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An Overview of Analysis, Measurement and Modelling of Dynamics Properties of Composite Materials using Oberst Beam Method

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ABSTRACT: ***Damping in composite materials is an important parameter affecting the dynamic behaviour of structures, controlling the resonant and near resonant vibration levels. Based on the rapid development in the automotive, aircraft industry etc. there have been many experimental and theoretical studies on composite damped structures subjected to dynamic loading. The first important work on measurement and calculations of loss factor and damping coefficient is done by using Complex Modulus apparatus or Oberst apparatus and validation of the results is done by using ANSYS Software. This paper tries to give an idea about the previous researches and their finding about the study of Oberst Beam Method which is essential to establish a very accurate measurement methodology and demonstrates its application for the identification of the dynamic properties of composite materials.***

Keywords: ANSYS Software, Composite Materials, Damping Coefficient, Oberst Beam Method, Loss Factor

I.INTRODUCTION

Reduction of vibration and noise is a major design aim throughout the complete manufacturing spectrum today. In industry, a reduction in vibration and noise means longer service life for machinery and equipment for the worker. The designer and manufacturer of domestic equipment such as vacuum cleaners or kitchen appliances known that the quite vibration free units have the best sales potential. Passengers in private or public transportation appreciate low noise and vibration levels and a reduction of the noise or vibration emitted to the surroundings is beneficial to the community as a whole. Structural and civil engineers are interested in reducing vibration in larger structures and in road surfaces to achieve better service life.

In some simple cases where only a few natural resonances are present in the item, a suitable modification of the stiffness to mass ratio during the design stage can move the resonant frequency out of range of the forcing frequencies. When the range of these frequencies is extensive, for example in a variable speed machines, simple “tunning out” of resonances becomes impracticable and as most mechanical constructions, whether they be machines or structures exhibit a large number of natural resonant frequencies often the only practical solution is to reduce the resonance amplitude by the use of damping materials or absorbers.

When a clamped steel panel is subjected to vibration with a frequency that coincides with one of its natural resonant frequencies, the energy transferred to the panel is stored as kinetic and potential energy and the panel behaves as a mass spring system. If the exciting energy is kept constant, the vibration amplitude will increase until the inherent energy losses due to internal friction become applied. As the internal friction in steel is comparatively low, most of the energy applied will be radiated into the surrounding air as noise. Even a relatively small amount of vibration energy can produce a high noise level. However, if the panel had been made of a material possessing high internal friction, the energy would have been dissipated within the material as heat, and the vibration amplitude and consequent noise level would have been much less.

Damping treatment is a standard practice in many industries for controlling excessive noise and vibration level. The level of noise reduction due to damping treatment depends on the structure itself the detailed nature of the excitation sources, properties of damping material as well as the type and location of the damping treatment. Damping in composite materials is an important parameter affecting the dynamic behavior of structures, controlling the resonant and near resonant vibration levels [1].

II. DAMPING EFFECT OF VISCOELASTIC MATERIALS ON SANDWICH BEAMS

P. Bangarubabu et.al; carried out work on “Damping Effect of Viscoelastic Materials on Sandwich Beams”. Various types of sandwich beams with viscoelastic cores are currently used in aerospace and automotive industry indicating the need for simple methods describing the dynamics of these complex structures, the dynamics of bare beam with free and constrained viscoelastic layers are investigated.

The viscoelastic layer is bonded uniformly on the beam. The effects of distributed viscoelastic layer treatment on the loss factors are studied. From the experiment it is observed that beams with constrained viscoelastic layer provide higher loss factors than free layer. The dynamics of sandwich beams is modeled using hexahedral element. Frequency dependent Young's modulus and loss factors are considered in the model of viscoelastic material. The predicted Eigen frequencies obtained from the model are compared with experimental results in cantilever boundary condition using free and constrained layers. Modal strain energy approach is used to predict loss factors. Results show that higher loss factor is obtained using constrained viscoelastic layers [2].

