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EXPERIMENTAL VERIFICATION OF DAMPING COEFFICIENT BY OBERST BEAM METHOD

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ABSTRACT

The Oberst Beam Method (OBM) is widely used for the measurement of damping level of 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 is to be used, it is essential to establish a very accurate measurement methodology.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 that the paper aims to address. The analysis is based on a frequency response function measured between the imposed velocity at the center and an arbitrary point on the beam. Structural damping coefficient of the material under test can be deduced using classical formulations of the ASTM E756 standard for typical materials or using a finite element model for more complex cases.

***Keywords**: Damping Coefficient, Frequency Response Function (FRF), Oberst Beam Method, Loss Factor.*

I. INTRODUCTION

Damping in composite materials is an important parameter affecting the dynamic behavior 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 aluminum. This method is useful in testing materials such as Metals, Enamels, Ceramics, Rubbers, Plastics, Reinforced Epoxy Matrices and Woods. The mentioned multilayer cantilever beam is given in Fig. 1.The root of the beam is wedged into a heavy and stiff clamping system.

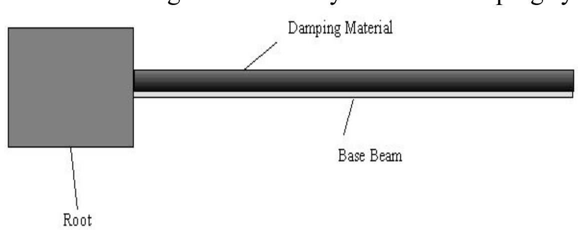

Fig1. Cantilever Beam used in the Oberst Beam Method.

Oberst beam method is based on performing some Frequency Response Function (FRF) measurements on both the bare and damped beams. First of all, the FRF measured on the bare beam is analyzed to determine natural frequencies within the frequency range of interest. Then, measured FRF on the damped beam is analyzed in order to determine the natural frequencies and corresponding modal loss factors of the composite beam. Using the determined natural frequencies of the bare beam, and the natural frequencies and loss factors of the damped beam, Young's modulus and damping level (loss factor) of the damping material are identified at frequencies corresponding to the vibration modes of the damped(composite) beam.

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The use of contacting transducers is not recommended in OBM. The use of contacting transducers adds damping and mass to the beam as a result of the attachments of the excitation and response sensors and this significantly reduces the quality of the results in Oberst Beam Method .Attachment of a shaker is not recommended as an exciter will lead to adding damping, mass and stiffness to the Oberst beam. Therefore, electromagnetic non contacting transducers are used. If aluminum is used as the material of base beam, it is necessary to glue a small piece of magnetic material for providing magnetic excitation. However, effects of mass and damping due to this piece must also be taken into account.

Non contacting response transducer is preferred. However, in the case of measurement of the response of the beam with an accelerometer, will results in additional damping and mass to the beam, and again their adverse effects must be taken into account. Although the clamping conditions of the beam are usually satisfactory, problems may occur in the case of misalignment, insufficient clamping force and bad machining of the root. Even though the drawbacks of contacting type of transducers can be eliminated by using non contacting response and exciting transducers, there are still other critical issues when Oberst Beam Method (OBM) are used in practice. Therefore it is 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 it is widely used in many scientific studies, detailed information in the literature on how to perform a successful Oberst Beam Experiment is very limited. This is precisely the main subject this paper is addressing here. In this paper, effects of various parameters on measured data using an Oberst test rigare examined in an attempt to improve the accuracy of the estimated material properties. Repeatability measurements are performed and the main parameters affecting the quality of the measured data are determined on the Oberst test rig set up.

Then, a lot of tests are performed in order to determine the effect of the amplitude of the excitation force, adverse effects of electromagnetic excitation and the effects of the lengths of the individual test specimens. Furthermore, it is noted that small differences between individual samples may also affect on 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.

II. TEST RIG AND MEASUREMENT PARAMETERS

The Oberst test rig consists of FFT analyzer, Magnetic exciter, Accelerometer, Hammer, and an Oberst beam mounted on a test stand. The measurement system used in this paper is given in Fig 2. The frequency range of interest is set to 2-2000 Hz, which is also compatible with the frequency range of the sensors used.

