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THE APPLICATION OF VIBRATION SYSTEM on DRYER MACHINE to DRY *RDF* and AGRICULTURAL PRODUCTS by using GREEN INCINERATOR

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ABSTRACT

ABSTRACT: Increasing heat and vapor transfer between air and product to be dried is an important issue in drying of Refuse Derived Fuel *(RDF*) and agricultural products. Generally, manual mixing is used in order to increase the contact area between air and product to be dried. The applications of vibration system on dryer machine can be used to dry *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, simulation 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 is to perform analysis, simulation and experimental of vibration in order that the *RDF* and agricultural products are on the each shelf can be dried fast and moved optimally. The study use observation, literature study, analysis, simulation 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. The final moisture content of vibrated samples was lower than the samples without vibration.
***Keywords*:** Analysis, Simulation, Experimental, Vibration.

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1. INTRODUCTION

Generally, modern drying typically uses the dryer machine to dry Refuse Derived Fuel *(RDF)* and agricultural products (i.e. 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 also 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 on dryer machine, among others:

1. 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 shown 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.
2. Harahap, 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.
3. Suyono, 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, simulation 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 drying chamber. The optimal movement cause the surface of *RDF* and agricultural products were on the shelf could get hot air flow.

The objectives of the study are to perform analysis, simulation 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 dried fast and moved optimally.

2. METHODS

The study was conducted in January until October 2017 in Laboratory of Mechanical Engineering, University of Pancasila, South Jakarta, Indonesia. 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; analysis, simulation and experimental. Instruments and material used in this study namely: vibration gauge, tachometer, ruler, weight scale, stopwatch and the material tested was cashew nuts.

3. DRYER MACHINE and VIBRATION SYSTEM

3.1 Dryer Machine to dry *RDF* And Agricultural Products

This study placed shelves in the drying chamber and they were made of stainless steel material. Walls of drying chamber were made of stainless steel and plastic material. To increase the air temperature in the drying chamber then dryer machine used heat energy source from green incinerator. At the time of drying process, *RDF* and/or agricultural products were placed on the each shelf. The dryer machine had green

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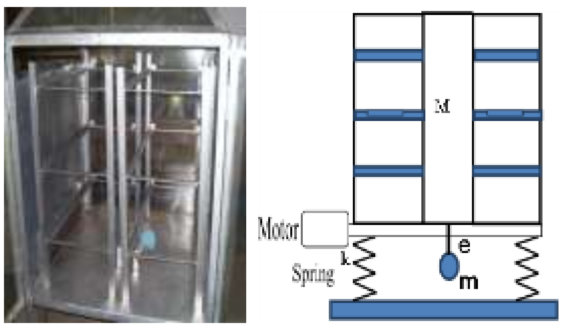
incinerator, cyclone, wet scrubber, heat exchanger, drying chamber, an electrical motor, an unbalance mass, shelves and spring as shown in Figure 1 and Figure 2.

(a) (b)

Fig.1.Green Incinerator (a);Heat Exchanger (b)



(a) (b)

Fig.2. Drying Chamber (a); Vibration Components (b)

3.2 Vibration

Vibration components were placed under the drying shelves and consist of an electrical motor, 4 springs, total of mass (*M*), and an unbalance mass *(m)* 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):

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

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:

(a) (b)

Fig.3. Spring and Cashew Nuts (a); An Unbalance Mass (b)

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 and simulation of *r, X, MX/me* and *X/Y*.

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4. RESULTS AND DISCUSSIONS

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.

The total length of the dryer machine is 6.7 m and its drying chamber has a dimension of: Length 5 m, Width 3 m, and Height 1.8 m. Left side wall and right side wall and the floor are made in three layers consisting of material: Aluminium Plate with thickness of 0.001 m, Glass wool with thickness of 0.1 m and Aluminium Plate with thickness of 0.001 m. Whereas the front wall, rear wall and the roof are made of transparent cover with thickness of 0.006 m. This is illustrated in Figure 4.

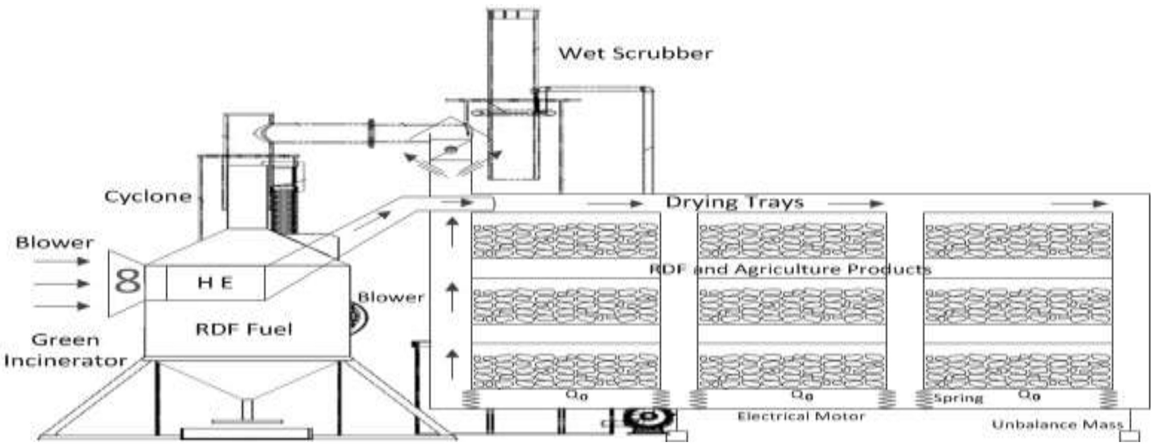

Fig.**4. Dryer Machine to dry *RDF* and Agricultural Products by using Green Incinerator**

Based on analysis, simulation and experimental 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. Table 2 shows the final moisture content of vibrated samples was lower (i.e. 3.5%) than the samples without vibration (i.e. 4.2%).

The analysis, simulation and the experimental results of vibration as shown in Figure 5, Table 1, Figure 6, Figure 7, Figure 8 and Table 2.

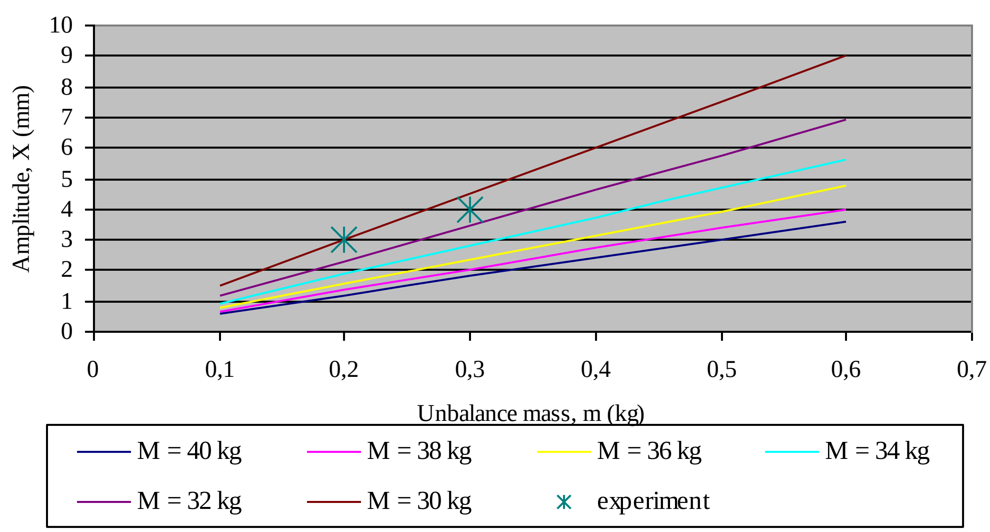

Fig.5. Change of X and m

Table 1: Analysis, Simulation and Eksperimental of 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

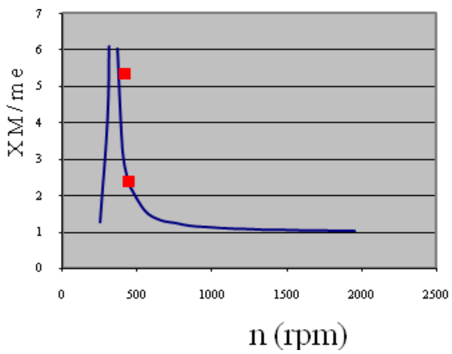

Fig.6. Change of *MX/me* vs *n*; *M* = 40 (kg)

Figure 5 shows vibration conditions could be found by changing m until cashew nuts placed on the each shelf could get hot air flow. Figure 6 and Table 1 show the results 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.

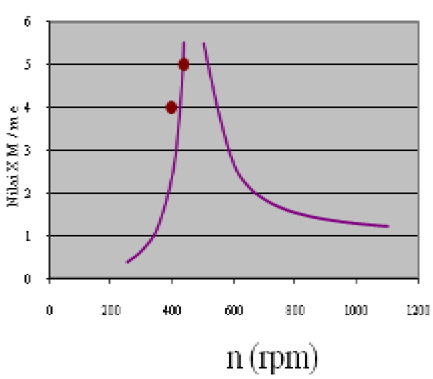

Fig.7. Change of *MX/me* vs *n*; *M* = 20 (kg)

Figure 7 shows the results 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.

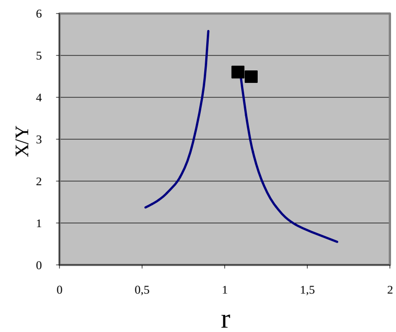

Fig.8. Change of *r* vs *X/Y*; *M* = 30 kg

Figure 8 shows the results 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 5, Figure 6 Figure 7 and Figure 8 explained that the vibration approached the resonance conditions and they result cashew nuts were on the shelves would be moved optimally.

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Table 2: Temperature in the Drying Chamber and the Final Moisture Content of Vibrated and Unvibrated Samples

No	Time	Temperature in the Drying Chamber (^oC)	Cashew nuts (samples)	
			Without Vibration (%)	Using Vibration (%)
0	07.30	59.5	10.9	10.9
1	08.30	56.0	8.6	7.8
2	09.30	60.1	8.3	6.7
3	10.30	60.4	7.2	6.6
4	11.30	60.4	7.1	6.3
5	12.30	61.5	6.4	6.2
6	13.30	59.5	5.6	5.4
7	14.30	50.7	5.6	5.0
8	15.30	58.9	5.4	4.3
9	16.30	58.8	4.3	3.9
10	17.30	54.0	4.2	3.5

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5. CONCLUSION

Based on analysis, simulation and experimental on dryer machine by using green incinerator shows:

1. Vibration conditions could be found by changing m and 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 = 0.20 kg, XM/me = 5.0
M = 20 kg, n = 395 rpm, m = 0.25 kg, XM/me = 4.0
M = 30 kg, r = 1.08, X/Y = 4.6
M = 30 kg, r = 1.16, X/Y = 4.5
2. The cashew nuts were on the each shelf could be dried fast by using vibration and the final moisture content of vibrated samples was 3.5% in 10 hours and the temperature in the drying chamber was 60 ^oC.

6. THANK YOU

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7. BIBLIOGRAPHY

Journal
Suyono, Design A Destilator to Process Plastic Waste Into Fuel Oil, *Jurnal Ilmiah Teknobiz*, Vol. 7 No.1, ISSN: 2088-5784, March 2017, pp. 184-192, 2017.
Harahap S., Green Drying Chamber By Using Vibration Components, Heat Exchanger, And Micro Hydro In Buton Island, Indonesia. *In: Proceeding of PIJIC2015-9, PAWEES-INWEPF, Joint International Conference 2015*, Kuala Lumpur, 19 - 21 August. Malaysia, 2015.
Wulandani, D., O' Nelwan, L., Abdullah, K., Firman, LM., Vibration Simulation on Cashew Rack. *Jurnal Teknologi FTI-UJ*, ISSN: 1643-0266, Vol. 1 No.2, pp. 179–192. 2011.

Thesis
La Ode M.F. "Pengaruh Getaran dan Energi Panas pada Alat Pengering Surya GHE Tipe Kabinet," Institut Pertanian Bogor, Bogor, Disertasi Doktor 2012.

Book
Holowenko, A.R., Dynamics of Machinery, John Wiley & Sons, New York, USA, 1992.
Palm, W.J., Mechanical Vibration. Wiley. New York. 1992.
Thomson, W.T., Theory of Vibration with Application. Prentice Hall. 1986.
William T.T. 1986*. Teori Getaran dan Penerapannya*. Erlangga, Jakarta.