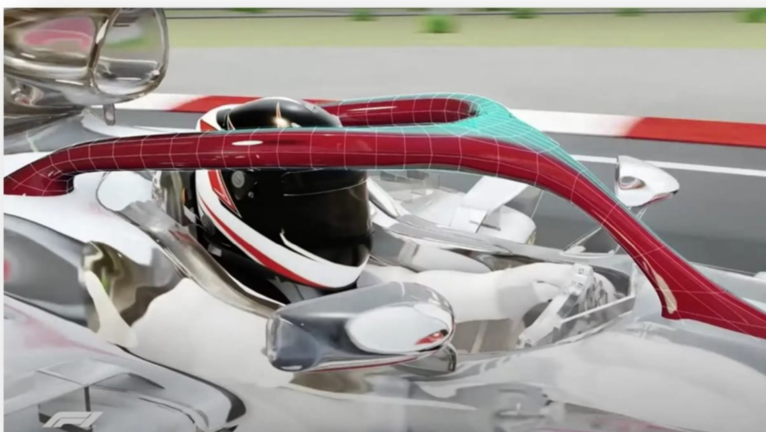


Figure 2[Design of halo]

Halo-system tests have demonstrated that the chance of driver injuries will dramatically be reduced. In certain situations, when testing for some previously existing injuries, the device was able to prevent a helmet from contacting the shield. During the last case study, it was observed that the halo could deflect large objects and provide more protection from smaller waste.

The Dallara F2 2018 was launched in August 2017 and the new Formula 2 car was the first to install the halo system. In January 2018, the SRT05e Formula E had a halo. The FIA Formula 3 car was also installed by the halo in November 2018 and was unveiled in Abu Dhabi.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue I Jan 2022- Available at www.ijraset.com

III. DEFINITION

The HALO is a driver crash protection system that is used in Formula racing cars, it is a curved bar placed around the driver's head to protect the driver's head during a race crash.

IV. LITERATURE REVIEW

[1] The *Fédération Internationale de l'Automobile* recently mandated the use of the halo frontal cockpit protection system to mitigate the risk of impact to the driver's head. Here we describe the effect of a halo-type structure on the neck muscle activity of one of the authors, who is a national-level amateur racing driver, during a full qualifying session. We found that the workload of sternocleidomastoid increased and the workload of cervical erector spinae decreased with the halo fitted which is indicative of a forward head position. Left sternocleidomastoid and right cervical erector spinae fatigued more rapidly; whereas, left cervical erector spinae fatigued more slowly. There was no change in the rate of fatigue of right sternocleidomastoid. In combination with a forward head position, this suggests an increase in lateral flexion during head rotation which may affect accuracy of navigation. Thus, drivers may need to be trained to adapt to the halo to mitigate the effects on head position and movement.

V. OBJECTIVES

Design, Halo system analysis and simulation to determine the impact of a crash during a race on Halo. Multiple analyses of various regions of the halo will be performed in order to understand the halo's status under different circumstances.

VI. METHODOLOGY

This study was conducted to better understanding of halo system's architecture, Function and interpretation. Using Onshape 3D software a 3D model for FEA is developed with tools like line, arc and features such as extrude.

