Paper - 09 Mei 2019

by La Ode Mohammad Firman

International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249-6890; ISSN(E): 2249-8001
Vol. 9, Issue 1, Feb 2019, 355-364

EXPERIMENTAL OF FORCED VIBRATION SYSTEM OF SINGLE DEGREE OF FREEDOM ON TRAY TYPE DRYER

LA ODE MOHAMMAD FIRMAN[1], SORIMUDA HARAHAP[1],
I GEDE EKA LESMANA[1] & DAUD HERU[2]

[1] *Lecturer, Department of Mechanical Engineering, Faculty of Engineering, University of Pancasila, Jalan Srengseng Sawah, Jagakarsa, Jakarta Selatan, Jakarta, Indonesia*

[2] *Student, Department of Mechanical Engineering, Faculty of Engineering, University of Pancasila, Jalan Srengseng Sawah, Jagakarsa, Jakarta Selatan, Jakarta, Indonesia*

ABSTRACT

This study aims to determine the speed of the briquette dryer used on the drying rack. The method used in this study is a payment system that is used to determine the system used to measure resonance, reliable and reverse the available briquettes in the shelf for later use in the drying process, and can be accessed from the rate of the flow of cement from charcoal briquettes. Charcoal briquettes are generally dried by drying in the sun or by using a dryer. The process of removing charcoal briquettes will result in poor shedding as a result of the charcoal briquettes sundries with other charcoal briquettes or with their shelves, dry air notes cannot touch the entire surface. Therefore, briquettes are needed to be reversed during the stacking process, so that the entire surface touches the air temperature evenly. To facilitate and speed up the briquette process, a system that can be used to reverse and reverse briquettes without the need to reverse them manually is added to the tool shelves. After testing the vibration system in this rack system, the system used to measure the load between 10 - 20 kg, eccentric mass (m) weighing 0.9 kg with eccentricity (e) 0, 0535 m, and motor rotation (n) at level 2 speed.

***KEYWORDS:** Vibration, Resonance, Drying, & Charcoal Briquette*

Received: Nov 10, 2018; **Accepted:** Dec 01, 2018; **Published:** Jan 10, 2019; **Paper Id.:** IJMPERDFEB201934

Original Article

1. INTRODUCTION

Vibration that occurs in a system generally causes undesired effects, such as inconvenience, inaccuracy in measurement or damage to components in the system. On the other hand, vibration can also be used for certain purposes, such as giving vibration to the charcoal briquette dryer to improve drying efficiency. Research conducted by Eko Teguh Ari Prasetyo with the title "The Impact of Using Vibrators on the Performance of Greenhouse Effect Type Dryers". Stating that using a vibrator, the drying efficiency obtained in this study reached 8.61 - 14.53% with a load of cocoa 76 - 139.9 kg. Whereas if it does not use a vibrator, the drying efficiency obtained is 5 - 9% with a cocoa load of 70 - 115 kg (Eko, 2000).

The process of drying charcoal briquettes with a dryer is very ineffective because it requires a long time, requires additional operators to reverse the charcoal briquettes at certain intervals, and there will be a lot of heat loss when you need to open and close the dryer to reverse the charcoal briquettes. Therefore, it is necessary to add a vibrating system to the rack-type dryer, so that charcoal briquettes can jump inside the rack so as to separate the charcoal briquettes attached to the stack, either with other charcoal briquettes or with shelves. So that it will speed up the drying process and flatten the dryer air contact with the entire charcoal briquette surface that is piled on the drying rack. The vibrations that occur on the drying rack are caused by rotational imbalances because the excitation originating from the eccentric mass rotating with the shaft connected to the electric motor results in up and down oscillation movements (vertical translational motion) on the drying rack that rests on 4 springs.

