Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 12, December-2020

Experimental Study of Free Vibration on The Comparison of 6061 Structural Aluminum and 7075 Structural Aluminum for Vibro-Acoustic Properties

[1]Virupaxappa, [2]S.N. Kurbet, [3]V. V. Kuppast
[1]Research Scholar, Basaveshwar Engineering College, Bagalkot-587102, Karnataka, India
[2,3]Professor, Basaveshwar Engineering College, Bagalkot-587102, Karnataka, India

***Abstract*:- Vibro-acoustic materials play very important role in modern engineering applications. The structural steels are widely used now days in aerospace and industrial applications. Modal analysis test is conducted for the steel and structural properties are found, the properties like logarithmic decrement, frequency and amplitude are the properties found by impact hammer test. In the Forced vibration system, the properties of the material structural aluminum 6061 and structural aluminum 7075 are found by the tests for forced vibration conditions. The base metal, and 6061 with Damping material and porous material have different properties and structural aluminum 7075 with Damping material and Porous presents different vibro-acoustic properties. The structural applications of the materials for different composition give the magnitude spectrum and frequency domain. Under damped condition the material shows resonant behavior and characteristics. Experimental Modal Analysis (EMA) is used for Frequency Response Functions (FRFs) obtained by measuring both output measurements and input forces of the experiment. In the present trend, there has been development of output-only Operational Modal Analysis (OMA) methods that do not require the measurement of input forces under strict assumptions in terms of the nature of excitation forces.**

Keywords: Vibro-acoustic materials, frequency, amplitude, logarithmic decrement and damping factor.

1. INTRODUCTION:

The technology of protecting metals and alloys from the damage by the surrounding medium in the contest of present field is an extremely important. The study of vibro-acoustic materials is an important task as there is a necessity for the low vibrating and enough working environment. The machine designers are now focusing on the use of the materials for this purpose for which the behavior of the materials leading for low cycled conditions for low cost and effective design works. The applications of vibro-acoustic materials are ranging from aerospace to various structural engineering designs. The experimental evaluation includes material behavior investigation and characterization. The material testing includes traditional and non-traditional methods. The vibro-acoustic modulation technique, ultrasonic methods, harmonic analysis etc. have been considered in the evaluation of the material properties. The characterization helps to reveal the material properties viz., mechanical and damping.

In the present paper the experimental results with impact hammer test with the boundary condition in vibration test, vibro-acoustic properties are determined.

2. METHODLOGY:

2.1 Experimental modal analysis

To focus on the vibro-acoustic materials an experimental setup is developed to measure the data which is used to find out the natural frequency of the material. The provisions are made in the experimental setup to incorporate the different testing conditions namely impact hammer test. The different vibro-acoustic material specimens are prepared and are used in the above experiment. The data corresponding to the mechanical behavior of the vibro-acoustic materials for structural applications are evolved.

Figure 1 Experimental setup

2.2 IMPACT HAMMER TEST:

The most common exciters are the impact hammer and the shaker. Impact hammers are convenient and relatively inexpensive compared to other actuators hence impact hammer test is conducted. In addition, because they are not attached to the test object, they do not change its dynamics. The impact hammer (Impulse hammer) resembles an ordinary hammer, but it has a specially designed tip that contains a sensor for measuring the impact force and is interpreted in terms of frequency. If the test object struck crisply with the hammer, the applied force is a pulse that

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 12, December-2020

resembles an impulse. This is the advantage of using an impact hammer because an impulse, simplifies the analysis while exciting all of the test materials into natural frequencies.

By adding specially designed weights to the hammer and by using tips with different hardness, one can adjust the applied force and the duration of pulse. A harder tip generates a force having higher frequency content but it transfers less energy to the test object.

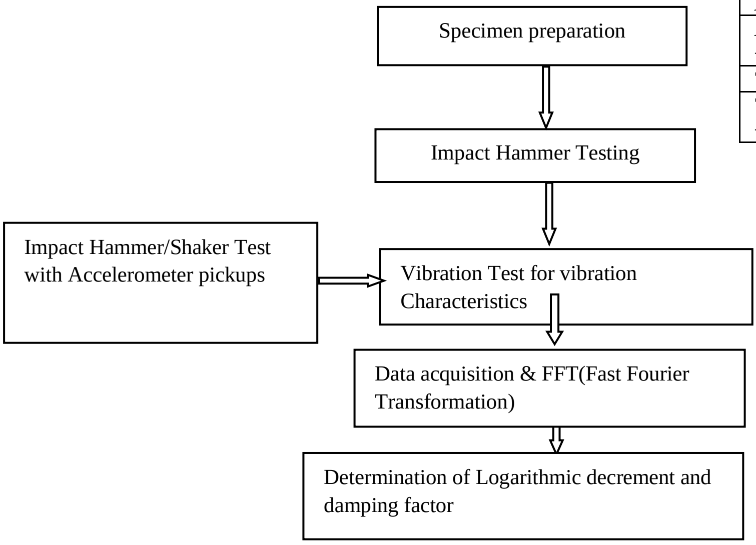


Figure 2: Flow chart showing experimental analysis

Table 1: The details of Material 6061 Structural aluminum and boundary conditions