Fig.2 Measurement System

The beams of different materials shown in Fig.3 are used for experimentation:

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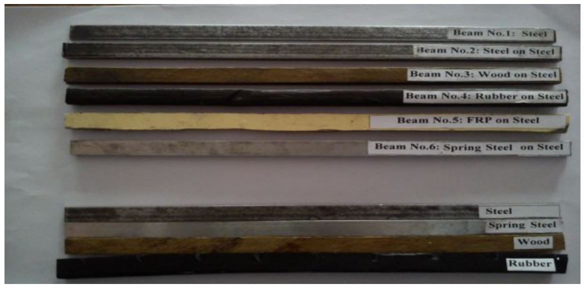


Fig.3 Beams of Different Materials

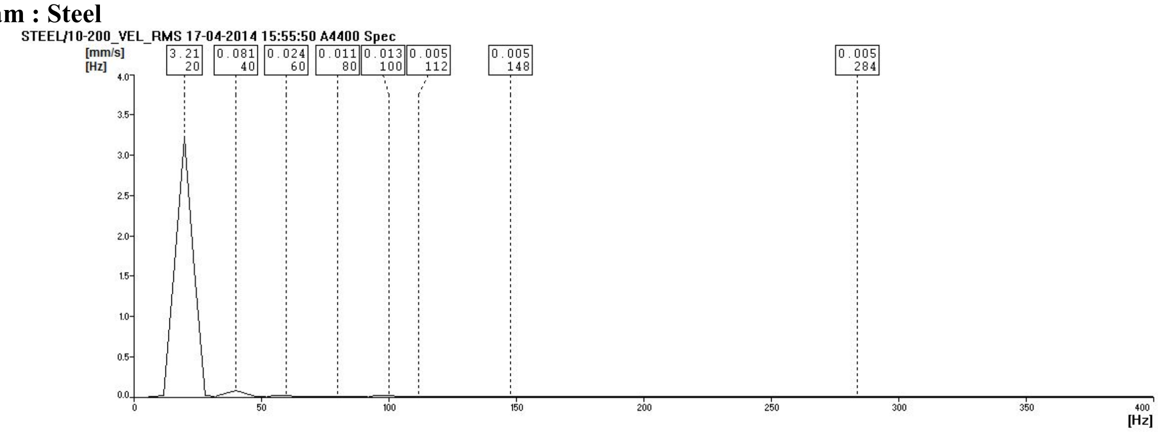
The procedure followed for the determination of damping coefficient is as follows

1. A beam of a particular material (mild steel, brass, aluminum), dimensions (L,w,d)was used as a cantilever beam
2. The fixed end was made by fixing the beam with the help of clamp fixed on the table.
3. The connections of the vibscanner, accelerometers were properly made.
4. Accelerometer was placed at the free end of the cantilever beam, to measure the vibration response.
5. The free end of a cantilever beam was struck with a wooden mallet and beam starts vibrating.
6. All the data was recorded obtained from the vibrating beam with the help of vibscanner as accelerometer is attached to it.
7. The experiments is repeated to check the repeatability of the experimentation
8. The whole experiment is repeated for different material by changing the parameters i.e. length and thickness.
9. The whole set of data was recorded and then the data was imported into the PC.

III. OBSERVATIONS AND CALCULATIONS

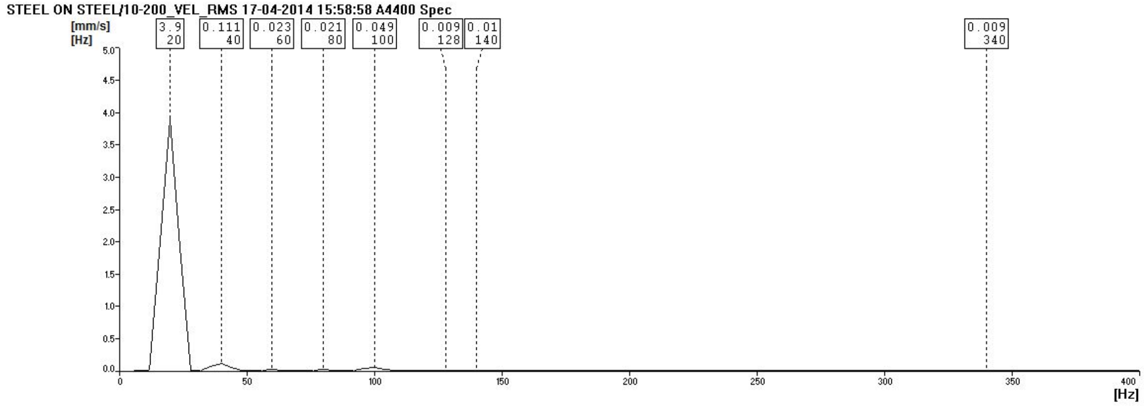
Results obtained on FFT Analyzer for different materials are shown in Fig.4

