ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 5, Issue 6, June 2016

Review of Experimental Investigation on Dynamic Properties of Materials

Jadhav Yogesh Bapu

***Abstract*— Dynamic properties of materials like Young's Modulus, Loss Factor, and Natural Frequency are very important for applications where accuracy is prime importance, hence finding dynamic properties of materials is very importance for the applications like cars, oil plant, airplane etc.,. Dynamic properties of materials can be finding by experimentally as well as by using FEA method. There are very limited experimental methods are available. Selecting proper method for proper materials is necessary. Experimental methods having adverse effects, removal of these effects is necessary for accurate results. 3-D modeling of set-up will be done using Uni-graphics, Nx-8.0 and CATIA and Properties of material by can be finding out by CAE using Ansys Work-bench. Validation of results from experimental test rig is done by using result from CAE work and properties are plotted.**

***Index Terms*— Dynamic Properties, Young's Modulus, Loss Factor, Natural Frequency, FEA method CAE**

I. INTRODUCTION

Dynamic design of a system aims at obtaining the desired dynamic characteristics of the system. Dynamic properties that are often required for systems include high dynamic stability and prescribed mode shapes or vibration patterns. Ultimately, the designer willshaveas an objective to find different dynamic properties to develop quieter and more comfortable products and increase reliability and efficiency. While fulfilling the above mentioned requirements, the designer has to look for solutions within specific economic constraints and in a highly evaluative global market. Experimental methods that are including Frequency Response Function (FRF) provide essential information on dynamical properties of the system during the process of designing.

This project has the objectives to study different experimental methods and find out different dynamic properties of materials. It is very important to know dynamic properties of materials in mechanical applications especially where accuracy have prime importance. Applications like noise and vibrations in cars, reliability of long span bridges, efficiency of loudspeakers, accuracy of wafer-steppers, avoid flutter of aircrafts requires high accuracy. So it is essential to find dynamic properties of materials & controlling excessive noise and vibration levels.

Damping treatment is a standard practice in many industries for controlling excessive noise and vibration levels. 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(s) of the damping treatment. Therefore, all these factors are to be considered while modeling and/or optimizing a system.

Oberst Beam Method- Damping in composite materials is an important parameter affecting the dynamic behaviour of structures, controlling the resonant and near-resonant vibration levels. For the solution of variety of noise and vibration problems, especially those associated with vibrations of structures made of sheet metal, surface damping treatments are often used. Such treatments can easily be applied to existing structures and provide high damping capability over wide temperature and frequency ranges. 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 measurements and calculations of loss factor of composite structures is published by Oberst in 1952. He derived a set of equations for free layer damping treatment. Although some other associated works were done by Ross et al., Gross, Edward and DiTaranto, mainly the driven equations by Oberst are used in Oberst Beam Method (OBM). OBM is the classical method for the characterization of damping materials 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 always made of a lightly damped material such as steel and aluminium. This method is useful in testing materials such as metals, enamels, ceramics, rubbers, plastics, reinforced epoxy matrices and woods.

Impact test-Accurate characterization of the mechanical properties of soft tissues is important for diagnosing medical pathologies and developing solutions for them. With the recent advances in technologies leading to the development of surgical simulators, medical robots, and computer-assisted surgical planning systems, this topic has gained even more importance. While strain and time-dependent material properties have been investigated extensively, less attention has been paid to the frequency-dependent dynamic material properties. However, the dynamic response of soft tissues to periodic or impact loading is important in many areas of biomechanics and biomedical engineering. For example, frequency-dependent mechanical properties play a crucial role when investigating the mechanisms of organ injury that result from high-speed impact such as car accident. The propagation speed and radius of the impact wave depends on the dynamic material properties of the organ. Similarly, when designing prosthetic devices for lower-body amputates, it is important to know how the soft tissue responds to the periodic impacts coming from the ground.

II. LITERATURE REVIEW

[1] "American Society for Testing and Materials (ASTM), 1916 Race St Philadelphia, Pa 19103, Reprinted from the Annual Book of ASTM Standards."(1993), given that Oberst beam test method measures the vibration-damping properties of materials, including loss factor, Young's modulus, and shear modulus. Accurate over a frequency range of 50 to 5 kHz and over the useful temperature range of the material, this test method is useful in testing materials that have application in structural vibration, building acoustics, and the control of audible noise. Such materials include metals, enamels, ceramics, rubbers, plastics, reinforced epoxy matrices, and woods that can be formed to the test specimen configurations.

