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A REVIEW ON ANALYSIS OF FUNCTIONALLY GRADED MATERIAL LEAF SPRING USING ANSYS

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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

Pure metals are of little use in engineering applications because of the demand of conflicting property requirement. For example, an application may require a material that is hard as well as ductile, there is no such material existing in nature. To solve this problem, combination (in molten state) of one metal with other metals or non-metals is used. This combination of materials in the molten state is termed alloying that gives a property that is different

from the parent materials. Bronze, alloy of copper and tin, was the first alloy that appears in human history. There is limit to which a material can be dissolved in a solution of another material because of thermodynamic equilibrium limit. When more quantity of the alloying material is desired, then the traditional alloying cannot be used. Another limitation of conventional alloying is when alloying two dissimilar materials with wide apart melting temperatures; it becomes prohibitive to combine these materials through this process. Powdered Metallurgy (PM)is another method of producing part that cannot be produced through the conventional alloying, as alloys are produced in powdered form and some of the problems associated with the conventional alloying are overcome. Despite the excellent characteristics of powdered metallurgy, there exist some limitations, which include intricate shapes and features that cannot be produced using PM; the parts are porous and have poor strength. Although these limitations are of advantage to some applications (e.g. filter and non-structural applications) butare detrimental to others. Another method of producing materials with combination of properties is by combining materials in solid state, which is referred to as composite material.

Composite material are a class of advanced material, made up of one or more materials combined in solid states with distinct physical and chemical properties. Composite material offers an excellent combination of properties which are different from the individual parent materials and are also lighter in weight. Wood is a composite material from nature which consists of cellulose in a matrix of lignin. Composite materials will fail under extreme working conditions through a process called delamination (separation of fibres from the matrix) [5]. This can happen for example, in high temperature application where two metals with different coefficient of expansion are used. To solve this problem, researchers in Japan in the mid1980s,confronted with this challenge in an hypersonic space plane project requiring a thermal barrier (with outside temperature of 2000K and inside temperature of 1000Kacross less than 10 mm thickness), came up with a novel material called Functionally Graded Material (FGM).

2. LITERATURE REVIEW

Dipendra Kumar Roy et. al. [4] have solved large displacement geometric nonlinear problem is obtained iteratively with the help of MATLAB computational simulation. It is observed that the free end displacements and the shortening of projected beam length are greatly affected by the variation in elasticity modulus value.

Madhava M C et. al. [10] have analyzed leaf spring in FGM with the help of ANSYS software considering combination of materials of grey cast iron and structural steel as of and optimized to get a new leaf spring model also obtained the natural frequency of the new model to check the model is safe and will not fail.

AjitabhPateriya, et. al. [2] studied dynamic characteristics of spring loaded using ANSYS. Fluid-solid interaction mesh deformation between the valve disc and surrounding fluid has been used to study the motion of the valve disc for different materials. Different materials have been used considering similar boundary condition for finding the best suitable material. FEM analysis result shows that La2Zr2O7 is best suitable material. Maximum shear stress considered is 0.20395 MPa which is greater for Aluminium alloy.

E. Mahdi a, et. al. [7] conducted study on light composite elliptic springs for vehicle suspension. They numerically and experimentally studied the impact of ellipticity ratio on woven roving wrapped composite elliptical spring performance. They conducted different experiments by changing the elasticity ratio (a/b) from one to two for composite leaf springs. They found that spring rate and failure loads get influenced by ellipticity ratio and get highest spring rate for ellipticity ratio (a/b) 2.0.

Y. N. V. Santhosh Kumar, et. al. [8] studied design and analysis of composite leaf spring. In addition to they talked about the advantages of composite material like higher specific stiffness and strength, higher strength to weight proportion. In their study they have used composite leaf spring utilizing E-Glass/Epoxy instead of steel leaf spring. They targeted their study towards the reducing the weight of it. They used Pro-E to design the spring and ANSYS Metaphysics to analyses it. They found that composite leaf spring with epoxy weighs 60.48 less compared to conventional steel leaf spring and stresses developed were within limits with factor of safety.