1. **Beam : Steel**



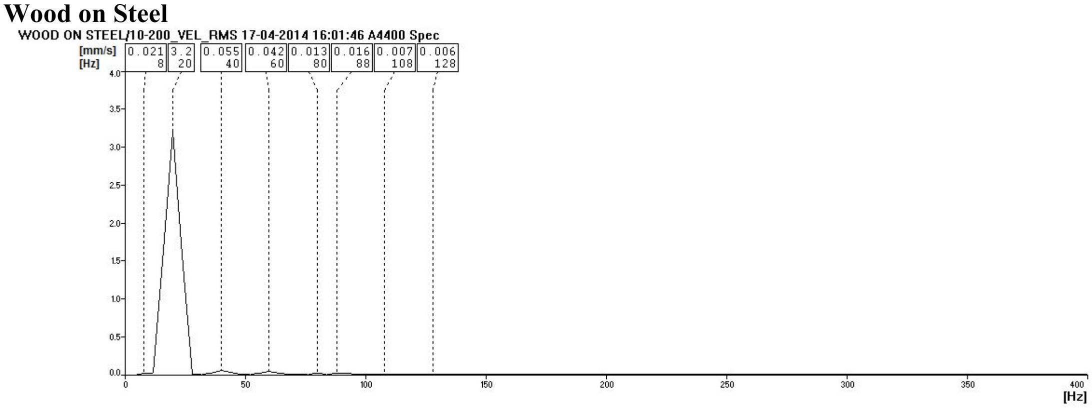
Peak Velocity = 3.21mm/sec at frequency 20Hz
Graph 1

2. Beam : Steel on Steel



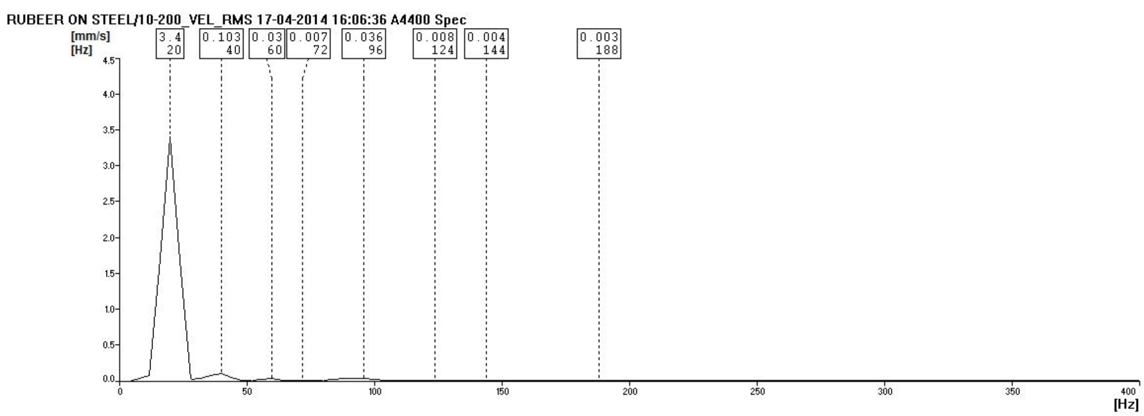
Peak Velocity : 3.9 mm/sec at frequency 20 Hz
Graph 2