III. VISCOELASTIC DAMPER PERFORMANCE TESTING

Gray C. Foss et.al carried out work on "Viscoelastic Damper Performance Testing". A test method has been developed for the evaluation of viscoelastic add-on damping treatments. The method utilizes a standard test plate, softy supported in an environmental chamber, to which damping treatments are applied. A remotely controlled instrumented impact hammer excites the plate and an accelerometer measures the response at different temperatures. RMS apparent mass over a frequency range of interest is used as a figure of merit. When plotted against temperature, it approximates the behaviour of individual loss factors averaged over a large number of modes.

ASTM E756 was designed to measure the loss factor and Young's modulus of homogeneous damping materials that can be applied to standard cantilever beam ("Oberst beam"). This test method was developed as an alternative to ASTM E756 for measuring the effectiveness of viscoelastic constrained layer damping treatments and materials over a range of temperatures. It was designed specifically for evaluating and comparing damping treatments for aircraft panels "pocket modes" resulting undesirable sound transmission. It could also be useful for automotive applications [3].

IV. OBERST BEAM AS A TOOL FOR COMPLEX YOUNG'S MODULUS MEASUREMENT OF POROUS MATERIALS

O. Danilov et.al. carried out work on "Oberst Beam as a Tool for Complex Young's Modulus Measurement of Porous Materials". This paper investigates the adaptation of Oberst Beam Method developed for viscoelastic materials to the determination of complex Young's modulus of porous materials. Analytical and numerical results based on a finite element model shows that there are some special conditions where porous materials behave as viscoelastic ones. It is then possible to determine the complex Young's modulus according to this method. For these configurations, acceptable experimental results are obtained in the case of different foamed and fibrous materials. Oberst's beam method has been adapted to determine complex Young's moduli of porous materials. The modified equations of loss factor determination and one principal limit of the method have been established [4].

V. USING PINNED-PINNED BEAM INSTEAD OF CANTILEVER BEAM IN THE MEASUREMENT OF LOSS FACTOR OF DAMPING MATERIAL

Engineer Liu Guoliang; carried out work on "Using Pinned-Pinned Beam Instead of Cantilever Beam in the Measurement of Loss Factor of Damping Material". The article explores the new estimation method using experiment parameters instead of theoretical parameters to improve the precision of the measurements of the loss factors of damping materials. This new estimation method can be widely used for many kind of beam, such as pined-pined beam (PPB) and clamped free beam and this kind of beam with spring support or a concentrated mass at any places of the beam. The accelerometer can be used for these measurements. The conditions at clamped end of a clamped free beam are difficult to satisfy. The new method with PPB is easy to use and much better to use for industry measurements [5].

VI. FINITE ELEMENT ANALYSIS OF DAMPING PERFORMANCE OF VEM MATERIALS USING CLD TECHNIQUE

Avinash kadam et.al published a paper on finite element analysis of damping performance of VEM materials using CLD Technique. This paper presents calculation of modal loss factor in passive constrained viscoelastic layer. The passive damping treatment implemented viscoelastic material in between two aluminium layers for forming shear deformation. The modal shape and natural frequencies are considered in design of a structure and the modal loss factor is obtained by modal strain energy method. Modal analysis is done by Hypermesh and Nastran software. The results obtained in Hypemesh and Nastran software shows that the modal loss factor increases with increasing thickness of materials. Hence this paper focuses on the effect of thickness of viscoelastic material in damping performance. As thickness increases the damping performance of constrained layer damping will also increases [6].

VII. ON MEASURING DYNAMIC PROPERTIES OF DAMPING MATERIALS USING OBERST BEAM METHOD

Hasan Koruk et.al. published a paper on "On Measuring Dynamic Properties of Damping Materials Using Oerst Beam Method". The Oberst Beam Method is widely used for the measurement of the mechanical properties of damping materials. This method is a classical method based on a multilayer cantilever beam which consists of a base beam and one or two layers of other materials. The base beam is almost made of a lightly damped material such as steel and aluminum.