3. OUTCOME OF LITERATURE REVIEW

Going through the literature it has been observed that 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.

4. PROBLEM IDENTIFICATION

To study the displacement response of leaf springs. Besides the free end displacement, the variation of stress, strain of the beam having variable material properties with the beam length will be obtained. The influence of material gradation for exponential for three different types of loading concentrated load, UDL (Uniformly distributed load), combined load (concentrated load + UDL) is considered.

5. CONCLUSION

The study is mainly focused on comprehensive overview of the various production techniques for manufacturing of functionally graded materials; characterizations, advantages and formulation of FGMs as well as recent developments in this field are presented.

Functionally graded shells, in recent years, are widely used in space vehicles, aircrafts, nuclear power plants and many other engineering applications. The stresses due to centrifugal load and internal or external pressure can have important effects on their strength and safety. Thus, control and optimization of stress and displacement fields can help to reduce the overall payload in industries.

Material modelling, geometric modelling and finite element modelling is done for the leaf spring using exponentially varying properties and then numerical problem is solved using the finite element software ANSYS 18.

REFERENCES

[1] Aguilar Escobar, V.G. and Garrido Vega, P. (2016), 'Applying the theory of constraints to the logistics service of medical records of a hospital', European Research on Management and Business Economic 22(3), 139-146.

[2] Prasanna D. Dhumal, Mayur S. Jadhav, Rushabh S. Tawar, Sameer A. Agrawal 2017. Review on Leaf Spring Type Suspension System. International Journal of Innovative Research in Science, Engineering and Technology Vol. 6, Issue1.

[3] BaviskarA.C.,BhamreV.G.,SarodeS.S, 2005. Design andAnalysisofa LeafSpring for automobile suspension system: A Review. International Journal of Emerging Technology and Advanced EngineeringVolume 3, Issue 6, June 2013.

[4] Dev Dutt Dwivedi, V. K. Jain, 2016. Review paper on design and fatigue analysis of leaf spring for automobile suspension system. International journal of current engineering and scientific research (ijcesr): volume-3, issue-1.

[5] Dipendra Kumar Royand Kashi Nath Sahab, 2012. Nonlinear Analysis of Leaf Springs of Functionally Graded Materials. Chemical, Civil and Mechanical Engineering Tracks of 3rd Nirma University InternationalConference (NUiCONE 2012).

[6] Stephan Krall, Richard Zemann 2014. Investigation of the Dynamic Behaviour of CFRP Leaf Springs. 25th DAAAM International Symposium on Intelligent Manufacturing and Automation, DAAAM2014.

[7] Chen Qian, Wenku Shi, Zhiyong Chen*, Shixiang Yang, Qianqian Song 2017. Fatigue Reliability Design of Composite Leaf Springs Based on PlyScheme Optimization, Composite Structures.

[8] J.P. Hou a, J.Y. Cherruault b, I. Nairne b, G. Jeronimidis a, R.M. Mayer, 2007. Evolution of the eye-end design of a composite leaf springfor heavy axle loads Composite Structures 78 (2007) 351–358.

[9] Muhammad Ashiqur Rahman*, Muhammad Tareq Siddiqui and Muhammad Arefin Kowser2012. Design and non-linear analysis of a parabolic leaf springJournal of Mechanical Engineering, vol. ME37, June 2007.

[10] H.A. Al Qureshi, 2013. Automobile leaf spring from composite materials. Journal of Materials Processing Technology 118 (2001) 58-61.

[11] Madhava M C, Deepak G, 2015. Design and analysis of functionally graded leaf spring structure. International Journal of Engineering Research, Volume No.5 Issue: Special 6, pp: 1129 - 1254.

[12] Mahmood M. Shokrieh, Davood Rezaei, 2003. Analysis and optimization of a composite leaf spring. Composite Structures 60 (2003) 317–325.

