AUTOMATED MODELING AND SHAPE OPTIMIZATION OF LOAD CARRIER BY USING TAGUCHI METHOD

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Abstract - The Load Carrier has been designed with the help of automated modelling Software Fusion360, further the component Optimized with the help of Taguchi's Robust design methodology. To optimize the Load-Carrier design Three parameters Material, Load, Volume and their three levels have been selected in order to reduce the von mises stress for better performance. Based on the requirement three parameters at three different levels L9 standard orthogonal array is selected for the design of experiments. After conducting the experiments, the results shows that load is the main parameter which has influences on von mises stress.
The level of parameter with the lowest stress value 7.262Mpa is the optimal level. The optimized condition for the lowest von-misses stress in the load carrier design obtained as Material (Steel ASTM A36), Load (1000N) and Low volume condition.

Key Words: Load carrier, Fusion360, Taguchi optimization.

1. INTRODUCTION

Automated Modeling quickly generates design alternatives for connecting existing geometries in to the design. A parametric, solid body that can be edited using the Timeline is produced by include one of the alternatives in the design. A brand-new feature called automated modelling combines aspects of the "loft" design tool with the AI-based Generative Design function to create a wide range of design alternatives that a user could never have thought of. Automated modeling, as opposed to the loft tool, may produce a transitional form between numerous solid bodies as well as merely between faces. This allows for the creation of far more imaginative and complicated bodies than could previously be achieved by a user without spending a lot of time and performing several procedures. The gap between the default Fusion360 design workspace and the Generative Design Extension may also be filled by automated modeling. By choosing which bodies to connect and which to avoid, the user of this tool may produce AI-powered designs. However, the customer doesn't have to pay any cloud credits for automatic modeling. It also speeds up the process of producing bodies since, unlike in generative design, the user is not required to specify any load constraints or choose any manufacturing restrictions. Even though it was inspired by generative design, the Automated Modelling feature doesn't replace the AI extension because the results are unique and can be used to solve design problems rather than being based on the same manufacturing or load requirements.

1.1: Automated Modeling

Fusion 360 is renowned for its creative approach to design and production, providing users the newest technology with an emphasis on usability. The most recent Fusion 360 solution, Automated Modelling, blends cutting-edge design technology and user effectiveness. For those Fusion 360 users who haven't investigated Automated Modelling, here we shall explore its potential. Eagle-eyed Fusion 360 users will have spotted the new Automate feature in the design ribbon and may have even tried out this new tool. A brand-new feature called automated modelling combines aspects of the "loft" design tool and the AI-based Generative Design function to create a wide range of design alternatives that a user could never have thought of. Automated modeling, as opposed to the loft tool, may produce a transitional shape between numerous solid bodies as well as merely between faces. This allows for the creation of much more imaginative and complicated bodies than could previously be achieved by a user without spending a lot of time and performing numerous operations. The gap between the default Fusion 360 design workspace and the Generative Design Extension can also be filled by automated modeling. By choosing which bodies to join and which to avoid, the user of this tool can produce AI-powered designs. However, the customer doesn't have to pay any cloud credits for automatic modeling. It also speeds up the process of producing bodies since, unlike in generative design, the user is not required to specify any load constraints or choose any manufacturing restrictions. Even though it was inspired by generative design, the Automated Modelling feature doesn't replace the AI extension because the results are unique and can be used to solve design problems rather than being based on the same manufacturing or load requirements.

1.2: Shape/Topology Optimization:

For a certain set of rules established by the designer, topology optimization (TO) is a procedure that optimizes material layout and structure inside a given 3D geometrical design space. By mathematically modeling and optimizing for elements such external forces, load conditions, boundary conditions, limitations, and material qualities within the design envelope, the aim is to maximize part performance. Traditional topology optimization employs finite element analysis to assess the effectiveness of the design and generate structures that meet the following goals:

- Reduced stiffness-to-weight ratio
- Better strain energy to weight ratio
- reduced material volume to safety factor ratio,
- natural frequency to weight ratio.

In engineering product design, topology optimization is used at the design stage of new products to optimize the form in order to maximize stiffness to weight ratio. Topology optimization has a wide range of applications across industries. Free form designs developed using TO are frequently challenging to produce using conventional manufacturing techniques. However, the design generated by Topology optimization may now be fed straight into a 3D printer because to growth and technological improvement in additive manufacturing, also known as so-called 3D printing. Since the beginning of the twenty-first century, CAD software programs like Solidworks, Autodesk, and others have frequently utilised the topology optimization approach.

Figure 1.1: Topology/ Shape optimization

In Autodesk Fusion 360, topology (or shape) optimization enables fast simulation of an improved model based on a specified load and constraints. Fusion 360 analyzes which particular parts of the material support the imposed load using the Load Path Criticality metric. By removing material from those less important locations, the simulation creates an updated version of the component. The simulation informs to update and remove extra material from the design, even though it does not necessarily produce a faultless model suited for fabrication. A potent approach for achieving a balance between two parameters is shape optimization.

- Maximize stiffness of assembly
- Minimize amount of material

Fusion 360 offers a great tool for this! Best of all it takes like 30 seconds to set one of these up and then it's all solved in the cloud.