Material condition	Composition			Boundary condition	
	Length (mm)	Breadth (mm)	Thickness (mm)	Specimen tested for Forced vibration cantilever	Specimen tested for Forced vibration fixed-fixed
Aluminum 6061 base metal	170	150	3	1	1
Aluminum 6061+ Damping	170	150	3+4.5	1	1
Aluminum 6061+Porous	170	150	3+7.5	1	1
Aluminum 6061 + Damping +Porous	170	150	3+4.5 +7.5	1	1

Table 2 Details of the Material 7075 Structural aluminum and boundary condition

Material condition	composition			Boundary condition	
	Length (mm)	Breadth (mm)	Thickness (mm)	Specimen tested for Forced vibration cantilever	Specimen tested for Forced vibration fixed-fixed
Aluminum7075	170	150	3	1	1
Aluminum7075 +Damping	170	150	3+4.5	1	1
7075+Porous	170	150	3+7.5	1	1
7075+Damping +Porous	170	150	3+4.5+7.5	1	1

IMAGES OF SPECIMENS

6061 Aluminum:

Fig.3: Structural Aluminum 6061

7075 Aluminum:

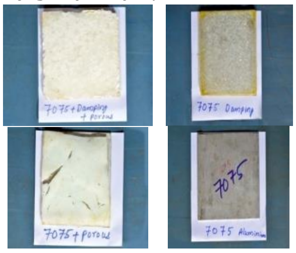


Figure 4: Structural Aluminum 7075

4. RESULTS AND DISCUSSIONS:

Type 1 : FREE VIBRATION CANTILEVER BOUNDARY CONDITION MATERIAL STRUCTURAL ALUMINUM 6061

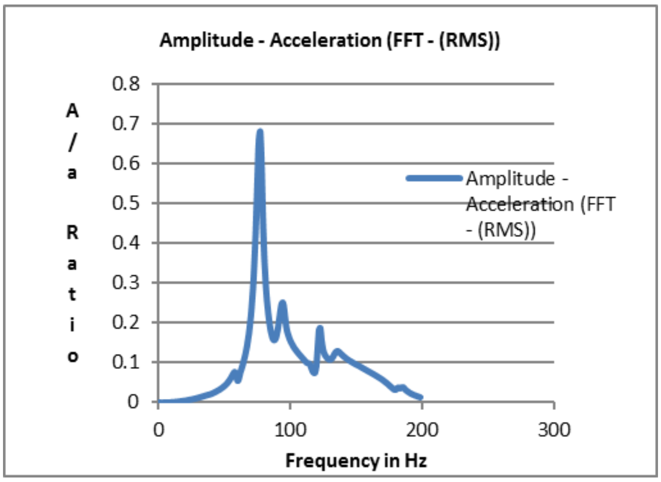


Figure 4.80 Amplitude acceleration curve for free vibration cantilever 6061+Damping-FFT

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 12, December-2020

Figure 4.80 shows frequency domain plot of free vibration with Cantilever type boundary condition, of 6061+Damping FFT. From the graph we can find the following value, the time domain is an expression of amplitude and individual amplitudes.
Difference in Time=93.46-77.20=16.2Hz,
Difference in Amplitudes=0.68-0.24=0.44 metre

$\delta = ln\frac{x0}{xn} = \ln\left(\frac{0.24}{0.68}\right) = -2.09$ (negative value because of amplitude decreases)

$\zeta = \frac{\delta}{\sqrt{4\pi 2+\delta 2}}$ = -0.31=Damping factor

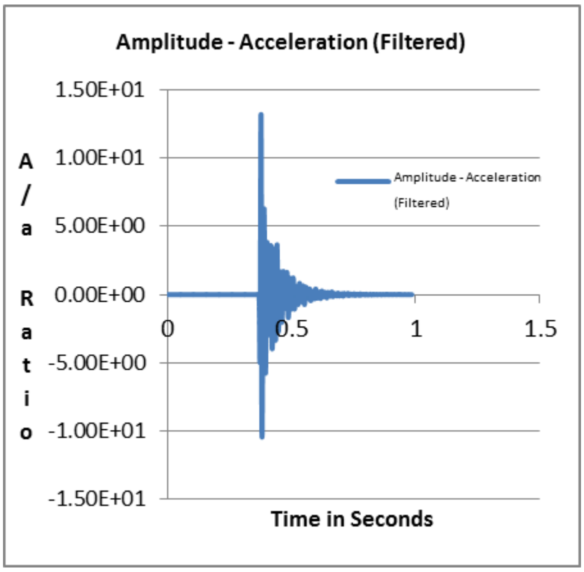


Figure 4.81 Amplitude acceleration curve for free vibration cantilever 6061+Damping

