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Study And Analysis of Functionally Graded Material By ANSYS 18.1.

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- **ABSTRACT--**

Functionally graded Materials are characterized as an anisotropic material and novel material whose physical properties change gradually as the dimensions varies randomly or strategically, to achieve the desired characteristic. The overall properties of the functionally gradient material are different from the properties of any of the individual parent materials which form it. They can be applied to metals, ceramics and organic composites to generate improved components, they are increasingly being considered in industry for various applications to maximize strengths and integrities of many engineered structures. The processing's of FGM is costly, but it is expected the researches carrying in this field for fabrication and processing of such materials will reduce the cost and makes the materials easily available as well as applicable in wide area of applications.

Material modelling, geometric modelling and finite element modelling is done for the leaf spring using exponentially varying properties and Mori tanaka scheme and then numerical problem is solved using the finite element software ANSYS 18.1

- **INTRODUCTION**

Functionally graded materials are characterized by a compositional gradient of one material into another. These are a class of advanced composites formed of two or more constituent phases with a gradual and continuously variable chemical composition, microstructure and material properties. They were initially introduced by a group of Japanese scientists for the purpose of addressing the needs of aggressive environment of thermal shock in the space shuttle in 1984 [1]. Since then, due to FGM' outstanding advantages including a potential reduction of in-plane and transverse stresses through-the-thickness, an improved residual stress distribution ,enhanced thermal properties, higher fracture toughness and reduced stress intensity factors, FGMs received much attention in both academic and engineering communities [2,3]. A number of reviews dealing with various aspects of FGMs have been published over the years [2, 4-6].

- **Theory of elasticity on hollow cylinders**

Hollow cylinder is a three-dimensional (3D) structure bounded by two parallel curved surfaces (an inner surface and an outer one), which are respectively formed by the points at a fixed distance from the axis of the cylinder. Hollow cylinders are axisymmetric. To analyse the mechanical behaviours of them, cylindrical coordinate（r, θ, z）is always applied, where r,θ and z denote the radial, circumferential land axial coordinates respectively.

A summary of equations for hollow cylinders is made in this section, and the geometric equations, constitutive equations and equilibrium equations are mainly described. These equations associated with boundary conditions (and initial conditions) make up a complete set of equations of hollow cylinder theories.

LITERATURE SURVEY

FGMs are revolutionary Material belong to a class of advance materials with varying properties over a changing dimensions. Numerical analysis has been carried out for large deflection of prismatic cantilever beams for various types of material properties with a transverse load at free end. In this project work, paper of M. Bayat et al. (2011) titled “Analysis of Functionally Graded Rotating Disks with Parabolic Concave Thickness Applying an Exponential Function and the Mori-Tanaka Scheme” is taken as base paper and paper of Dipendra Kumar Roy et al. (2012) titled “Nonlinear Analysis of Leaf Springs of Functionally Graded Materials” is also taken as base paper.

A lot of work has been done in the field of FGM but very few in the field of leaf spring so an analysis describing comparison between different material gradation relation like exponential and Mori Tananka scheme with different loading conditions viz. UDL, concentrated load and combined load of both and comparison between different ceramic materials has yet not been carried out.

PROBLEM FORMULATION AND VALIDATION

In an FGM the variation of material properties is usually attained by adjusting the volume fractions of two or more compatible constituents, and the material used is in the base paper assumed to be functionally graded in the radial direction. Thus, variations in the material properties such as Young’s modulus and Poisson’s ratio may be arbitrary functions of the radial coordinate. In the base paper Young’s modulus with exponentially-varying properties and constant Poisson’s ratio is considered as the variation of Poisson’s ratio ν is small for engineering materials.

The influence of material gradation relation for exponential and Mori Tanaka scheme distribution for three different types of loading concentrated load, UDL (Uniformly distributed load), combined load (concentrated load + UDL) is considered and comparison between different ceramic materials is also considered for the analysis.

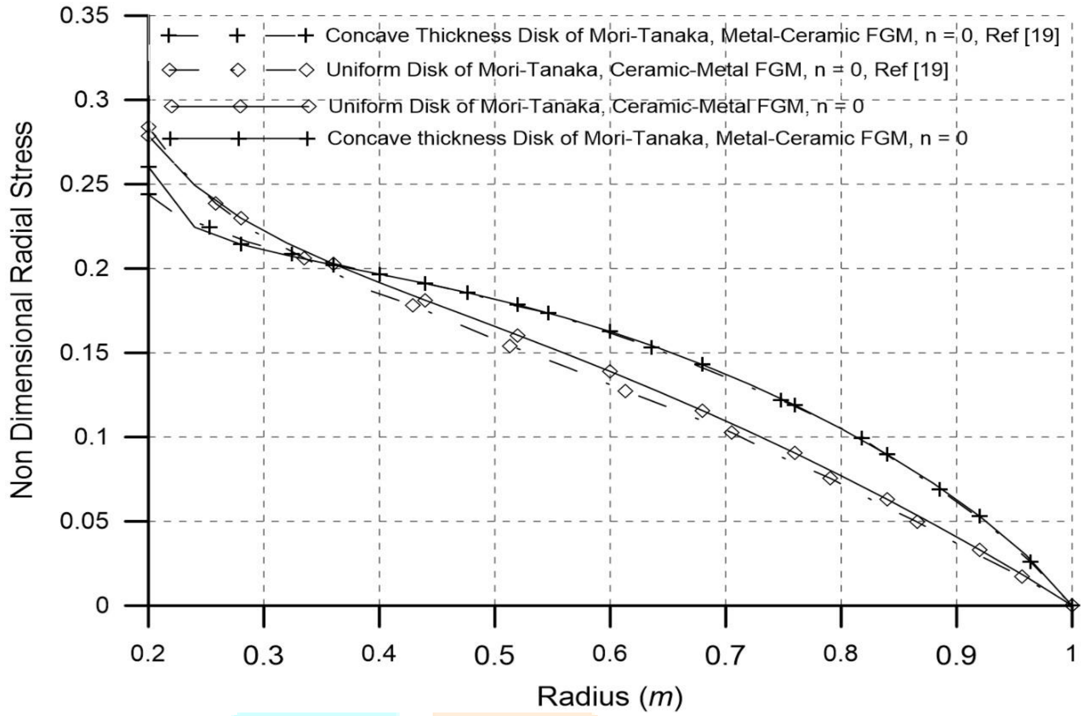

Fig 3.1: Comparison of radial stress of the current work with results of reference [19]

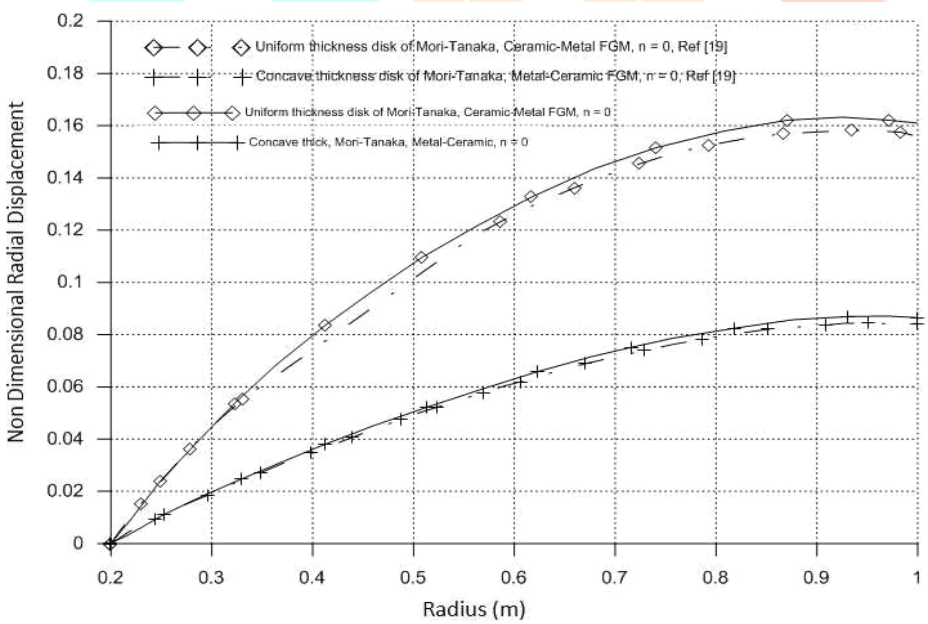

Fig 3.2: Comparison of radial displacement of the current work with results of reference [19]

Gradation relation - Exponential model

In this part exponential model is considered as of base paper since annular disc is considered having angular velocity so only gradient relations have only been considered and modelling is done same as of a cantilever beam depicting a semi elliptical leaf spring as done in the base paper an annular disc considered in 2D front view will be rectangle and that the rectangle is symmetrical therefore considered only half part along the axis of the disc therefore the modelling done for the leaf spring is same as that of disc and three different types of loads are being considered

- concentrated load
- UDL (Uniformly distributed load)
- Combined load (concentrated load + UDL)

Based on the different types of loading

- **Cantilever beam under Concentrated load**

The aim of this project is to make a comparative study of the displacements, stresses along X and Z axis and von mises stresses developed in a leaf spring made of functionally graded material of with concentrated load, UDL load, combined load with both mori tanaka scheme and exponential law and comparison between different ceramic materials for FGM.

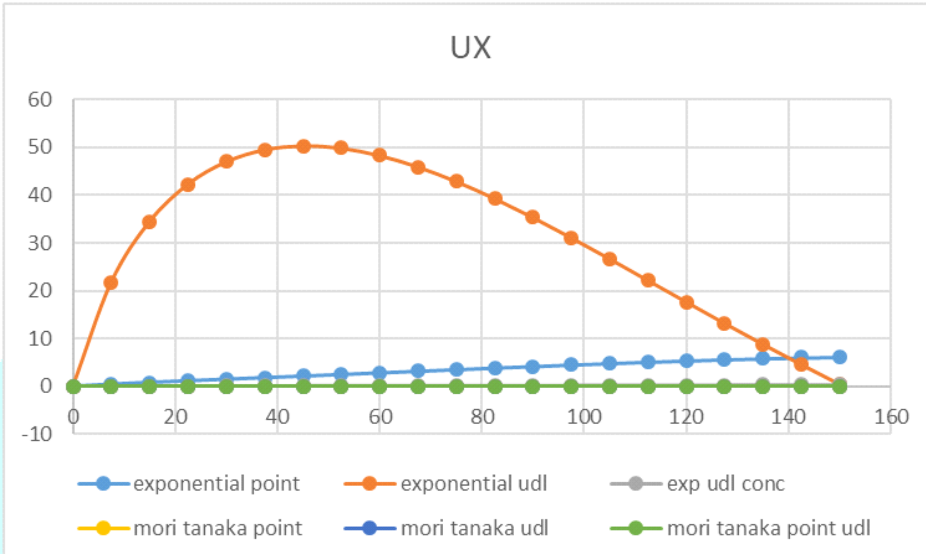

Fig 3.3 Variation of displacement along X direction

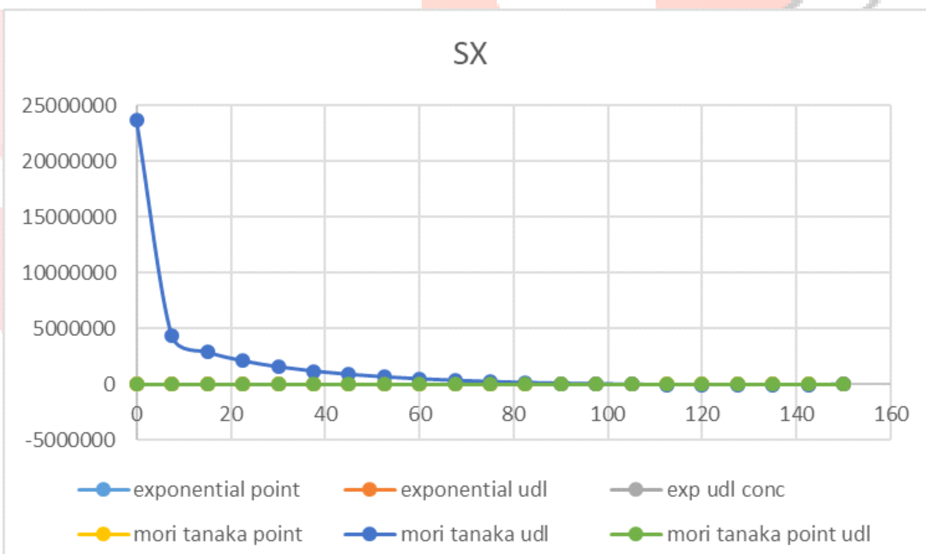

Fig 3.4 Variation of stress along X direction

Mori tanaka scheme with concentrated load and uniformly distributed load together when tested with others is showing the best result compared with the rest.