Step 1: Constrain some part of the model
Step 2: Apply a force to the model
Step 3: Add keep-out zones and symmetry
Step 4: Solution! Materials for Load carrier hook

1.3: Shackle

A shackle is a load-bearing, u-shaped connection tool made to be used with a detachable pin. Shackles can be used to connect various lifting slings, chains, or ropes to an item or to one another in a variety of rigging and load securement applications. Shackles can be applied to a wide range of situations, such as:

- Rigging
- Towing or pulling
- Lifting
- Hoisting
- Tie-down

Shackles come in a variety of styles and arrangements, just as lifting slings and sling hooks. Understanding the kind of shackle to use for your application might be complex, but you don't want to assume or make the wrong choice because that could lead to rigging failure and serious harm or damage!

Shackle Material

Carbon Steel Shackles

Design Factor of 6:1. More ductile than alloy. Available in round pin, screw pin, bolt type.

Alloy Steel Shackles

Design Factor of 5:1. Stronger than carbon steel. Can achieve an equivalent WLL as carbon shackles in a smaller product design. Available in round pin, screw pin, bolt type.

Galvanized Shackles

Zinc oxide is added as a thin layer during the galvanization process to provide protection from rust and corrosion. Galvanized shackles can be utilized in industrial situations where moisture isn't a major concern, but the shackles still need to be protected against elements that could hasten corrosion or cause the product to degrade.

Stainless Steel Shackles

Shackles made of stainless steel have the highest level of corrosion resistance and are best used in maritime applications. The shackle can be protected against situations that contain chemicals or salt water by using different grades of stainless steel. Galvanized shackles are often less expensive than stainless steel shackles. Steels that include at least 10.5% chromium, less than 1.2% carbon, and other alloying elements are known as stainless steels. Other elements, such as nickel, molybdenum, titanium, niobium, manganese, etc., can be added to stainless steel to further improve its mechanical and corrosion resistance.

Properties of Stainless Steel

- Corrosion resistant.
- High tensile strength.
- Very durable.
- Temperature resistant.
- Easy formability and fabrication.

Table1.1: Chemical composition of Stainless steel

Element	Weight percentage
Carbon	0.08
Manganese	2.00
Phosphorous	0.045
Sulphar	0.030
Silicon	0.75
Chromium	16.0-18.0
Nickel	10.0-14.0
Nitrogen	0.10
Molybdenum	2.0-3.0

Table1.2: Mechanical Properties of Stainless steel 316L

Property	Units	SS316L
Density	Kg/m^3	8000
Elastic modulus	GPa	165
Thermal conductivity	W/m.K	16.3 at 100°C
Specific heat 0-100°C	J/Kg.K	500
Electrical resistivity	nΩ.m	740
Tensile strength	MPa	673
Yield point	MPa	332
Hardness	Rockwell	95

2. LITERATURE REVIEW

Paula Logozzo et.al, [1] has published a paper entitled "Generative Design for Additive Manufacturing of Satellite Optical Tracker Mount". This study focuses on the process of creating and testing a mounting bracket for a satellite optical sensor using Autodesk Fusion 360's generative design and simulation tools. The optical instrument design challenge's design criteria are used to create generative design studies for the instrument bracket. After that, the instrument bracket is thermally load tested using Fusion 360's FEA software and its mechanical behavior is examined.

Loris Barbieri and Maurizio Muzzupappa [2], "Performance-Driven Engineering Design Approaches Based on Generative Design and Topology Optimization Tools: A Comparative Study". The comparison seeks to illustrate the potential and restrictions of these optimization tools when used in an integrated manner with the CAD systems and to offer a perspective on the evolution of the traditional method when TO and GD tools are utilized. Additionally, based on their requirements and project resources, designers may find this comparative research to be a useful and practical resource for choosing the best strategy to utilize. The design analysis of a rocker arm and brake pedal prototype for the Formula Student race car is used to conduct the comparison study. When their findings are evaluated in terms of mechanical performances, it becomes clear that both TO and particularly GD tools may be effectively used early in an AM-focused design process to redesign components and make them stronger and lighter.

M. Mata et.al [3], "Topological Optimization of a Metal Extruded Doorhandle using nTopology." Doors are used to close off entranceways. These are among the inventions that we use the most in our daily lives because door handles need to be moved in order to be opened. This article discusses a door handle's topological optimization, how it may be made using additive manufacturing (AM), and whether metal extrusion can be used to fabricate the part. With the addition of lattices and generative design, two distinct door-handle designs were developed, optimized, and fabricated using Inconel 625 filament.

R S Harish, et.al [4], "Topology Optimization of Aircraft Wing Fuselage Lug Attachment Bracket". Particularly in the aeronautics and aerospace sector, topology optimization has developed into a powerful tool for performance and light-weight design. It has demonstrated that it can make complex parts that are lighter and more resilient. In the aircraft industry, this technique has proven to be cost-effective, expanded payload capacity, improved fuel efficiency, and allowed structural components to provide the same or better performance while using less material. The wings and the fuselage are significant structural elements of an aircraft. The piece of hardware that joins the wings and the fuselage is called the wing fuselage lug attachment bracket. The airplane structure may occasionally separate due to catastrophic failure of the bracket. The modeling, shape optimization, and analysis of a bracket used to join an aircraft's wing to its fuselage are the main goals of this work. Using several sets of materials, the process entails modeling and shape optimization of the bracket. To investigate the stresses and deformation on the bracket, structural analysis and finite element modeling were used. To investigate how a bracket responds to repetitive cycle loads, fatigue damage assessment is used.