Figure 4.81 shows time domain plot of free vibration with Cantilever type boundary condition, of 6061+Damping. From the graph we can find the following value, the time domain is an expression of amplitude and individual amplitudes.
Difference in Time=0.3998-0.3879=0.019 Hz,
Difference in Amplitudes=6.14-3.73=2.41 Metre

$\delta = ln\frac{x0}{xn} = \ln(\frac{3.73}{6.14}) = 0.214$ (positive value because of amplitude increases)

$\zeta = \frac{\delta}{\sqrt{4\pi 2+\delta 2}}$ = 0.034=Damping factor.

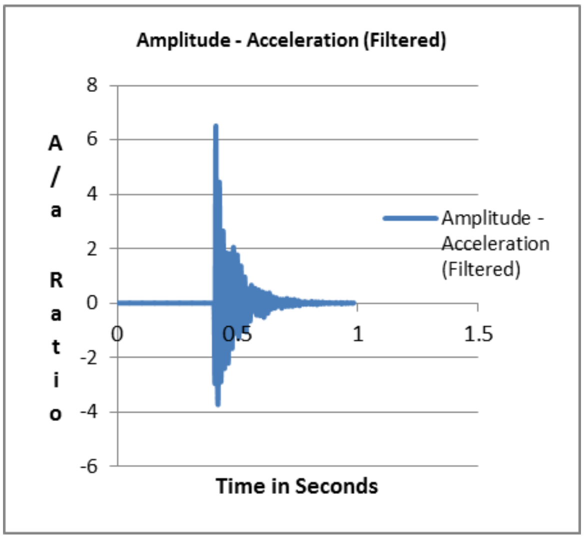


Figure 4.82 Amplitude acceleration curve filtered for free vibration cantilever 6061+Damping+Porous

Figure 4.82 shows time domain plot of free vibration with Cantilever type boundary condition, of 6061+Damping+Porous. From the graph we can find the following value, the time domain is an expression of amplitude and individual amplitudes.
Difference in Time=0.4247-0.4103=0.0144Hz,
Difference in Amplitudes=6.44-4.37=2.07 Metre

$\delta = ln\frac{x0}{xn} = \ln(\frac{4.37}{6.44}) = 0.23$ (positive value because of amplitude increases)

$\zeta = \frac{\delta}{\sqrt{4\pi 2+\delta 2}}$ = 0.036=Damping factor.

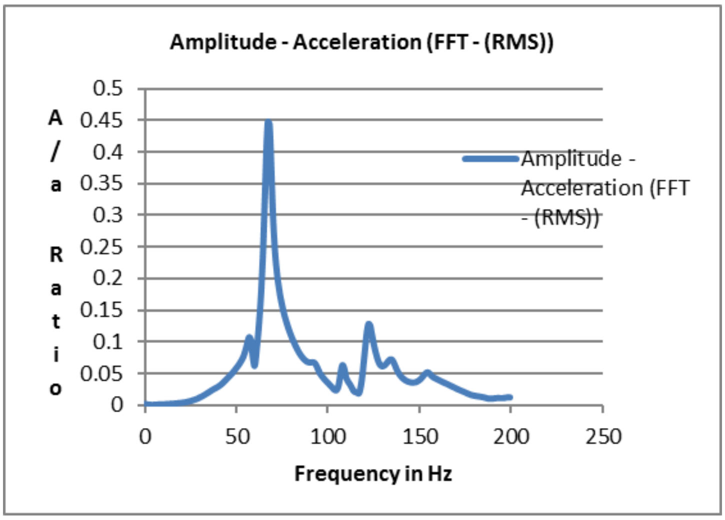


Figure 4.83 Amplitude acceleration curve for free vibration cantilever 6061+Damping+Porous FFT

Figure 4.83 shows time domain plot for free vibration with Cantilever type boundary condition, of 6061+Damping+Porous FFT. From the graph we can find the following value, the time domain is an expression of amplitude and individual amplitudes.
Difference in Frequencies =67.04-56.88=10.16 Hz,
Difference in Amplitudes=0.44-0.10=0.34 metre

$\delta = ln\frac{x0}{xn} = \ln\left(\frac{0.1}{0.44}\right) = -5.23$ (negative value because of amplitude decreases)

$\zeta = \frac{\delta}{\sqrt{4\pi 2+\delta 2}}$ = 0.64=Damping factor

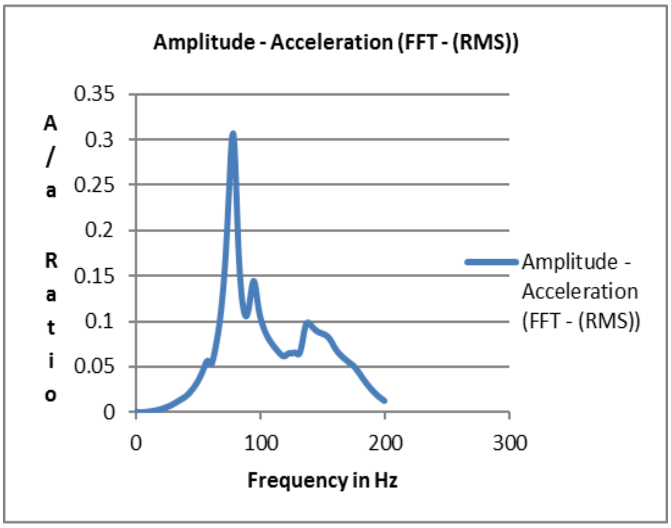


Figure 4.84 Amplitude acceleration curve for Free vibration cantilever for Aluminum 6061+Porous FFT

Figure 4.84 shows time domain plot of free vibration with Cantilever type boundary condition, of 6061+Porous FFT. From the graph we can find the following value, the time domain is an expression of amplitude and individual amplitudes.
Difference in frequency=94.47-78.22=16.25Hz,
Difference in Amplitudes=0.3074-0.1451=0.1623Metre

$\delta = ln\frac{x0}{xn} = \ln(\frac{0.1451}{0.3074}) =$ -6.28(negative value because of amplitude decreases)

$\zeta = \frac{\delta}{\sqrt{4\pi 2+\delta 2}}$ = -0.707=Damping factor.

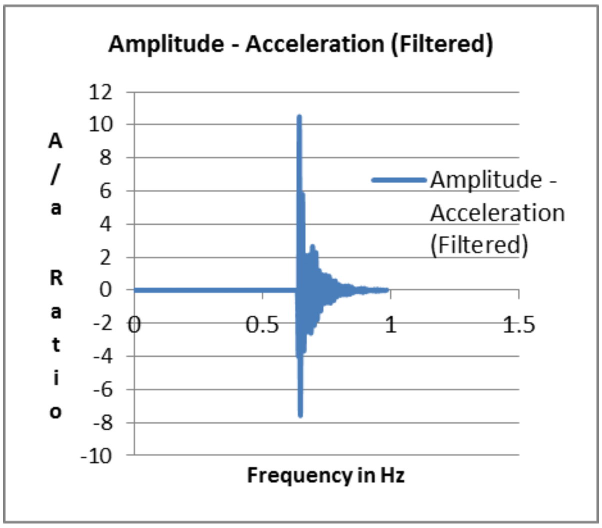


Figure 4.85 Amplitude acceleration curve for free vibration cantilever for Aluminum 6061+Porous

Figure 4.85 shows time domain plot of free vibration with Cantilever type boundary condition, of 6061+Porous. From the graph we can find the following value, the time domain is an expression of amplitude and individual amplitudes.
Difference in frequency=6439-6427=12Hz,
Difference in Amplitudes=10.40-5.87=4.53 Metre

$\delta = ln\frac{x0}{xn} = \ln(\frac{5.87}{10.40}) =$ 0.17(positive value because of amplitude increases)

$\zeta = \frac{\delta}{\sqrt{4\pi 2+\delta 2}}$ = 0.027=Damping factor.

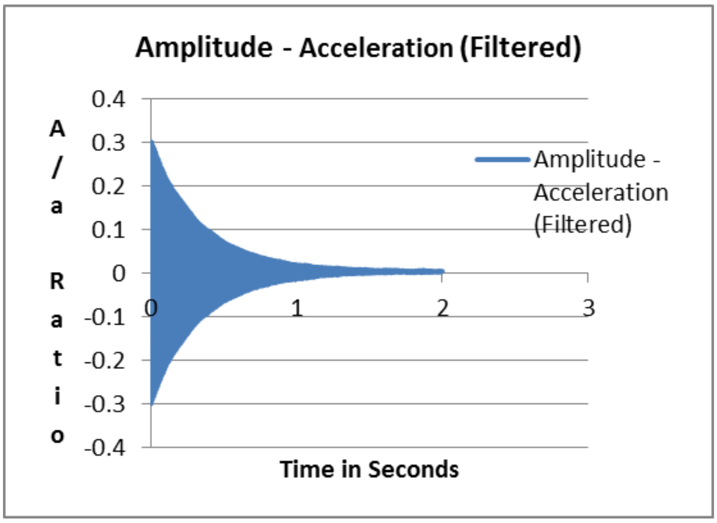


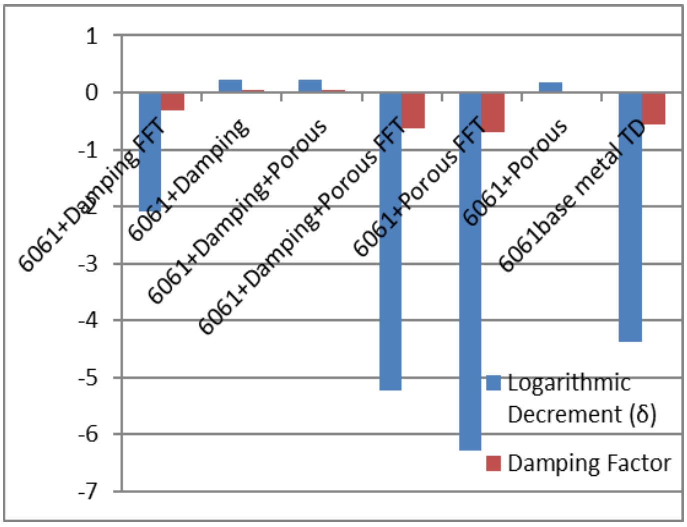
Figure 4.86 Amplitude acceleration curve filtered for free vibration cantilever

for Aluminum 6061 base metal-TD
Figure 4.88 shows time domain plot of free vibration with Cantilever type boundary condition, of al6061 base metal-TD. From the graph we can find the following value, the time domain is an expression of amplitude and individual amplitudes.
Difference in frequency=0.0072-0.0071=0.0001Hz,
Difference in Amplitudes=0.29-0.28=0.01 Metre

$\delta = ln\frac{x0}{xn} = \ln\left(\frac{0.28}{0.29}\right) = -4.39$ (negative value because of amplitude decreases)

$\zeta = \frac{\delta}{\sqrt{4\pi 2+\delta 2}}$ = -0.57=Damping factor.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 12, December-2020

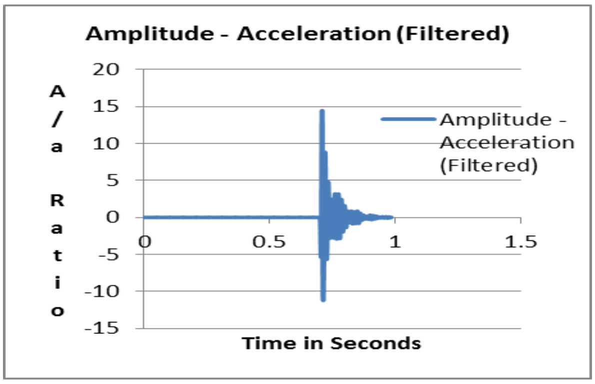


4.88 The trend of the Logarithmic decrement and damping factor -Column diagram

Figure 4.88 shows the trend of the Logarithmic decrement and damping factor. from the above diagram , it clearly shows that the logarithm decrement and damping factor are negative value and positive value because free vibration cantilever boundary condition .The base metal 6061+DampingFFT,and 6061+Damping+Porous FFT, 6061+Porous FFT only have negative value both the values of logarithmic decrement and are coming negative because frequency is high for frequency domain plot, where as in time domain plot the amplitude is decreases continuously here the value is positive because it is under damped system. Where in 6061base metal have negative value, another base metal not have LD and DF. it clearly shows negative value, here damping material PVDF objects the signals, so here it affects the natural frequency of the material. In 6061+Porous-FFT, here positive value are coming here porous material EOC, suppress the signal in frequency plot, but in 6061+Porous-FD,number of amplitude is high so here positive values are coming due to amplitudes ,so it clearly shows it is under damped system. When 6061+Porous+Damping-FFT here positive values are coming also logarithmic decrement decreases comparatively and damping factor are positive and the values are less. In 6061+Porous+Damping-TD are positive values and the values comparative slightly increases.

Type 2: FREE VIBRATION FIXED-FIXED BOUNDARY CONDITION

MATERIAL STRUCTURAL ALUMINUM 7075



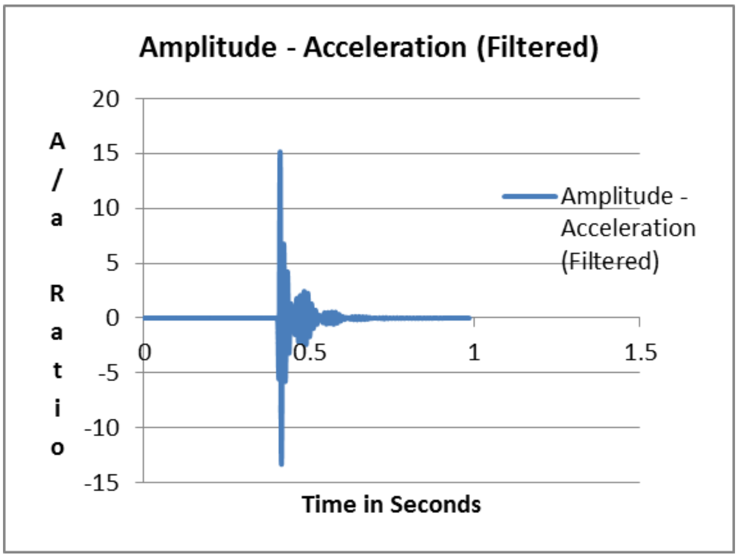


Figure 4.1 Amplitude acceleration curve for free vibration Cantilever Aluminum 7075 with Porous

Figure 4.1 shows time domain plot of free vibration with Cantilever type boundary condition, of 7075+Porous. From the graph we can find the following value, the time domain is an expression of amplitude and individual amplitudes.

Difference in Time=0.7206-0.7091=0.0115sec,

Difference in Amplitudes=14.14-8.53=5.61 metre

$\delta = \ln\frac{x_0}{x_n} = \ln(\frac{8.53}{14.14}) = 0.151$ (positive value because of amplitude increases)

$\zeta = \frac{\delta}{\sqrt{4\pi^2+\delta^2}}$ = 0.024=Damping factor.

Figure 4.2 Amplitude acceleration curve filtered for free vibration cantilevers for Aluminum 7075 with Damping

Figure 4.2 shows time domain plot of free vibration with Cantilever type boundary condition, of Aluminum7075+Damping. From the graph we can find the following value, the time domain is an expression of amplitude and individual amplitudes.

Difference in Time=0.4227-0.4119=0.0108 Sec

Difference in Amplitudes=14.95-6.62=8.33 Metre

$\delta = \ln\frac{x_0}{x_n} = \ln(\frac{8.53}{14.14}) = 0.126$ (positive value because of amplitude increases)

$\zeta = \frac{\delta}{\sqrt{4\pi^2+\delta^2}}$ = 0.02=Damping factor

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 12, December-2020

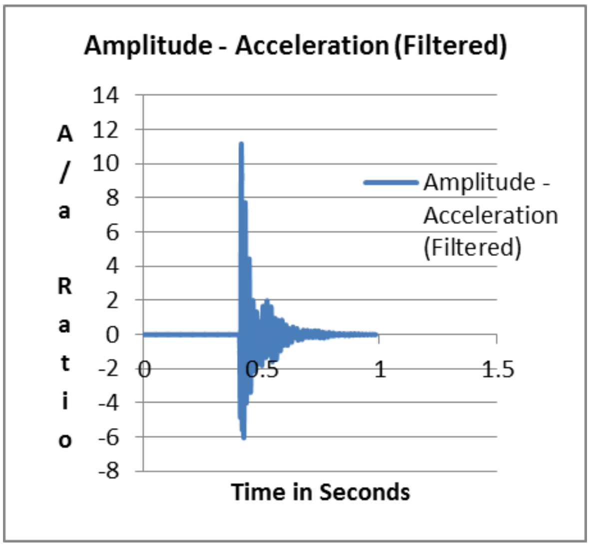


Figure 4.3 Amplitude acceleration curve for Free vibration cantilever for Aluminum 7075 +Damping +Porous

Figure 4.3 shows time domain plot of free vibration with Cantilever type boundary condition, of Aluminum 7075+Damping+Porous. From the graph we can find the following value, the time domain is an expression of amplitude and individual amplitudes.
Difference in Time=0.4300-0.4140=0.016Sec,
Difference in Amplitudes=11.07-7.59=3.48 Metre

$\delta = ln\frac{x0}{xn} = \ln(\frac{7.59}{11.07}) = 0.183$ (positive value because of amplitude increases)

