A Topological optimization solution for the automobile wheel rim: A case study.

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ABSTRACT

The present study focuses on the topological optimization of the automobile wheel rim. Current design life cycles cares about the conserving the material resources, so the topological optimization technique helps in the finding the shape of the wheel rim. The maximization of the stiffness matrix was made as the constraint while the stiffness goals are defined parametrically. The final solutions are studied and on the detail, analysis shows that the shape generated by the optimization algorithm justifies the maximum deformation of the wheel.

Keyword: - *wheel rim, topological optimization, Maximum stiffness matrix, shape generation*

1. INTRODUCTION

The design life cycles consist of the many phases, identification of problem to actual product life delamination. While the designing the process the materials are chosen and there is always the thumb rule that the as the thickness of the design increases there is always the guarantee for the lower in the deformation and the failure. Allowing the more material means for the single unit may cause the chain allocation of the material by the rules of the production. In order to optimize the design based on the material has been a good way of the design. Topological optimization is the key for the achieving this constraint. The topological optimization is a mathematical method, which searches in the design space. A design space is the search area where the desired of optimization need to take place and this should not be combined with the loaded part so that they need to be split. This is not same as the shape generation. Shape optimization is part of the field of optimal control theory. The typical problem is to find the shape , which is optimal in that it minimizes a certain cost functional while satisfying given constraints. In many cases, the functional being solved depends on the solution of a given partial differential equation defined on the variable domain. Topology optimization is concerned with the number of connected components/boundaries belonging to the domain. Such methods are needed since typically shape optimization methods work in a subset of allowable shapes.

2. METHODOLOGY

The aim of the study says that the by the using the topological optimization the material is saved, therefore the reverse approach is made by considering the an arbitrary circular geometry with the support holes and with the the circumferential rim of thickness 10 mm. The loads are applied to the object and the constant load of 5MP is made to apply as the compression load to mimic the actual road load condition. The maximum stiffness matric is taken as the goal and the iterative solutions of 5%,15%, 25%, 30% reduction is studied. The material that is applied was the stainless steel of 304L grade. The genetic algorithm has been applied to study the solution. The natural condition that have been applied is for the stiffness behavior is given as follows.

$$\min_{p} \int_{\Omega} \frac{1}{2} \sigma : \varepsilon \, d\Omega \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Subjected to

$$p \in [0,1], \qquad \int_{\Omega} p \, d\Omega \le V^{*}, \quad \nabla \cdot \sigma + F = 0 \quad , \sigma = C : \varepsilon$$

Where the

1. p is the section filed

2. Ω is the search space.
3. σ Stress tensor or the stress field.
4. F is the force tensor.
5. C is the constant.
6. V^* is the volume.