Dr. Nadir Yilmaz P.E [5], "Use of Generative Design and Shape Optimization Tools for Advanced Engineering Design". Early exposure to advanced engineering graphics, design, and analysis tools in undergraduate courses is being made possible by the rapid development of high power computing hardware, user-friendly interfaces, and commercial software capabilities. Students can practice engineering analysis parts other than solid modeling or engineering graphics thanks to the simplicity of computer-aided design software. This paper will include information on shape optimization and generative design, two ground-breaking methods for engineering component optimization for advanced engineering analysis and complicated design situations. Students who were surveyed gave the course and group projects extremely positive reviews, suggesting that they had gained practical experience with advanced design and engineering analytic software.

3. METHODOLOGY

To ensure that the experimental data is collected under the best possible circumstances, this study employs the Taguchi robust design technique. Results for the Analysis of Mean (ANOM) and Analysis of Variance (ANOVA) are obtained using the statistical program Minitab 15.0. In order to authenticate the findings, the confirmation test is carried out under ideal circumstances. The foundation of the engineering design activity is knowledge of scientific phenomena and prior experience with comparable product designs and production techniques. However, a lot of engineering work is expended on carrying out experiments (either with hardware or by simulation) to generate the data necessary to inform these decisions. These decisions relate to the specific design, the process architecture, and the parameters of the manufacturing processes. Meeting marketing deadlines, keeping development and production costs low, and having high-quality goods all depend on how efficiently this information is produced. An engineering technique called robust design aims to increase productivity throughout design and development so that high-quality goods may be manufactured affordably.

Signal-to-Noise ratio (S/N ratio):

To assess a system's performance, Dr. Taguchi created the notion of the Signal-to-Noise ratio in resilient design. This is a translation of the data to a different value that represents a measurement of the level of variation. The S/N ratio shows how predictable a process or product performs in the presence of noise effects. The variation of predictable performance and the variance of unexpected performance are combined into a signal measure via the S/N ratio.

In order to make performance less vulnerable to noise effects and hence increase product quality, robust design improves the S/N ratio in the area of control factor. Depending on the kind of feature, there are three significant forms of S/N ratios.

- Smaller the better
- Larger the better
- Nominal the best

Smaller-the-better type:

The quality attribute in this case is continuous and non-negative, meaning that it may take any value between 0 and. Zero is the preferred value. Examples of this kind include the number of surface flaws, air pollution from power plants, EM radiation from telecommunications networks, and metal corrosion, among others.

S/N ratio (η) = −10log$_{10}$(mean square quality characteristic)

$$-10\log_{10}\left[\left(\frac{1}{n}\right)\sum_{i=1}^{n} y_i^{2}\right] \quad \text{......................... (3.1)}$$

where,

n: no. of tests in trial (no. of repetitions regardless of noise levels);

yi: is the ith observation of the quality characteristic.

Larger-the-better type:

The quality attribute in this case is constant and non-negative. The optimum value should be as high as it can be. There is no adjustment factor present. Examples of this kind are the miles travelled per gallon of gasoline for a vehicle carrying a certain amount of weight and the mechanical strength of a wire per unit cross-section area. By taking into account the reciprocal of the quality feature, this issue may be converted into a smaller, better sort of problem.

η = −10log$_{10}$ (mean square reciprocal quality characteristic)

$$\eta = -10\log_{10}\left[\left(\frac{1}{n}\right)\sum_{i=1}^{n}\left(\frac{1}{y_i^{2}}\right)\right] \quad \text{......................... (3.2)}$$

Nominal-the-best type:

The quality characteristic of this type is continuous, non-negative, and may take any value between 0 and ; nevertheless, its goal value must be non-zero and finite. When the mean for these types of issues equals zero, the variances likewise equal zero. Engineering designs commonly have issues of this kind. To obtain a desired paint thickness on the surface is an example of this kind.

The S/N ratio for nominal-the-best is given by:

The S/N ratio for nominal-the-best is given by:

$$\eta = 10\log_{10}\left[\frac{\mu^2}{\sigma^2}\right] \quad \text{....................... (3.3)}$$

where, $\mu = \frac{1}{n}\sum_{i=1}^{n} y_i$ & $\sigma = \frac{1}{n}\sum_{i=1}^{n}(y_i - \mu)^2$

Minitab software:

Minitab is often a statistical software program. Researchers Barbara F. Ryan, Thomas A. Ryan, and Brian L. Joiner created it at Pennsylvania State University in 1972. A statistical analysis application developed by NIST, Minitab originally came in a lite form. Minitab Inc., a privately held firm with its headquarters in State College, Pennsylvania, and subsidiaries in Coventry (Minitab ltd.), Paris (Minitab snarl.), and Sydney (Minitab pty.), distributes Minitab. Today, Six Sigma, CMMI, and other statistics-based process improvement techniques are often utilized in combination with Minitab. Seven languages are supported by Minitab 16, the most recent version of the program: English, French, German, Japanese, Korean, simplified Chinese, and Spanish.

Two further items made by Minitab Inc. complete Minitab 16. The quality companion 3 is an integrated tool for managing Six Sigma and lean manufacturing projects that enables the combination of Minitab data with project management and governance tools and documents. Quality trainer is an e-learning package that teaches statistical tools and concepts in the context of quality improvement and integrates with Minitab 16 in order to simultaneously develop the user's statistical knowledge and proficiency with the Minitab software.