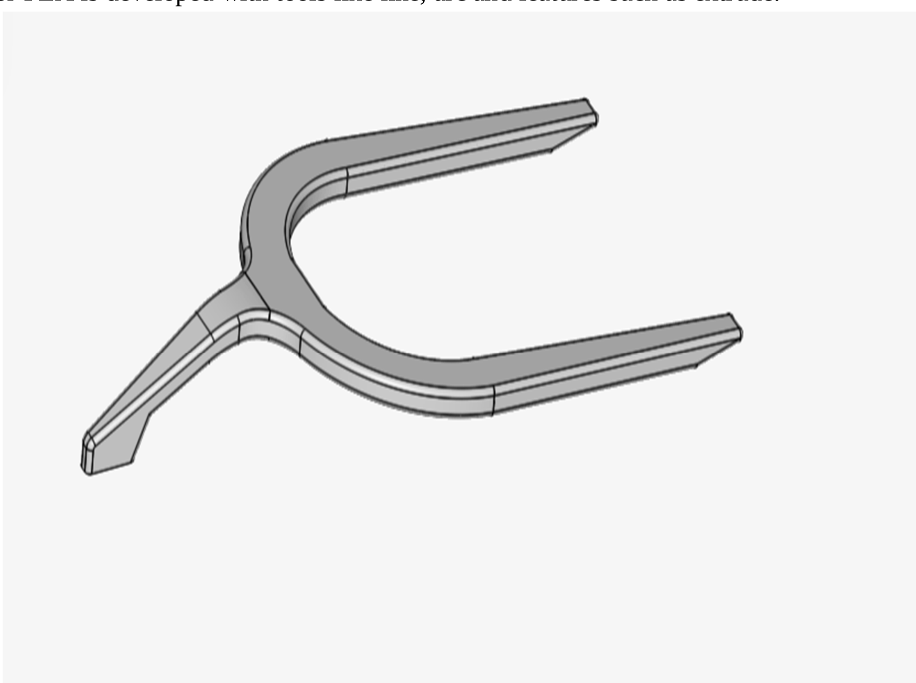


Figure 3(Proposed Design of Halo)

The input values needed for FEA are calculated and noted. The model is then imported in Simscale software. Then Several analyses done on halo.

1) *Model analysis*
2) *Dynamic analysis*
3) *Static analysis*

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue I Jan 2022- Available at www.ijraset.com

A. Frequency Analysis

a modal analysis is carried out. Modal analysis helps identify natural frequencies and modal shape of the system. It also helps in predicting dynamic behaviours of a system. The Halo set for modal analysis provided the maximum displacement magnitude.

First of all imported Halo geometry into simscale from Onshape. Then selected material according to research i.e Titanium.

Select Material behavior as linear elastic, (E) young's Modulus=114000000000 Pa, Poissons ratio (V)= 0.33 and density= 4500 Kg/m^3 then select Halo geometry in assigned volume.