The study was conducted by La Ode Mohammad Firman with the title "Effect of Vibration and Heat Energy on Cabinet Type GHE Solar Dryers". Stating that the experiment with a shelf load of M = 20 kg found that the condition of the commodity above the shelf was able to jump when the vibration approached resonance which occurred at r = 0.96, n rotation = 475 rpm and eccentric mass of m = 0.2 kg and MX value / me = 5. (La Ode, 2012)

In this paper will be tested the vibration system on the rack type dryer to determine the vibration system settings that produce vibrations close to resonance conditions, so that it can jump and reverse the charcoal briquettes that are inside the rack to be applied to the drying process in a rack type dryer.

Figure 1.1: Tray Type Dryer

2. RESEARCH METHODS

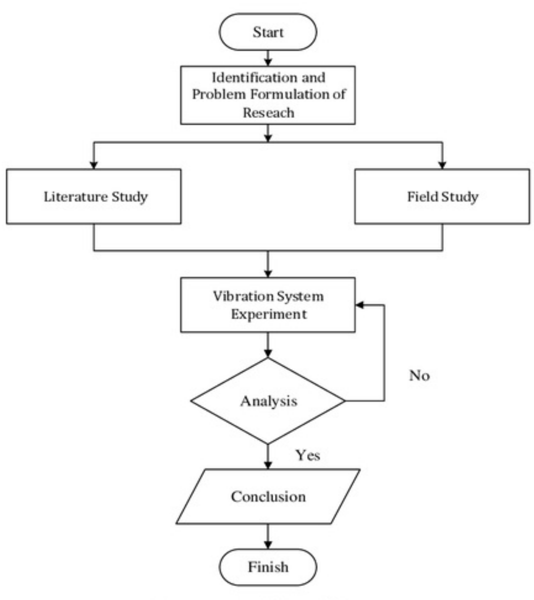

Figure 2.1: Flow Chart

2.1. Identification and Problem Formulation of Reseach

The first stage in this research is to identify and formulate the problems of this study. Based on observations made several existing dryers, the drying process results in an uneven drying due to the drying air, which does not affect the entire surface due to the sticking of objects to be drained from each other or by the shelf. Therefore, the object to be dried needs to be reversed during the drying process so that the entire surface is8 exposed to the dryi Whng air. To facilitate and speed up the process of reversing, it is necessary to use a vibration system on the dryer which functions to jump and reverse the dried objects without the need to reverse them manually. In this study, the object to be dried is charcoal briquettes.

2.2. Field Study and Literature Study

The second stage in this study is to conduct a field study conducted by observing and studying the vibration system on a rack type dryer, while the literature study is by studying the excitation force that can cause vibration. The vibration that occurs on the drying rack is caused by a rotation imbalance because the excitation that comes from an eccentric mass that rotates with the shaft connected to the electric motor causes an up and down oscillation movement (translational motion in the vertical direction) on the drying rack. The above vibration system, where M is the overall mass of the vibration system (inner frame load, drying rack, and charcoal briquette), m is the eccentric mass mounted on the shaft with eccentricity e, k is spring stiffness (spring constant) and x is the shelf construction deviation dryer. An electric motor that rotates the shaft with speed n produces the excitation frequency ω and natural frequency ωn.

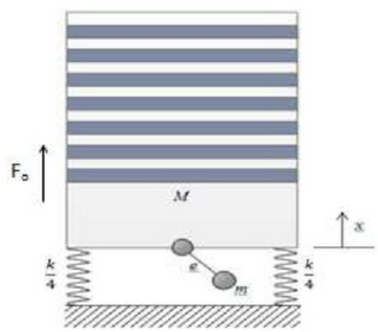

Figure 2.2: Model of Tray Type Dryer Vibration System

In a forced vibration system, it means that there is a disturbance force on the system coming from outside (Jhon, 2004). The external force can be a forced harmonic excitation force obtained from a spinning imbalance due to an eccentric mass and is limited to moving in a vertical direction identical to the equation. : (William, 1986)

$$X = \frac{F_o}{\sqrt{(k - M\omega^2)^2 + (c\omega)^2}} \quad (1)$$

With:

X = Resonance amplitude (m)

F_o = Outer force (N)

k = Spring rate (N/m)

M = Vibration system mass (kg)

ω = Excitation frequency (rad/s)

c= Damper (Ns/m)

The outer force (Fo) is substituted by meω2, so it becomes: (William, 1986)

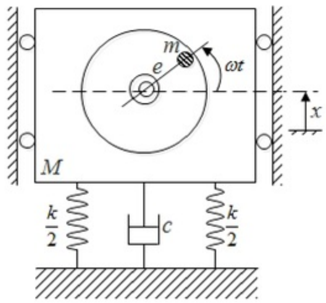

Figure 2.3: Imbalance Rotation

$$X = \frac{me\omega^2}{\sqrt{(k - M\omega^2)^2 + (c\omega)^2}} \quad (2)$$

With:

X = Resonance amplitude (m)

M = Eccentric mass (kg)

e = Eccentricity (m)

k = Spring rate (N/m)

M = Vibration system mass (kg)

ω = Excitation frequency (rad/s)

c = Damper (Ns/m)

Equation (2) will be expressed in non-conventional form so that it becomes resonance amplitude, to allow the appearance of these results in a concise graph. (William, 1986)

$$\frac{MX}{me} = \frac{\left(\frac{\omega}{\omega_n}\right)^2}{\sqrt{\left[1 - \left(\frac{\omega}{\omega_n}\right)^2\right]^2 + \left[2\xi \frac{\omega}{\omega_n}\right]^2}} \quad (3)$$

With:

MX/me = Resonance amplitude for imbalance rotation

ω = Excitation frequency (rad/s)

ω_n = Natural frequency (rad/s)

Increasing the value of the spring constant can cause a decrease in resonance amplitude values. An oscillating system can cause the vibration of surrounding objects to participate. That can be called resonance. The occurrence of resonance, if the vibrating source has the same frequency as the surrounding object and is in the vibration propagation area, then the object will also vibrate. To find out how much resonance, the system can use the frequency ratio equation: (William,1986)

$$r = \frac{\omega}{\omega_n} \quad (4)$$

With:

r = Frequency ratio

ω = Excitation frequency (rad/s)

ω_n = Natural frequency (rad/s)

The frequency ratio (r) is the ratio between the excitation frequency (ω) and the natural frequency (ωn) of the system, which if the ratio of both is equal to 1 then there will be a resonance in the system. Excitation frequency is the result of forced harmonic excitation force derived from harmonic motion, which is often expressed as angular velocity with the equation:

$$\omega = \frac{2\pi n}{60} \quad (5)$$

With:

ω = Excitation frequency (rad/s)

n = Rotational speed (rpm)

The frequency of a mass element M that gets interference from outside and is supported by a spring with a linear stiffness equal to k is called the natural frequency, which can be written with an equation. (Joni, 1999):

$$\omega_n = \sqrt{\frac{k}{M}} \quad (6)$$

With:

ω_n = Natural frequency (rad/s)

k = Spring rate (N/m)

M = Vibration system mass (kg)

An oscillating system can cause the vibration of surrounding objects to participate. That can be called resonance. The occurrence of resonance if the vibrating system has the same frequency as the surrounding objects and is in the vibration propagation area, then the object will also vibrate. To find out how much resonance the system can use the frequency ratio equation: (William, 1986). The frequency ratio (r) is the ratio between the excitation frequency (ω) and the natural frequency (ωn) of the system, which if the ratio of both is equal to 1 then there will be a resonance in the system. Increasing the value of the spring constant can cause a decrease in resonance amplitude values. (Equation.2) will be expressed in nondimensional form to allow the appearance of these results in a concise graph, to be: (William, 1986). The frequency ratio (r) is the ratio between the angular velocity / excitation frequency (natural) and the natural frequency (ωn) of the system, which if the ratio of the two is equal to 1, there will be a resonance in the system. By taking x as a non-rotating mass deviation (M) from the static equilibrium position, the frequency and amplitude ratio of the resonance can be described as follows: (William, 1986)

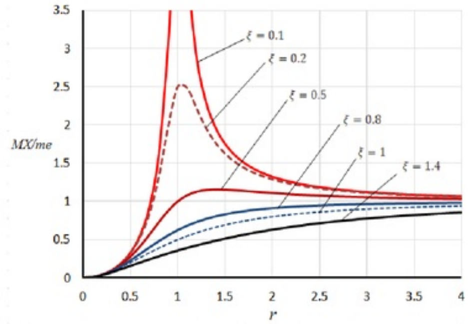

Figure 2.4: Comparison Graph of Frequency Ratio and Imbalance Rotation

This graph shows that the damping factor has a large influence on non-rotating mass deviation (M). For frequency ratio values less than 1 (r <1), the inertial force and attenuation style are small. So the excitation force (Fo) is almost the same as the spring force. For frequency ratio values equal to 1 (r = 1), the inertia force and spring force in this state are greater, while the excitation force (Fo) overcomes the damping force so as to produce resonance. If balanced with a large MX / me value, the resonance will be even greater. For a frequency ratio of more than 1 (r> 1), the excitation force (Fo) is used almost entirely to overcome the large inertia force.

2.3. Vibration System Experiment

The third stage in this study is to test the vibration system. This test aims to ensure the function of the vibration system works properly, and to look for the most suitable conditions to be applied during the drying process.

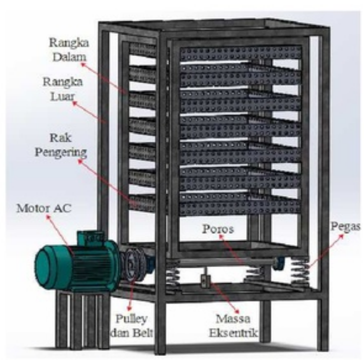

Figure 2.5: Schema of Tray Type Dryer Vibration System

The vibration system in the dryer consists of an electric motor, belt, pulley, shaft under the drying rack, eccentric mass mounted on the shaft, and a spring that supports the drying rack. The test is done by turning on an electric motor which will then rotate the shaft which is connected to the eccentric mass so that it will produce a rotation imbalance.

2.4. Analysis

Test results data is first processed for analysis, whether the vibration system testing has produced vibrations that are close to resonance conditions or not. If it has not reached, then the parameters to be used when testing are checked again. After that, the last stage is a process to draw conclusions on what was done during the research. Basic conclusions include the results of data processing and analysis of the results of data collected.

3. RESULTS AND ANALYZING

Vibration system testing is divided into 3 tests, namely with eccentric mass load (m) weighing 0.3 kg, 0.6 kg, and 0.9 kg with eccentricity of 0.0535 m. With the overall mass of the system (M), before being filled with charcoal briquettes weighing 35.6 kg will be added with charcoal briquettes with 4 times the addition, namely 10 kg, 20 kg, 30 kg, and 40 kg. The rotational speed of the motor (n) was also varied with 2 levels of speed, namely the speed of level 1 resulted in a rotation on the shaft of ± 500 rpm and the speed of level 2 resulted in a rotation on the shaft of ± 1120 rpm. Following are the results of the tests that have been carried out:

3.1. Experiment of Vibration System by Using 0.3 kg Eccentric Mass

Table 3.1: Condition of Vibration System by Using 0.3 kg Eccentric Mass

Briket Arang (kg)	Putaran Motor (rpm)	Rasio Frekuensi	Amplitudo Resonansi
10	493	0.4171	0.2105
10	1122	0.9491	9.0946
20	490	0.4574	0.2646
20	1116	1.0418	10.6936
30	503	0.5098	0.3512
30	1113	1.1282	4.6652
40	498	0.5417	0.4154
40	1117	1.2151	3.0984

