International Journal of Mechanical and Industrial Engineering

Volume 2 | Issue 3 Article 4

January 2013

Design Optimization of Formula One Student Sports Car Upright Using Hypermesh

Pathri Bhargav Prajwal
Mechanical Engineering Deptt, Dehradun Institute of Technology, Dehradun,
prajwal.autovision@gmail.com

Recommended Citation

Prajwal, Pathri Bhargav (2013) "Design Optimization of Formula One Student Sports Car Upright Using Hypermesh," *International Journal of Mechanical and Industrial Engineering*: Vol. 2 : Iss. 3 , Article 4.
DOI: 10.47893/IJMIE.2013.1088
Available at: https://www.interscience.in/ijmie/vol2/iss3/4

Design Optimization of Formula One Student Sports Car Upright Using Hypermesh

Pathri Bhargav Prajwal

Mechanical Engineering Deptt, Dehradun Institute of Technology, Dehradun
E-mail: prajwal.autovision@gmail.com

Abstract - This project mainly aims to develop a light weight upright to the formula one student sports car, where it can withstand the various loads that are coming on the uprights, and also to propose a material for the upright to decrease the weight of the upright, and also to propose a manufacturing procedure for the selected material, validation is carried out on the upright for the selected material on Hypermesh to check whether the selected design can withstand the loads coming on to it by applying various load paths in Hypermesh and manufacturing the design by using the RAPID PROTOTYPING technique.

I. INTRODUCTION

The ability of a sports car to negotiate a turn in a race is influenced by many parameters which includes overall car's geometry, its shape, weight distribution, type of suspension used, spring and shock absorber characteristics that are used in the tire properties, static and dynamic loading. A sports car while racing when taking a turn at steady state only reaches equilibrium position when all its forces are in balanced state, like the sum of the lateral acceleration. Many software's and simulation methods are there, they all try to predict the performance of the car in either steady state or transient manures or both have been developed but very few software's and simulations combine the kinematic analysis of the vehicle to the force analysis. These two are interconnected and influence each other. When we think of a sports car the only thing that comes into our mind is its speed, racing ability and its performance. To have the maximum speed for the sports car the weight have to be minimum, so while designing the sports car the designers keep this in mind and design the vehicle for minimum weight and maximum stress and force sustaining ability. So optimizing the uprights can also help in reducing the weight of the car and also increase heat dissipating properties.

In all the suspension unit the uprights play an important role they are the critical and supporting part's of the suspension system, they form a connection between the wheel like tire, rim, brake, disc, hub on one side of the suspension system like lower and upper wishbones, push rod arms steering arm or toe-in arm. The brake calliper is also connected to it. The criticality of the piece is that it is considered as an un-suspended body, but in fact it is subjected to very high stresses. Due to the dynamics of the vehicle from various road conditions, braking and also shifting of suspensions, which generate continuous stresses on the uprights. The most criticality occurs when all these forces acts at a time on the body when the wheels are fully turned. Considering all the above factors the performance of the uprights are key features because if it breaks the vehicle losses the control and leads to accidents. So the following are most important points:

1. The uprights should have more rigidity to withstand loads
2. It should have less weight
3. It should have great reliability and quality

After the design and material is been decided a final validation is done on the analysis software's to check whether they are withstanding the above mention load cases.

For the above mentioned properties to be included into the component it is important that what type of material is been used for the component. A number of materials are available in where we can use for the component but it is very important to choose material that best choose for the working conditions and as well as it should be economically easily available in the market. The manufacturing process also plays an important role for the component because in future if we need any modification it has to be easily possible and the process should be cheap (International, 2005)