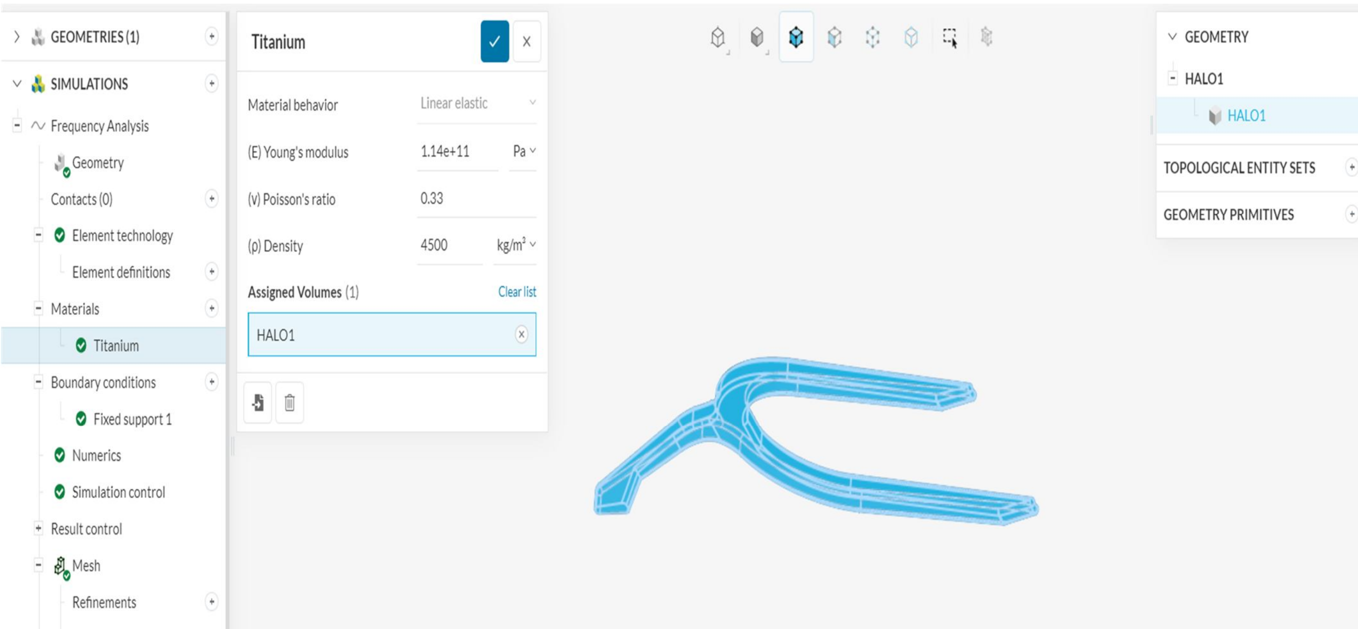


Figure 4

After that select fixed support for germetry

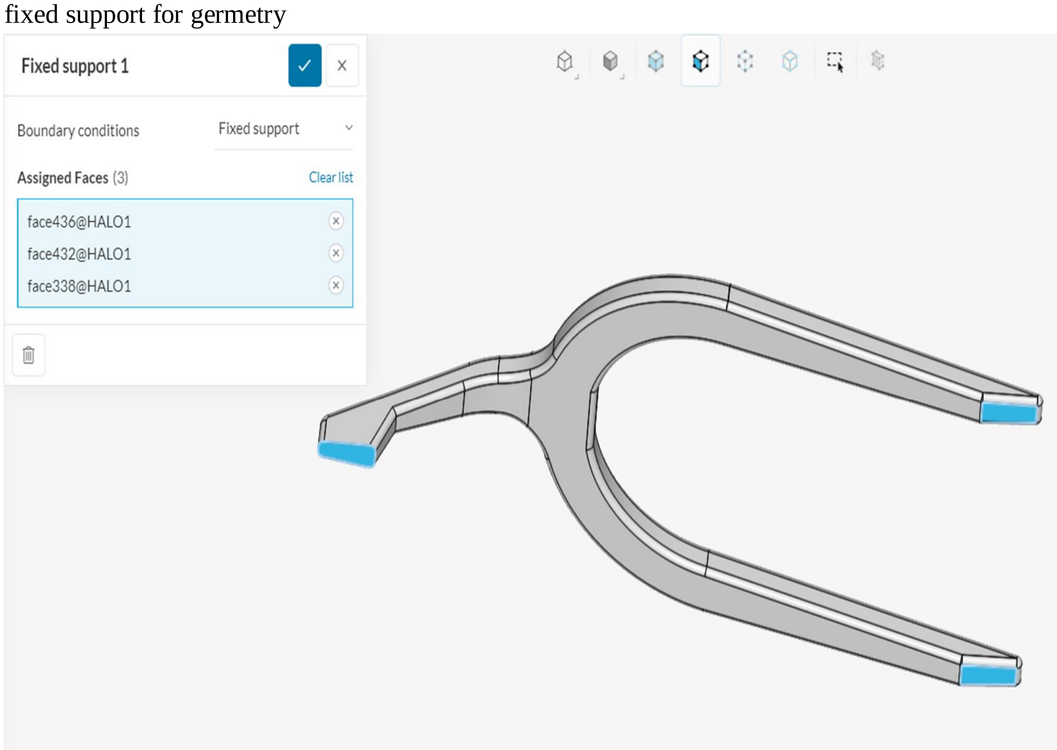


Figure 5 (Fixed Support of Halo During Simulation)

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue I Jan 2022- Available at www.ijraset.com

B. Numerics

Filled all data shown in below image.