[13] I. Rajendran, S. Vijyarangan, 2001. Optimal design of a composite leaf spring using genetic algorithms Element Method. Computers and structures 79 (2001) 1121- 1129.

[14] Nitant M. Tandel, Jigneshkumar M. Parmar, "A Review on Pressure Vessel Design and Analysis" Volume 3, Issue 4, May 2013, ISSN - 2250-1991 pp. 119-121.

[15] Mutahir Ahmed, Rafi Ullah Khan and Saeed Badshah, Sakhi Jan, "Finite Element Investigation of Geometry Effect on Pressure Vessel under Combined Structural and Thermal Loads" International Journal of Engineering and Advanced Technology Volume-4 Issue-2, December 2014 ISSN: 2249 – 8958, pp. 118-124.

[16] H.L. Dai, Y.M. Fu, Z.M. Dong, "Exact solutions for functionally graded pressure vessels in a uniform magnetic field" International Journal of Solids and Structures, 2005, pp. 5570-5580.

[17] M. Shariyat, "Dynamic thermal buckling of suddenly heated temperature-dependent FGM cylindrical shells, under combined axial compression and external pressure" International Journal of Solids and Structures, 2008, pp. 2598–2612.

[18] Mohammad ZamaniNejad, Majid Abedi, Mohammad Hassan Lotfian and Mehdi Ghanna, "An exact solution for stresses and displacements of pressurized FGM thick-walled spherical shells with exponential-varying properties" Journal of Mechanical Science and Technology, 2012, pp. 4081-4087.

[19] A.M. Afsar, H. Sekine, "Optimum material distributions for prescribed apparent fracture toughness in thick walled FGM circular pipes" International Journal of Pressure vessels and Piping 2001, pp. 471-484.

[20] TolgaAkis, "Elastoplastic analysis of functionally graded spherical pressure vessels" Computational Materials Science 2009 pp. 545–554.

[21] Y.Z. Chen *, X.Y. Lin, "Elastic analysis for thick cylinders and spherical pressure vessels made of functionally graded materials" Computational Materials Science,2008,pp. 581–587.

[22] Zewu Wang, Shujuan Gao, Qian Zhang, Peiqi Liu, and Xiaolong Jiang, "Distribution parameter optimization of an FGM pressure vessel"vol. 3202011 pp. 404-409.

[23] A.R Ghasemi, A. Kazemian, M. Moradi, "Analytical and Numerical Investigation of FGM Pressure Vessel Reinforced by Laminated Composite Materials" Journal of Solid Mechanics Vol. 6, No. 1 2014 pp. 43-53.

[24] M. Zamani Nejad and G. H. Rahimi, "Deformations and stresses in rotating FGM pressurized thick hollow cylinder under thermal load" Scientific Research and Essay Vol.4 (3), March, 2009, ISSN 1992-2248, pp. 131-140.

[25] M. Arefi and G. H. Rahimi, "Thermo elastic analysis of a functionally gradedcylinder under internal pressure using first order shear deformation theory"Scientific Research and Essays Vol. 5(12), June, 2010, pp. 1442-1454.

[26] M.R. Eslami*, M.H. Babaei, R. Poultangari, "Thermal and mechanical stresses in a functionally graded thick sphere" International Journal of Pressure Vessels and Piping 2005 pp. 522–527.

[27] M. Jabbaria, S. Sohrabpourb, M.R. Eslami, "Mechanical and thermal stresses in a functionally graded hollow cylinder due to radially symmetric loads" International Journal of Pressure Vessels and Piping, 2002, pp. 493–497.

[28] M. Jabbari, A. H. Mohazzab, A. Bahtui, "One-Dimensional Moving Heat Source in a Hollow FGM Cylinder", Journal of Pressure Vessel Technology 2009, Vol. 131 pp.021202-1 - 021202-7.

