EXPERIMENTAL VIBRATIONAL STUDY ON Al2024-Cu BIMETALIC CANTILEVER BEAM BY USING DEWI SOFT

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Abstract Bimetallic bars can be manufactured in medium and small-size shape rolling mills from the previously produced bimetallic feedstock. Proper strength of bond between the core and the cladding layer and to assure the uniform plastic flow of both bimetal layers. A considerable increase in interest in using corrosion resistant steel bars in the construction industry has been observed in modern years. This is owing to the particular properties of these bars, namely high durability and rigidity, good quality mechanical properties and high corrosion resistance.This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale and governing equations.

Key Words: Bimetallic bars, cladding, corrosion, optimization.

1. INTRODUCTION

Any motion repeats itself after an interval of time is called vibration (or) oscillation (or) periodic motion. All bodies possessing mass and elasticity are capable of producing vibrations. Vibration is undesirable, wasting energy and creating unwanted sound – noise. In its simplest form, vibration can be considered to be the oscillation or repetitive motion of an object around and equilibrium position. The equilibrium position is the position the object will attain when the force acting on it is zero. This type of vibration is called “whole body motion”, meaning that all parts of the body are moving together in the same direction at any point of time.

The vibration of an object is always caused by an excitation force. This force may be externally applied to the object, or it may originate inside the object. It will be seen later that the rate (frequency) and magnitude of the vibration of a given object is completely determined by the excitation force, direction and frequency. This is the reason that vibration analysis can determine the excitation forces at work in a machine.

In this study, the modal analysis started with the experimental approach. Dewetron software was used to analyze the raw data which gave the value of dynamic characteristic of natural frequencies and mode shapes for every node. Then the structure is modeled and analyzed using the FEA tools software. It produced some optimal location gathered from theoretical analysis was then applied in the field testing. By doing that the comparisons between the experimental and theoretical approaches were gathered in terms of natural frequency value and mode shape.

Reasons for vibrating testing

- Reduce product development time
- Ensure new products are fit for purpose
- Reduce in-plant rework due to QA rejection

- Reduce damage in transit and subsequent rejection by the customer
- Reduce marginal or non-performance rejection under Warranty
- Reduce legal costs and damage claims due to incorrect operation of the product
- Maintain a good reputation for the company and its products
- Maintain profit margins.

2. Properties of Material

Al2024 alloy plates and Copper alloy were cut into the required dimensions 48 X 48X 5mm.

Al2024 & Cu for required dimension

Material 1: aluminium

- Density = 2200 kg/m^3
- Poisson's ratio = 0.34
- Young's Modulus = 67.5 Gpa
- Thermal conductivity=0.530k
- Melting point=660 c(max)

Material 2: Copper

- Density = 2580 kg/m^3
- Poisson's ratio = 0.26
- Young's Modulus = 123 Gpa
- Thermal conductivity=0.940k
- Melting point= 1083 c (max)
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3. Diffusion Bonding

The Copper (Cu) and Aluminium (Al2024) alloys have good characteristics such as high electrical conductivity, thermal conductivity, machinability and low casting costs and hence widely applied in electronics and electrical power industry, electrical appliances, machinery and automobiles. The application of copper and aluminium alloys to heat exchanger for cooling the electronic component is the most common. However, as the need for more efficient heat transfer increases, more innovative heat exchanger designs and devices are emerging. Many times, the parts being cooled are attached to Cu or Al base plates. This leads to make an attempt to join copper-aluminium dissimilar materials. However, the refractory oxide films of Cu and Al results in inclusion at the weld metal during fusion welding. Moreover, the conventional fusion welding technique causes several thermal cracking and easy formation of brittle intermetallic in the joints produced. This makes the performance of joints very poor, and makes it very difficult to obtain satisfactory joints.Therefore, Cu/Al dissimilar materials are to be joined by diffusion bonding technique.

4. Diffusion bonding techniques

According to "Diffusion bonding of materials Aluminium 2024 & Copper in solid state is a process for monolithic joint through the formation of bonds at atomic level, as a result of closure of the mating surfaces due to local plastic deformation at elevated temperature which aids inter diffusion at the surface layers of the materials being joined". Diffusion bonding is relatively simple joining process, which is controlled by three important process parameters. They are bonding temperature, bonding pressure and holding time. In addition, these three parameters are interrelated and thus have an effect on each other. The bonding temperature should be between 50% and 70% of the melting point of either of the lowest melting point material. The use of elevated temperature will aid the inter diffusion of atoms across the interface of the bond and assist surface deformation. The bonding pressure should be high enough to ensure a tight contact between the joining surfaces. Moreover, it should be sufficient to aid in the deformation of surface asperities and to fill all the voids in the bonding zone. Also, the holding time should be sufficient for an intimate contact to be formed and for the diffusion process to take place. However, excessive holding time may lead to degradation of physical and chemical properties of the bonds

5. Process Mechanism

Stage 1: Holding at temperature and under pressure causes continued growth of contact asperities.

Stage 2: Through creep, while the influence of temperature alone causes surface boundaries to begin to migrate into more energetically stable arrays.

Stage3: As the effects of temperature and pressure continued the contact area approaches 100% and only small voids are left behind at the faying surface location.

Stage4: Further, as interfacial or grain boundaries leave the original faying surface, the joint becomes relatively indistinguishable except for residual voids. Finally disappears through continued diffusion process.

Table 1. Diffusion bonding parameters

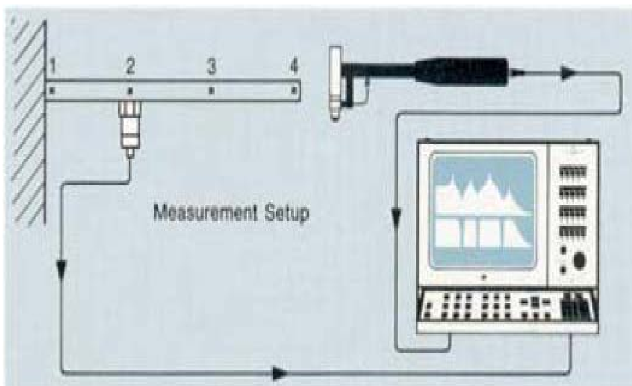
S.No	Good bonding parameter value	
1	Holding time	15Min
2	Optimum pressure	16.666Mpa
3	Optimum temperature	500Ċ

6. Modal Analysis

Modal analysis is defined as the study of the dynamic characteristics of a mechanical structure. this application note emphasizes experimental modal techniques, specifically the method known as frequency response function testing. we describe a structure in terms of its natural characteristics which are the frequency, damping and mode shapes its dynamic properties. , i often explain modal analysis in terms of the modes of vibration of a simple plate. let's apply force to one mode point of the plate we will also measure the response of the plate due to the excitation with an accelerometer attached to one corner of the plate.

7. Experimental Modal Analysis

The **dewi software** analysis was used to measure the frequency ranges of bimetallic material when the varies load are act to using the modal hammer. This will help us in designing the material of various machines in such a way that they are able to resist the vibration caused in them.



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7.1 Experiment Procedure

Aluminium & copper bimetallic beam of required dimension 48X48X5 mm was cut from a bulk available beam.By the use of vernier gauge were measured required dimensions of 10 mm length of beam was properly inserted to the fixture.Now the length of the cantilever beam from fixed end to the free end was found out.The connections of the FFT analyzer, laptop, transducers, and model hammer along with the requisite power connections were made.The accelerometer -4507 type was fixed by beeswax to the cantilever beam at one of the nodal points.The 2302-5 modal hammer was kept ready to struck the beam at the singular points **[2].**Then at each point the modal hammer was struck once and the amplitude Vs frequency graph was obtained from graphical user interface.The FFT analyzer and the accelerometer are the interface to convert the time domain response to frequency domain. Hence the frequency response spectrumH1 (response, force) was obtained..By moving the cursor to the peaks of the FFT graph (m/s2/N), the cursor values and the resonant frequencies were recorded. At the time of the striking with modal hammer to the singular point precautions were taken whether the striking should have been perpendicular to the aluminum beam surface. The above procedure is repeated for all the nodal points. The values (i.e., natural frequencies and resonant frequencies) obtained from the FRF spectrum was compared with respect to the FEM analysis.

8. Experimental Results

The results obtained from the experiments were tabulated.

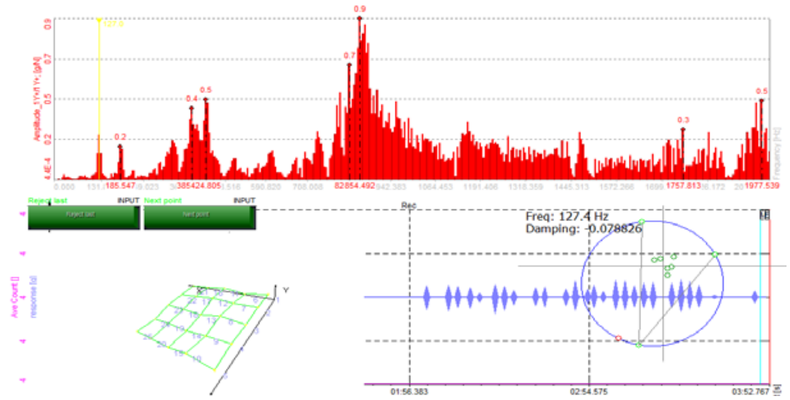

Fig 8.1 Frequency Response Function for First Node

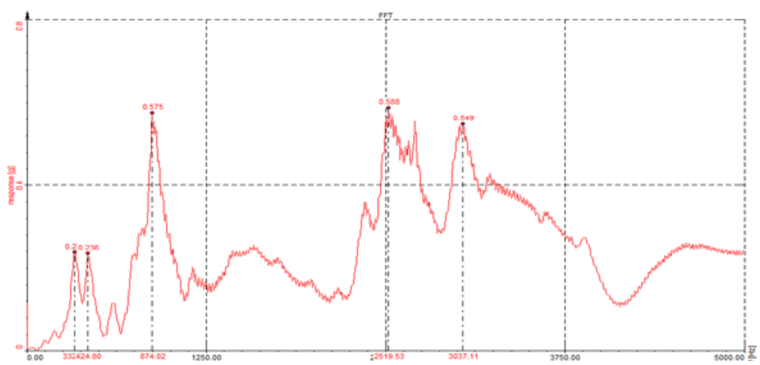

Fig 8.2 Fast Fourier Transform

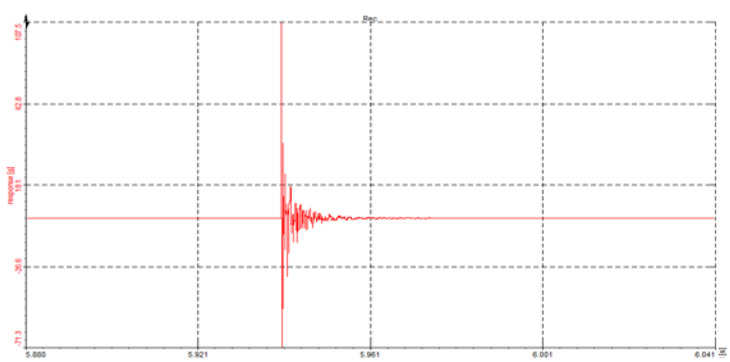

Fig 8.3 Response from Accelerometer

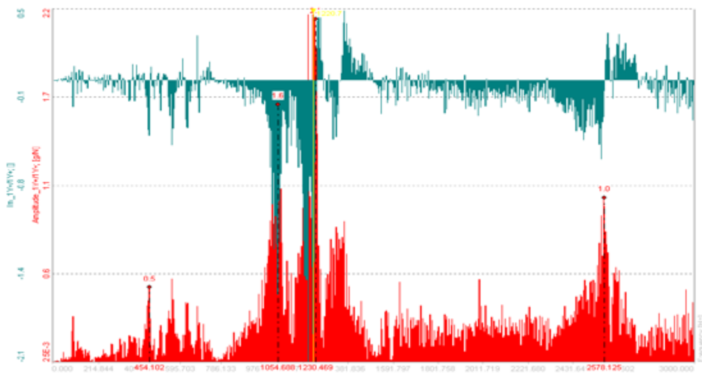

Fig 8.4 Real and Imaginary Part

Mode	F1	F2	F3	F4	F5	F6
First	156	302	434	1040	1162	2661
Second	157	322	434	1035	1157	2651
Third	156	327	434	1020	1166	2651
Four	156	327	439	1040	1176	2656
Five	156	327	434	1035	1162	2651

Table 2. FRF range for first job

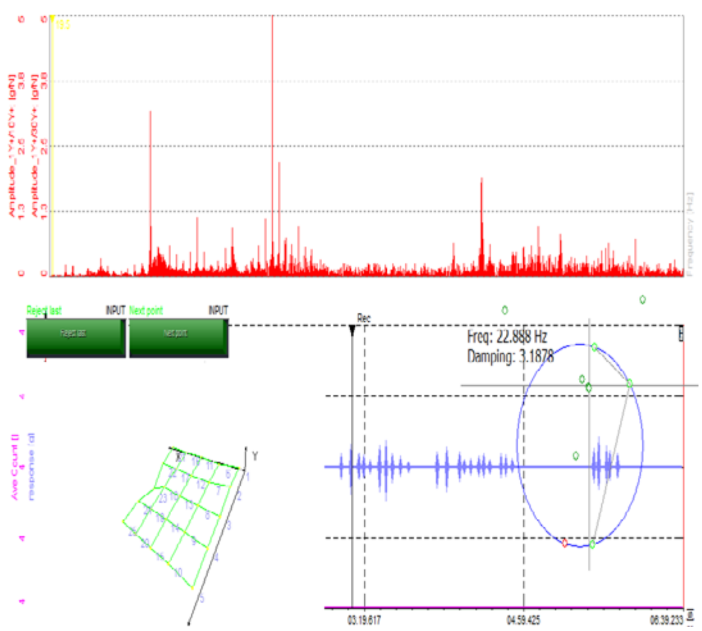

Fig 8.5 Frequency Response Function For Second Node

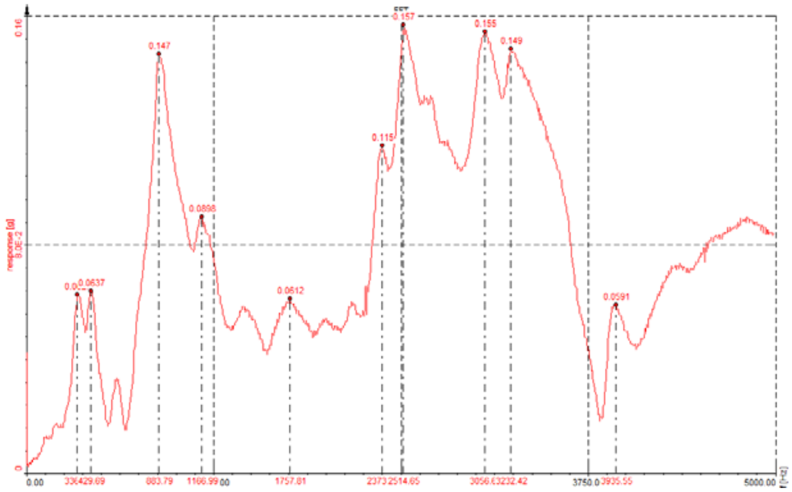

Fig 8.6 Fast Fourier Transform

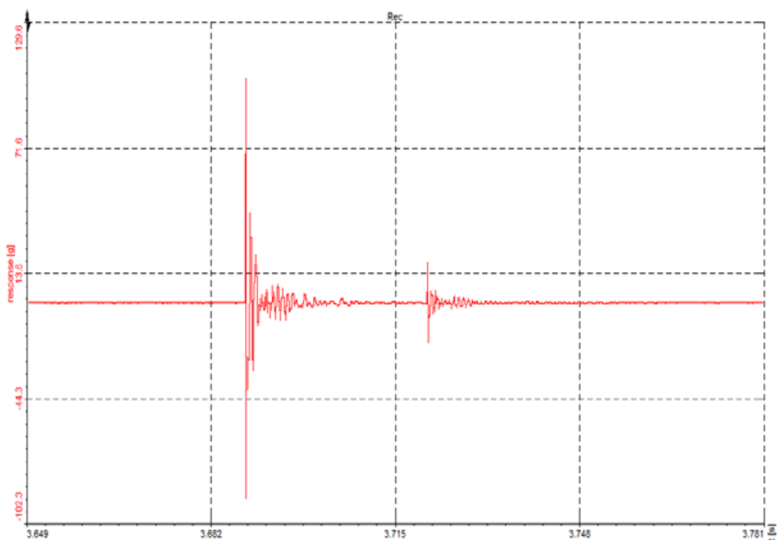

Fig 8.7 Response from Accelerometer

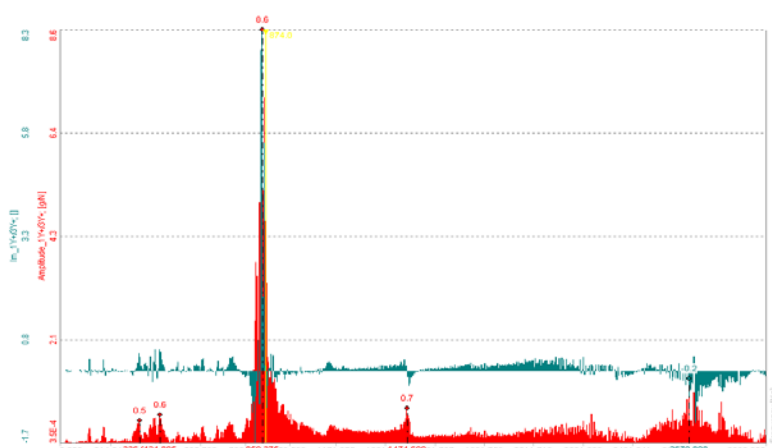

Fig 8.8 Real and imaginary part

Mode	F1	F2	F3	F4	F5	F6
First	190	341	429	874	2509	3881
Second	190	336	429	883	2514	3066
Third	190	346	429	874	2519	3041
Four	190	332	429	869	2509	3232
Five	190	332	429	878	2509	3232

Table 2. FRF range for second job

9. Conclusion

The Aluminium 2024) –Copper (Cu) bimetallic material to be fabricated by diffusion bonding technique with optimized parameters. The mode shapes with resonance frequencies will be obtained numerically by assuming reduced superposition techniques and the Eigen values and Eigen vectors are identified. The Finite Element Analysis results to be compared with the experimental results and mode shapes. The deflection and resonance frequencies are compared, which will tabulate the behavior of bimetallic material.

This work leads to very appealing thoughts about modal analysis. This work is carried out to find the mode shapes and safe frequencies which the material can design. This work will certainly help in those types of situations where a small part of the structure is to be examined. But doing analysis for the whole structure is often required. There are many factors concerned but those factors should be accounted for higher studies in this perspective. Further dynamic analysis can be done such as transient dynamic analysis through which velocity – time, Displacement – time plot graphs can help more about to learn dynamic behavior of bimetallic materials.

References

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