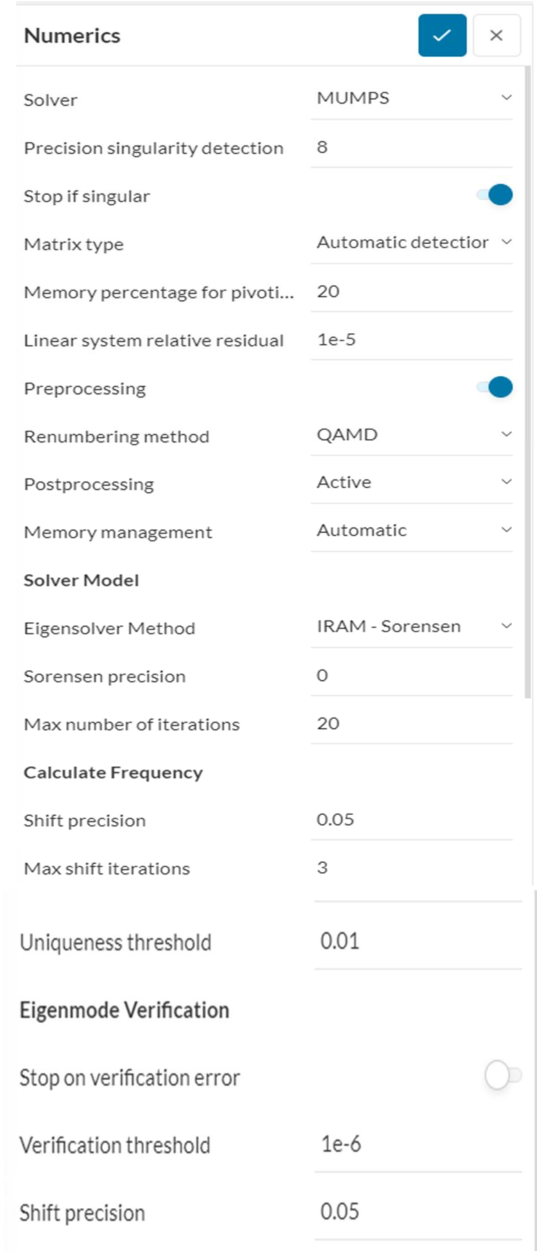


Figure 6

C. Meshing Process

After putting all data according to research design is ready for simulation but before that we have to mesh design.

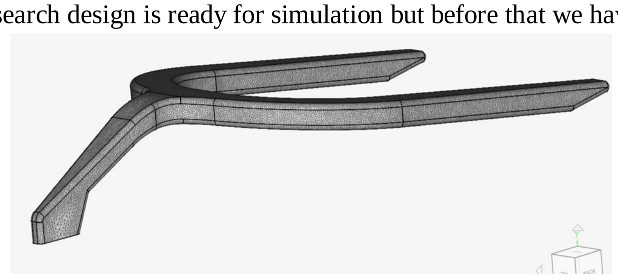


Figure 7 (Design After Meshing)

