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ANALYSIS AND EXPERIMENTAL OF VIBRATION ON GREEN DRYER MACHINES TO DRY RDF AND AGRICULTURAL PRODUCTS

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ABSTRACT

The applications of vibration system on dryer machine can be used to dry Refuse Derived Fuel *(RDF)* and agricultural products. Even if the use of dryer machines has been widely used to dry *RDF* and agricultural products with avoiding the heat loss needs to be verified. The observations shown that the using of vibration system for moving *RDF* and agricultural products were on the shelf could not be moved optimally. The previous study found that the spring load on dryer machine was too large and most of the surface of *RDF* and agricultural products were on the shelf could not get hot air flow. That's why the spring used as pedestal of shelves would be broken fast and on a specific moment *RDF* and agricultural products must be taken out of the drying chamber to be manually moved. To solve the problems and to develop the results of previous study, then it needs to do the study about analysis and experimental of vibration. In this study, vibration was analyzed to having an insight on suitable condition of the dryer machine for use in drying *RDF* and agricultural products. Beside that the study only uses an unbalance mass and it does not use a piston engine, so spring load would be smaller. The objectives of the study are: To perform analysis and experimental of vibration in order that the *RDF* and agricultural products are on the each shelf can be moved optimally. The study use observation, literature study, analysis and experimental methods and cashew nuts as the material tested on the each shelf. The study results show that the condition of vibration approached resonance cause cashew nuts placed on the each shelf could be moved optimally, therefore the surface of *RDF* and agricultural products were on the shelf could get hot air flow.

Keywords: analysis, experimental, vibration.

1. INTRODUCTION

Modern drying typically uses the dryer machine to dry *RDF* and agricultural products (cashew nut, cocoa, coffee, bean, and corn) are on the shelf. The observations shown that there were many dryer machines to dry *RDF* and agricultural products ineffective. The previous study found that the spring load on dryer machine was too large. And also most of the surface of *RDF* and agricultural products were on the shelf could not get hot air flow because the using of vibration system for moving *RDF* and agricultural products were on the shelf could not be moved optimally. Therefore the spring used, as pedestal of shelves would be broken fast and on a specific moment *RDF* and agricultural products must be taken out of the drying chamber to be manually moved. These cases caused the drying time must be added and it would arise heat losses due to the drying doors opened often.

The previous studies on the utilization of shelf vibration for dryer machine, among others:

a) Research of vibration system on the cashew nut shelves using piston engine and unbalance mass had been done (Wulandari *et al.*, 2011). The experimental results shown that movement of cashew nuts were on the shelf not cause damage to the surface of cashew nuts, but the spring used as pedestal of shelves was broken fast. The vibration components were placed under the shelf such as springs, piston engine, unbalances mass and electrical motor. Analysis and simulation results showed that rotation speed of electrical motor influenced vibration. The most vibration condition occurred at n = 334.59 rpm and r = 1. The utilization of piston engine caused greater spring load, that's why the spring used as pedestal of shelves would be broken fast.
b) Harahap *et al*, 2015 did research about vibration analysis on cashew nut racks by using unbalance mass. The total length of a drying chamber of 4.83 m and its drying chamber had a dimension of: length 4 m, width 3 m, and height 2 m. The optimal motion for 120 kg cashew nuts on each drying tray occurred at ratio r = 0.97 or the angular speed near its natural frequency. Analysis of each parameter and experimental are needed to develop the results of the research.
c) Suyono *et al*, 2017 did research about green and zero waste pyrolysis. To increase temperature in the reactor of pyrolysis, then the green and zero waste pyrolysis used *RDF* as solid fuel but water content of *RDF* relatively still high, so it needs drying process by using dryer machine.

To solve the problems and to develop the results of previous study, then it needs to do the study about analysis and experimental of vibration. Beside that the study only uses an unbalance mass and not use a piston engine, so spring load would be smaller. The study is expected to produce vibration, so *RDF* and agricultural products are on the each shelf could be moved in the dryer machine. The optimal movement cause the surface of *RDF* and agricultural products were on the shelf could get hot air flow. The dryer machine in this study was green dryer machine by using vibration to dry *RDF* and/or agricultural products.

The objectives of the study are to perform analysis and experimental of vibration by using an unbalance mass and smaller spring load with total of mass: M = 40 kg, M = 30 kg and M = 20 kg; also to perform experimental of vibration in order that the *RDF* and/or agricultural products are on the each shelf can be moved optimally.

2. METHODS

The study was conducted in January 2017 in the Laboratory of Mechanical Engineering, University of Pancasila, South Jakarta. The methods used in this study are observation on some dryer machines to dry *RDF* and/or agricultural products; study of literature in accordance with the field of research; also analysis and experimental. Instruments and material used in this study namely: vibration gauge, tachometer, ruler, weight scale, stopwatch and the material tested is cashew nuts.