II. DESIGNING THE UPRIGHT IN CATIA

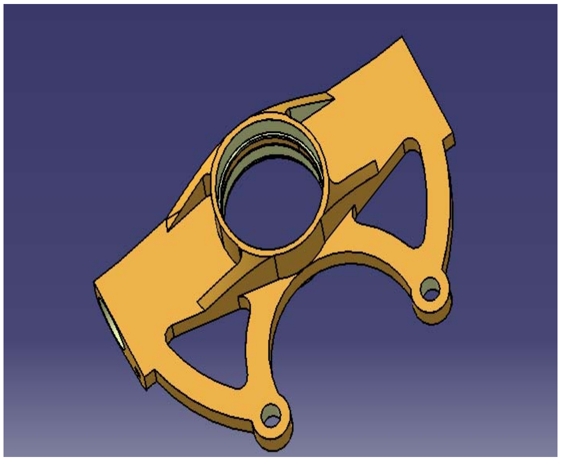


Fig. 1: Original figure of the Sports car Upright

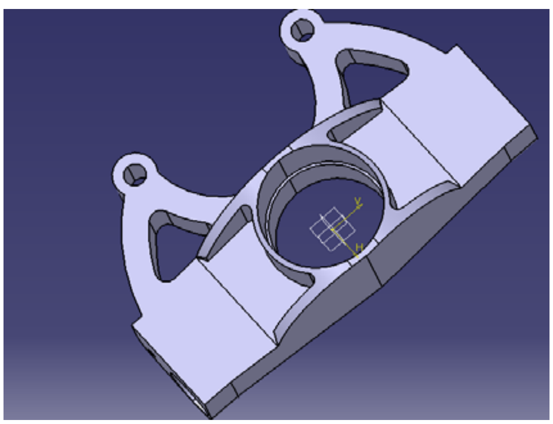
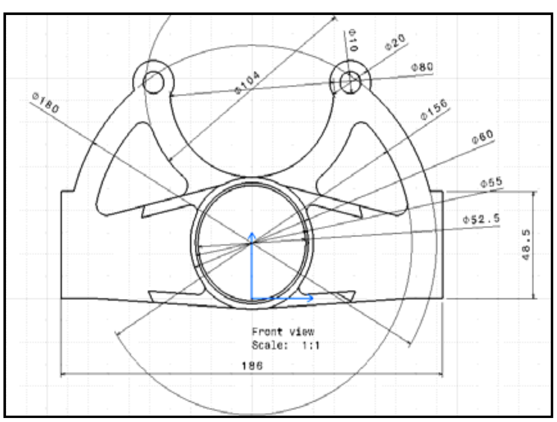


Fig. 2: Designed in Catia



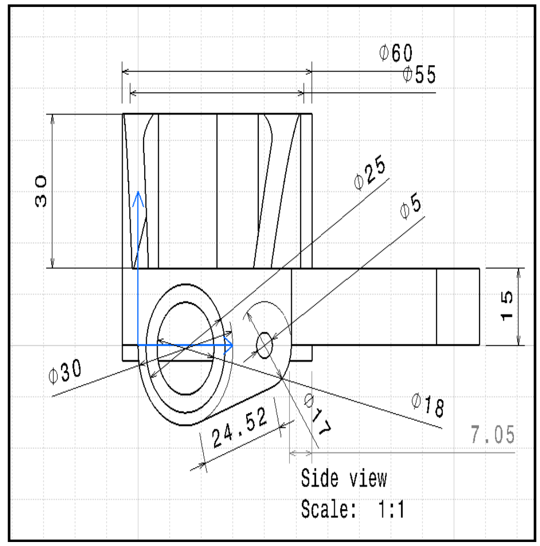
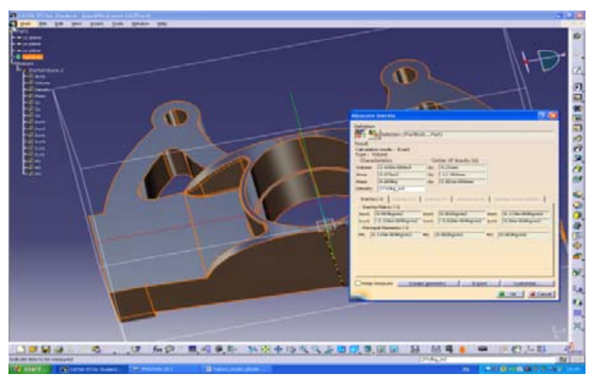