D. Result of Displacement Magnitude

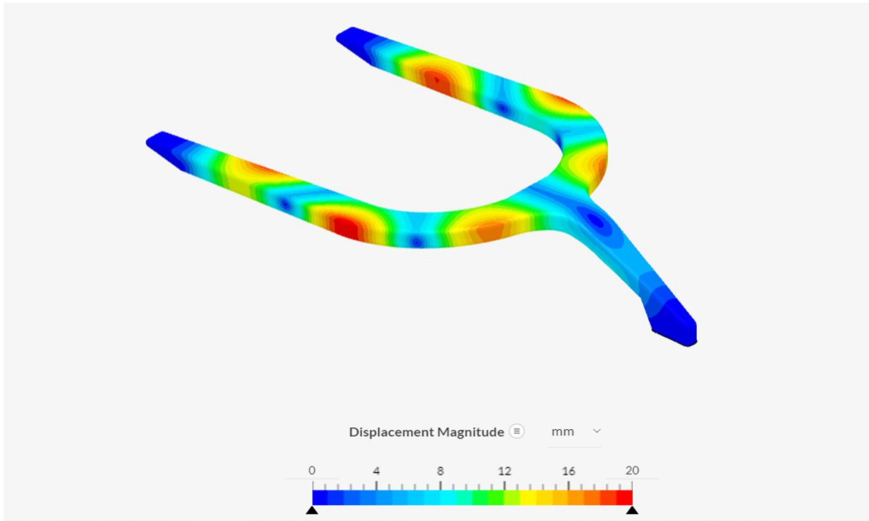


Figure 8 (Displacement Magnitude)

E. Dynamic Analysis

After that, a Dynamic review is carried out. When a body is exposed to a certain acceleration or deceleration and the load varies quickly, dynamic analysis comes into play. Inertial forces will be present, and complex analysis will be needed to catch their results. A 1m wall is placed between the Halo and the wall for this analysis. The wall was made of concrete, and Halo was made of the same material. The halo is then given a 60m/s velocity against the wall. The outcomes are shown below.

F. Physical Contact between Halo and wall

In this analysis we are testing Halo during collision with wall. This will shows us how it will react in crash.