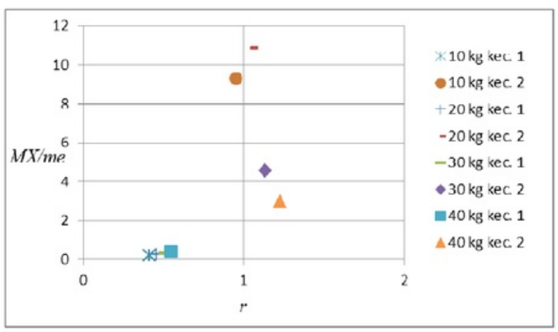

Figure 3.1: Comparison Graph of Frequency Ratio and Imbalance Rotation

Base on the graph above, it is known that for an eccentric mass weighing 0.3 kg, the arrangement that closest to the resonance condition or r value close to 1, so that it can be used during the drying process is when the charcoal briquette load is between 10 kg and 20 kg, and with the motor rotation speed at the rate 2. This is because the r value of the two conditions is closest to 1 compared to the others, which is 0.9491 for the 10 kg load and 1.0418 for the 20 kg load. The choice of charcoal briquette load between 10 kg and 20 kg is also influenced by the high MX / me value or resonance amplitude, where the higher the MX / me value the greater the resonance. The MX / me value for the 10 kg charcoal briquette load is 9.0946 and for 20 kg, 10.6936. This situation is very different from the charcoal briquette load of 30 kg and 40 kg; whose MX / me value is not up to 5.

3.2. Experiment of Vibration System by using 0.6 kg Eccentric Mass

Table 3.2: Condition of Vibration System by Using 0.6 kg Eccentric Mass

Briket Arang (kg)	Putaran Motor (rpm)	Rasio Frekuensi	Amplitudo Resonansi
10	488	0.4141	0.2071
10	1119	0.9497	9.2023
20	492	0.4605	0.2692
20	1121	1.0493	10.8869
30	502	0. 5101	0.3515
30	1121	1. 1388	4.3661
40	493	0. 5373	0.4061
40	1118	1. 2186	3.0617

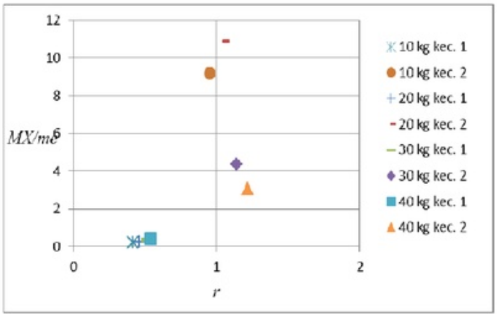

Figure 3.2: Comparison Graph of Frequency Ratio and Imbalance Rotation

Base on the graph above, it is known that for an eccentric mass load of 0.6 kg, the arrangement closest to the resonance condition or the r value close to 1 and can be used during the drying process is when the charcoal briquette load is between 10 kg and 20 kg, and with the motor rotation speed at the level speed 2. This is because the r value of the two conditions is the closest compared to the others, which is 0.9497 for the 10 kg load and 1.0493 for the 20 kg load. The choice of charcoal briquette load between 10 kg and 20 kg is also influenced by the high MX / me value or resonance amplitude, where the higher the MX / me value the greater the resonance. The MX / me value for the 10 kg charcoal briquette load is 9.2023 and for 20 kg, 10.8869. This situation is very different from the charcoal briquette load of 30 kg and 40 kg whose MX / me value is not up to 5.

3.3. Experiment of Vibration System by using 0.9 kg Eccentric Mass

Table 3.3: Condition of Vibration System by Using 0.9 kg Eccentric Mass

Briket Arang	Putaran Motor (rpm)	Rasio Frekuensi	Amplitudo Resonansi
10	483	0.4112	0.2035
10	1116	0.9502	9.3071
20	486	0.4561	0.2627
20	1118	1.0493	10.8908
30	499	0.5081	0.3481
30	1112	1.1323	4.5446
40	501	0.5471	0.4273
40	1122	1.2253	2.9937

