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ANALYSIS OF FUNCTIONALLY GRADED MATERIAL LEAF SPRING USING ANSYS 18.1

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Abstract

Functionally graded Materials (or also can say, Functionally Gradient materials) are characterized as an anisotropic material whose physical properties varies continuously 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.

With the use of the Lean & Six Sigma methodology, it is inferred from the research data that the objective rate has improved. Moreover, it has been determined that the effectiveness of the objective achievements using the theory of constraints, lean manufacturing, and six sigma. Lean, Six Sigma, and the Theory of Constraints, the second strategy, perform better than the first way. The second integrated strategy improves both employee and employer knowledge of the performance metric. The second strategy boosts shareholder and employer confidence more effectively. Implementing this strategy thereby boosts the financial gains for the shareholder and the employee.

Keywords: *Functionally graded Materials, Ansys, Leaf Spring, Analysis.*

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1. INTRODUCTION

These are multi-phase materials with graded properties. The gradation of material properties in FGMs is achieved by continuously varying the volume fractions of the constituents. The resulting material properties can be tailored so that to fit the requirements posed in a multitude of technically demanding applications. FGMs are a class of advanced composites composed of two or more discrete constituent phases with continuous and smoothly varying composition. These advanced materials with designable gradients of composition can integrate the advantages of constituent phases and show stronger superiority than homogeneous materials made of similar constituents in applications. Often, the accurate information of the shape and distribution of particles may not be available, thus the effective material properties, viz. elastic module, shear module, density, etc. of the graded composites are being evaluated only by the volume fraction distribution and the approximate shape of the dispersed phase.

With the advent in modern technology a wide variety of suspension systems are now used in vehicles, although majority of heavy vehicles utilize leaf springs as their suspension sub-system due to a wide merit base such as low cost, easy maintenance and high load carrying capabilities. Leaf springs are an assembly of various components like leaves stacked together, centre bolt, U-bolt. Main leaf has eyes at both ends for the ease of mounting. There are various types of eyes such as Berlin, Upturned, Downturned, Military-Wrapper type etc. which are used based upon the loads it encounters and manufacturing feasibility. Vehicle suspension system is classified into three type's i.e. passive, semi- active and active suspensions, which depends on working feature to enhance vehicle safety, ride comfort and overall performance. Springs absorb the static and dynamic loads within yield point thus providing proper handling and comfort. The energy is stored as strain energy and hence the strain energy of material becomes an important aspect in the design of springs. Originally it is called as laminated or carriage spring, a leaf spring is a simple form of spring that commonly used for suspension in wheeled vehicles. It is also one of the oldest springing and dating back to medieval times.

2. METHODOLOGY

2.1 Validation Using Ansys

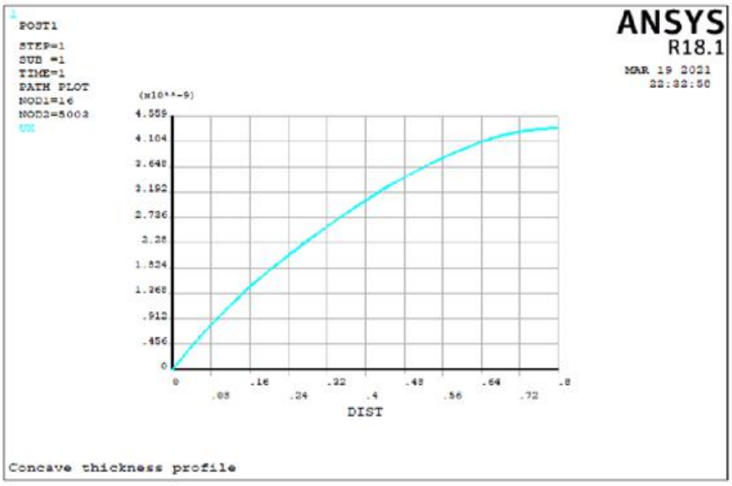

Figure 1. Variation of radial displacement for concave thick disk, by exponential scheme, fix-free boundary condition

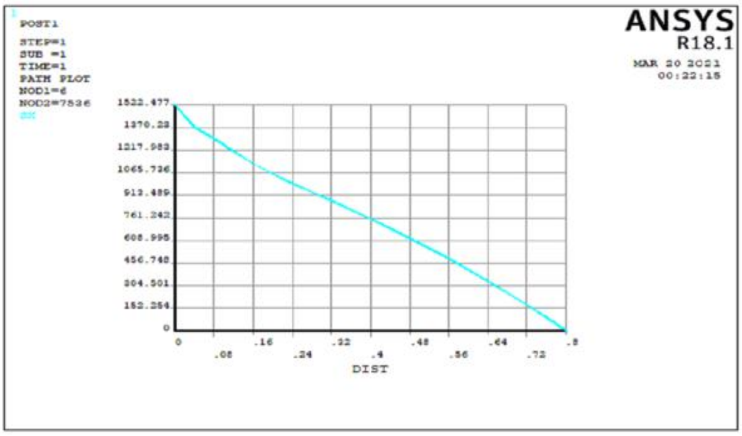

Figure 2. Variation of radial stress for concave thick disk, by exponential scheme , and fix-free boundary condition

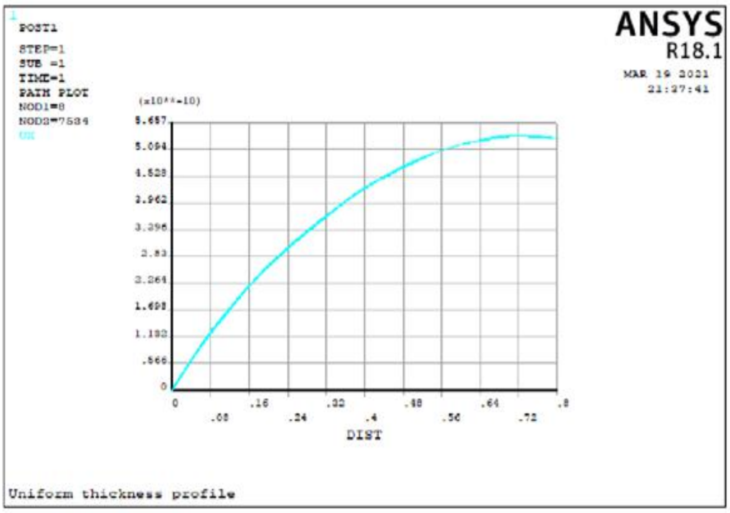

Figure 3. Variation of radial displacement for uniform thick disk, by Mori Tanaka scheme, fix-free boundary condition

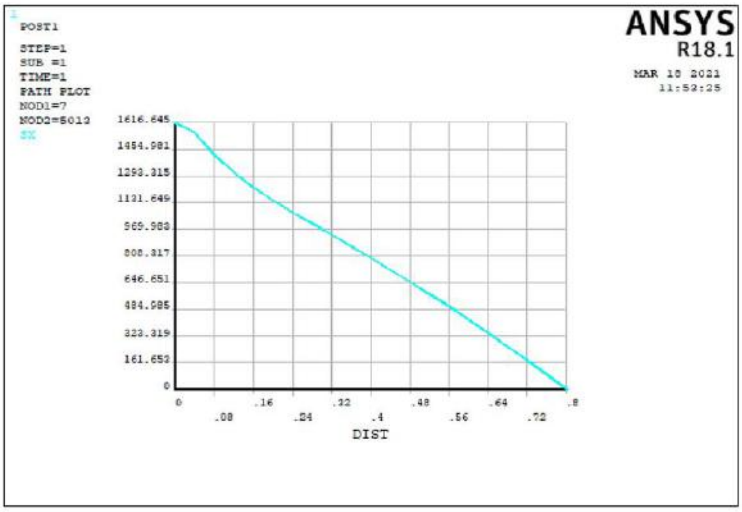

Figure 4. Variation of radial stress for uniform thick disk, by Mori Tanaka scheme, fix-free boundary condition

Figures shows the comparison of the results of the current work with results of reference [4]. Results for uniform thick disk and concave thickness disk subjected to mechanical load in the form of centrifugal force are evaluated and compared. Results of current work are in good agreement with pre analysed results of literature. The results are presented in a non-dimensional form so that absolute values of properties and loading speed are unimportant. Displacements, stresses were normalized by diving by the factors and respectively.

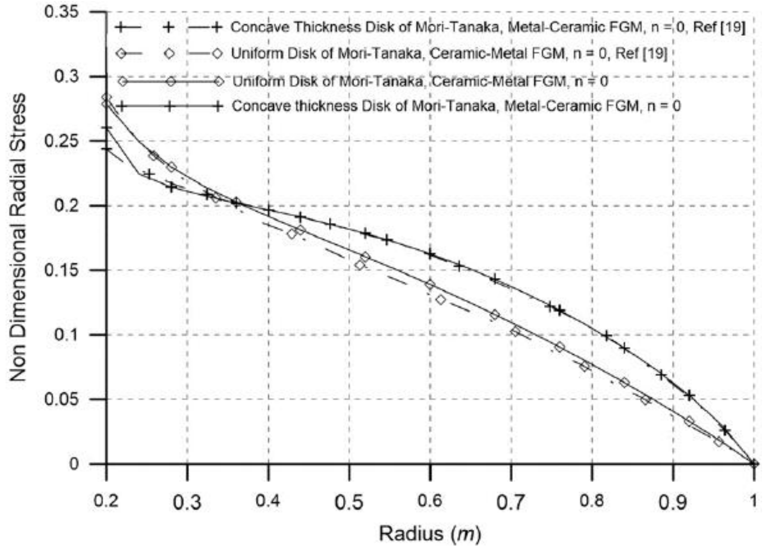

Figure 5. Comparison of radial stress of the current work with results of reference [4]

2.2 Results Obtained in ANSYS Mechanical APDL

All the iterations are done in CAE software APDL ANSYS Parametric Design Language using ANSYS 18.1 and results were plotted in the form of graphs for comparison.

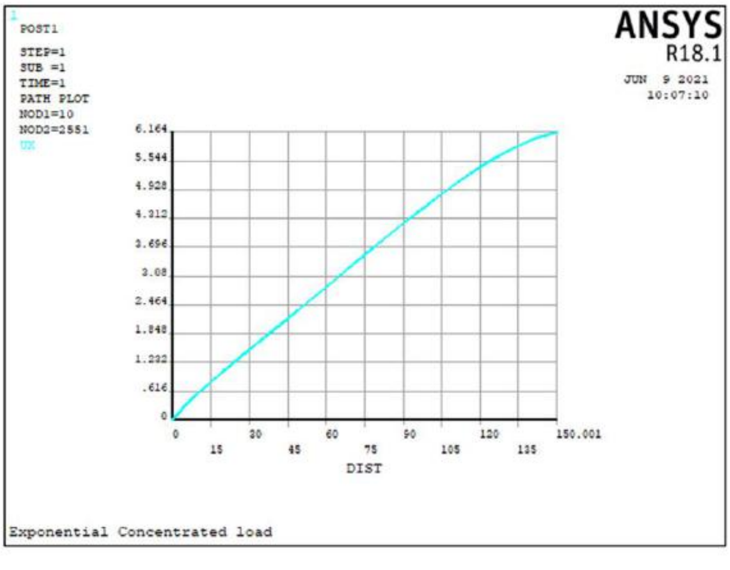

Figure 6. Variation of displacement by exponential scheme, under concentrated load

Displacement is maximum where load is acting and minimum where it is fixed end since the loading is of concentrated nature so the displacement is maximum at the free end and gradually decreases as it moves towards the free end.

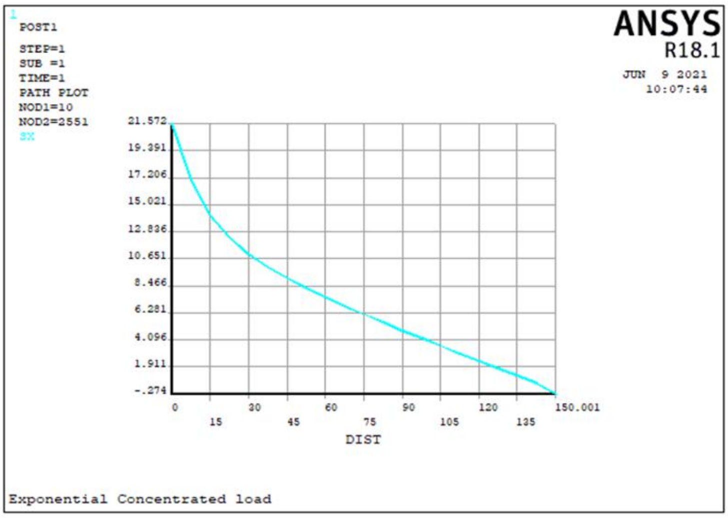

Figure 7. Variation of stresses acting along X direction by exponential scheme, under concentrated load

2.3 Comparative study based on combination of different materials

In this section ceramic material combination (zirconia, alumina, titanium carbide) with metal (aluminium) is studied in exponential model. Since stress is not dependent on material but strain is a dependent variable on material therefore, by varying different ceramic materials deformation or strain will change

- TiC (Titanium carbide)

An annular disc comprising of aluminium and titanium carbide (FGM) will be analyzed, the mechanical properties are shown in Table 1.

Table 1. Mechanical properties of TiC

Material	**E (GPa)**	**ρ (g/cm^3)**	**α (/ ^{0}C)**
TiC	439	4.90	8.31×10^{-6}

- ZrO3 (Zirconia)

An annular disc comprising of aluminium and zirconia (FGM) will be analysed, the mechanical properties are shown in Table 2.

Table 2. Mechanical properties of ZrO3 (Zirconia)

Material	**E (GPa)**	**ρ (g/cm^3)**	**B (GPa)**	**G (GPa)**
Ceramic	151	5.70	128.333	58.0769

- Al2O3 (alumina)

An annular disc comprising of aluminium and alumina (FGM) will be analysed, the mechanical properties are shown in Table 3 .

Table 3. Mechanical properties of Al2O3 [17]

Material	**E (GPa)**	**ρ (g/cm^3)**	**α (/ ^{0}C)**
Al_2O_3	380	0.96	8.0×10^{-6}

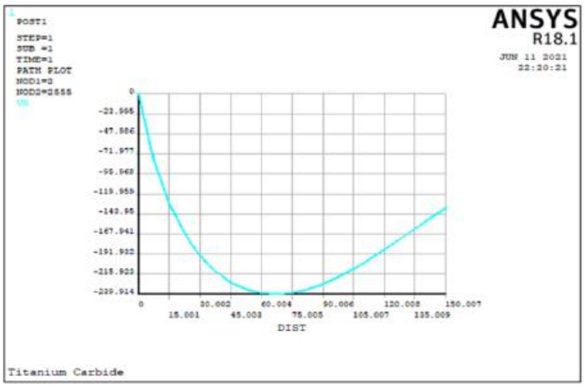

Figure 8. Variation of displacement along X direction by exponential scheme, under combined load

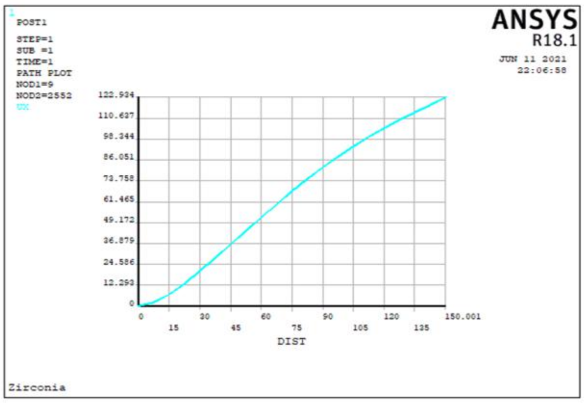

Figure 9. Variation of displacement along X direction by exponential scheme, under combined load

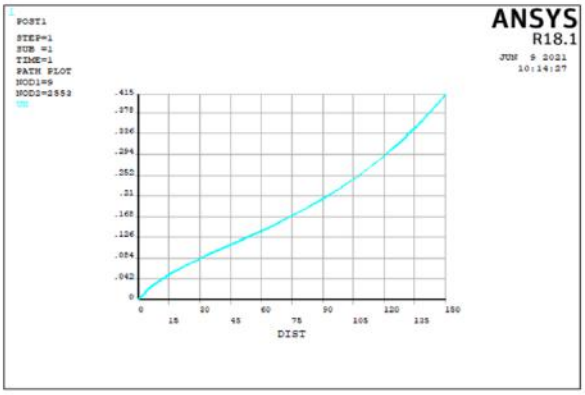

Figure 10. Variation of displacement along X direction by exponential scheme, under combined load

3. RESULTS AND DISCUSSIONS

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.