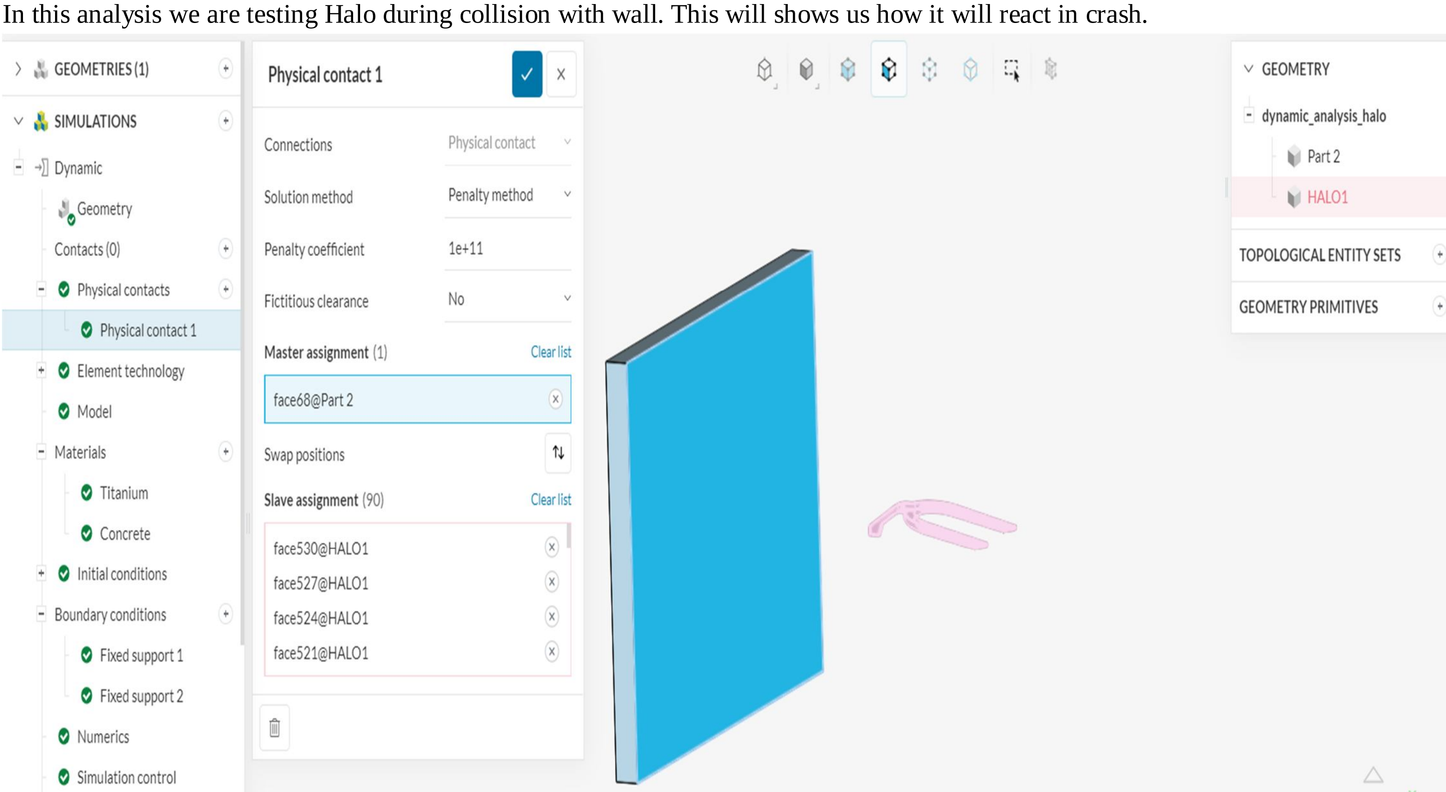


Figure 9 (Physical Contact between Halo and wall)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue I Jan 2022- Available at www.ijraset.com

G. Material Selection

Titanium is the Material selected for halo during simulation and concret for wall

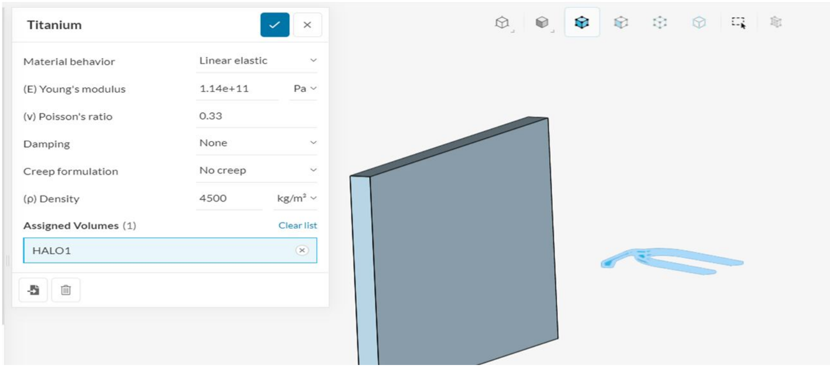


Figure 10(Material Selection for Halo= Titanium)

H. Result of Dynamic Analysis

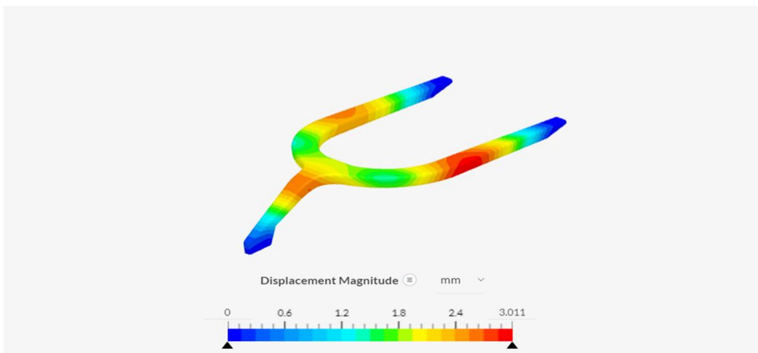


Figure 11(Dynamic Analysis Result)

1) Static Analysis 1

In Static analysis forced was applied on different sides of halo.
In this result force was applied in front on halo.