After setting up the Oberst test rig, repeatability measurements are performed and the main parameters affecting the quality of the measured data are determined. After that, extensive tests are performed in order to determine the effect of the amplitude of the excitation force, electromagnetic excitation and the effects of length of the test specimen [7].

VIII. COMPOSITE MATERIALS WHICH EXHIBIT HIGH STIFFNESS AND HIGH VISCOELASTIC DAMPING

Brodt M. et al. published a paper on "Composite Materials which Exhibit High Stiffness and High Viscoelastic Damping". In this paper composite micro structures are studied, which give rise to high stiffness combined with high viscoelastic loss. They demonstrate that such properties are most easily achieved if the stiff phases are as stiff as possible. Incorporation of a small amount of damping in the stiff phase has little effect on the composite damping. Experimental results are presented for laminated consisting of cadmium and tungsten and of In-Sn alloy and tungsten.

Viscoelastic materials are of use in the damping of vibration and in the absorption of sound waves in some applications it is desirable to use material which are stiff enough to carry out a structural role and which also exhibit significant mechanical damping. Most stiff materials are low in damping and most high damping materials are compliant. The attainable damping in many configurations is limited by the fact that polymers, though they may exihibit high damping are not stiff. The loss tangent, tan delta, is used throughout as the measure of visco elastic damping or loss. The development of materials which exhibit a Young's modulus of 70 GPa, corresponding to aluminium, and a loss tangent of 0.06, representative of a glassy or of a crystalline polymer. Finally, a combination of high stiffness and high mechanical damping is attainable in laminates of a stiff phase such as tungsten and a phase with high loss and moderate stiffness such as Cadmium or Indium-Tin alloy [8].

IX. EFFECTIVENESS OF A SEPARABLE DAMPER STUDIED USING MULTIPLE TEST METHODS

Abhijit Gupta et.al. carried out work on"Effectiveness of a Separable Damper Studied using Multiple Test Methods". The paper discusses the comparison of Oberst and Honda test methods and the damping material's performance using these methods. The purpose of the two test was to understand how the damping performance varies. A liquid damper sprayed onto a metallic substrate provides damping to the substrate and its effect can be experienced during structural vibration. In Oberst Beam Method typically magnetic sensors are used for excitation and response. That sensors are not directly attached to the beam so it does not precise the distance between the beam and the sensor. In centre impedance method the impedance head is mounted directly on the sensor, the force is always desirable to avoid any error due to nonlinearity. This exercise of testing a liquid damper using multiple test methods shows that the material will be robustness. So this material accepted in wide range of industry applications [9].

X. ANALYSIS OF NONLINEAR VIBRATION OF HARD COATING THIN PLATE BY FINITE ELEMENT ITERATION METHOD

Hui Li et.al. carried out work on "Analysis of Nonlinear Vibration of Hard Coating Thin Plate by Finite Element Iteration Method". This paper studies nonlinear vibration mechanism of hard coating thin plate based on macroscopic vibration theory and proposes Finite Element Iteration Method (FEIM) to theoretically calculate its nature frequency and vibration response. First of all, strain dependent mechanical property of hard coating is briefly introduced and polynomial method is adopted to characterize the storage and loss modulus of coating material. Then, the principal formulas of inherent and dynamic response characteristics of the hard coating composite plate are derived. And consequently specific analysis procedure is proposed by combining ANSYS APDL and self-designed MATLAB program. Finally, a composite plate coated with MgO and Al_2O_3 is taken as a study object and both nonlinear vibration test and analysis are conducted on the plate specimen by considering strain dependent mechanical parameters of hard coating. Through comparing the resulting frequency and response results, the practicability and reliability of FEIM have been verified and the corresponding analysis results can provide an important reference for further study on nonlinear vibration mechanism of hard coating composite structure [10].

XI. CONCLUSION

Literature review exists the area of measurement of dynamics properties of material. In earlier recherches study of various materials has been focused on damping, mode shape, resonant frequency, young's modulus and damping coefficient, but in practise the material damping has not paid much attention. So it is important to consider the nonlinearities in composite material to find out the loss factor, young's modulus and damping coefficient.

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