Uses of Minitab:

- File and data management, including a spread sheet for improved data analysis.
- Analysis of regression
- Tables and graphs, power, and sample size
- Multivariate analysis, which encompasses correspondence analysis, cluster analysis, and factor analysis.
- Tests that is nonparametric, such as the song test, runs test, Friedman test, etc.
- Time series and forecasting are tools that assist in identifying data patterns and making future value predictions. Exponential smoothing, trend analysis, and time series charts.
- Statistical process control • Analysis of measurement systems
- Variance analysis to ascertain the variation between data points.

The Minitab program is utilized in the current study to generate regression models and produce ANOVA (mathematical modeling is done using multiple regression analysis).

Minitab instructions: ANOVA

The Minitab program has a number of options for obtaining ANOVA. The next section includes a step-by-step description and an example of the tools needed to produce an ANOVA using Minitab software.

Step 1: open Minitab: To launch Minitab, double-click the icon.

1) Results are shown in the session window.
2) The spreadsheet is where the unprocessed data from Figure came from.

The worksheet columns have already been filled with the soft data from the ANOVA: complete factorial design instruction.

- Each row corresponds to a test (or run).
- The first grey row represents the column labels.
- One variable is represented by each column.

Step 2: ANOVA: Go to stat >> ANOVA >>general linear models

- As illustrated in Figure 3.4, double-click "c6 results" while the cursor is in the "responses:" area.
- Position the cursor in the "model:" field, then double-click factors a, b, and c. • Use the * symbol to see all 2-way interactions.

Step 3: Validating model (Fisher assumptions):

- Produce residual plots to demonstrate the independence and normal distribution of the sampling errors.
- In the general linear models box, click OK.

4. EXPERIMENTAL DESIGN AND SETUP

The Taguchi technique was employed in this work to examine the effects of crucial process variables, such as type of material, load, and component volume, for automated modeling and topology optimization.

The table above lists the chosen process parameters and their levels. The type of material, load, and volume of the component are taken into account in this work to analyze their effects on the stresses, safety factors, and strain in the body.

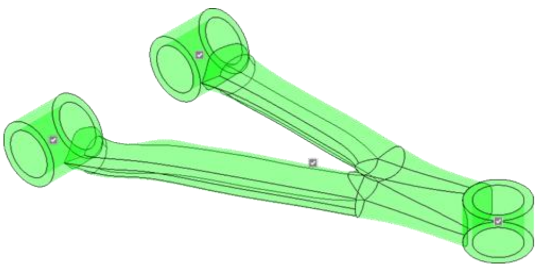
Table No.: 4.1 Process Parameters

FACTORS	LEVELS		
	1	2	3
Type of Material (A)	Steel ASTM A36	TiG5	Inconel 718
Load (B)	1000 N	1500 N	2000 N
Volume of component (C)	Low	Medium	High

Table No. 4.2: Taguchi L9 Orthogonal with parameter values

No. of Exp.	Type of Material (A)	Load (kg) (B)	Volume of component (C)
1	Steel ASTM A36	1000	Low Volume
2	Steel ASTM A36	1500	Medium Volume
3	Steel ASTM A36	2000	High Volume
4	TiG5	1000	Medium Volume
5	TiG5	1500	High Volume
6	TiG5	2000	Low Volume
7	Inconel 718	1000	High Volume
8	Inconel 718	1500	Low Volume
9	Inconel 718	2000	Medium Volume

4.3: Design of Shackle



Condition 1: Automated Modelling and results for Steel ASTM A36, 1000N loading condition at Low Material volume.