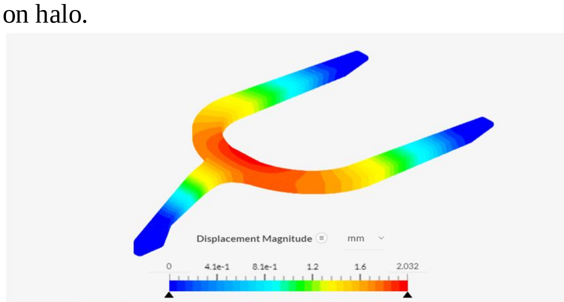


Figure 12 (Displacement Magnitude of Static Analysis 1)

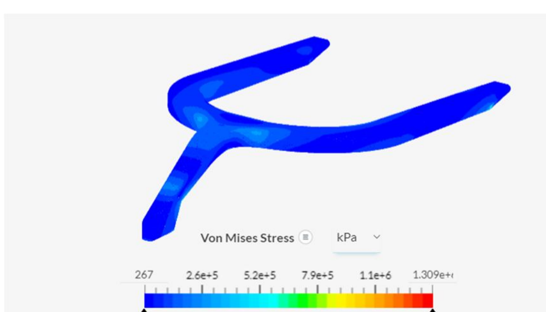


Figure 13(Von Mises Stress of Static Analysis 1)

2) Static Analysis 2

Forced is applied on side of halo

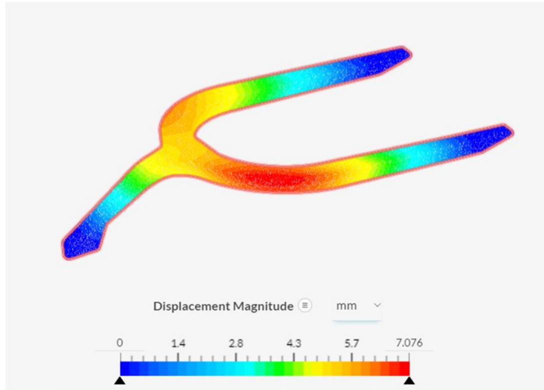


Figure 14 (Displacement Magnitude of Static Analysis 2)

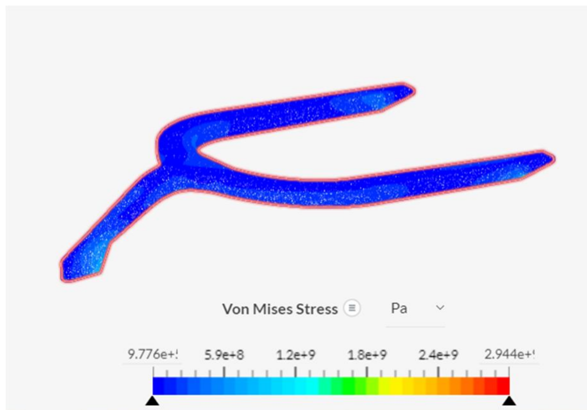


Figure 15 (Von Mises Stress of Static Analysis 2)

