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Design and Topology Optimization on Car Wheel Rim Using FEA

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ABSTRACT - Since their beginnings, automotive wheels have evolved over decades. Wood and stone were used to make the antique wheel rims. The wheel rim, as an essential and crucial portion of the vehicle, was concentrated on with excessive effort as research and development blossomed throughout the industrial revolution. The study is primarily concerned with improving and optimizing the mass of a car's wheel rim. The primary goal is to reduce the weight of the wheel in order to improve the vehicle's overall performance and economy. Cast iron is the material assigned to the basic model. Following design optimization, the rim is subjected to material optimization, which involves assigning several competitive materials to the optimized design and analyzing and observing them under the identical boundary circumstances. Solid Works is used to solid model the underlying model and redesign it. Solid works software is used to do simulations for static analysis and topology optimization.

KEYWORDS - Topology, Solid Works, Static and Mass.

I. INTRODUCTION

Topology Optimization (TO) is an interaction that streamlines material format and construction inside a given 3D mathematical plan space for a characterized set of rules set by the fashioner. The objective is to amplify part execution by numerically displaying and streamlining for elements, for example, outer powers, load conditions, limit conditions, imperatives, and material properties inside the plan envelope.

Ordinary geography streamlining utilizes limited component examination to assess the plan execution and produce designs to fulfill targets like the accompanying:

- Diminished firmness to-weight proportion
- Better strain energy to weight proportion
- decreased material volume to somewhere safe variable proportion,
- regular recurrence to weight proportion.

In spite of the fact that geography enhancement has a wide scope of utilizations across ventures, in designing item plan, it is utilized at the plan phase of new item plan to upgrade the structure to expand solidness to weight proportion.

A. Structure Optimization

TO generated free form designs are often difficult to manufacture using traditional manufacturing methods. But due to growth and technological advancement in additive manufacturing or so-called 3D printing, the design output by Topology optimization can be fed directly into a 3D printer.