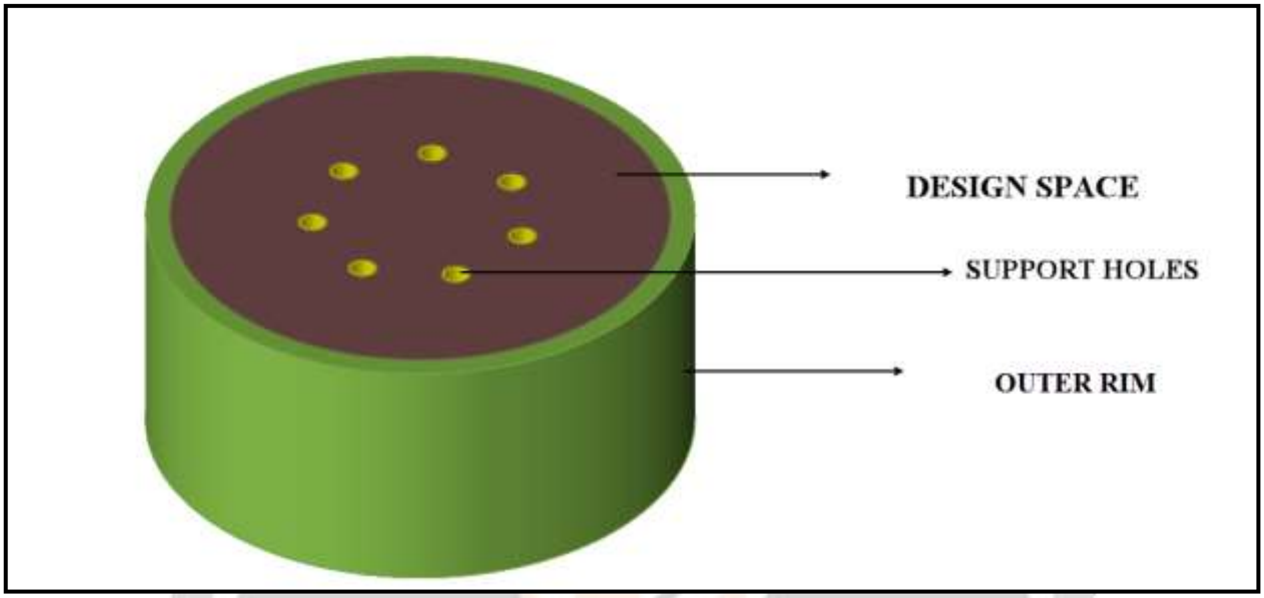

Figure -1: The 3D model of the wheel and the it has assigned design space.

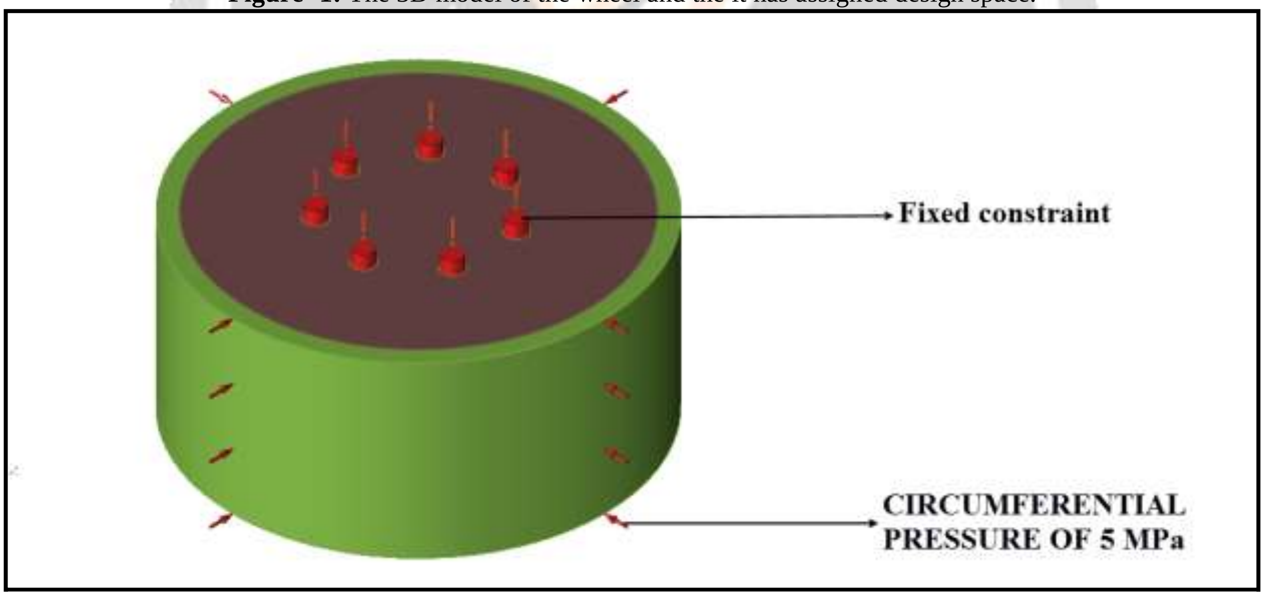

Figure -2: the load and boundary conditions applied to solve the topological optimization

3. RESULTS AND CONCLUSION

Since the solution is at the middle of the rim as shown in the figure-1, the maximization of the stiffness matrix is made as the goal.

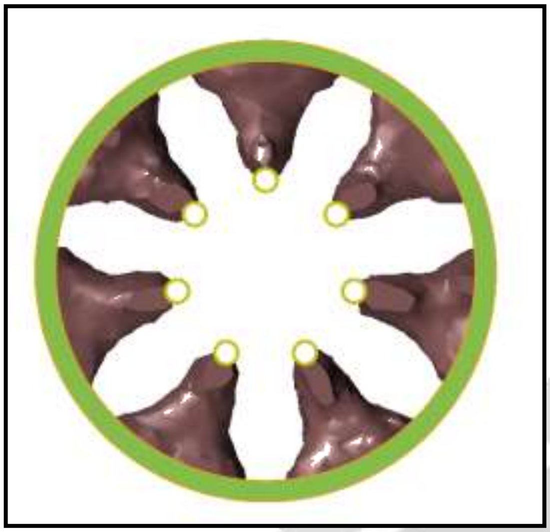

Figure -3: the topologically optimized structure of the wheel for 30% of maximizing the stiffness matrix