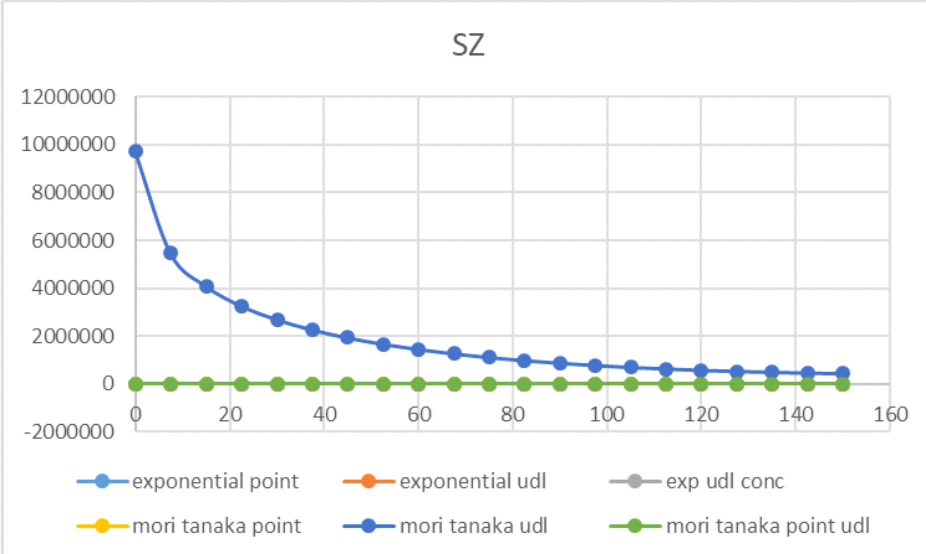

Fig 3.5 Variation of stress along Z direction

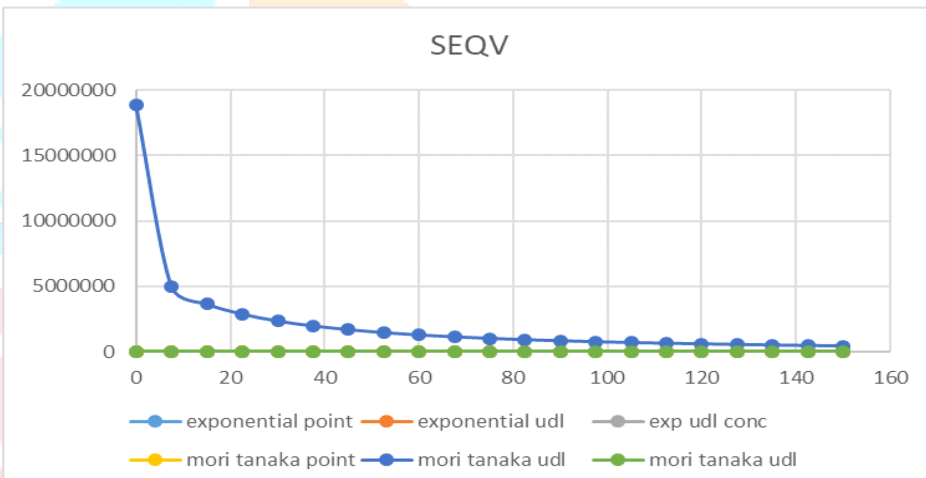

Fig 3.6 Variation of von mises stress

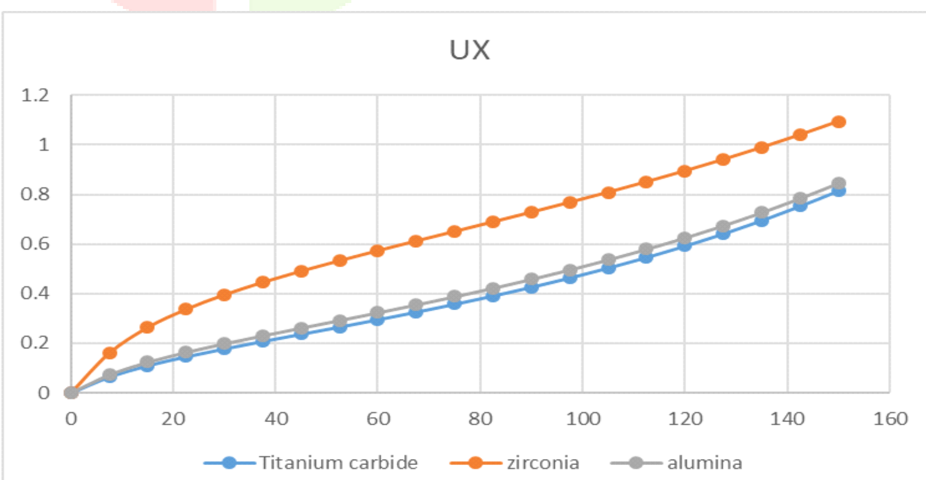

Fig 3.7 Variation of displacement along X direction for different materials

Fig. 3.7 show the variation of the displacement along the radius for different materials it is found that titanium carbide is found to have minimum deformation than alumina followed by zirconia i.e. the later ones can be used for small vehicles.

• CONCLUSION

In this project work pressure vessel made up of functionally graded material is analysed. The leaf spring has exponentially varying material properties and mori tanaka scheme varying material properties subjected to concentrated load, UDL load, combined load. Finite element modelling is done and numerical problem is analysed by the help of ANSYS Mechanical APDL 18.1 and a comparison is made for all different loads and different material.

The results obtained may be concluded as:

- Mori Tanaka scheme results found to be more promising compared to exponential model.
- Three different materials were analysed and within the given boundary conditions titanium carbide is found to be capable of withstanding the maximum pressure.

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