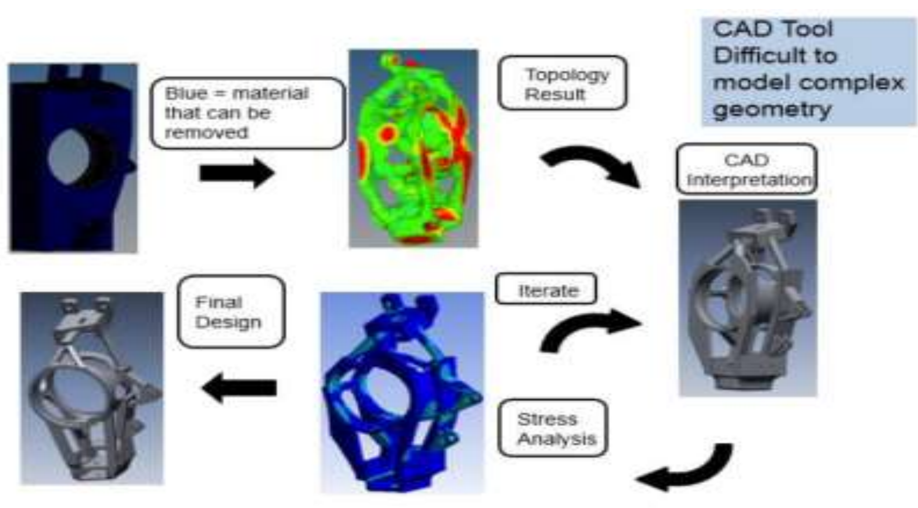


Figure 1: Optimization Cycle

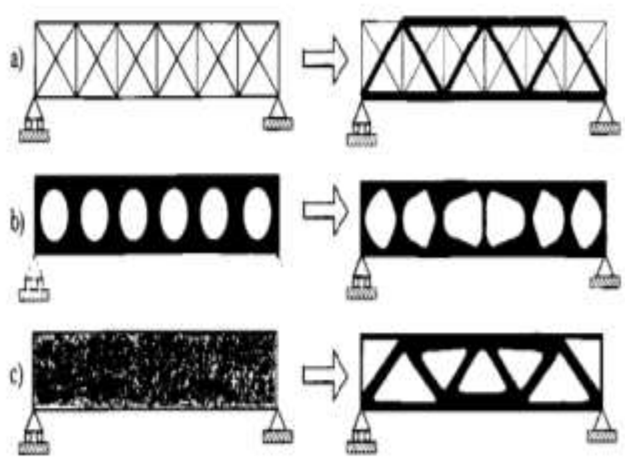


Figure 2: a) Sizing, b) Shape, c) Topology

II. LITERATURE REVIEW

Enhancement can be separated into 3 kinds: parametric, where the development presents a decent form and geography and shifts (upgrades) just in constitutive materials applied or doubtlessly the additives of the underlying additives [1]; form, where the layout presents a proper geography, differing its form and not having starting additions; as such, the plan factors signify the restrict of the gap whose shape is enhancing during the streamlining machine [2]; and topological, that's a hypothesis of other improvement modes, because for this situation, the addition of openings within the underlying location is authorized and the underlying restriction can be worn out [3]. Concerning strategies for enhancement, as in keeping with [4], they may be delegated: Density approach (like SIMP), Topological subsidiaries, stage set approach (as an instance, Hamilton-Jacobi situation), phase subject technique and Evolutionary methodologies (like ESO/BESO/SESO), the final option being considered as Discrete methodologies, of which one (the SESO - clean Evolutionary Structural Optimization approach) became embraced inside the technique applied in this paintings. As indicated through [5], whilst contrasted with the giant measure of distributions with regard to little uprooting geography development plan, not very many examination works have been completed on large removals development area. Hence, the creators implemented ideas of enhancement thinking about mathematical nonlinear investigation under full loads related to consistence as the goal paintings. The responsiveness of the suggest consistence, because the enhancement become performed by using a slope based totally method, applied the joint technique to compute the subordinates.

IV. OBJECTIVES

- To boost the automobile rim's strength while simultaneously reducing its weight and form.

A. *Uniqueness*

- Nowadays, automobile rims are made of cast iron, which is being phased out in favor of aluminum alloy due to its less weight.
- On the automobile rim, we are doing topology optimization.
- Topology optimization is used to optimize form and weight.

V. METHODOLOGY

- Drawing the CAD report of the underlying edge plan.
- Characterizing the material to be utilized for the brink
- Placing the hundreds under which the brink is appearing.
- Applying the examination and figuring out the consequences.
- Picking the satisfactory shape and plan to be made

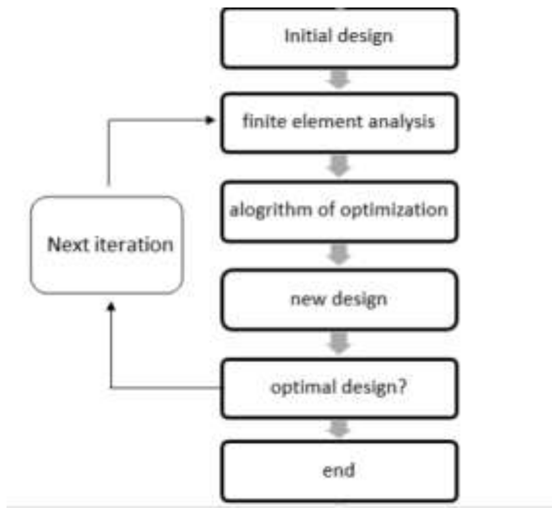


Figure 3: Flow chart

A. *Materials and Methods*

- Cast iron
- Aluminum
- Magnesium

B. *Modeling and Analysis*

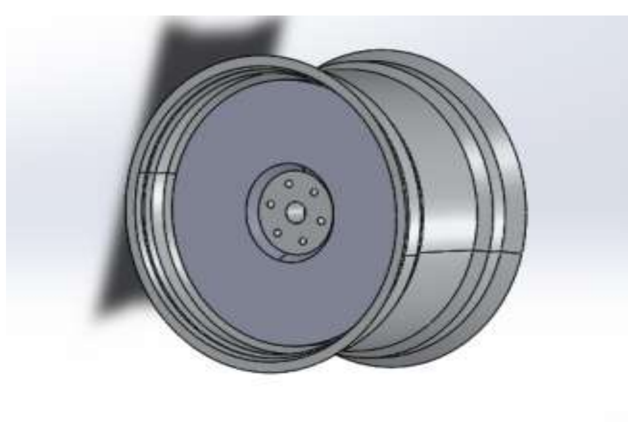


Figure 4: D model of car rim

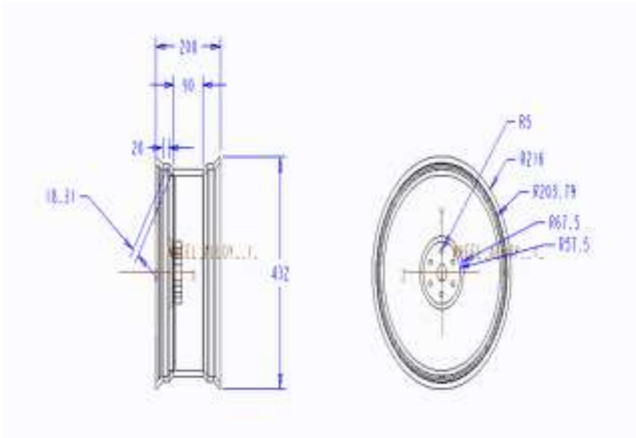
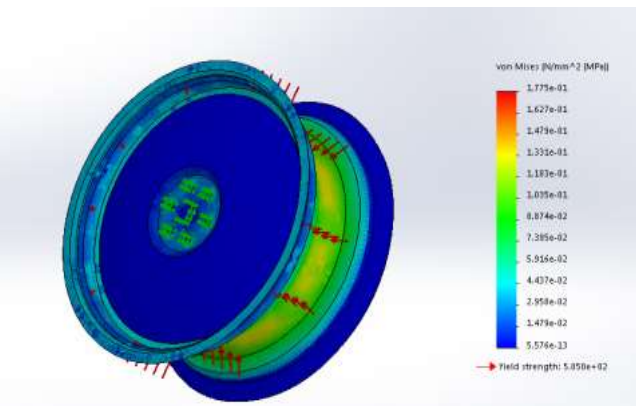


Figure 5: 2D Drawing

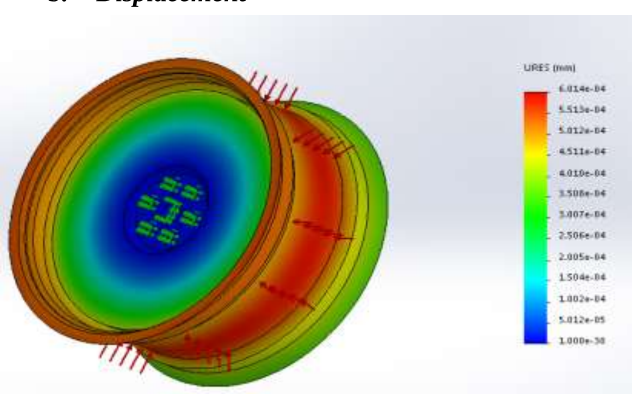
VI. RESULTS AND DISCUSSIONS

The analysis of car wheel rim using FEA is shown in figure.6. it shows the wheel stress, displacement and strain.

a. Stress



b. Displacement



c. Strain

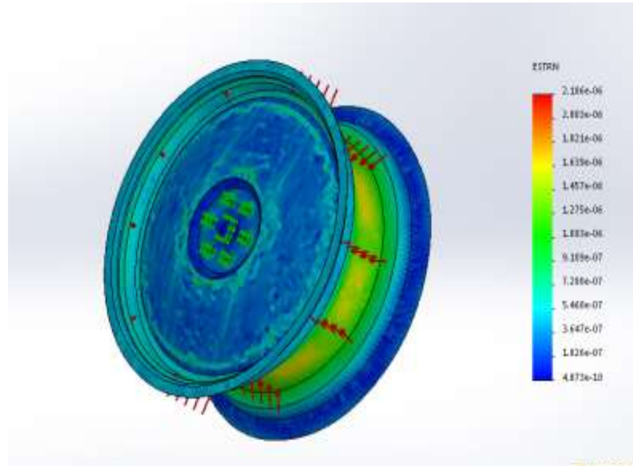


Figure 6(a)(b)(c): Results of stress,displacement and strain

The static analysis of different materials along with strss, displacement and strain as shown in table 1. the topological study results of same material as shown in table 2.