VII. DETAILED RESULT DISCUSSION AND CONCLUSION

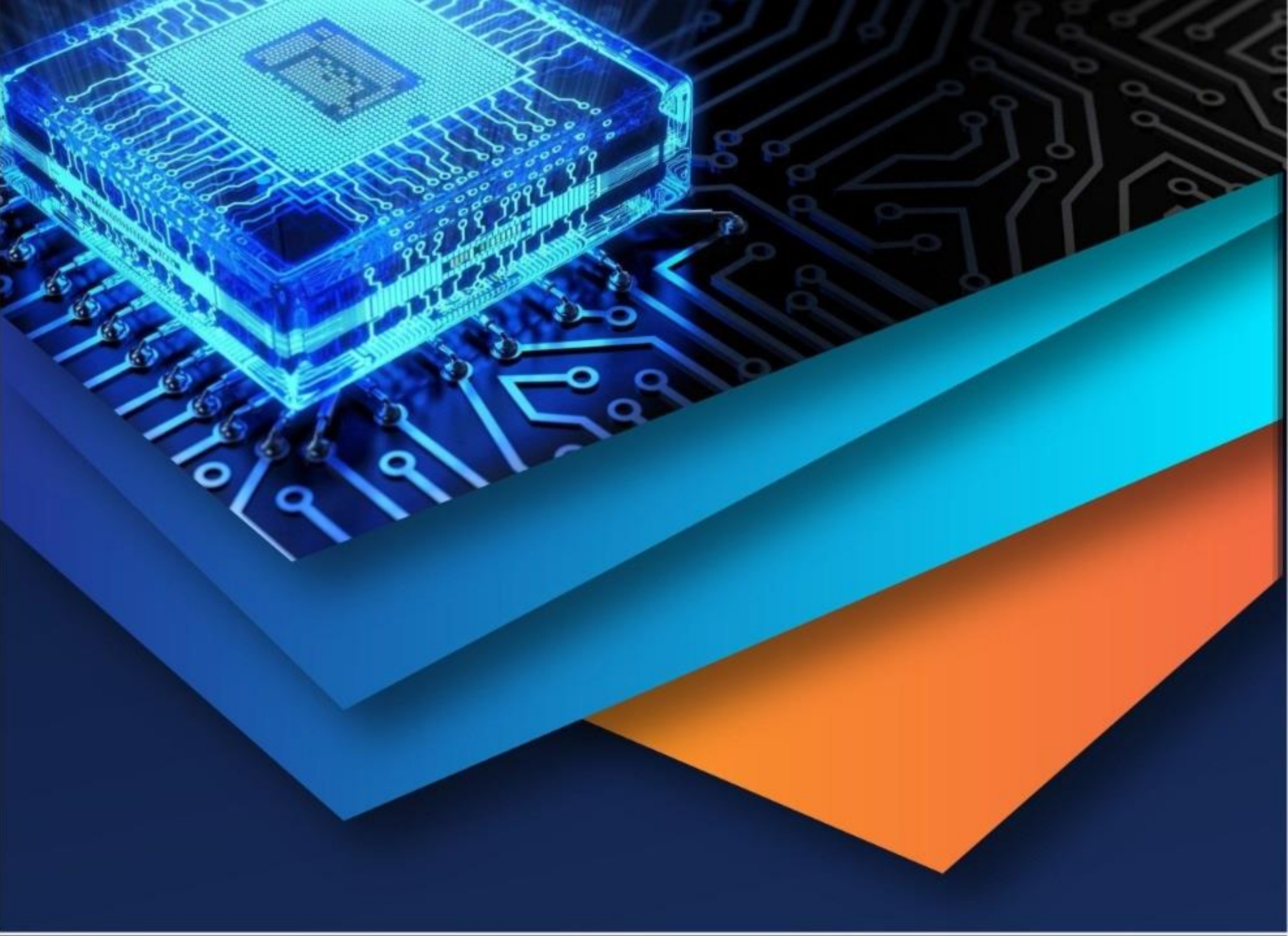
Three different techniques were used to model and analyze the proposed halo safety device architecture. Simscale was used to analyze the FEA model, which was developed in Onshape. The static, dynamic, and modal analysis results are all satisfactory. As a result, draw the conclusion that the proposed design can be used anywhere it is needed.

REFERENCES

[1] "Canoe," 21 03 2021. [Online]. Available: https://canoe.com/sports/auto-racing/i-was-lucky-charles-leclercs-halo-saved-him-in-frightening-belgian-gp-crash.

[2] "News18," 18 03 2021. [Online]. Available: https://www.news18.com/news/sports/what-is-the-halo-system-in-f1-that-saved-romain-grosjeans-in-horrific-crash-at-bahrain-gp-3130982.html.

[3] S. M. Rosalie and J. M. Malone, "Effect of a halo-type structure on neck muscle activation of an open-cockpit race car driver training under qualifying conditions," Case Reports, vol. 2018, p. bcr, May 2018, doi: 10.1136/bcr-2017-224013.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY