EFFECT OF PALM FIBER EPOXY COMPOSITE ON PROPERTIES OF DAMPING VIBRATION

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ABSTRACT:

This work deals with a study of the effect of natural fibers -epoxy composite on damping .Palm fiber was used in this investigation. Four blocks of dimensions (10X20)cm were prepared using epoxy-resin and palm fiber by volume fractions ratio of (0%,4%,8%,16%). After preparation of the composite material some of mechanical properties of prepared samples were studied. The specimens were cut from the blocks and tested in the scleroscope system by using a 50g steel ball on specimens released from a height of 70 cm. The vibration signal was obtained by the accelerometer and fed to the oscilloscope .The oscilloscope output signal was analyzed using logarithmic decrement method, to obtain the damping ratio. The effect of three testing temperatures (-30,25,65)C^o was checked. It was observed that the damping ratio decreases by 24.4% with increasing volume fraction of reinforcement materials at temperature 25C^o. While at temperature 65C^o this ratio reached 53% and at temperature (-30)C^o the ratio reached 31.25%. The results showed that using a filler of natural fiber will decrease the damping ratio as compared with 0% volume fraction specimen. While the effect of testing temperature (-30,25,65)C^o on the damping ratio with deferent volume fractions showed an increase in percentage of damping ratio as temperature increased and volume fraction increased. These result were compared to the another composite material used glass fiber and carbon fiber for the same author which found that the percentage of ζ for palm fiber increased up to 40%when used glass fiber and 46% in the case of use carbon fiber.

Keywords: Natural fibres (Palm fibre) - epoxy composite; damping ratio; vibration damping.

تأثير التقوية بألياف النخيل على خواص التخميد للمواد المتراكبة ذات اساس ايبوكسي

الخلاصة :

يتناول هذا البحث دراسة تأثير التقوية بالألياف الطبيعية لمركب الايبوكسي على خواص التخميد. تم استخدام الياف النخيل في هذا البحث واعداد اربع قوالب ذات أبعاد (10 x 20) سم باستخدام راتنج الايبوكسي وألياف النخيل باختلاف نسبة الكسر الحجمي (0٪، 4٪، 8٪، 16٪). و بعد إعداد المواد المركبة تم دراسة بعض الخواص الميكانيكية للعينات التي تم قطعها. تم اختبار خاصية التخميد للعينات باختلاف نسبة الكسر الحجمي وباختلاف درجات الحرارة باستخدام جهاز scleroscope وذلك بإسقاط كرة من المعدن ذات كتلة 50 غم على العينات من ارتفاع 70 سم. تم تحليل إشارة الاهتزاز التي حصلنا عليها باستخدام مقياس التعجيل واستلام الاشارة على جهاز قياس التذبذب. وتحليلها باستخدام طريقة التناقص اللوغاريتمي للحصول على نسبة التخميد تحت تأثير ثلاث درجات حرارة فحص (30,25,65-) درجة مئوية ونسبة كسر حجمي (0٪، 4٪، 8٪، 16٪). لوحظ أن نسبة التخميد تنخفض بنسبة 24.4٪ مع زيادة نسبة الكسر الحجمي للمواد المدعمة عند درجة حرارة 25 درجة مئوية اما في درجة الحرارة 65 درجة مئوية بلغت هذه النسبة 53٪ وعند درجة الحرارة (- 30) درجة مئوية لوحظ ان النسبة تصل الى 31.25٪. لقد أظهرت النتائج أن استخدام حشو من الياف النخيل سيقلل من نسبة التخميد. في حين أن تأثير درجة الحرارة أظهرت زيادة في نسبة التخميد مع ارتفاع درجة الحرارة وزيادة نسبة الكسر الحجمي . تم اجراء مقارنة للمادة المستخدمة في البحث مع مادة مركبة باستخدام الياف الكاربون والياف الزجاج لنفس الباحث حيث وجد ان هناك زيادة في معامل التخميد تصل اكثر من 40 % في حالة استخدام الياف الزجاج و46 % في حالة استخدام الياف كاربون وهذا بالتالي يحسن من استخدام المادة كمادة مخمده للاهتزاز .

INTRODUCTION

Over the last few years, many studies have focused on predicting critical speeds, natural frequencies, and damping properties on composite materials. There has been recently a growing interest in utilizing natural fibres reinforcements in preparing epoxy composite for making low cost construction material. Natural fibres are prospective reinforcing materials and their use until now has been more traditional than technical. Many studies had been carried out on natural fibres like kenaf, bam boo ,jut ,hemp ,coir, sugar palm and oil palm[Arib2006 et al.],[Lee2006 et al.],[Rozman2005 et al.] and [Sastra 2009].The advantages of these natural resources are low weight, low cost ,low density, high toughness and acceptable specific strength enhanced energy recovery. Natural fibres are considered as strong candidates to replace the conventional glass and carbon fibres. The chemical, mechanical and physical properties of natural fibres have distinct properties; depending upon the cellulosic content of the fibres which varies from fibre to fibre [R.Malkapuram 2009].The combination of the plastic matrix and reinforcing fibres gives rise of composites having the best properties of each component. The most commonly used are thermoset polymers such as polyesters, epoxies and phenolic [J.Geare 2001]. Damping refers to the extraction of mechanical energy from a vibration system usually by conversion energy into heat. There are two types of damping: material damping and system damping. Material damping inherent in the material while system or structural damping include the damping at the supports, boundaries , joints, interfaces, etc. in addition to material damping .Damping is the most common way to reduce resonances response. Damping or loss factor measurements are rarely straight forward due to the complexity of the dynamic instruction of the system joint, trim, and geometry further more.

1-1 LITERATURE REVIEW ON DAMPING

Chung in (2001) made investigation for materials of vibration damping, by using metals, polymers, cement and their composite. The investigation showed that polymers and metals are better than cement in damping due to their viscoelasticity.
Adams and Maheri in (2003) investigated the damping capacity of fiber reinforced plastic and developed a damping energy equation, using the finite element method, Rayleigh Ritz method. Mohamed colakoglu in 2006 investigated the damping and frequency properties of polyethylene fiber composite under varied temperature. For this purpose, the tension test is first applied to specimen to obtain the mechanical properties of composite. The temperature dependent frequency response is analyzed experimentally by using damping monitoring technique.

Other researchers have supplied the basis for the development of particulate composites for applications that require vibrations damping. Piratelli-Filho et al 2008 studied vibrations damping in epoxy resin based composites. This composite, called polymeric concrete was developed using materials such as granite and marble, plus the addition of acrylonitrile-butadiene rubber.

1-2 THE OBJECTIVES OF THIS WORK:

Damping is an important model parameter for the design of structures for which vibration control and dynamic loading are critical [Mohamed 2006]. Hence, the objective of this study is to investigate the damping properties of the composite material contain natural fibre (palm fibre) as a filler and epoxy resin as a matrix under different volume fractions of palm fibre (0%,4%,8% ,16%) and different temperatures (-35,25,65) C^{o} by using liquid nitrogen to reach temperature (-35) C° and heated the specimens to reach the temperature (65 C˚),and make a comparison between natural fibre and another composite such that carbon fibre and glass fibre.

2- EXPERIMANTAL WORK :-

2-1 specimen Preparation

The specimens were cut to dimensions (10x10x200) mm from blocks prepared that consist of a matrix material and filler with different volume fraction (0%,4%,8% and 16%).

2-2 Matrix

The properties of epoxy resin [Diglycidy Ether of Bisphenol-A DGEBACY 223 with hardener (Polyimide type 964)] used in this research was recorded in table (1) used as a matrix .The ratio between resin and hardener for this study was 2:1 by weight.

2-3 Filler

Date palm fiber as fabric form was extracted from the stem of date palm tree as in fig.(1). The Palm fibers had taken from the rules of palm leaves after cleaning operations performed annually .This was cleaned and washed with water to remove all foreign matter such as dust, and dirt. The fiber fabric was dried in an oven to remove residual moisture and then a constant weight obtained for fiber diameter 1±0.1 mm .The modulus of elasticity was found by using the measurement of tensile fibers device for range of fiber diameter 1±0.1 mm . Table (2) show the mechanical properties of palm fiber.

2-4 Properties of Composite

The fabrication of various composite materials specimens were carried out by hand layout technique. The mould that was used in this work is made of aluminum with dimensions (100 x 200) mm as shown in fig.(2).The mould was cleaned and the inside walls were covered with Vaseline to prevent the adhesion between the mould and epoxy matrix.

The composite material was prepared by mixing the epoxy resin with hardener (2:1)mixing ratio at room temperature .The palm fiber were prepared in the mold before putting the epoxy resin to make different volume fraction (4%,8%,16%)as in fig.(3). Solidification process for all moulds was completed after 24 hours. The casts are released from the mould and then cut into specimen with dimension 10x10x200mm .The palm fiber are arrange in the composite according to the volumetric ratio as shown in fig (4) .

2-5 Measurement of Damping

From a theoretical point of view there are different methods used to measure damping .These methods are divided in two main groups depending on wether the response of the system is expressed as a function of time or as a function of frequency , i.e time response method and frequency – response method. Logarithmic decrement methods, Step-Response method and Hysteretic Loop method are time response ,while Magnification – factor methods and Band –width method are frequency – response. Dealing with time response methods , the LDM is the most common method used to measure damping .In this method ,an initial excitation is applied to a single degree of freedom oscillatory system with viscous damping .Fig.(5)shows the form of response in a time decay ,which is expressed by the formula (1-1)

$$y(t) = y\, e^{-\xi \omega t} . \sin(\omega t) \qquad (1\text{-}1)$$

If the response is known, then it is possible to determine the logarithmic decrement **δ** through the formula (1-2)

$$\delta = \frac{1}{r} \ln \frac{x_i}{x_{i+r}} = \frac{2\pi\zeta}{\sqrt{1-\zeta^2}} \qquad (1\text{-}2)$$

Then the damping ratio (ζ) is easily calculated with the formula (1-3)

$$\zeta = \frac{\delta}{\sqrt{4\pi^2+\delta^2}} \qquad (1\text{-}3)$$

2-6 Vibration Damping System

Fig(6-a)and (6-b)shows the system used in this investigation .The prepared specimen is fixed and stroked by a 50g ball released from a height of 70 cm . A glass tube was used to guide the ball to the reinforced sample.

Logarithmic decrement Method is used to measure damping. In this method, an initial excitation is applied to a single degree of freedom oscillatory system with viscous damping. Figure (5) shows the logarithmic decrement method [Manuel 2006]. If the response is known, then it is possible to determine the logarithmic decrement using the formula (1-2).

3- RESULT AND DISCUTION :

Damping test was executed for specimens prepared from epoxy before and after adding the natural reinforcement materials under test temperatures of (-30,25 and 65)C^o. Damping ratio was obtained by employing logarithmic decrement method. This method of measuring damping utilizes a vibrating system in which the deflected member, usually the specimen under test acts as a spring. For example, one end of the specimen may be fixed and the other end attached to a mass which is caused to vibrate. By measuring any two successive amplitudes as shown in figure (5) and using equation (1-2) we get the value of logarithmic decrement (δ) .By substituted this value in equation (1-3) we get damping ratio value (ζ). This behavior appears in all the specimens with the difference in their types of natural reinforcement material and test temperature.

Figures (8) shows the relationship between Young modules of composite materials with different volume fractions .This figure shows that when the volume fraction increased, Young modulus decreased for all temperature (-30, 25, 65)C^o . However, in reality this assumption is not really true because interfacial bonding at interface between fiber and matrix play an important role in determining the composite strength.

Fig.(9) shows the relationship between the volume fraction and the damping ratio (ζ) at different testing temperatures . As temperature was increased the damping ratio increased with percentage of 20% for volume fraction 0%.While when volume fraction is 4% the damping ratio was increased with percentage of 7%. This percentage increased to 17% when the volume fraction increased to 8%.And when the volume fraction reached to 16% the percentage of damping ratio increased to 18%.

This work used palm fiber as composite material with different volume fraction was compared with a previous research work that done by Author using glass and carbon fiber [Ibtihal et al2013].as in table (3):

For V_f = 4%,volume fraction of fiber ,the Palme fiber gave an increase of 35% more than glass fiber and 21% more than carbon fiber .

For V_f = 8%,volume fraction of fiber ,the Palme fiber gave an increase of 37% more than glass fiber and 29 % more than carbon fiber .

For V_f = 16 %,volume fraction of fiber ,the Palme fiber gave an increase of 40% more than glass fiber and 46% more than carbon fiber .

These results show that the damping ratio (ζ) of Palme fiber is higher than the damping ratio of carbon and glass fiber [Ibtihal A 2013]. Hence, the palm fiber can be used in damping application instead of carbon and glass fiber. Using palm fiber also causes reduction in weight. These properties made Palme fiber composite more useful in applications that need reduction in weight and acceptable damping with limited Young's modulus.

4- CONCLUSIONS

From this investigation, the following conclusions are drawn:

1- The vibration damping of the palm fiber composite material is significantly lower than of the matrix material and it decreases with the increasing of reinforcement material volume fraction.
2- The damping ratio (ζ) of palm fiber is found higher than the damping ratio of carbon and glass fiber which found from previous work[Ibtihal A 2013] the percentage of ζ for palm fiber increased up to 40%when used glass fiber and 46% in the case of use carbon fiber.
3- When the volume fraction increased the Young modulus decreased for all test temperature (-30, 25, 65)C^o.
4- As test temperature was increased from (-30)C^o to (65)C^o, the damping ratio increased with percentage of 20% for volume fraction 0%.while when volume fraction is 4% the damping ratio increased with percentage of 7% .This percentage increased to 17% when the volume fraction increased to 8%.And when the volume fraction reached to 16% the percentage of damping ratio increased to 18%.
5- These properties made Palme fibre composite more useful in applications that need reduction in weight and acceptable damping with limited required Young's modulus.
6- Natural fibers have become important items in the economy and in fact, they have turn out to be a significant source of jobs for developing countries.Natural fibers can be easily obtained in many tropical and available throughout the world.

List of symbol		
E	Young modules of elasticity	N/m^2
T	Temperature	C^o
r	No. of cycle	cycle
V_f	Volume fraction	%
X_i	Initial displacement	mm
X_{i+r}	Final displacement	mm
δ	Logarithmic decrement	---
ζ	Damping ratio	

Table (1) Physical and mechanical Properties of epoxy resin

Specific heat	**1.05kJ/kg.k**
Tensile strength	**20-25 GPa**
Density	**1.004 g/cm^3**
E young modulus	**1.35 GPa**

Table(2) Physical and mechanical Properties of Palm fiber

Max. tensile strength	**62 MPa**
Density	**0.64 g/cm^3**
E young modulus	**0.737 GN/m^2**

Table (3) The compression between palm fiber , glass fiber and carbon fiber at temperature =25 C^o.

% V_f Palm fiber	**ζ_c composite material with palm fiber**	**Percentage of increased of ζ for palm fiber than glass fiber.**		**Percentage of increased of ζ for palm fiber than carbon fiber**	
		ζ_c for glass fiber	**% increased**	**ζ_c for carbon fiber**	**% increased**
4%	**0.14**	**0.0908**	**35%**	**0.11**	**21%**
8%	**0.123**	**0.099**	**37%**	**0.085**	**29%**
16%	**0.13**	**0.078**	**40%**	**0.0702**	**46%**

Fig.(1) Palm fiber taken from the rules of palm leaves after cleaning operations performed annually

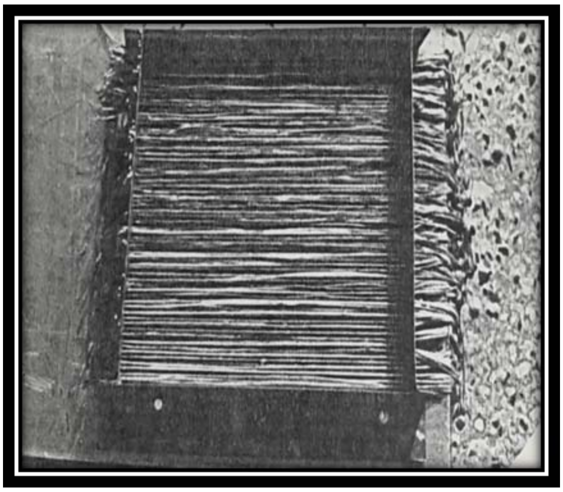


Fig. (2) The shape of the mould. specimen

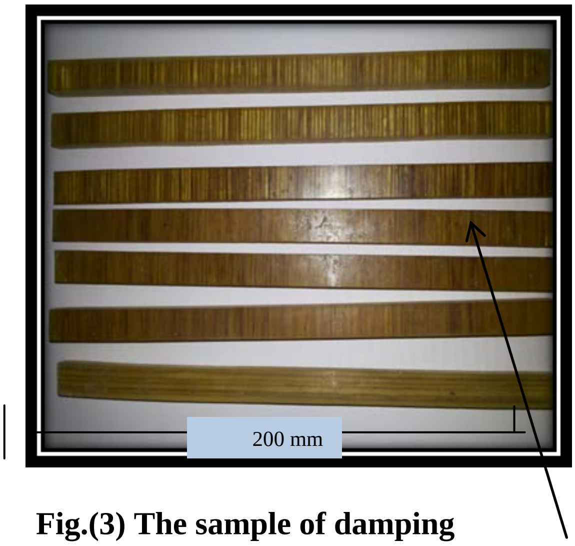


Fig.(3) The sample of damping

10x10

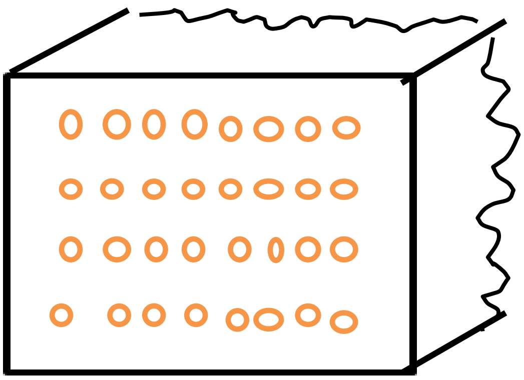


Fig.(4) structured construction to arrange Palm fibers in the composite according to the volumetric ratio of the fracture.

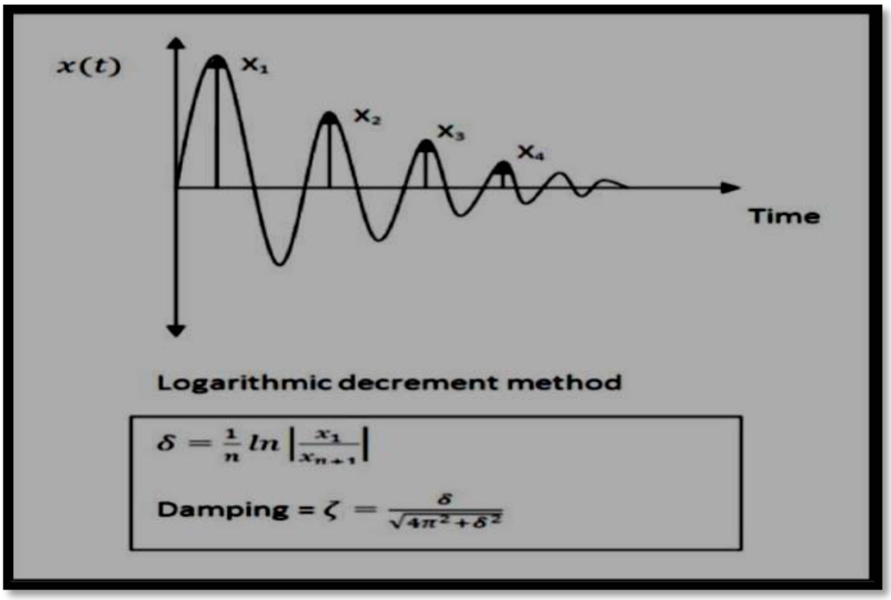
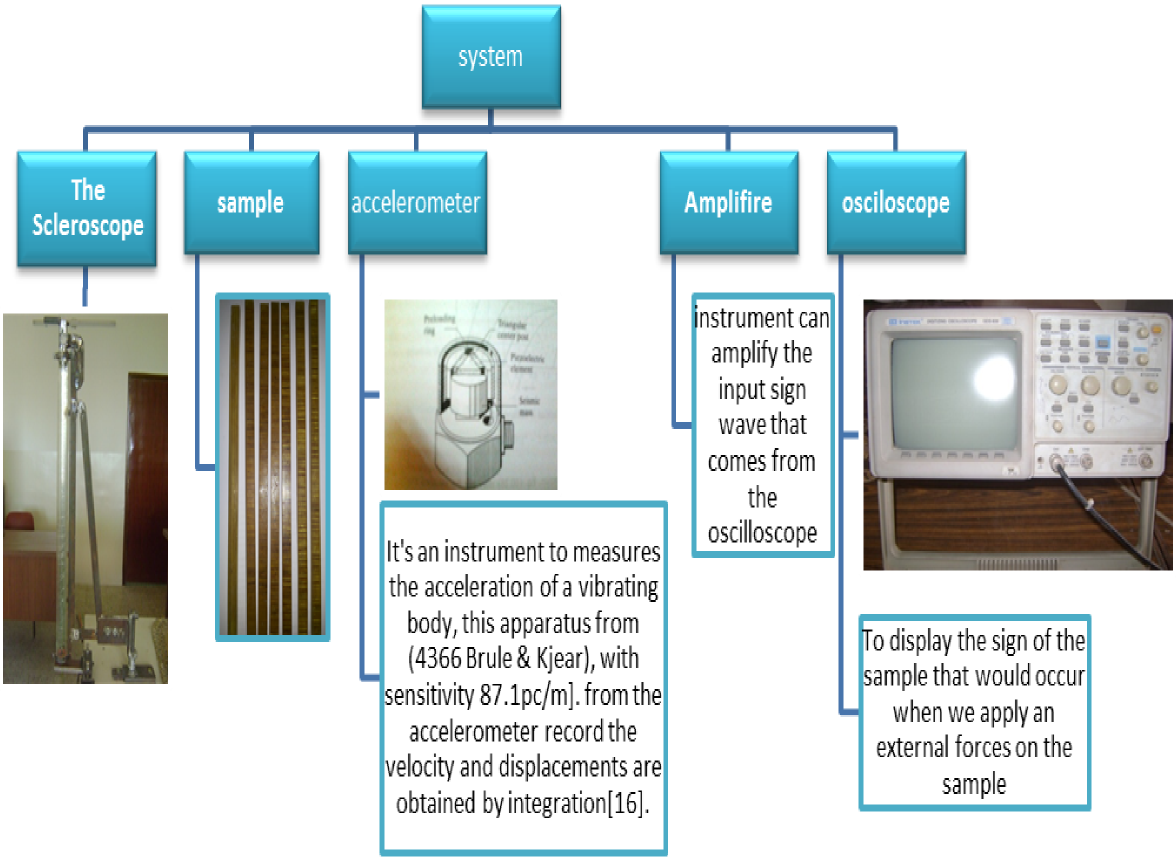
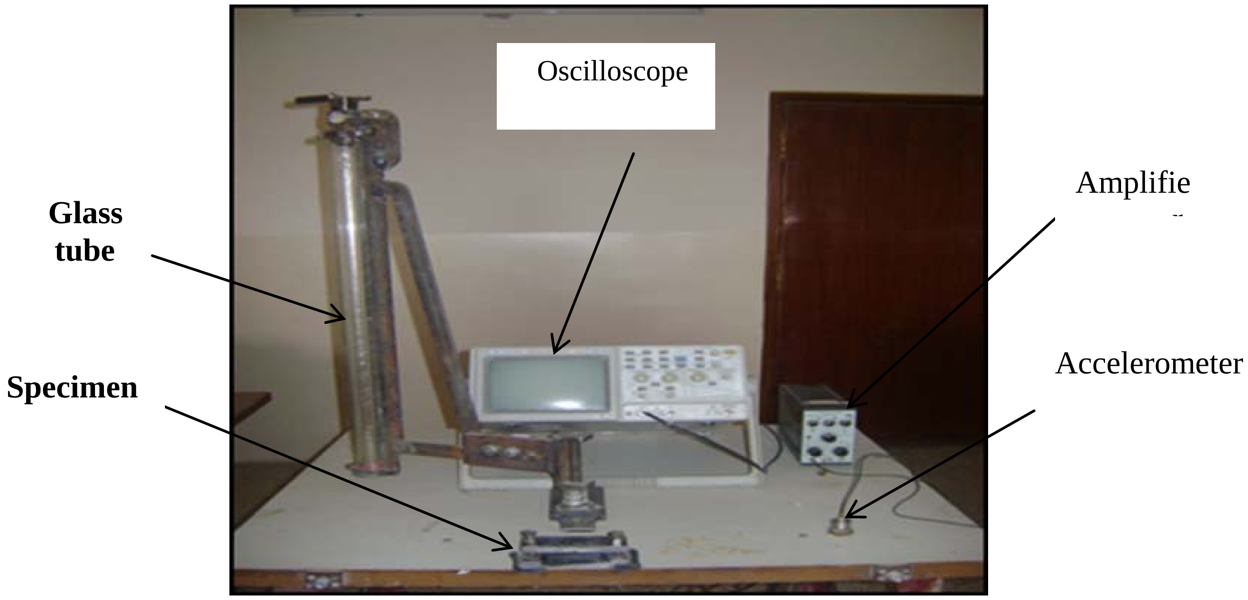


Figure (5) :Impulse response of a simple oscillator .[Manuel 2006]



Fig(6-a) The flow chart of the damping system.



Fig(6-b) Measurement of damping.

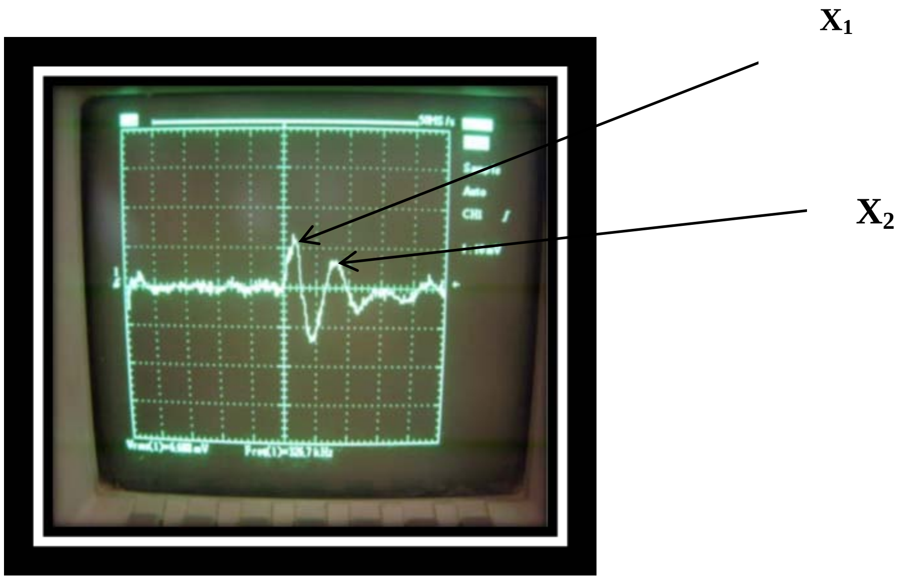
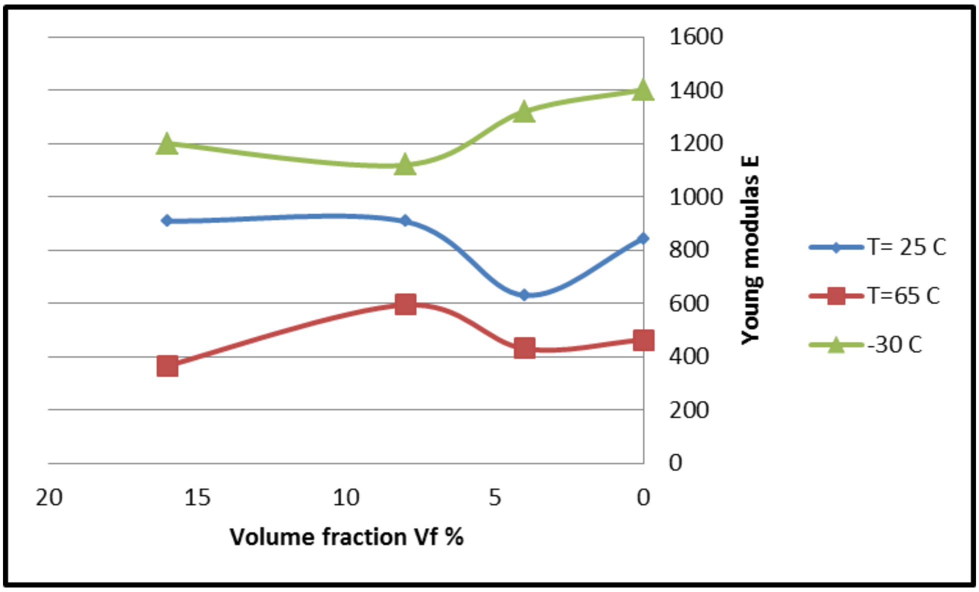


Fig.(7) Signal Damping on Oscilloscope screen.



Fig(8)The relationship between Young modules and volume fraction of palm fiber at different testing temperatures.

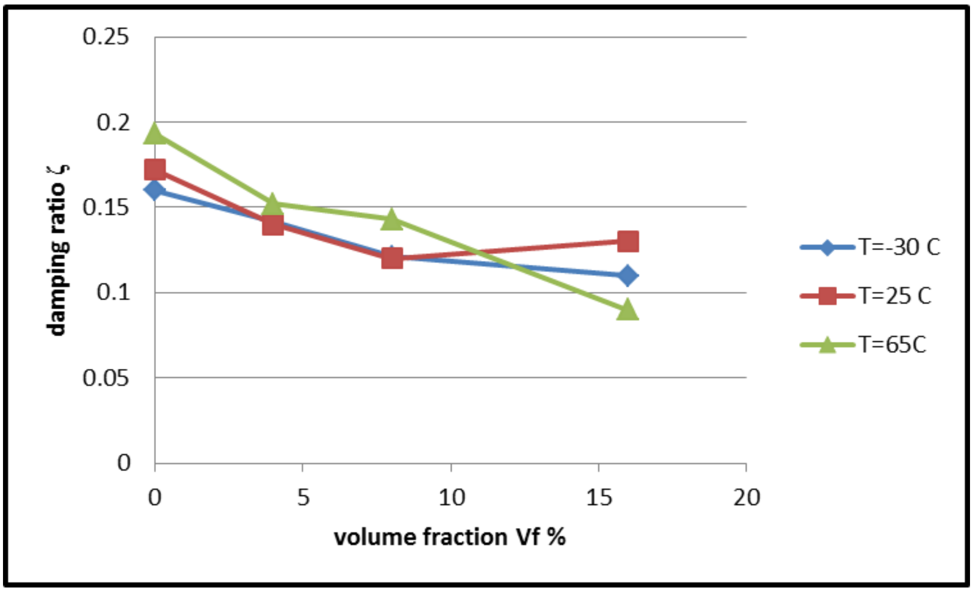


Fig.(9) The relationship between the volume fraction of palm fiber and damping ratio at different testing temperatures.

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