Table 1: Results tables Static analysis results

Materials	Stress (N/mm2)	Displacement(mm)	Strain
Cast iron	3.628	0.01228	3.863e-5
Titanium alloy	3.568	0.00769	2.477e-5
Aluminum alloy 7075	3.537	0.0114	3.61e-05

Table 2: Topological study results

Materials	Mass (Kg)	Stress (N/mm2)	Displacement(mm)	Strain
Cast iron	19.594	1.825e-1	6.552e-4	2.33e-6
Titanium alloy	12.035	1.729e-1	4.127e-4	1.494e-6
Aluminum alloy 7075	7.627	1.755e-1	6.014e-4	2.186e-6

The Static analysis graphs of materials along with stress and mass as shown in figure.7 and figure8. Finally, the comparison of material before topology and after topology as shown in figure.9.

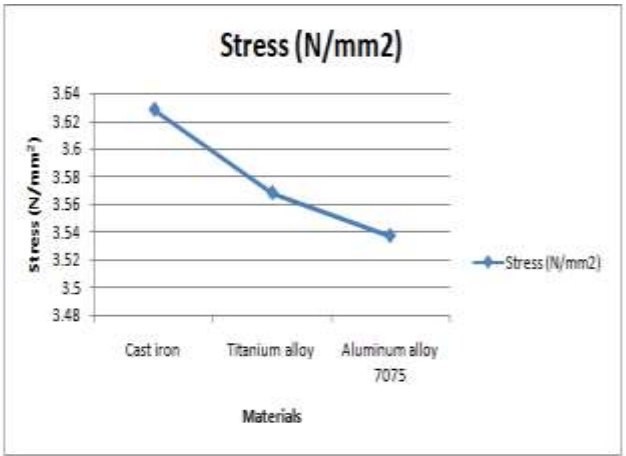


Figure 7: shows materials versus stress

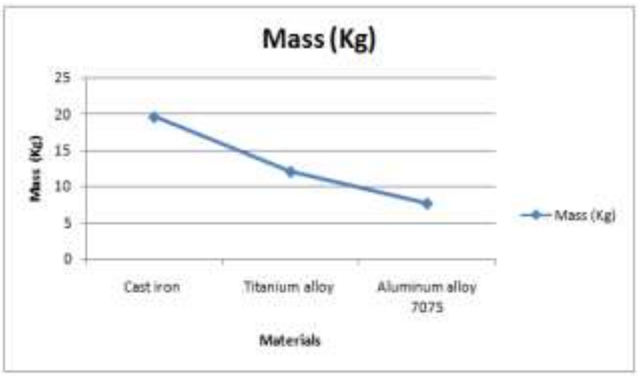


Figure 8: Materials versus Mass

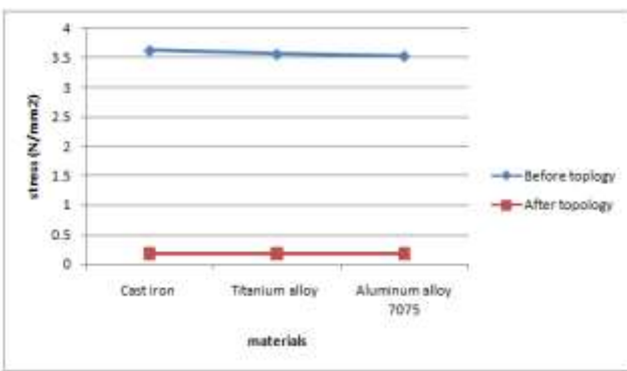


Figure 9: Comparison graphs

VII. CONCLUSION

The wheel structure and its traits are split into two portions in the optimization of wheel rims, specifically design area and non-design area. The non-design space is the default layout and cannot be modified. The layout space is the region where the burden can be optimized. The wheel layout place is customized to bear the vehicle's cutting-edge load while maintaining a excessive degree of protection while the usage of the least quantity of fabric and minimizing manufacturing expenses and losses. The subsequent are the conclusions reached during the optimization and evaluation of the wheel's life:

- The usage of the topological approach, the burden of the rim became reduced from 12.6 kg to 7.6 kg.
- The shape of the arm's go phase is made easier to manufacture and to distribute the pressure brought about within the rim

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