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Topology optimization of beam structure using ANSYS

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Abstract – *Topology optimization is a technique to optimize material conditions in the given set of design constraint limits by reducing the number of compliance variables in structure. In the present paper, the significant theory of topology optimization and experimental validation of continuum structure using ANSYS software is performed on a structural one end fixed Beam. The optimized evidence is established by validating theoretical and computational evidence based on the pseudo density factor.*
Key Words: *Topology optimization-TO, Ansys, Continuum structure, Beam, Optimality creation (OC method).*

I. Introduction

Topology optimization is a technique to optimize material conditions in a given set of design constraints, by preparing a mathematical model that sets a goal of maximizing system performance by optimizing material sets loading and boundary conditions in a given constraint limit. In shape optimization and size optimization, there is a limit in designing features where a final geometry creation cannot obtain configure results in freedom of shape change whereas in Topology optimization there is a freedom in geometry creation in which the design can obtain any size and shape accordingly in between the given sets of constraint limits.

In the creation of topology optimization, it uses a Finite Element Method and Finite Element Analysis technique to validate and configure design structural performance of the systems. The topology optimization works on the factor of pseudo density factor which is state variable forms of response accordingly in mass and volume compliance of the structure. The pseudo density factor range from 0 – 1 where 0 means no material condition and 1 means a rigid material condition that can be vital from the geometry based on mass or volume constraints.

II. Optimization Techniques

The structural optimization has broadly classified in several working limit in which it is mainly classified into four types, a)Shape and Size optimization b) Topology optimization c) Layout optimization and Structural and material optimization. The main prime serves functional characteristics of topology optimization is to find out the most prominent material distribution in the system.

In 1988 Bendsoe and Kikuchi were the first pioneer of an optimization technique in which they have proposed the method of homogenization for ainstopic material based on boundary variation techniques. In **1991 Suzuki and Kikuchi**, have continued the research of the Homogenization method which with later modification they presented the strength based on plane structures for linear elasticity.

In 2008 Hui Zhang & Xiong Zhang & Shutian LiuIn have proposed the theory with practical validation that corresponding nodes in element carry a similar part of loading as the previous node carries with them in connection**.**

There is very Scant Knowledge about topology optimization but later on, upgrading decades Designers got to know the benefit of topology optimization which can effectively use for developing efficient low weight structure which can sever for very wide applications from industrial to medical products. In the presented paper the Topology optimization scheme has been developed for a continuum structural beam where the aim is to showcase how optimality creation method works by vitalizing out the stiff part from the structure based on pseudo density factor.

III. Materials And Methods

In the present paper, The Topological optimization has been developed on a continuum structural beam which again further has been validated to check the stability against fracture and creep development by using the FEA Structural Analysis package of ANSYS software based on FEM equation of optimality creation approach.

Numerical Scheme.
General formulation: Set of function to find design variable, **X**
Minimize F(X) (1)

Subject to:

$G_j(X) < 0$; j=1, m (2) ${}_iX^L < X_i < X_i{}^U$; i=1, n (3) [K]u = p (4)

Equation 4 states the Finite element method to solve the displacement of vectors and minimum weight structure in constrained limits.

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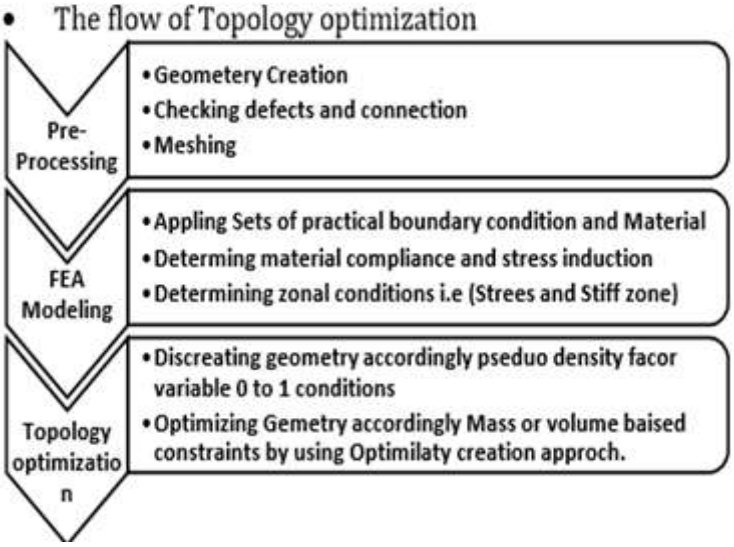
Optimilatity creation approach.

Optimality creation method is also known OC method of moving asymptotes it is based on multiplying the number of elements N1…Nn with the lagrangian variables stated λ1…. λn to justify and expose the maximum stiffness area in the structure which can be performing using for Optimizing layout based on Mass or volume-based constraints.

IV. Finite Element Scheme And To Initialization

The flow of Topology optimization



Pre-Processing.

In the present paper, a continuum structural beam is used for the execution of experimental study to perform and validate topology optimization using Ansys software. The continuum structural beam is a type of a structure whose elements and nodes are closely backed with each other, this type of structure is widely used in the heavyweight sustainable application and connecting pathway of two distinct or similar structures.

FEA Modelling.

The design structure is been validated for equivalent stress to determine the induce stresses in geometry and determine the material compliance on the structure whereas the aim is to expose the zone of stress and rigidity in the structure by performing static structural investigation for equivalent stress.

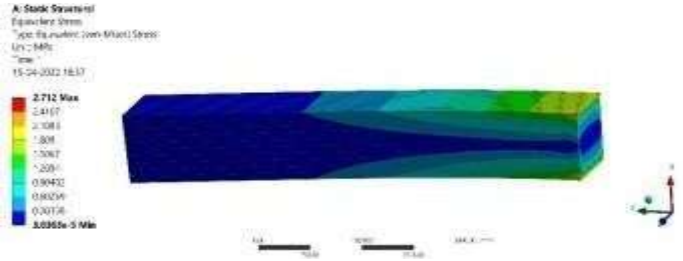


Figure 2. Equivalent stress in the Beam.

Topology optimization.

In Topology optimization, the aim is to vital in the induce rigid zone of the structure while reducing and minimizing compliances in the structure. A Topology optimization works on based of Pseudo Density Factor in which it discreet material in 0 to 1 configuration where 0 means stress induce zone and 1 means Rigid/Stiff zone which can remove from the structure based on Mass or volume constraints of Optimality creation method.

Figure 3. Topology optimized geometry based on Pseudo density discretion.

V. Results

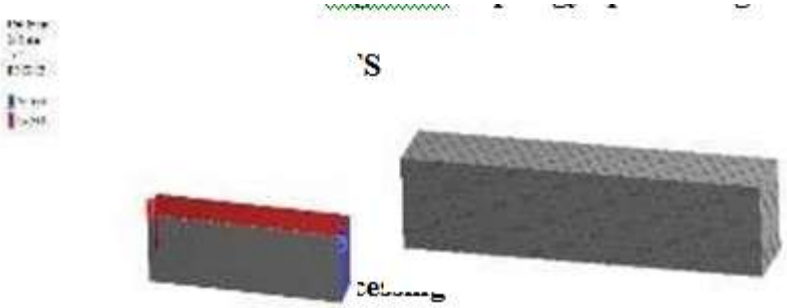


Figure.1. Pre-processing

Above Fig shows the preparation of geometry creation and vitalizing out the major defects in connections. Hexa dominant meshing is been developed on the structure where the material used is static structural steel for the structure.

FEA modeling of optimizes structure.

After completingthe Topology optimization operation it is must- revalidate our new obtained geometry for the sensible design approach. After all, if the induce compliance or stress in the geometry gets increase above working limit after Topology initialization it doesn't make worth manufacturing it because it causes fail of the structure. In present results we can see the induce stress in the Geometry is within the working limits.

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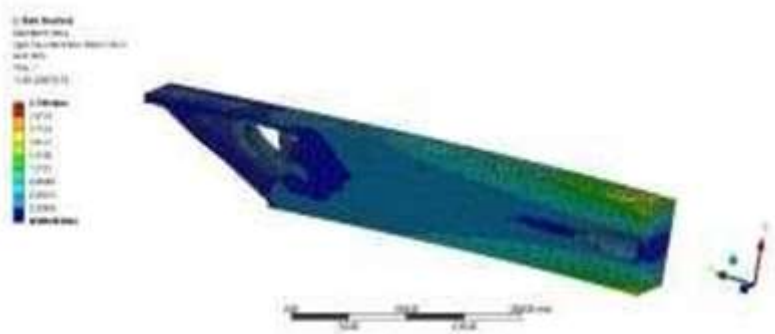

Figure 5. FEA Validification of Optimize geometry for the sensible design approach.

VI. Conclusions

In present paper, The detail overview and working of Topology optimization is presented whereas the continuum structural beam is used for an operation of TO in which first it has been validated for initial FEA boundary condition to flash the zonal stress and stiffness area in the structure. Further based on the pseudo density factor the geometry has been discredited according to the zone for topology optimization initialization in it vital out the stiff region based on mass constraint to get optimize the shaped layout. To make this approach more towards sensible design the optimize shape is again validated for induce stress to determine if there is any certain failure induce in structure after optimization.

The sensible design approach is very important factor in Topology optimization because it bridges the point of Optimization theory and final development of productby means of Additive manufacturing.

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