3. DRYER MACHINE TO DRY *RDF* AND AGRICULTURAL PRODUCTS

This study placed shelves in the dryer machine and they were made of stainless steel material. Walls of drying chamber were made of stainless steel and plastic material with thickness of 0.001 m. The drying chamber dimensions are length of 1 m, width of 1 m, and height of 1 m. To increase the air temperature in the drying chamber then dryer machine used heat energy source from green and zero waste pyrolysis. At the time of drying process, *RDF* and/or agricultural products were placed on the each shelf. The green dryer machine had drying chamber, an electrical motor, an unbalance mass, 6 shelves and 4 spring as shown in Figure-1 and Figure-2.

Figure-1. Green dryer machine by using vibration components to dry *RDF* and/or agricultural products.

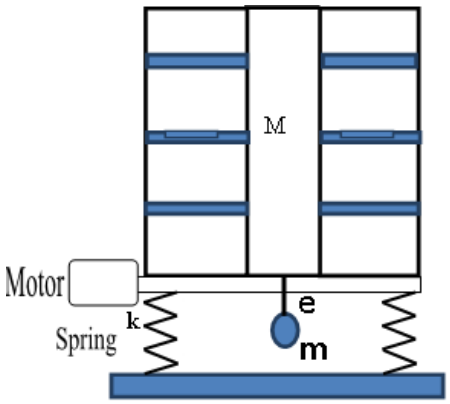

Figure-2. Vibration components.

3.1 Vibration

Vibration components were placed under the drying shelves and consist of an electrical motor, 4 springs, total of mass, and an unbalance mass which was connected to the motor shaft as shown in Figure-2. At the time electrical motor was operated with the certain rotation speed then an unbalance mass would be rotated. This condition caused vibration to each shelf, so that entire of *RDF* and agricultural products were on the shelf would be moved.

If the Total of mass is M, Proportionality constant is k (see Figure-2), Natural frequency is ω_n and its equation is obtained as follows (Holowenko, 1992):

$$\omega_n = \sqrt{\frac{k}{M}} \quad . \qquad (1)$$

Rotating an unbalance mass cause vibration and movement in vertical direction. An unbalance mass is placed under the shelves as shown in Figure-3 below:

Figure-3. An unbalance mass is placed under the shelves.

The parameters are used in this study such as: Angular speed is ω, Rotation speed of electrical motor is n, An unbalance mass is m and its Length is e (see Figure-2), and also Ratio of Angular speed and Natural frequency

is r. These parameters could be defined as the following equations (Palm, 1992):

$$r = \frac{\omega}{\omega_n} \quad (2).$$

$$\omega = \frac{2\ \pi\ n}{60} \quad (3).$$

$$Y = \frac{m\ e\ \omega^2}{k} \quad (4)$$

$$\frac{X}{\frac{m\ e\ \omega^2}{k}} = \frac{X}{Y} \quad (5)$$

Vibration amplitude is X and could be defined as the following equations:

$$X = \frac{me\omega^2}{\sqrt{(k - M\omega^2)^2}} \quad (6)$$

$$\frac{X}{m\ e/M} = \frac{r^2}{\sqrt{(1-r^2)^2}} \quad (7)$$

In addition that the Proportionality constant is k, Horsepower of electrical motor is P and Length of an unbalance mass is e. They are constant, namely: k = 49050 N/m, P = 0.5 HP and e = 0.1 m. To find data for optimal movement in this study, then total of mass and an unbalance mass were measured using weight, and its length using ruler. Electrical motor was operated and its rotation speed was measured using tachometer. These data could be used for analysis of r, X, MX/me and X/Y.

4. DISCUSSIONS

Green dryer machine in this study only uses an unbalance mass without a piston engine. That's why the spring would not quickly break. Beside that optimal movement cause the surface of *RDF* and agricultural products were on the shelf could get hot air.

Based on analysis and experiments were obtained that the maximal vibration occurred when the vibration condition was resonance or r = 1, and the optimal movement occurred when the vibration conditions approached resonance. Table-1 shows the optimal movement, namely: n = 438 rpm, X = 0.00288 m, and r = 1.31, where the number of cashew nut was being drained of 26.3 kg, M = 40 kg and m = 0.48 kg.

The analysis and the experimental results of vibration as shown in Table-1, Figure-4, Figure-5 and Figure-6.