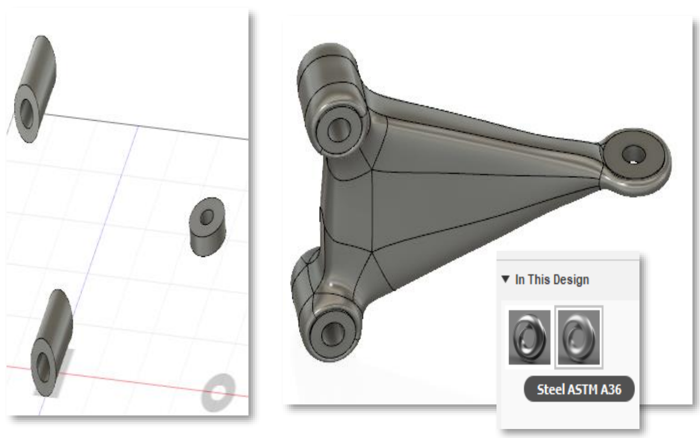


Figure 4.1: Condition 1: (a) 2D sketch (b) 3D sketch of load carrier

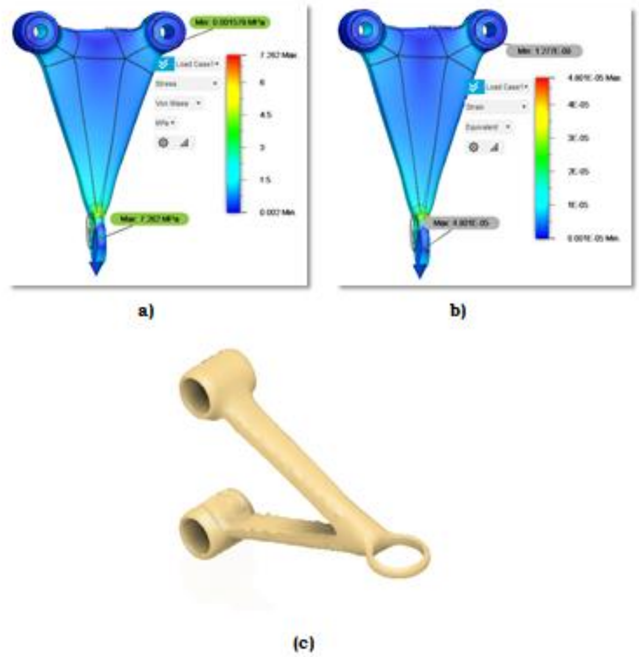


Figure 4.2: Condition 1: (a) Model under stress (b) Strain (c) Shape optimized

S. No.	Condition	Min	Max
1	Factor of safety	15	----
2	Stress (MPa)	0.001579	7.262
3	Strain	1.277e-8	4.80e-5

Condition 2: Automated Modelling and results for Steel ASTM A36, 1500N loading condition at Medium Material volume.

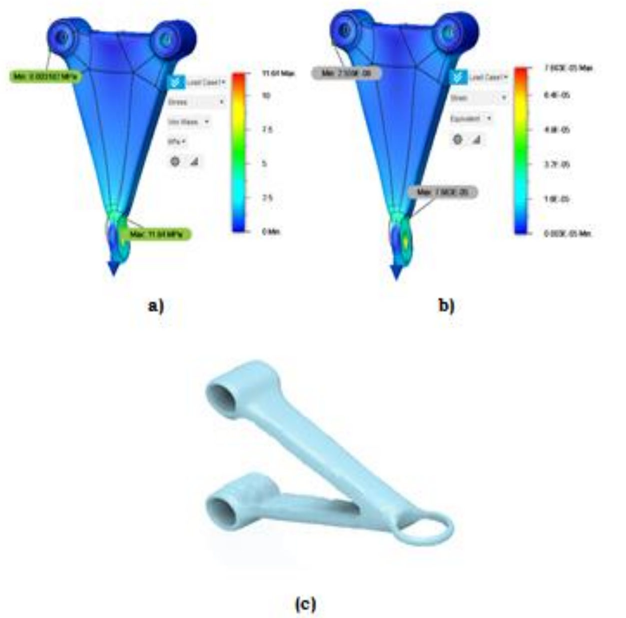
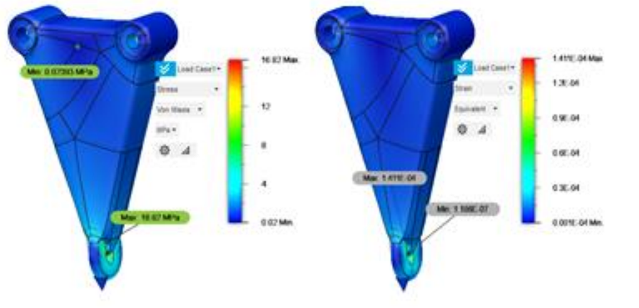


Figure 4.3: Condition 2: (a) Model under stress (b) Strain (c) Shape optimized

S. No.	Condition	Min	Max
1	Factor of safety	15	----
2	Stress (MPa)	0.003182	11.54
3	Strain	2.559e-8	7.663e-5

Condition 3: Automated Modelling and results for Steel ASTM A36, 2000N loading condition at High Material volume.



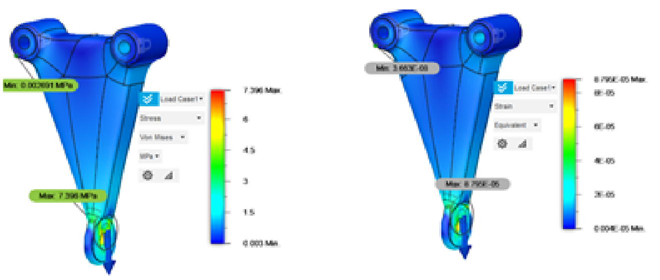
a) b)

(c)

Figure 4.4: Condition 3: (a) Model under stress (b) Strain (c) Shape optimized

S. No.	Condition	Min	Max
1	Factor of safety	15	----
2	Stress (MPa)	0.02393	16.82
3	Strain	1.188e-7	1.411e-4

Condition 4: Automated Modelling and results for Ti-G5, 1000N loading condition at Medium Material volume.



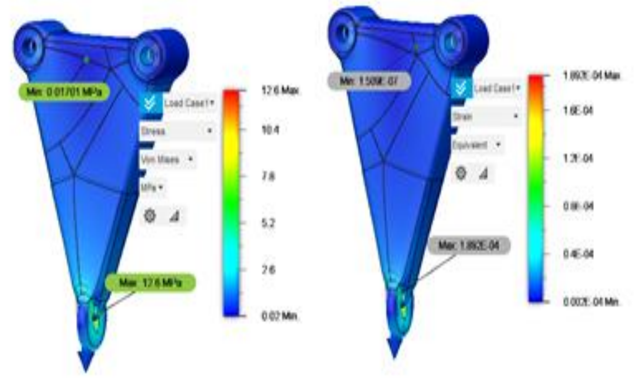
a) b)

(c)

Figure 4.5: Condition 4: (a) Model under stress (b) Strain (c) Shape optimized

S. No.	Condition	Min	Max
1	Factor of safety	15	----
2	Stress (MPa)	0.002691	7.396
3	Strain	3.663e-8	8.79e-5

Condition 5: Automated Modelling and results for Ti-G5, 1500N loading condition at High Material volume.



a) b)

(c)

Figure 4.6: Condition 5: (a) Model under stress (b) Strain (c) Shape optimized

S. No.	Condition	Min	Max
1	Factor of safety	15	----
2	Stress (MPa)	0.01701	12.6
3	Strain	1.50e-7	1.89e-4

Condition 5: Automated Modelling and results for Ti-G5, 1500N loading condition at High Material volume.