3. Beam Wood on Steel



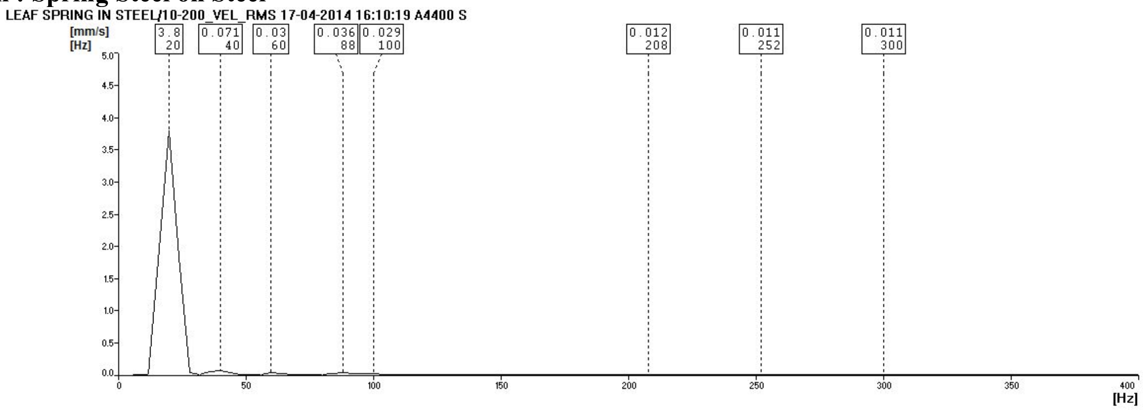
Peak Velocity: 3.2 mm/sec at frequency 20 Hz
Graph 3

4. Beam : Rubber on Steel



Peak Velocity: 3.4 mm/sec at frequency 20 Hz
Graph 4

5. Beam : Spring Steel on Steel

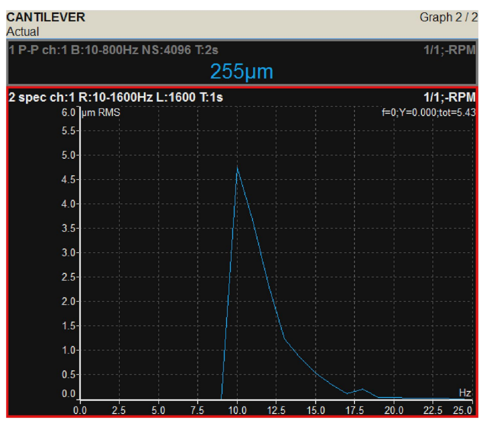


Peak Velocity: 3.8 mm/sec at frequency 20 Hz
Graph 5
Fig. 4 Velocity Vs Frequency Graphs

6. Effects of Amplitude of Excitation Force

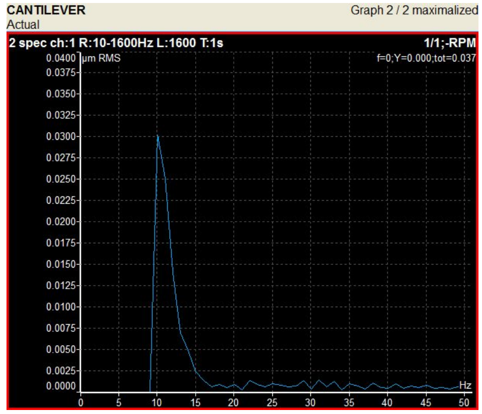
There is a range of excitation level that can be applied by the noncontact exciter. It is essential that the excitation must be strong enough to obtain high signal to noise ratio. However, it is also necessary not to exceed certain level in order to remain within the linear range. This is assured after some trial tests so as to establish a range that is appropriate for reliable measurements. Some FRFs are measured using forcing levels within this range, identified here as low, medium and high and results are compared in Fig. 5.