Fig. 3: 2D drawings of the Upright in catia

III. IMPORTING THIS FILE TO HYPERMESH

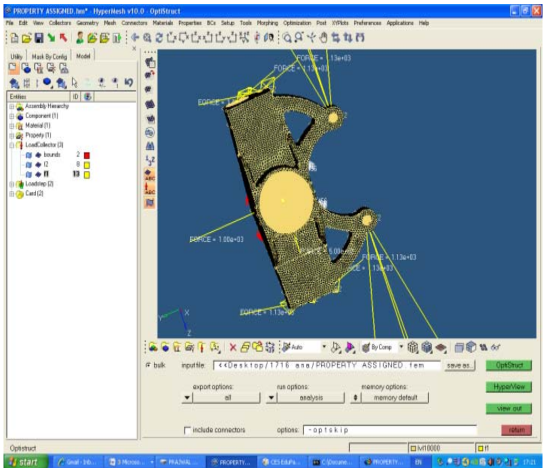
The file that is been designed in catia is saved as .igs, .step, and .cat so that it can be imported into the hypermesh software for analysis.

Weight of the upright = **659 GRAMS**



IV. VARIOUS FORCES APPLIED ON THE COMPONENT

1. Forces acting on the upper control arms are = F_{UCA} [(X=1052),(Y= -532)]
2. Forces acting on the lower control arm are= F_{LCA} [(X=1052),(Y= 532)]
3. The lateral force acting on the upright (Braking force) = 1000N (actual 967.5)
4. The longitudinal force acting on the Upright (Tyre force)= 750 N



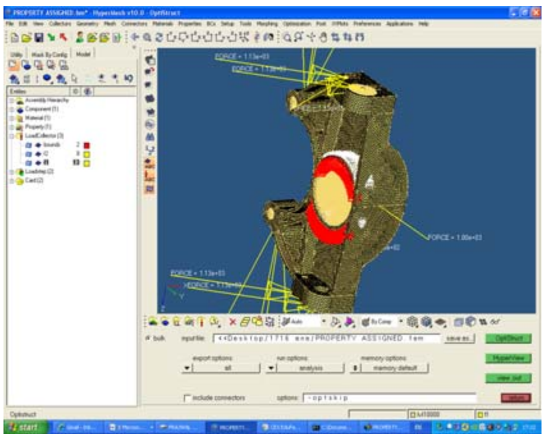
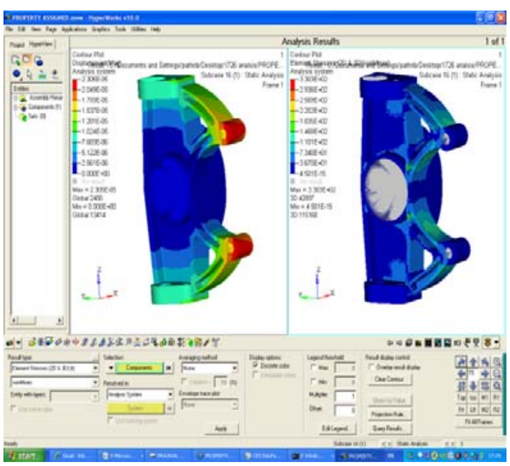