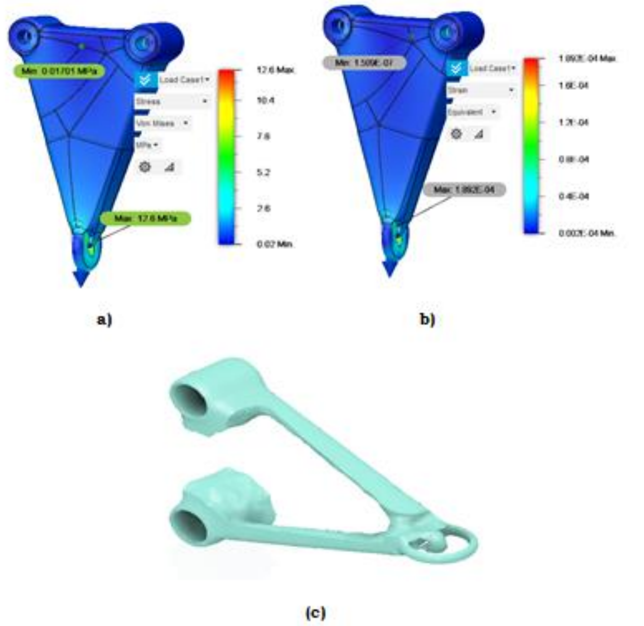


Figure 4.6: Condition 5: (a) Model under stress (b) Strain (c) Shape optimized

S. No.	Condition	Min	Max
1	Factor of safety	15	----
2	Stress (MPa)	0.01701	12.6
3	Strain	1.50e-7	1.89e-4

Condition 6: Automated Modelling and results for Ti-G5, 2000N loadin condition at Low Material volume.

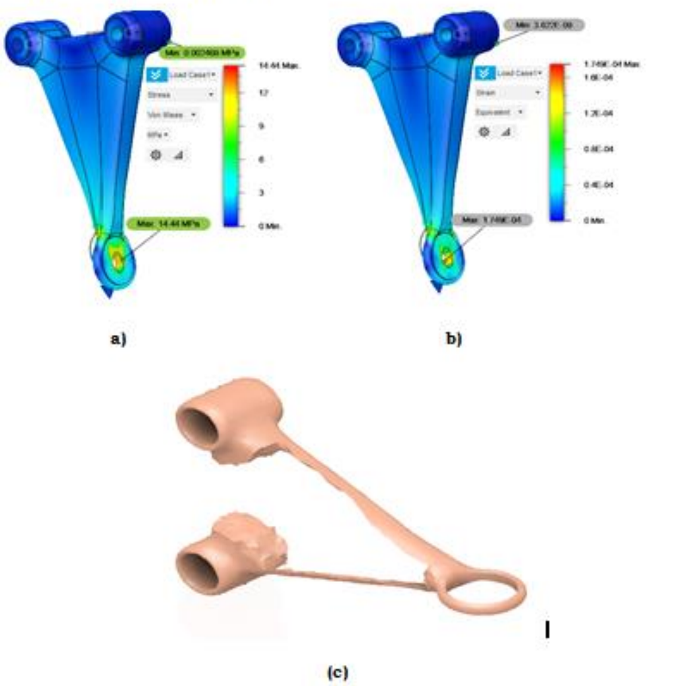


Figure 4.7: Condition 6: (a) Model under stress (b) Strain (c) Shape optimized.

S. No.	Condition	Min	Max
1	Factor of safety	15	----
2	Stress (MPa)	0.0024	14.44
3	Strain	3.62e-8	1.74e-4

Condition 7: Automated Modelling and results for Inconel718, 1000N loading condition at High Material volume.

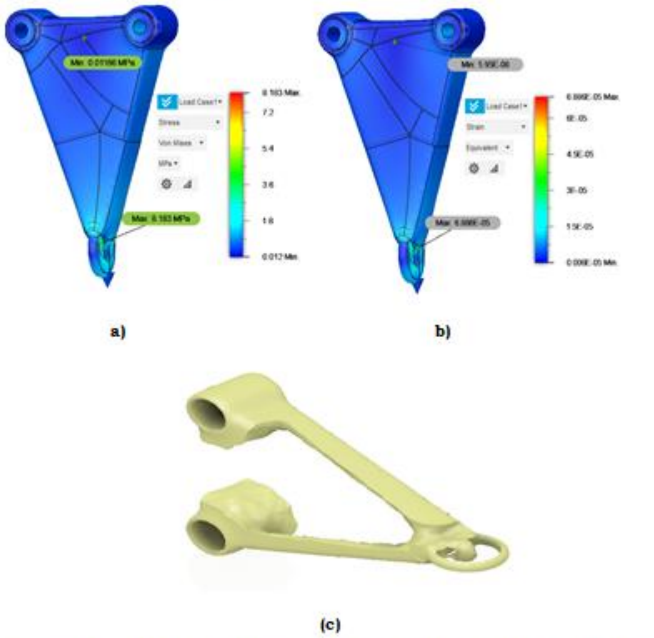


Figure 4.8: Condition 7: (a) Model under stress (b) Strain (c) Shape optimized

S. No.	Condition	Min	Max
1	Factor of safety	15	----
2	Stress (MPa)	0.0116	8.183
3	Strain	5.95e-8	6.88e-5

Condition 8: Automated Modelling and results for Inconel718, 1500N loading condition at Low Material volume.