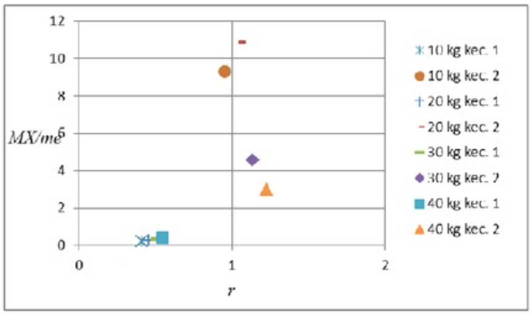

Figure 3.3: Comparison Graph of Frequency Ratio and Imbalance Rotation

Base on the graph above, it is known that for an eccentric mass load of 0.9 kg, the arrangement that is closest to the resonance condition or r value approaching 1, and can be used during the drying process is when the charcoal briquette load is between 10 kg and 20 kg, and with the motor rotation speed at the level speed 2. This is because the r value of the two conditions is closest to the others, which is 0.9502 for a load of 10 kg and 1.0493 for a load of 20 kg. The choice of charcoal briquette load between 10 kg and 20 kg is also influenced by the high MX / me value or resonance amplitude, where the higher the MX / me value the greater the resonance. The MX / me value for the 10 kg charcoal briquette load is 9.3071 and for 20 kg, 10.8908. This situation is very different from the charcoal briquette load of 30 kg and 40 kg whose MX / me value is not up to 5.

4. CONCLUSIONS

Based on the results of research that has been done on the rack type dryer vibration system, it can be concluded that:

The condition of the vibration system obtained at the load of charcoal briquettes every 10 kg, 20 kg, 30 kg, and 40 kg explained that each increase in the load of charcoal briquettes has an impact on the decrease in the natural frequency of the vibration system. It has an impact on the increasing value of the frequency ratio.

The heavier the eccentric mass, the higher the resonance amplitude value (MX / me), which results in the greater vibration generated. With an eccentric mass of 0.3 kg obtained the highest resonance amplitude value of 10.6936, then the eccentric mass of 0.6 kg obtained the highest resonance amplitude value of 10.8869, and the last at the eccentric mass of 0.9 kg obtained the highest resonance amplitude of 10.8908.

The vibration system, which is closest to the resonance condition to be applied to the charcoal briquette drying process in a rack type dryer occurs at the charcoal briquette load between 10-20 kg, with a motor rotational speed at level 2 speed and an eccentric mass load of 0.9 kg.

REFERENCES

1. *Joni D. " Theoretical Study of One Degree of Freedom Vibration Damping System," Mechanical Engineering Journal, vol. 01, no. 02, pp. 156 - 162, October 1999*
2. *Jhon M. " Test the Performance of One-Degree Freedom Vibrating Table with STFT Method," Mechanical Engineering Journal, vol. 01, no. 02, pp. 47 - 52, December 2004*

For PhD Thesis:

3. *Al-Waily, M. (2013). Experimental and Numerical Vibration Study of Woven Reinforcement Composite Laminated Plate with Delamination Effect.*

4. *La Ode M.F. " Effect of Vibration and Heat Energy on Solar Dryer GHE Type Cabinet, "Bogor Agricultural Institute, Bogor, 2012 Doctoral Dissertation*

5. *For PhD Thesis:*

   Jadhao, V. B., & Ingole, S. B. (2015). Vibration analysis of three parameter model of adhesively bonded joints.

6. *Eko T.A.P. " The Impact of the Use of Vibrators on the Performance of Greenhouse Effect Type Dryers, "Bogor Agricultural Institute, Bogor, Undergraduate Thesis 2000*

   For Book:

7. *William T.T. 1986. Vibration Theory and Its Application. Erlangga, Jakarta*

Paper - 09 Mei 2019

ORIGINALITY REPORT

6%	3%	1%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to National University of Ireland, Galway Student Paper	2%
2	Submitted to Harper Adams University College Student Paper	1%
3	dosen.univpancasila.ac.id Internet Source	1%
4	www.tjprc.org Internet Source	1%
5	Submitted to University of Sheffield Student Paper	1%
6	Internet Source	<1%
7	Submitted to University of Nottingham Student Paper	<1%

Exclude quotes Off

Exclude matches Off