Fig. 4: Various Forces acting on upright

V. DISPLACEMENT AND STRESS FIGURES IN HYPERMESH BEFORE OPTIMIZING THE UPRIGHT



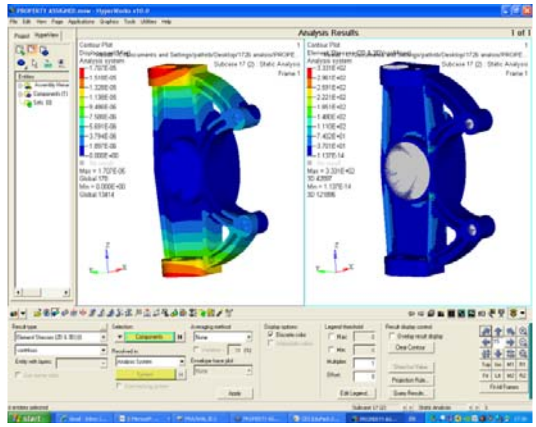


Fig 5: Various Constraints applied

VI. OPTIMIZING THE UPRIGHT USING HYPERMESH

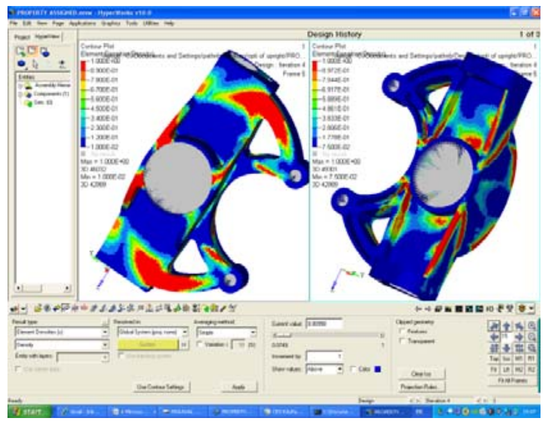
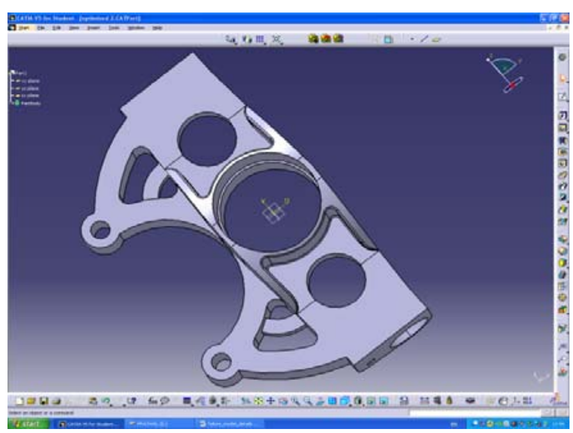


Fig. 6: Elemental densities of the Upright

VII. DESIGN AFTER OPTIMIZING



The weight of the component after optimization = **616 GRAMS**

VIII. STRESS VALUES FOR THE OPTIMIZED DESIGN

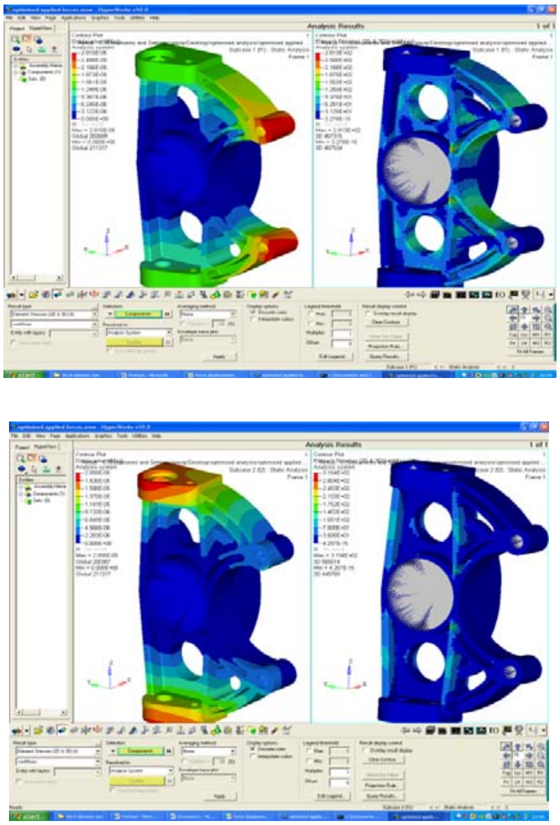


Fig. 7: Stress values for the optimized design

IX. MANUFACTURING USING RAPID PROTOTYPING

It is the technology that is evolved in recent years, which constructs the plastic models directly from computer models. This process converts CAD Models into 2dimensional Contours which are used to generate machine commands to produce the objects one layer by another. Normally the CAD models are converted to STL format before they are sliced. While STL file conversion method, the triangular faces are lined in a row to form surface of three dimensional models. With the use triangular faces, they cannot exactly matched to form curved surfaces. Those errors can be minimized by using small triangular faces, but this surely increases the file size, which increases the conversion time that connects with the purpose of Rapid prototyping. The direct slicing method has been proposed to minimize the error caused by STL conversion. This method slices layers directly from CAD models. Since, the model that composes of minimum number of layers requires less construction time; therefore, layers requires less construction time.