1. Beam : Steel



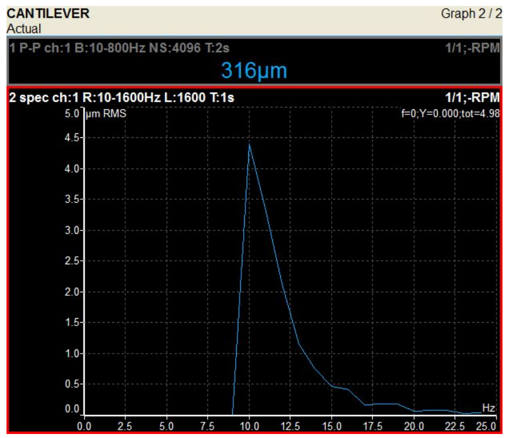
Graph 6: Steel

2. Beam : Steel on Steel



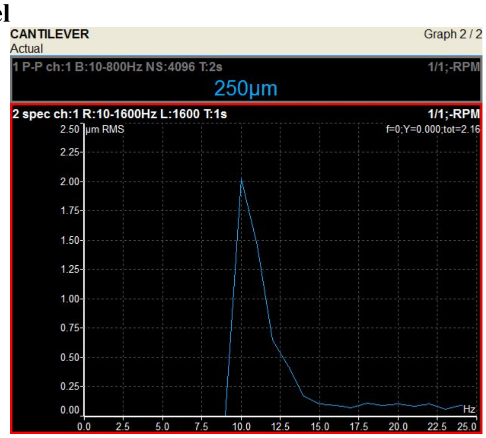
Graph 7: Steel on Steel

3. Beam : Wood on Steel



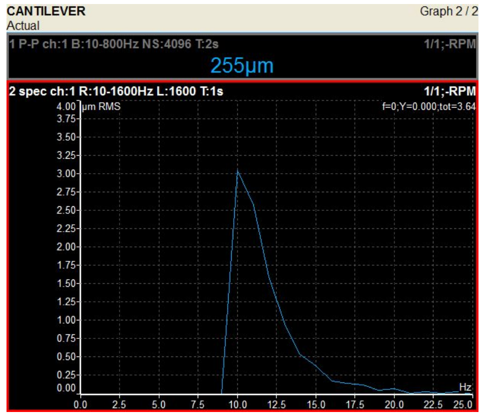
Graph 8: Wood on Steel

4. Beam : Rubber on Steel



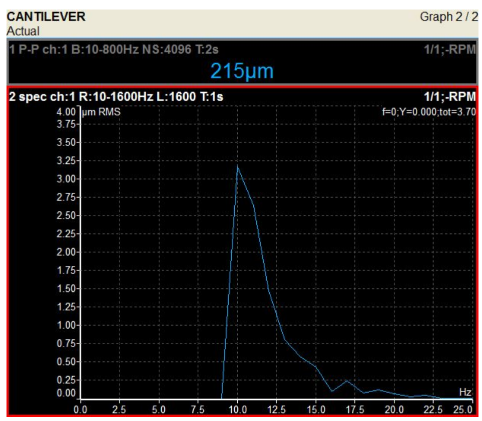
Graph 9: Rubber on Steel

5. Beam : Spring Steel on Steel



Graph 10: Spring Steel on Steel

6. **Beam : FRP on Steel**



Graph 11: FRP on Steel

Fig. 5 Velocity Vs Frequency Graphs

IV. RESULTS

Table 6.1:Variation of Damping Coefficient with Respect to Steel

Sr. No.	Damping coefficient of Beams		Percentage Variation
	Steel	Steel on steel	
1	39.089	167.74	76.69 %

Table 6.2: Variation of Damping Coefficient with Respect to Steel on Steel

Sr. No.	Beam	Damping Coefficient Ns/m	Percentage Variation
1	Steel on steel	167.74	-
2	Wood on steel	108.99	35.024 %
3	Rubber on	253.61	33.859 %

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	steel		
4	Spring steel on steel	171.83	2.83 %
5	FRP on steel	197.25	14.96 %

V. DISCUSSIONS

Variation of Damping Coefficient of Wood on Steel with respect to Steel on Steel is 35.024 %,Variation of Damping Coefficient of Rubber on Steel with respect to Steel on Steel is 33.859 %,Variation of Damping Coefficient of Spring Steel on Steel with respect to Steel on Steel is 2.83% and Variation of Damping Coefficient of FRP on Steel with respect to Steel on Steel is 14.96 %.

From above results it is observed that, damping behavior of spring steel is similar to that of steel. As the variation of damping coefficient is maximum for wood on steel, wood has more damping property as compared to rubber and FRP.

VI. CONCLUSION

After setting up the Oberst test rig, repeatability measurements are performed and the main parameters affecting the quality of measured data are determined. Repeatability tests must be performed in Oberst Beam Method (OBM) in order to ensure reliable and repeatable measurements. Sample preparation, geometric tolerances and joining the individual layers of composite beam affects the results significantly. Low level of excitation may lead to noisy data while the high forcing levels cause nonlinear effects.

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