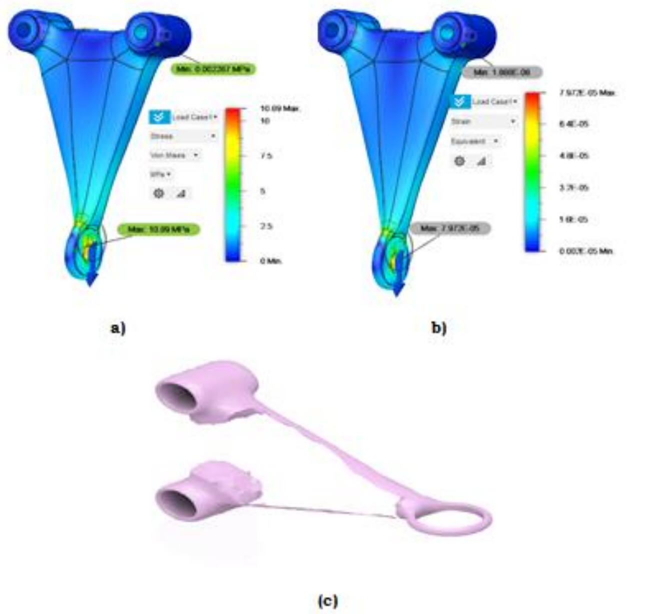


Figure 4.9: Condition 8: (a) Model under stress (b) Strain (c) Shape optimized

S. No.	Condition	Min	Max
1	Factor of safety	15	----
2	Stress (MPa)	0.0022	10.89
3	Strain	1.88e-8	7.97e-5

Condition 9: Automated Modelling and results for Inconel718, 2000N loading condition at Medium Material volume.

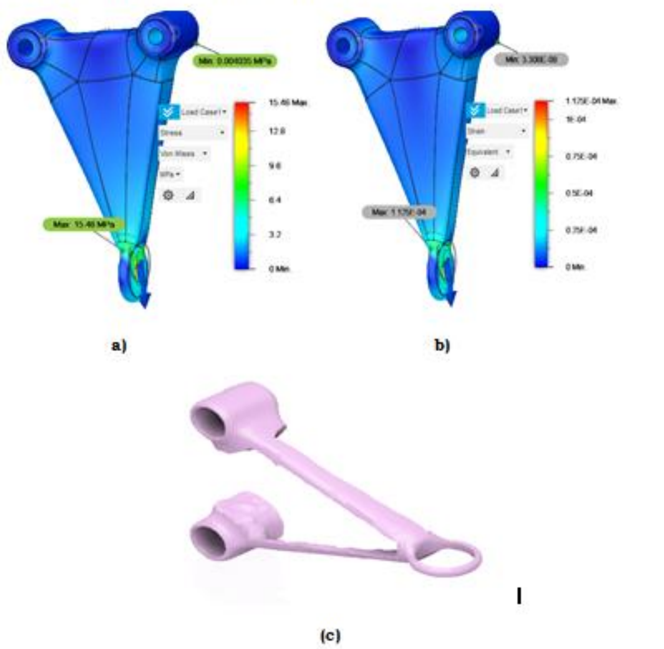


Figure 4.10: Condition 9: (a) Model under stress (b) Strain (c) Shape optimized

S. No.	Condition	Min	Max
1	Factor of safety	15	----
2	Stress (MPa)	0.0040	15.46
3	Strain	3.30e-8	1.125e-4

Table 4.3: Stress Test Results

Exp.	Type of Material (A)	Load (N) (B)	Volume of component (C)	Stress (MPa)	S/N ratio (dB)
1	Steel ASTM A36	1000	Low Volume	7.262	-17.2211
2	Steel ASTM A36	1500	Medium Volume	11.64	-21.3191
3	Steel ASTM A36	2000	High Volume	16.82	-24.5165
4	TiG5	1000	Medium Volume	7.396	-17.3799
5	TiG5	1500	High Volume	12.6	-22.0074
6	TiG5	2000	Low Volume	14.44	-23.1913
7	Inconel 718	1000	High Volume	8.183	-18.2583
8	Inconel 718	1500	Low Volume	10.89	-20.7406
9	Inconel 718	2000	Medium Volume	15.46	-23.7842

Table 4.4: Strain Test Results

Exp.	Type of Material (A)	Load (N) (B)	Volume of component (C)	Strain	S/N ratio (dB)
1	Steel ASTM A36	1000	Low Volume	$4.80\ e^{-5}$	86.373
2	Steel ASTM A36	1500	Medium Volume	$7.66\ e^{-5}$	82.312
3	Steel ASTM A36	2000	High Volume	$1\ e^{-7}$	138.518
4	TiG5	1000	Medium Volume	$8.79\ e^{-5}$	81.115
5	TiG5	1500	High Volume	$1.89\ e^{-4}$	74.462
6	TiG5	2000	Low Volume	$1.74\ e^{-4}$	75.144
7	Inconel 718	1000	High Volume	$6.89\ e^{-5}$	83.241
8	Inconel 718	1500	Low Volume	$7.97\ e^{-5}$	81.969
9	Inconel 718	2000	Medium Volume	$1.12\ e^{-4}$	78.977

5. RESULTS AND DISCUSSIONS

The Load Carrier has been designed with the help of automated modelling Software Fusion360, Taguchi's robust design methodology has been successfully implemented to identify the optimum parameters from selected process parameter and their levels in order to reduce the von mises stress for improved performance. Experiments are conducted according to design of experiments by using three perimeters at three different levels and the results are tabulated below.