$\zeta = \frac{\delta}{\sqrt{4\pi 2+\delta 2}}$ = 0.029=Damping factor

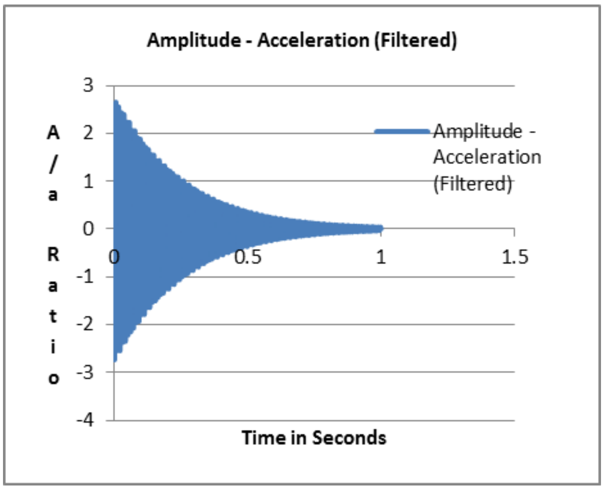


Figure 4.4 Amplitude acceleration curve for Free vibration cantilever for Aluminum 7075 base metal

Figure 4.4 shows time domain plot for free vibration with Cantilever type boundary condition, of Aluminum7075 base metal. From the graph we can find the following value, the time domain is an expression of amplitude and individual amplitudes.
Difference in Time=0.01847-0.00855=0.0099 Sec,
Difference in Amplitudes=2.56-2.49 =0.07 metre

$\delta = ln\frac{x0}{xn} = \ln\left(\frac{2.49}{2.56}\right) =$ 0.356(positive value because of amplitude increases)

$\zeta = \frac{\delta}{\sqrt{4\pi 2+\delta 2}}$ = 0.056=Damping factor

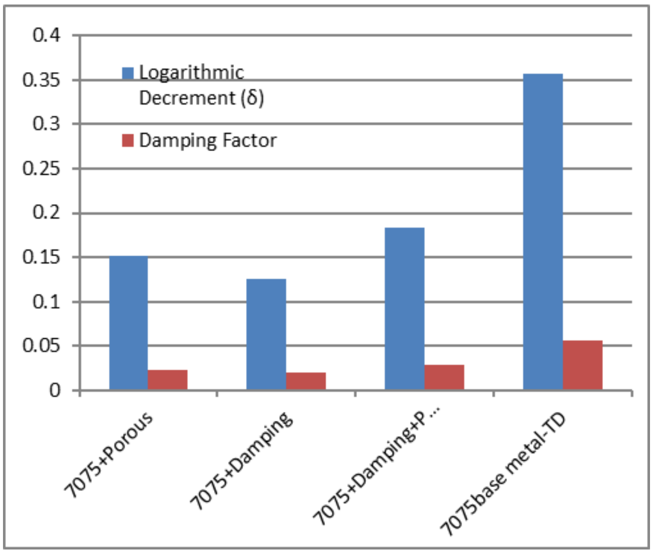


Figure 4.129 Magnitudes of Logarithmic decrement and damping factor-Vertical column diagram

Figure 4.129 shows the trend of the Logarithmic decrement and damping factor. From the above diagram, it clearly shows that the logarithm decrement and damping factor are positive al7075+Damping. Aluminum 7075+Porous have positive in LD and DF for free vibration cantilever with boundary condition. The base metal Aluminum7075+DampingFFT, have positive value and Aluminum 7075+Damping+Porous,Aluminum 7075+Porous have positive value both the values of logarithmic decrement and damping factor are also positive because frequency is high for frequency domain plot, where as in time domain plot the amplitude decreases continuously here the value is positive means it is under damped system. Damping material PVDF objects the signals, so here it affects the natural frequency of the material. In Aluminum 7075+Porous, have positive value. Porous material EOC, suppress the signal in frequency plot, but in Aluminum 7075,FFT have high amplitudes hence no LD and DF values. So it clearly shows it is under damped system.

Table 3: Damping factor for all materials with different boundary conditions.

Figure number	Type of composition	Cantilever boundary condition Free vibration	Damping Factor(ζ)
4.1	Aluminum 6061 base metal -FD		-0.537
4.2	Aluminum 6061 base metal -TD		0.036
4.3	6061+DampingFFT		-0.132
4.4	6061+Damping-TD		-0.16
4.5	6061+Porous-FFT		-0.98
4.6	6061+Porous-TD		0.01

4.7	6061+Porous+Damping-FFT		-0.69
4.8	6061+Porous+Damping-TD		0.025
Figure number	Type of composition	Fixed-Fixed boundary condition Free vibration	Damping Factor(ζ)
4.10	7075 base metal		0.056
4.11	7075 -TD		0.0228
4.12	7075+Damping +Porous -TD		0.029
4.13	7075+Porous-FFT		0.97
4.14	7075 with Damping -TD		0.032

CONCLUSION:

Table 3 shows the details of Material steel 6061, under free vibration, with Cantilever boundary condition. From the above table, it clearly shows that the some damping factor have negative value because for the base metal 6061 has damping factor negative because frequency is high for frequency domain plot, where as in time domain plot the amplitude decreases continuously hence the values are positive because it is under damped system. Where in 6061+Damping it clearly shows negative value, for damping material PVDF objects the signals, so here it affects the natural frequency of the material, so it is neglected. In 6061+Porous-FFT, negative values are coming here for porous material EOC that suppress the signal in frequency plot, but in 6061+ Porous-TD, number of amplitude is high so here positive values are coming due to amplitudes, so it clearly shows it is under damped system. When 6061+Porous+Damping-FFT have negative values decreases comparatively and damping factor are negative and the values are less. In 6061+Porous+Damping-TD are positive values and the values comparative slightly increases.

In case of 7075 material, it clearly shows that the damping factor are positive value and negative value because free vibration fixed-fixed boundary condition .The base metal 7075 FFT only has damping factor negative value because frequency is high for frequency domain plot, where as in time domain plot the amplitude is decreases continuously here the value is positive because it is under damped system. Where in 7075+Damping-FFT it clearly shows positive value, here damping material PVDF objects the signals, so here it affects the natural frequency of the material. In 7075+Porous, has damping factor positive value. The porous material EOC, suppress the signal in frequency plot, but in 7075+Porous-FD,number of amplitude is high so here positive values are coming due to amplitudes ,so it clearly shows it is under damped system. When 7075+Porous+Damping-FFT here positive values are coming also logarithmic decrement decreases comparatively and damping factor are positive and the values are less. In 7075+Porous+Damping-TD are positive values and the values comparative slightly increases.

From the above Table 3, the following observation

The 316+porous has 0.97 best damping factor

REFERENCES:

[1] Bin Liu, ”Analysis of nonlinear modulation between sound and vibrations in metallic structure and it’s use for damage detection”., Taylor & Francis ,24 March,2015 ,vol30, No3.ISSN:1058-9759.

[2] Wei-Xin Ren and Guido De Roeck, ”Structural damage Identification using modal data”. DOI: 10.1061/ASCE 073-9445, 2002, vol128, No1.ISSN:1058-9759.

[3] D. Ravi Prasad and D.R. Seshu and C Mbohwa “A study on dynamic characteristics of structural materials using modal analysis”.asian journal of civil engineering, 2008, vol 9, No2.

[4] Hyeongill Lee and Hwan-Sik Yoon “Acoustic radiation from modal vibration of automotive brake drum”. Springer, 26 March, 2017, vol31, No7.DOI 10.1067/s12206-017-0610-6.

[5] Andrei Zagra “Micro and macro scale damage detection using the non linear acoustic vibro modulation technique”. Taylor & Francis, 24 March, 2008, vol104-128, No19.ISSN:0934-9847.

[6] Tatiana Pias” Analytical and numerical computation of added mass in vibration analysis for a super yacht”. Taylor & Francis, 27 Dec, 2017, vol13, No4.ISSN:1744-5302.

[7] Sung Hee Kim “Interior noise analysis of a construction equipment cabin based on airborne and structure-borne noise predictions”. Taylor & Francis, 24 March, 2015, vol30, No3.ISSN:1058-9759.

[8] Gianmarco Vergassola “Visco-elastic materials.Visco-elastic items are used in ships and yachts constructions for floating floors, engine foundation and laminated glass”. Taylor & Francis, 24 March, 2018, vol13, No5.ISSN:1058-9759.

[9] Wang Xiaoqing “An experimental method of measuring acoustic surface radiation resistance”. Taylor & Francis, 24 March, 2015, vol30, No53.ISSN:1058-9759.

[10] Mitsuharu Shiwa1 “Non-linear ultrasonic and acoustic emission (AE) signals when ultrasonic fatigue testing are analyzed by using Laser Doppler vibrometer(LDV)and continuous AE waveform analysis system”. Taylor & Francis, 24 March, 2015, vol30, No3.ISSN:1058-9759.

[11] M.Vivolo1 “An experimental-numerical approach to tackle the vibro-acoustic characterization of composite sandwich structures”. Taylor & Francis, 24 March, 2015, vol30, No3.ISSN:1058-9759.

[12] Olivier Robin “An experimental method to estimate the absorption coefficient of sound absorbing materials under synthesized diffuse acoustic field in free conditions”. Taylor & Francis, 24 March, 2015, vol30, No3.ISSN:1058-9759.

[13] Anjali,Sanjay Choudhary & Vijaykumar “Effect of porosity on the mechanical strength of composite materials”. International Journal of mechanical & Industrial engineering (IJMIE), 2012, vol2, No3.ISSN:2231-6477.