Table-1. Analysis and vibration results at M = 40 kg and m = 0.48 kg.

n (rpm)	ω det^{-1}	ω^2 $(det^{-1})^2$	X (m)	ω_n (det^{-1})	r	MX/me (-)	X/Y (-)
334.59	35.02	1 226.4	9.81	35.02	1	8 175	≈
438	45.84	2 101.3	0.00288	35.02	1.31	2.40	1.4
950	99.43	9 886.32	0.00137	35.02	2.84	1.14	0.141
1 050	109.9	12 078.01	0.0007	35.02	3.14	0.58	0.059

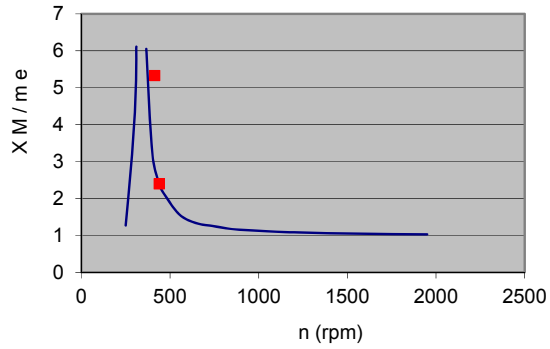

Figure-4. Change of MX/me vs. n by using total of mass, M = 40 (kg).

Table-1 and Figure-4 show the results of the analysis and experimental of vibration using total of mass, M = 40 kg. The number of cashew nuts was being drained of 26.3 kg. The experimental results shown that the optimal movement occurred when the vibration conditions approached resonance namely: n = 438 rpm, m = 0, 48 kg and XM/me = 2.4. And also the vibration conditions approached resonance occur at n = 413 rpm, m = 0.26 kg and MX/me = 5.38.

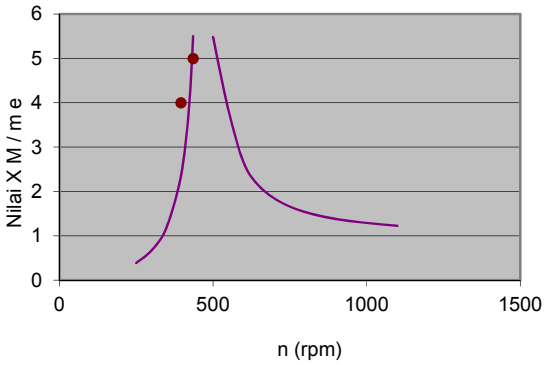

Figure-5. Change of MX/me vs n by using total of mass, M = 20 (kg).

Figure-5 shows the results of the analysis and experimental of vibration using total of mass, M = 20 kg. The numbers of cashew nuts were being drained of 6.3 kg. The experimental results shown that the vibration conditions approached resonance occur at n = 475 rpm, m = 0.2 kg and the value of XM / me = 5. The results of subsequent experimental shown that the vibration conditions approached resonance occur at n = 395 rpm, m = 0. 25 kg and MX/me = 4.

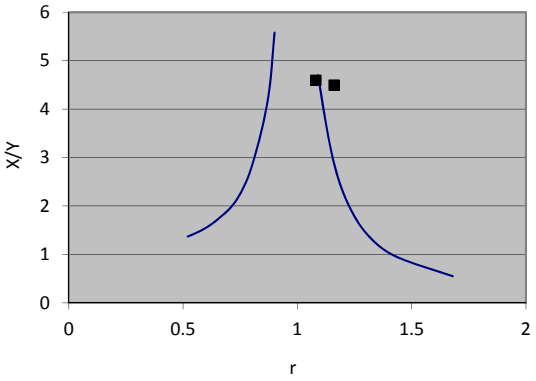

Figure-6. Change of r vs. X/Y by using total of mass, M = 30 kg.

Figure-6 shows the results of the analysis and experimental of vibration using total of mass, M = 30 kg. The numbers of cashew nuts were being drained of 16.3 kg. The experimental results shown that the vibration conditions approached resonance occur at r = 1.08 and X/Y = 4.6. The results of subsequent experimental shown that the vibration conditions approached resonance occur at r = 1.16 and X/Y = 4.5.

The experimental results as shown in Figure-4, Figure-5 and Figure-6 explained that the vibration approached the resonance conditions and they result cashew nuts were on the shelves would be moved optimally.

5. CONCLUSIONS

Based on analysis and experimental were obtained that the cashew nuts were on the each shelf had been moved optimally when the vibration conditions approached resonance, explicitly:

- M = 40 kg, n = 438 rpm, m = 0.48 kg, XM/me = 2.4.
- M = 40 kg, n = 413 rpm, m = 0.26 kg, XM/me = 5.38.
- M = 20 kg, n = 475 rpm, m = 0.2 kg, XM/me = 5.
- M = 20 kg, n = 395 rpm, m = 0.25 kg, XM/me = 4.
- M = 30 kg, r = 1.08, X/Y = 4.6.
- M = 30 kg, r = 1.16, X/Y = 4.5.

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