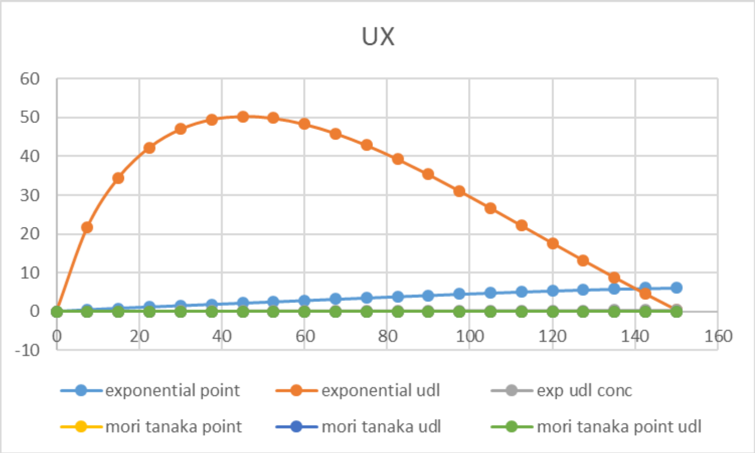

Figure 11. Variation of displacement along X direction

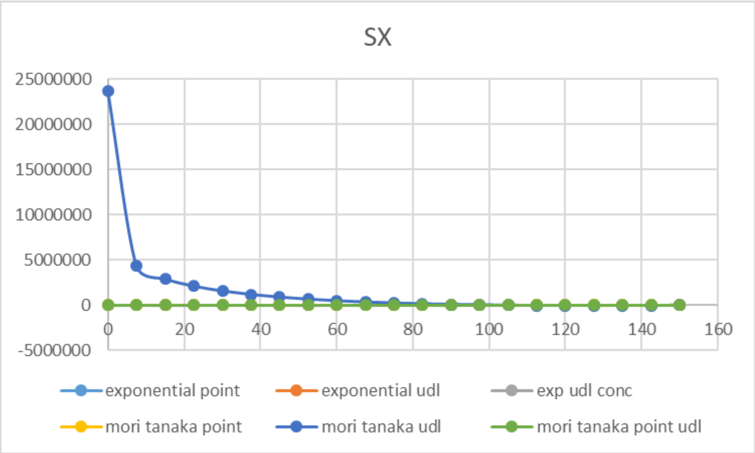

Figure 12. Variation of stress along X direction

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

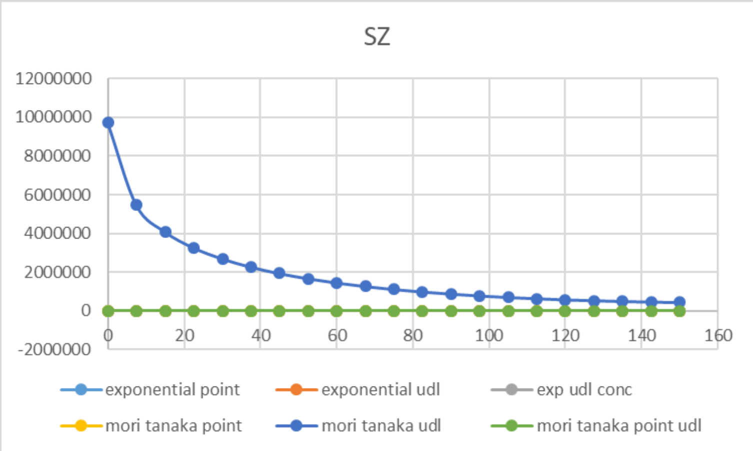

Figure 13. Variation of stress along Z direction

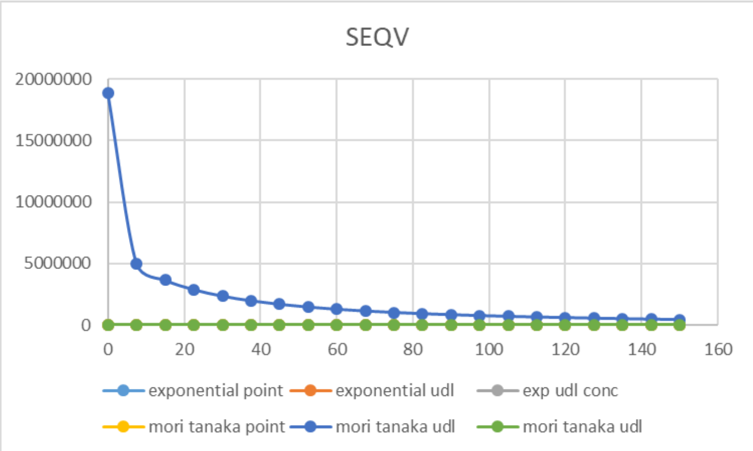

Figure 14. Variation of von mises stress

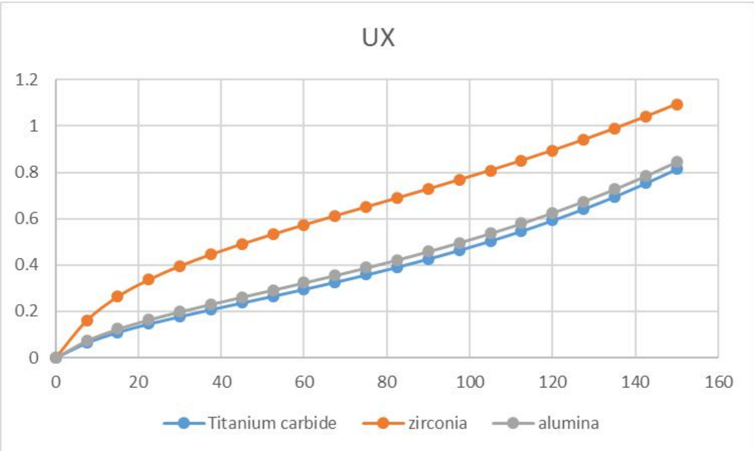

Figure 15. Variation of displacement along X direction for different materials

Figure 15 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.

4. CONCLUSION

In this project work leaf spring 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:

1. Mori Tanaka scheme results found to be more promising compared to exponential model.
2. 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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