A three dimensional printer uses a false and mathematical model to construct a mechanical structure. For example, if a designer wants to create a new car model in three dimensional printing he can use a software package to create a three dimensional model that can be manipulated and can be seen on the screen. The three dimensional printer can only take representations of the symbol as a new object and use it to build a full size mechanical model that can be held and change the design according to his taught helping the architect for better understanding the strengths and weaknesses of the model that he have produced. An architect can mould his ideas into a three dimensional model and print a scale model to help him understand and communicate with the art. A medical scientist can print accurate models of body parts, different molecules and enlarges by many orders in magnitude to help his colleagues in better understanding of the model that he is making research.

These rapid prototyping techniques were first introduced twenty years ago, when three dimensional systems introduced the Stereo lithography machine while these machines were a sensational at those times for their capability to create complicated parts they were highly expensive and very complex parts to operate. With the evolution of the rapid prototyping equipment we have seen the revolution like an introducing a mini computer in olden days. However these are the system which costs you less than ten thousand pounds requires a less training time for the students who want to learn and can be operated in office, computer labs, and colleges or in homes.

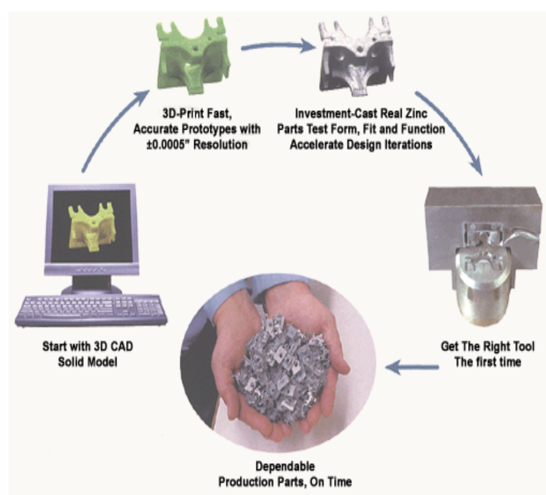


Fig. 8: Rapid prototyping cycle

X. CONCLUSIONS

The weight optimisation of the upright is done and its weight is reduced up to 5%, and also the stress concentration is reduced up to 15%, these are the conclusion that has been drawn after the performing analysis as well as optimisation the following are the results that are been drawn, the material that is been chosen for the uprights is aluminium.

The weight of the upright that have been supplied to me was 659 grams, the stresses developed in the upright initial and final results are stated below:-

Initial stresses in the component for load case -1 = 330MPa

Initial stresses in the component for load case- 2 = 333MPa

After the optimisation it is surprisingly seen that the stresses are drastically reduced as shown below

Final stresses in the component for load case -1 = 281 MPa

Final stresses in the component for load case- 2 = 315 MPa

Therefore, when compare to initial and final in the load case – 1 there is an decrease in stress value of 14.8%

For the load case-2 there is a decrease in stress value of 5.4%

In case of the weight there is an overall weight reduction of 6%.

REFERENCES

[1] A Mihailidas, Z. S. (November 28, 2008). The design of a formulae student race car. IMechE 2009, Dept of mechanical engineer, Jornal of Automobile , vol 223, No D6.

[2] Berkum, A. v. (2006). Chassis ans suspension design.

[3] Blog, S. c. (1999). F1 technology. Retrieved 01 17, 2010, from F1 Technical: http://www.f1technical.net/forum/viewtopic.php?f=6&t=5616&start=60

[4] Borg, L. t. (May 28, 2009). An approch to using finite element models to predict suspension member loads. Virginia.

[5] Campbell, L. Automotive suspension.

[6] Car, T. s. (1989). Price list of parts. Retrieved 03 22, 2010, from Tornodo sports car : http://www.tornadosportscars.com/GT40/partslist.html

[7] Daniels, J. (1988). Car suspension at work.

[8] Eduardo, G. d. (2005). Formula SAE Suspension Design. SAE TECHNICAL 2005-01-3994 , 22-24.

[9] Ellis, P. J. (1969). Vehicle dynamics.

[10] Fenton, J. (1980). Vehicle body layout and analysis .

[11] Gibbons, D. G. (n.d.). Warwick formula student. Retrieved 02 22, 2010, from WMG Innovative Solutions: http://www.imeche.org/NR/rdonlyres/1081D434-E678-4961-BDB0-99AB9877AED9/0/greggibbonssintering.pdf

[12] Giles, J. (1968). Steering, suspension and tyres. lliffs books Ltd.

[13] giles, J. (1968). Steering,suspension and tyres. Luffs Books Ltd.

[14] Hanstrue. (August 20-24, 2001). The dynamics of vehicles on roads and tracks. Denmark: 17th Preceesings IIAVSD Symphosim .

[15] Interactive, C. (2004, june). Fabricating metal working. Retrieved march 22, 2010, from Brush Research manufacturing: http://www.fandmmag.com/print/Fabricating-and-Metalworking/Making-a-Comeback-/1$711

[16] J reimbell, H. s. Automotive chassis, second edition.

[17] L.Daniel metz, W. F. (n.d.). Race car and vehicle dynamics. SAE International .

[18] Malmberg, G. (2008, 03 18). Suspension upright. Retrieved 04 18, 2010, from http://www.hemipanter.se/#Rollbars%20springs%20schocks%20and%20A-arms

[19] Mark Holvek, R. P. (2000). Design and integration of suspension brake and steering system. Retrieved may 02, 2010, from SAE paper: http://www.steerbythrottle.com/hccyong/files/VC_Spring_Report_(HTML)/DESIGN~1.HTM

[20] matchircky, W. (n.d.). Road vehicle suspension. ISBN 186058 .

[21] Michael ashby, H. S. (2007). Materials, engineering science processing and design,First edition. University of Cambridge,UK: British library catalogng .

[22] Miltera machining research. (2009, september 23). Retrieved march 12, 2010, from http://www.miltera.com/Miltera/Projects/Entries/

2008/12/2_Project_0017_-_Track_Day_Race_Car_Suspension_Upright.html

[23] more, J. b. (200, may). New project suspension. Retrieved may 11, 2010, from The Morris Minor Webring : http://www.beardmorebros.co.uk/website%20pages/new_project_suspension_page4.htm

[24] Mortimer, J. (1934). Advanced manufacturing in the Automotive industry. IFS Publications.

[25] P.Norbye, J. (June 1980). The car and its wheels, First editioin.

[26] paper, S. (2009). IMechE Preceedings. Retrieved march 18, 2010, from Professional Engineering publishing: http://journals.pepublishing.com/content/b330304481r6m03l/

[27] paper, U. (2009, OCTOBER 22). Panther racing. Florida university .

[28] Paphakorn Sunanon, P. K. (2005). Image processing for rapid prototyping technology. Proceedings of the 2005 International Conference on Simulation and Modeling .

[29] Polega, B. A. (2002). Design of Formula SAE. SAE TECHNICAL .

[30] PRNchilds, R. K. (September 18-19, 2001). Total vehicle technology . University of Sessex, Brighton,UK.

[31] segal, l. (1995,August 21-25). The dynamics of vehicle on roads and tracks. U.S.A: proceedings of 14th LAVSD.

[32] Stotz, M. H. (2006, april 07). 3D CAD, CAM and Rapid Prototyping. Retrieved march 13, 2010, from LAPA Digital Technology Seminar: http://fractals-ibois.epfl.ch/wiki/images/4/42/3D_CAD_CAM_Rapid_Prototyping.pdf

[33] T.Gillespie. (1992). Fundamentals of vehicle dynamics. sae , 258.

[34] The Automotive chassis,Engineering principles. (1996).

[35] website, U. (n.d.). Formula student. Retrieved may 12, 2010, from University of Sunderland: http://www.formulastudent.sunderland.ac.uk/su09/suspension

[36] Wright, P. (2001). Formulae 1 Technology. SAE International.

◈◈◈