www.ijecs.in
International Journal Of Engineering And Computer Science
Volume 9 Issue 12 December 2020, Page No. 25260-25264
ISSN: 2319-7242 DOI: 10.18535/ijecs/v9i12.4546

Dynamic Responses at Various Points of Aluminum Cantilever Beam

Nanang Endriatno[1], Budiman Sudia[2], Raden Rinova Sisworo[3], Muhammad Faisal[4]

[1,2,3]Mechanical Engineering, Halu Oleo University-Indonesia
[4]Mechanical Engineering Alumni, Halu Oleo University-Indonesia

Abstract:
The aim of the study was to analyze the dynamic response along an aluminum cantilever beam. The data measured were displacement (mm), velocity (mm / s), and acceleration (m/s^2) with 3 measurement positions on the cantilever beam. The 6061 series aluminum beam being used have length of 80 cm, height of 32 cm, and width of 32 cm. The data were collected experimentally using a vibration meter to measure beam vibrations at the various positions from the cantilever beam at a distance from support: 10 cm, 35 cm, and 60 cm, respectively. The results of the analysis showed that the values of the displacement, velocity and acceleration of the object vibrations change when the measuring point was far from the cantilever support. The maximum displacement value is 0.02 mm at 60 cm from the support, and the lowest value is 0.12 mm at 10 cm. The velocity value also increases, maximum value is 38.58 mm/s at 60 cm from the support, and the minimum value is 12.30 mm/s at 10 cm from the support. Accordingly, the acceleration value is maximum at 60 cm from the support: 91150 mm/s^2 and the minimum at 10 cm: 66900 mm/s^2.

Keywords: vibration, beam, cantilever, measurement, position

1. Introduction

Vibration is very important to be analyzed, especially for mechanisms which support an exciter or a moving part and obtain external periodic forces because of it. Almost all moving objects experience vibrations at a certain frequency and the frequency of a vibrating object is generally associated with how many vibration cycles per unit time. When an object vibrates with a certain frequency, there is a certain displacement, velocity, and acceleration of the vibration on the object. Several studies have examined effects of vibration on beams, including damage detections of the beam-structures by using a vibration method [1]. Vibration analysis is also widely used to determine level of vibration in machine components and to detect damages. Many undesirable vibrations occur in structures or machines and lead to discomforts and damaging to the materials [2], [3], [4], [5]. Other studies examine the difference of vibration frequency at a certain distance from the cantilever beams and prove that vibration testing is very important in planning and damage detection in machines or structures [6].

Many studies analyze vibrations in machines or structures. When shape and type of the support are changed, the vibration responses are also changing. Vibration is very important to be applied to analyze damages of the objects. When objects are damaged, their vibration will be different from their normal conditions. Thus, research on vibration responses or patterns of the objects is very important. Vibration characteristics such as displacement, velocity, and acceleration are measured to determine the severity of the vibration. In machine operations, vibration indicator is the first indicator to assess whether the machines are still in a normal condition or not. In general,
either high or low value of the vibration is in accordance with the degree of defects or damages of the machines. In this study, the vibration analysis is focused on investigating the vibration responses at several measurement points of the cantilever-supported beam. The research aims to determine displacement, velocity, and acceleration of the vibrations experimentally at some points along the cantilever beam.

Mechanical Vibration

Vibration is a repetitive movement around the equilibrium point at a constant time or a certain time. Vibration occurs in objects which have mass and elasticity. The vibration responses occurred in a system is different and this is not only depending on the factors mentioned earlier, but also due to support and position of the applied force. According to the force applied, generally, vibrations can be grouped into two types: free vibrations and forced vibrations. Free vibration occurs because of the first force exerted on an object so that it vibrates by itself at one or more of its personal frequencies. Meanwhile, forced vibrations are caused by a force that is continuously exerted on the objects or mechanisms [7].

Figure 1 shows the waveform of the vibration. Points B through C shows one full wave. In some parts, the curve is above point 0, and in another part, the curve is below point 0. Therefore, one wave has two peaks. The time required for one full wave is called period (T) and the point at the peak of the wave is an amplitude (A) [8]. The amplitude (A) in the figure is at point A, and the amplitude represents the largest number of transmitted waves. Focus of the analysis in this study is the value of displacement (x), velocity (v), and acceleration (a) of vibrations obtained from direct measurements using a vibration meter.

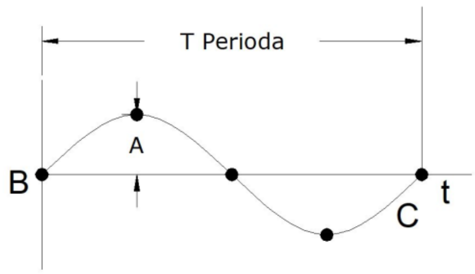

Figure 1: Wave of vibration

Vibration analysis is used to determine operating conditions of machines or structures. Vibration analyzers can detect dynamic responses without damaging the object and the information can be used for maintenance and observations of the machines or structures' conditions. Thus, components' failures can be prevented earlier after the undesirable vibrations occur. Uncontrollable vibration can cause discomfort, noisy, and low durability of the elements or machine components. Dynamic responses measured in this study is displacement, velocity, and acceleration, respectively. Displacement is the total distance traveled by a vibrating object, from peak to peak. When a mass moves, its velocity changes, the International Standards Organization (ISO) determines an internationally acceptable vibration measurement unit, namely the velocity-root mean square (rms) as the standard unit of measurement. It was decided to obtain a criterion that would determine the effective values for the various speed functions. The vibratory acceleration is defined as the rate of change in velocity. Vibration indicators can be in forms of displacement, velocity, and acceleration, but the analysis of these values depends on a given frequency range [10].

2. Research Methodology

This research was carried out starting on January 1, 2020 and located in the Design and Construction Laboratory of the Halu Oleo University, Kendari City, South East of Sulawesi, Indonesia. The research was performed experimentally. The apparatus and direct measurements using a vibration meter (Type KW0600332 Vibration Testes) are shown in Figure 2.

Figure 2: Vibration Meter

To record vibration responses, Aluminum Beams are placed on a cantilevered or clamp-free support. The installation of the aluminum beam is as shown in Figure 3 and Figure 4. The measurement of the vibration response is taken at a constant rotation of the vibrating motor placed at the end of the beam. The test was carried out by taking data of displacement, velocity, and acceleration at the positions of 10 cm, 35 cm, and 60 cm from the free-fix support.

Figure 3: Vibration Testing Installation

Figure 4: Vibration data collection

Initial data of the research are as follows:
- The aluminum material used in the 6061 series
- Aluminum length (L) = 60 cm from the support
- Aluminum width (b) = 3.2 cm
- Aluminum height (h) = 3.2 cm
- motor rotation = 12000 rpm 12 Volt DC

The results of testing the displacement, velocity, and vibration acceleration using experimental methods can be seen in Table 1, 2, and 3. The Table shows the experimental data taken 6 times at the position of 10 cm, 35 cm, and 60 cm. The test was carried out by placing the vibrating motor at the end of the beam, then the vibration measuring device was moved to a position of 10 cm, 35 cm, and 60 cm, in order to obtain direct data of the vibration response.

Table 1: Results of measurement of displacement

Data	*Displacement (mm)*		
	10 cm	*35 cm*	*60 cm*
1	0,02	0,137	0,183
2	0,014	0,139	0,193
3	0,015	0,117	0,209
4	0,014	0,109	0,226
5	0,014	0,109	0,188
6	0,015	0,109	0,145
Average (mm)	0,02	0,12	0,19

Table 2: Results of velocity measurements

Data	*Velocity (cm/s)*		
	10 cm	*35 cm*	*60 cm*
1	1,25	1,27	4,39
2	1,25	2,1	4,1
3	1,26	2,3	3,64
4	1,24	2,4	3,67
5	1,23	2,4	3,67
6	1,23	2,4	3,68
Average (cm/s)	1,23	2,40	3,86
Average (mm/s)	12,30	24	38,58

Table 3: Results of acceleration measurements

Data	*Acceleration (m/s^2)*		
	10 cm	*35 cm*	*60 cm*
1	67,8	75,1	90,6
2	64,5	75,2	90,7
3	64,4	75,3	91
4	66,2	75,1	91,6
5	69	75,1	91,4
6	69,5	75,1	91,6
Average (m/s^2)	66,9	75,15	91,15
Average (mm/s^2)	66900	75150	91150

3. Results and Discussion

Graphs 5, 6, and 7 below were made from Tables 1, 2, and 3 which are obtained from the test results of the beam at various positions.

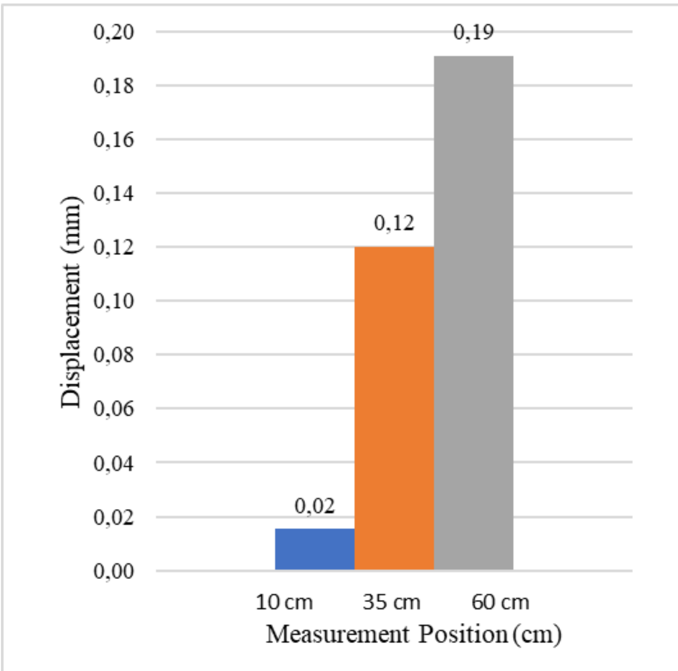

Figure 5: Displacement of the aluminum beam

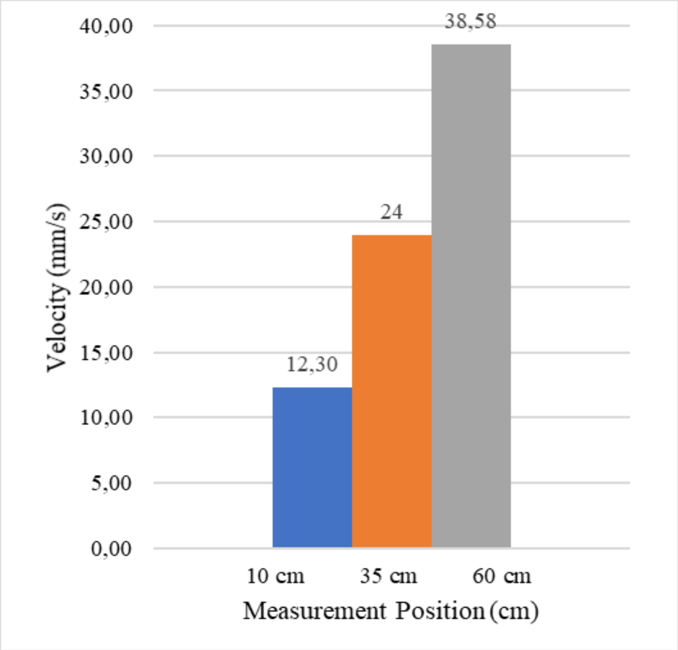

Figure 6: Velocity of the aluminum beam

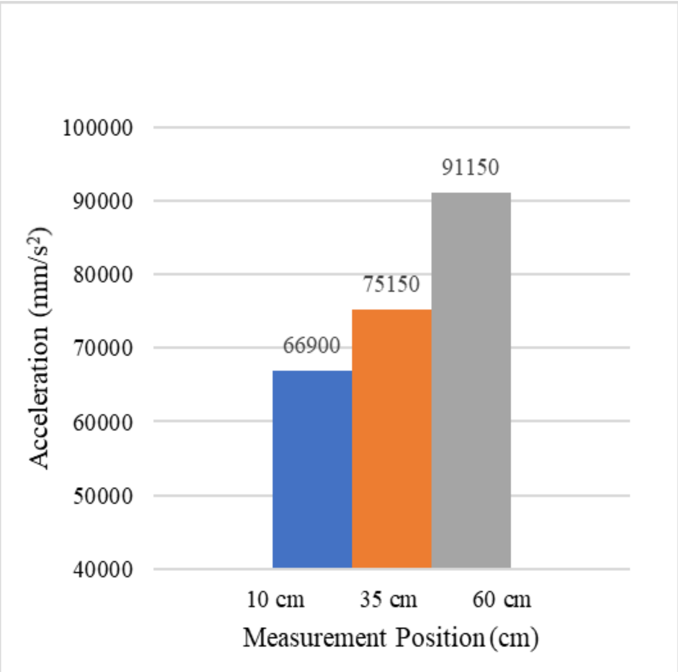

Figure 7: Acceleration at the aluminum beam

Table 1 and graph 1 show the displacement values. The lowest value at 10 cm is 0.02 mm, meanwhile the highest value is 0.19 mm positioned at 60 cm from the clamp-free support. The graph shows that the displacement is increasing significantly when the measuring instrument is away from the cantilever support. The position away from the support makes it easy for the beam to experience deviation so that when it is vibrated under the certain conditions, the deviation value becomes greater at the end of the beam than those of the positions closed to the pinch support [9]. For further positions from support of the beam, more flexible vibrations are observed. Table 2 and graph 2 show the values of the vibration velocity on the beam which have the same tendency, maximum at 60 cm from cantilever support: 38.58 mm/s, and minimum at 10 cm from the cantilever support:12.30 m/s. Velocity is generally correlated with the intensity of the vibration or how fast the object moves at the equilibrium point [10]. Table 3 and graph 3 shows the value of the acceleration measurements. The acceleration values also show the same tendency as of the displacement value and velocity values. Maximum value at the point of 60 cm: 91150 mm/s^2, and minimum at the point of 10 cm which is 669000 mm/s^2. At the end of the cantilever, the beam experiencing largest displacement and velocity, these values may contribute to the great change in acceleration value positioned at the point of 60 cm.

4. Conclusion

This study analyzes the values of displacement, velocity, and acceleration of aluminum cantilever positioned at distances of 10, 35, and 60 cm from the support. Based on the results of experiments and calculations, it can be concluded as follows:

1. Exciter positioned at the free end of the aluminum cantilever causes the aluminum beam to be vibrated and the vibration values are varied along the length of the beam.
   The difference positions of vibration meter measurements along the aluminum beam shows different values of displacement, velocity, and acceleration. When the measurement point is positioned at the end of the beam, the values of vibration's respond are increased significantly.
2. The resulting vibration response for the maximum displacement is 0.19 mm at 10 cm and a minimum of 0.02 mm at 60 cm. The maximum speed at a 60 cm is 38.58 mm/s and the minimum speed at 10 cm is 12.3 mm/s. Accordingly, the acceleration value also has the same tendency i.e. maximum acceleration is 91150 mm/s^2 at 60 cm and minimum acceleration is 66900 mm/s^2 at 10 cm.

References

[1] S. Khatir, I. Belaidi, R. Serra, M. A. Wahab, and T. Khatir, "Damage detection and localization in composite beam structures based on vibration analysis," *Mechanika*, vol. 21, no. 6, pp. 472–479, 2015, doi: 10.5755/j01.mech.21.6.12526.

[2] N. Eddy, Andriyansa, A. Halim, and R. W.

Purbaya, "Analisis Getaran pada Bantalan Luncur yang Diakibatkan oleh Pengaruh Kekentalan Pelumasan," *Pros. Semin. Nas. Apl. Sains Teknol.*, no. November, pp. 111–116, 2014.

[3] J. T. Mesin, P. Manufaktur, and N. Bangka, "Manutech : Jurnal Teknologi Manufaktur Pengukuran Getaran Untuk Menentukan Tingkat Getaran Pada Sistem Transmisi Variable Speed Mesin Milling Dengan Menggunakan Getaran Overall," vol. 11, no. 02, 2019.

[4] S. Aritonang, P. H. Wulanuari, and U. Pertahanan, "Analisis kerusakan yang disebabkan oleh vibrasi pada sistem suspensi kendaraan roda empat damage analysis cau [1]sed by vibration at suspension system of four wheels vehicle," *J. Teknoogi Daya Gerak*, 2018.

[5] "Analisis Sinyal Getaran untuk Menentukan Jenis dan Tingkat Kerusakan Bantalan Bola (Ball Bearing)," *J. Tek. Mesin*, 2004, doi: 10.9744/jtm.6.2.pp.39-48.

[6] N. Endriatno, "PENENTUAN FREKUENSI PRIBADI BALOK KANTILEVER PADA DIMENSI YANG BERBEDA," *Din. J. Ilm. Tek. Mesin*, 2020, doi: 10.33772/djitm.v11i2.11689.

[7] J. M. Krodkiewski, "Mechanical vibration 436-431 Mechanics 4 Unit 2," p. 247, 2008.

[8] "Fundamentals of mechanical vibrations," *Choice Reviews Online*, vol. 31, no. 01. pp. 31-0327-31–0327, 1993, doi: 10.5860/choice.31-0327.

[9] I. Esen, "Dynamic response of a beam due to an accelerating moving mass using moving finite element approximation," *Math. Comput. Appl.*, vol. 16, no. 1, pp. 171–182, 2011, doi: 10.3390/mca16010171.

[10] A. Hamid, Praktikal Vibrasi Mekanik Teori dan Praktik, Yogyakarta: Graha Ilmu, 2012.