[2]"HasanKoruk&Kenan Y. Sanliturk, said that in "On Measuring Dynamic Properties of Damping Materials Using Oberst Beam Method", Proceedings of the ASME 2010 10th Biennial Conference on Engineering Systems Design and AnalysisESDA2010July 12-14, 2010, Istanbul, Turkey" (2010),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 always made of a lightly damped material such as steel and aluminum. If the Oberst Beam Method (OBM) is to be used, it is essential to establish a very accurate measurement methodology. In this respect, the response and the excitation sensors in the Oberst test rig are generally non-contact type. Although the drawbacks of contacting type of transducers are eliminated by this way, there are other critical issues when OBM is used. It is therefore essential to be aware of the parameters that might adversely affect the measured data and also to avoid them as much as possible. Consequently, all the parameters affecting the result need to be optimized in order to obtain the material properties with high accuracy. Although the OBM is referenced in some standards and widely used in scientific studies, detailed information in the literature on how to perform a successful Oberst Beam experiment is very limited. This is the main subject this paper aims to address. In this paper, after setting up the Oberst test rig the effects of various parameters on measured data using an Oberst test rig are examined in an attempt to improve the accuracy of the estimated material properties. Then repeatability measurements are performed and the main parameters affecting the quality of the measured data are identified. After that, extensive tests are performed so as to determine the effect of the amplitude of the excitation force, adverse effects of electromagnetic excitation and the effects of length of the test specimen. Furthermore, it is found that the small differences between individual samples may also affect the results significantly. Finally, some suggestions are given to the potential users of the OBM so as to avoid undesirable effects of certain parameters during such measurements.

[3] "Hasan Koruk & Kenan Y. Sanliturk, said that in "Identification and removal of adverse effects of non-contact electromagnetic excitation in Oberst Beam Test Method", research paper publish in science direct on 2 March 2012, Although the Oberst Beam Test Method is widely used in practice, detailed information about how to perform a successful Oberst beam experiment is quite limited. In this paper, first, the effects of various parameters in an Oberst test rig, including the amplitude of the excitation, mounting conditions, input excitation type and the length of the test sample, are examined in an attempt to improve the accuracy of the estimated material properties. As it is observed that the electromagnetic effect created by a non-contact exciter can be the most significant source of error in estimated material properties, this paper then presents the results of extensive tests so as to quantify the level of the adverse effects of non-contact electromagnetic excitation. It is found that non-contact electromagnetic exciter creates a stiffness effect that can be modeled as a spring attached between the non-contact exciter location on the Oberst beam and the ground. In contrast to the common belief that the use of non-contact electromagnetic excitation has little drawbacks, it is shown that such excitation can introduce very significant level of errors in identified material properties. This paper also proposes a method for removing the adverse effects of the electromagnetic excitation in order to obtain more accurate material properties for uniform as well as composite beams.

[4]Cagatay Basdogan stated in "Dynamic Material Properties of Human and Animal Livers" that, Accurate characterization of the mechanical properties of soft tissues is important for diagnosing medical pathologies and developing solutions for them. With the recent advances in technologies leading to the development of surgical Simulators, medical robots, and computer-assisted surgical planning systems, this topic has gained even more importance. However, most of the earlier research studies conducted with animal and human livers have focused on the investigation of static (strain-dependent) material properties. The number of studies investigating the dynamic material properties (time and frequency-dependent) of animaland human livers are much less than the ones investigating the static material properties. In fact, there is almost no data available in the literature showing the variation in dynamic material properties of healthy or diseased human liver as a function of excitation frequency.

[11] "M. UmutOzcan , SinaOcal , CagatayBasdogan , GulenDogusoy , YamanTokat" states in "Characterization of frequency-dependent material properties of human liver and its pathologies using an impact hammer" research paper publish in science direct on 1 July 2010, that, The current methods for characterization of frequency-dependent material properties of human liver are very limited. In fact, there is almost no data available in the literature showing the variation in dynamic elastic modulus of healthy or diseased human liver as a function of excitation frequency. We show that frequency-dependent dynamic material properties of a whole human liver can be easily and efficiently characterized by an impact hammer. The procedure only involves a light impact force applied to the tested liver by a hand-held hammer. The results of our experiments conducted with 15 human livers harvested from the patients having some form of liver disease show that the proposed approach can successfully differentiate the level of fibrosis in human liver. We found that the storage moduli of the liver shaving no fibrosis (F0) and that of the cirrhotic livers (F4) varied from 10 to 20 kPa and 20 to 50 kPa for the frequency range of 0–80 Hz, respectively. Accurate characterization of the mechanical properties of soft tissues is important for diagnosing medical pathologies and developing solutions for them. With the recent advances in technologies leading to the development of surgical simulators, medical robots, and computer-assisted surgical planning systems, this topic has gained even more importance. While strain and time-dependent material properties have been investigated extensively, less attention has been paid to the frequency-dependent dynamic material properties.

III. PROBLEM STATEMENT

Dynamic design of a system aims at obtaining the desired dynamic characteristics of the system. Dynamic properties that are often required for systems include high dynamic stability and prescribed mode shapes or vibration patterns. Ultimately, the designer will have as an objective to find different dynamic properties to develop quieter and more comfortable products and increase reliability and efficiency. While fulfilling the above mentioned requirements, the designer has to look for solutions within specific economic constraints and in a highly evaluative global market. Experimental methods that are including Frequency Response Function (FRF) provide essential information on dynamical properties of the system during the process of designing.

It is becoming increasingly important and desirable to realistically represent and measure the damping possessed by materials and composite structures. High-damping materials are playing a widening role in the ship silencing program. As a result, the measureme1nt of the damping parameters using common methods operating near resonances has become increasingly difficult, since resonances are hard to establish.

The properties obtained are useful for material selection tasks based on modulus & material loss factor as a function of temperature & frequency. The properties can be particularly useful when combined with suitable analytic (FEA or Closed-form solution) models to predict model damping in structures as a function of temperature. Such data can be used to assess structural integrity issues, damping performance, noise & vibration concerns, and cycle fatigue issues.

Thus there is a need for finding dynamic properties of materials with the specified experimental method to avoid excessive vibration & noise.

Objective of Research:

1. Study different experimental methods for finding dynamic properties of material.
2. Set up a specific experimental test rig for finding dynamic properties of material.
3. Design& Development of test specimen for experimental test rig.
4. Finding different dynamic properties of materials.
5. 3-D cad modeling using CATIA and analysis for test using FEA.

IV. METHODOLOGY

Impact Test Method

Input Parameters-

1) Test materials.
2) Impact load.
3) Pre-load.

Process Steps-

In this experiments, an impulse excitation force is applied to the cylindrical pre- placed on top of the specimen by the impact hammer equipped with a force sensor (see Fig.4.2).A soft tip and an extender mass were utilized for better response at low frequencies. The impulse response of the specimen was measured by a piezoelectric accelerometer attached to the pre-load using a thin film of adhesive wax.

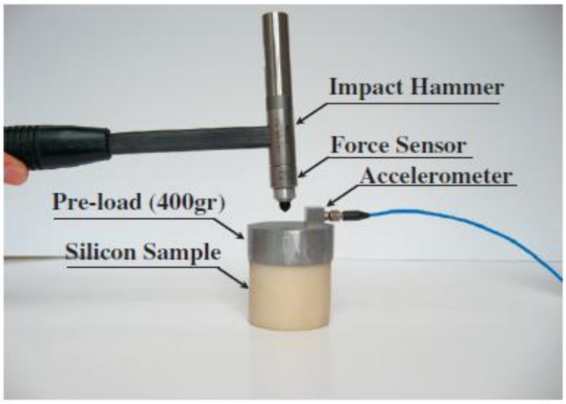

Fig IV Experimental Set-up for Impact test method.

Five measurements were taken from each test specimen and then the average values were used in the analysis. The accelerometer and the force sensor were connected to a dynamic signal analyser for data processing. The FRF was obtained by taking the Fourier transform of the impulse response. In dynamic loading test, the same FRF is obtained by the frequency sweep method (i.e. small periodic strains are applied to the specimen and its force response is measured for a range of frequencies).

Output Parameter-

1) Natural frequencies.
2) Young's modulus.
3) Loss factor.

V. CONCLUSION

Dynamic properties of materials are important for applications where accuracy is prime importance.

From detailed literature review it's concluded that impact hammer method is suitable for finding dynamic properties of materials than obrest beam method.
Natural frequency can be calculated by using FRF function and from natural frequency other dynamic properties like loss factor, Young's modulus, dynamic stiffness, dynamic elastic modulus can be find out.

ACKNOWLEDGMENT

I would like to express my sincere thanks and gratitude Prof. Gaikwad M. U., PG Coordinator (Mechanical – Design Engg.) of DGoI's FOE, Bhigwan for their valuable help and guidance. I wish to express my gratefulness for the most cooperative attitude of Prof. Karande A.V. for their able guidance thoughtful suggestions and the constant moral support. Credit to a great measure goes to Prof. Kadhane S.H. from SVPM's COE Malegaon (Bk.) for providing necessary experimental facility and help. I also thankful to principal, SVPM's COE Malegaon (Bk) and Principal, DGoI's FOE, Bhigwan for their valuable help at every stage of my research work

REFERENCES

[1] "American Society for Testing and Materials (ASTM), 1916 Race St Phlladelphia, Pa 19103, Reprinted from the Annual Book of ASTM Standards."(1993).

[2] "HasanKoruk&Kenan Y. Sanliturk, "On Measuring Dynamic Properties of Damping Materials Using Oberst Beam Method", Proceedings of the ASME 2010 10th Biennial Conference on Engineering Systems Design and AnalysisESDA2010July 12-14, 2010, Istanbul, Turkey" (2010).

[3] "HasanKoruk&Kenan Y. Sanliturk, "Identification and removal of adverse effects of non-contact electromagnetic excitation in Oberst Beam Test Method", research paper publish in science direct on 2 March 2012.

[4] "M. UmutOzcan , SinaOcal , CagatayBasdogan , GulenDogusoy , YamanTokat" "Characterization of frequency-dependent material properties of human liver and its pathologies using an impact hammer" research paper publish in science direct on 1 July 2010,

[5] CagatayBasdogan,"Dynamic Material Properties of Human and Animal Livers"

AUTHOR

Mr. Jadhav Yogesh Bapu
BE (Mechanical)
Student of ME (Design) at DGOIFOE Swami-Chincholi.
1) National level paper presentation on topic "Design of travelling grad e for Boiler"
2) Paper presented in IEEE on topic Modeling and simulation of hybrid solar-wind-grid power generation system for electrification." At Nagapattanum, Chennai.