Table 5.1: Stress Test Results

Exp. No.	Type of Material (A)	Load (N) (B)	Volume of component (C)	Stress (MPa)	S/N ratio (dB)
1	**Steel ASTM A36**	**1000**	**Low Volume**	**7.262**	**-17.2211**
2	Steel ASTM A36	1500	Medium Volume	11.64	-21.3191
3	Steel ASTM A36	2000	High Volume	16.82	-24.5165
4	TiG5	1000	Medium Volume	7.396	-17.3799
5	TiG5	1500	High Volume	12.6	-22.0074
6	TiG5	2000	Low Volume	14.44	-23.1913
7	Inconel 718	1000	High Volume	8.183	-18.2583
8	Inconel 718	1500	Low Volume	10.89	-20.7406
9	Inconel 718	2000	Medium Volume	15.46	-23.7842

After analysis of data from the robust design experiments the optimum process parameters are found. These optimum process parameters are validated by conducting confirmation test.

Table 5.2: Confirmation Test

S.No.	Materials	Load	Volume of Components	Stress (Mpa)
1	Steel ASTM A36	1000N	Low volume	7.26

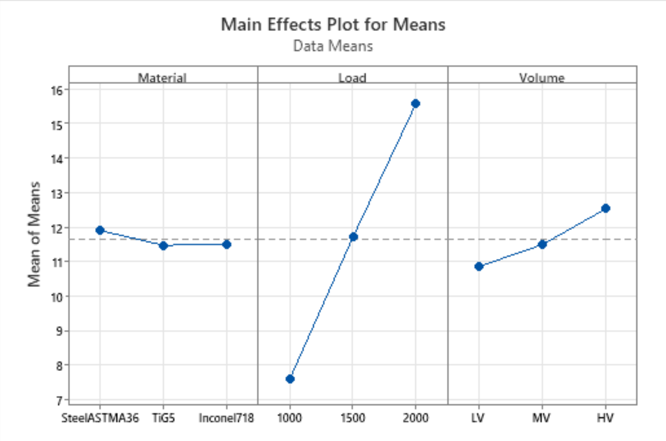


Figure 5.1: Main effect plots for Means related to Stress

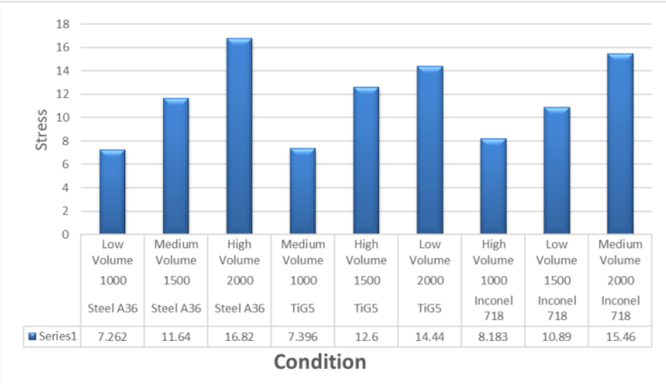


Figure 5.2: Results related to Stress

From the above test results, it is observed that the level of parameter with the lowest stress value 7.262Mpa is the optimal level. The optimized condition for the lowest von-misses stress in the load carrier design obtained as Material (Steel ASTM A36), Load (1000N) and Low volume condition.

6. CONCLUSIONS

Automated modelling SoftwareFusion360 is used to design the Load Carrier, Automated modeling and shape optimization of load carrier is done by using Taguchi method. Factors are selected for designing of Load carrier by using automated modelling to find optimum von mises stresses. The factors Load and volume are identified significant parameters. Which means that, those parameters are having countable impact on result (von mises stress)

1. Each factor percentage contributions are calculated. The percentage contributions are as follows Load has major contribution (95.17%) followed by volume (4.270%), Material (0.342%). The optimized condition for von-misses stress in the load carrier design obtained as Material (Steel ASTM A36), Load (1000N) and Low volume condition.

2. The factors are selected for designing of Load carrier to find optimum strains. Those factors are identified as in-significant. Which means that, all the factors are not having countable impact on result (strain). The factor of safety is within the limits in all the conditions, which means model is safe.

ACKNOWLEDGEMENT

It's my pleasure to acknowledge with deep appreciation to all those who have helped and guided me all through the project work.

I wish to express my deep sense of gratitude to my Project Guide **Mr. Shaik Ahsraf**, Assistant Professor, Mechanical Engineering Department, JBIET for his extremely valuable guidance and hearted co-operation throughout the project.

I wish to express sincere thanks to P.G Coordinator, **Mr. G. Gopinath**, Assistant Professor, Department of Mechanical Engineering, for timely guidance, technical Inputs and suggestions in spite of his busy schedule.

I also thank **Dr. Anoop Kumar Shukla**, Head of the Department, Department of Mechanical Engineering, for encouraging me throughout the project by giving necessary technical guidance.

A special thanks to **Dr. P.C. Krishnamachari,** Principal, JBIET and Management of JBIET for providing facilities to this project.

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