[29] A.T. Kalali, S. Hadidi-Moud, "A Semi-analytical Approach to Elastic-plastic Stress Analysis of FGM Pressure Vessels" Journal of Solid Mechanics Vol. 5, No. 1 (2013) pp. 63-73.

[30] X.-F. Li,X.-L. Peng, and Y.-A. Kang, "Pressurized Hollow Spherical Vessels with Arbitrary Radial Non-homogeneity" Vol. 47, No. 9, September 2009, pp. 2262-2265.

[31] Peng-fei LIU, Ping XU, Shu-xin HAN, Jin-yang ZHENG, "Optimal design of pressure vessel using an improved genetic algorithm" Journal of Zhejiang University SCIENCE A ISSN 1862-1775, 2008 pp. 1264-1269.

[32] Zeinab Mazarei, Mohammad Zamani Nejad and Amin Hadi, Thermo-Elasto-Plastic Analysis of Thick-Walled Spherical Pressure Vessels Made of Functionally Graded Materials, International Journal of Applied Mechanics Vol. 8, No. 4 (2016) 1650054-1 1650054-25.

[33] Mohammad Rahim Nami, HadiEskandari, "Three-dimensional investigations of stress intensity factors in a thermo-mechanically loaded cracked FGM hollow cylinder" International Journal of Pressure Vessels and Piping 89 (2012) 222-229.

[34] Mohammad Zamani Nejad a &GholamHosein Rahimi, "Elastic analysis of FGM rotating cylindrical pressure vessels" Journal of the Chinese Institute of Engineers Vol. 33, No. 4, (2010), pp. 525-530.

[35] Mohammad Zamani Nejad, Mehdi Jabbari, Mehdi Ghannad, "Elastic analysis of FGM rotating thick truncated conical shells with axiallyvarying properties under non-uniform pressure loading" Composite Structures 2014.

[36] Mohammad Zamani Nejad, Parisa Fatehi, "Exact elasto-plastic analysis of rotating thick-walled cylindrical pressure vessels made of functionally graded materials" International Journal of Engineering Science, 2015 pp. 26–43.

[37] X.L. Peng, X.F. Li, "Thermoelastic analysis of a cylindrical vessel of functionally graded materials" International Journal of Pressure Vessels and Piping, 2010 pp. 203-210.

[38] MojtabaSadeghian , Hamid EkhteraeiToussi, "Axisymmetric yielding of functionally graded spherical vessel under thermo-mechanical loading" Computational Materials Science, 2011, pp. 975–981.

[39] Hui-Shen Shen, Jie Yang, SritawatKitipornchai, "Postbuckling of internal pressure loaded FGM cylindrical shells surrounded by anelastic medium"European Journal of Mechanics A/Solids 29 2010 pp. 448–460.

[40] L.H. You, J.J. Zhang, X.Y. You,"Elastic analysis of internally pressurized thick-walled spherical pressure vessels of functionally graded materials" International Journal of Pressure Vessels and Piping2005pp. 347–354.

[41] J.D. Claytona, J.J. Rencisb, 2000. Numerical integration in the axisymmetric finite element formulation. Advances in Engineering Software, 31: 137–141.

[42] NakiTuntuncu, Murat Ozturk, "Exact solutions for stresses in functionally graded pressure vessels" Composites Part B 2001, pp. 683-686.

[43] Azam Afshin, Mohammad Zamani Nejad, Kia Dastani, "Transient thermoelastic analysis of FGM rotating thick cylindrical pressure vessels under arbitrary boundary and initial conditions", JCAMECH Vol. 48, No. 1, June 2017, pp 15-26.

[44] M.Bayat, "Analysis of Functionally Graded Rotating Disks with Parabolic Concave Thickness Applying an Exponential Function and the Mori-Tanaka Scheme" (2011).

[45] Hong-Liang Dai, Yan-Ni Rao and Ting Dai, "A review of recent researches on FGM cylindrical structures under coupled physical interactions" Composite Structures, 2016.