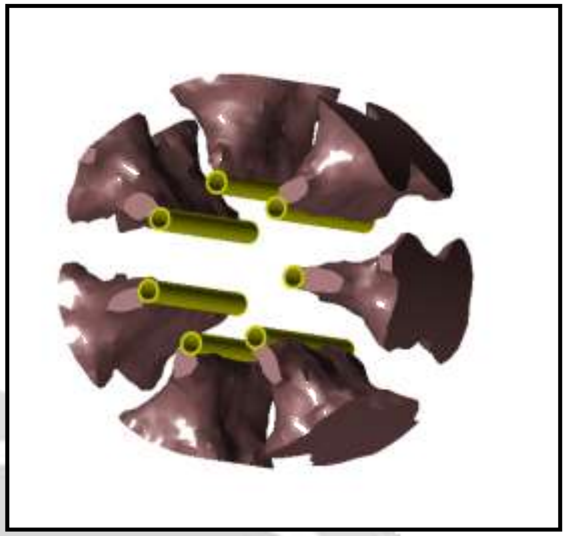

Figure -4: the topologically optimized structure of design space that have mimicked the real time structure of the wheel the wheel for 30% of maximizing the stiffness matrix

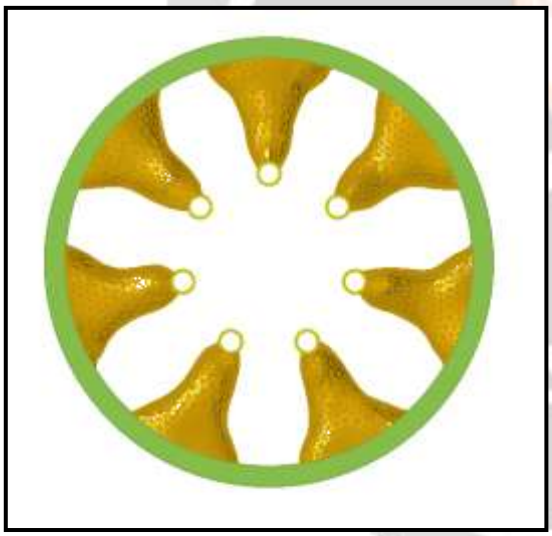

Figure -6: the topologically optimized structure of the wheel for 25% of maximizing the stiffness matrix

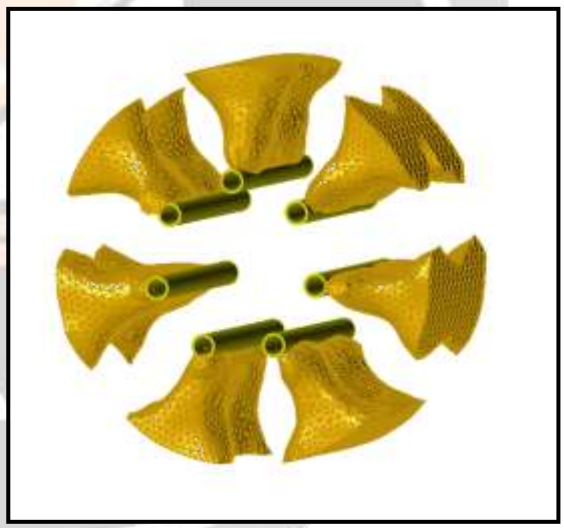

Figure -7: the topologically optimized structure of design space that have mimicked the real time structure of the wheel the wheel for 25% of maximizing the stiffness matrix

Figure -8: the topologically optimized structure of the wheel for 15% of maximizing the stiffness matrix

Figure -9: the topologically optimized structure of design space that have mimicked the real time structure of the wheel the wheel for 15% of maximizing the stiffness matrix

Figure -10: the topologically optimized structure of the wheel for 5% of maximizing the stiffness matrix

Figure -11:the topologically optimized structure of design space that have mimicked the real time structure of the wheel the wheel for 15% of maximizing the stiffness matrix it has been observed that the as the percentage of the stiffness matrix decreasing the maximum amount of the mas has been accumulated. However, it has been observed that the real-time wheel design often takes the 5% reduction in the stiffness matrix

6. REFERENCES

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