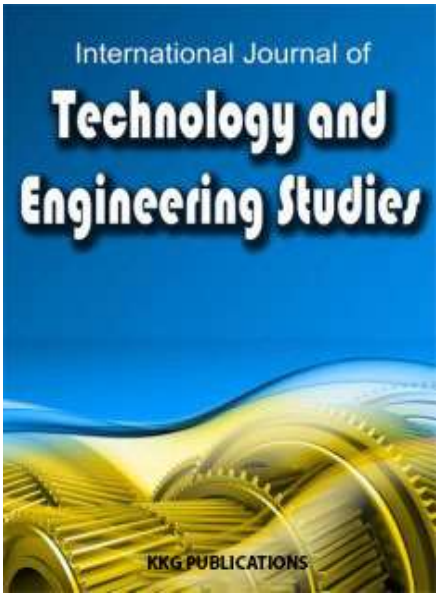


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GISKA SETYA PRIAJI

Department of Mechanical and Bio System Engineering, Faculty of Agricultural, Engineering and Technology, Bogor Agricultural University, Indonesia

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# DESIGN CLOVE DRYER TYPE BASIN UTILIZING WOODY BIOMASS AS A SOURCE OF HEAT

GISKA SETYA PRIAJI *

Department of Mechanical and Bio System Engineering, Faculty of Agricultural, Engineering and Technology, Bogor Agricultural University, Indonesia

**Keywords:**
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**Abstract.** The aim of this research is to conduct a design innovation cloves drying machine body types utilizing woody biomass as an energy source for farmer's cloves. Dryer machine design aims to conduct a clove dryer design innovation to produce a large capacity and fast drying. The drying machine uses fuel (heating) derived from biomass (wood), which is burned at a 3.8 kg/hour rate. Cloves drying machine capacity is 100 kg, which is the desired moisture content down from 70.83% to 14%. Some parameters that must be specified include air condition dryer, dryer basin specifications, specifications fan, furnace specifications, and the drying time. Dryer design specifications tub is calculated based on capacity, bulk density, and height of a pile of cloves. The rate is calculated based on the air mass flow rate and the specific volume of air heaters. Blower power is needed to calculate the value of pressure drop and flow rate of air. Furthermore, the motor power is generated through the blower power ratio of the blower efficiency. Motor power required to design cloves drying machine is 0.5 Hp. Furnace power is determined by the difference in enthalpy of the air heater with ambient air. Drying time is faster than traditional dryers to 34 hours.

## INTRODUCTION

Clove is an agricultural commodity that plays an important role in the field of food and non-food. Clove production is mostly used in the cigarette industry, as well as medicine, cosmetics, and perfumes.

As a result of the plantation, clove is seasonal. Therefore, to maintain the quality of the plantation and willingness throughout the year, the preservation needs to be done so that the result is more durable for storage and adds value. One way is with the preservation of plantation drying. Drying is a process for reducing the water content of the material until it reaches a final concentration limit of certain water content thus slowing the rate of product failures due to biological and chemical activity [1]. Microorganisms which cause damage to crops grow well in the presence of free water in the food. Besides, the enzyme that causes a chemical change in the biological material can function with the presence of free water.

Drying cloves in Indonesia generally uses natural drying by using the sun's heat or sun drying. Drying of this type requires considerable time and only depends on the weather and the sun. And traditional clove drying (drying) takes 5-7 days to achieve moisture content of 14%. Clove optimum drying temperature is less than 65 0C, the temperature that is too high (above the material) is not good because it will cause water levels to drop essential oil of clove.

Drying may also be done mechanically, namely using the machine or dryer. But the substantial capital is required than using traditional means. So that the dryer is needed that can provide a large capacity and rapid drying in the drying process so as to provide the cost of production is relatively small with a large capacity. This final project aims to conduct a clove dryer design innovation, so as to produce a large capacity and fast drying.

### Objectives

The aim of this research is to conduct a design innovation cloves drying machine body types utilizing woody biomass as an energy source for farmer's clove.

## LITERATURE REVIEW

Clove (Syzygium aromaticum, syn. Eugenia aromaticum), in English called cloves, is the aromatic dried flower stalks from the tribe Myrtaceae. Clove tree is an annual plant that can grow with the height reaching 10-20 m, has oval shaped leaves that bloom in the bud. Fruit stalks are first green, and red if they had bloomed. Cloves will be harvested if it reaches a length of 1.5-2 cm. This plant is the identity of the flora of North Maluku province, it can grow 20-30 m high and can reach more than 100 years old. Clove plant canopy is generally conical, pyramid or double pyramid, with the main stem soaring upwards. Branches are innumerable, show a horizontal growth

* Corresponding author: Giska Setya Priaji
E-mail: giskasetya@gmail.com

with relatively small branches compared to the size of the main stem. Stiff leaves are green or reddish green and elliptical with the pointed end. The leaves are usually out every period in the period end and the branch will issue a set of leaves that consists of two leaves that lie opposite to each other, all the leaf branches will form a beautiful canopy [2], [3].

Post-harvest treatment of cloves, to reach a state of productivity requires every kind of clove to take different time. Zanzibar clove takes time of 4.5-6.5 years. Cloves Sikotok begins flowering at the age of 5.5 to 7.5 years. Cloves are generally flowering in about a month from May to July. However, in some areas, cloves can be harvested from October to December [4].

Post-harvest handling of cloves at farm level is done traditionally, flower threshing is done by hand, so it takes a long time. Therefore, the drying must be done immediately after harvesting due to delay drying can adversely impact quality. Under these conditions it is necessary to study to get a model of drying that is able to present clove behavior during drying. Basically it takes several treatments for cloves drying process more efficiently, so that the cloves drying machine is designed with the purpose of fulfilling the functions of drying wet cloves into dry clove harvest ready for sale.

Drying consists of two processes, namely manual drying and mechanical drying. Manual drying is the drying process that is done by using the media wind and sunlight. Excellence in a natural drying process is very simple, inexpensive and does not require special equipment so it is easily done by everyone. While the mechanical drying is used because of the many difficulties that are obtained in the drying process manually, especially during the rainy season, then humans tried to create new tools to produce a better product in a more efficient way.

According to [5], the mechanical drying of cloves is arranged above the storage tub in a closed room that is equipped with several ventilation holes. Then put in the room and blown heat is generated from biomass energy that is used for the combustion process. Hot air is blown by a fan or blower that is driven by an electric motor so as to flow towards the storage tubs that brings moisture from the cloves that will come out of the ventilation holes. In addition, the mechanical drying has several advantages such as the height of the temperature, humidity and air speed is regulated, the drying process does not require a large place and drying time becomes more organized (not affected by the rainy season).

## METHODOLOGY

### Tools

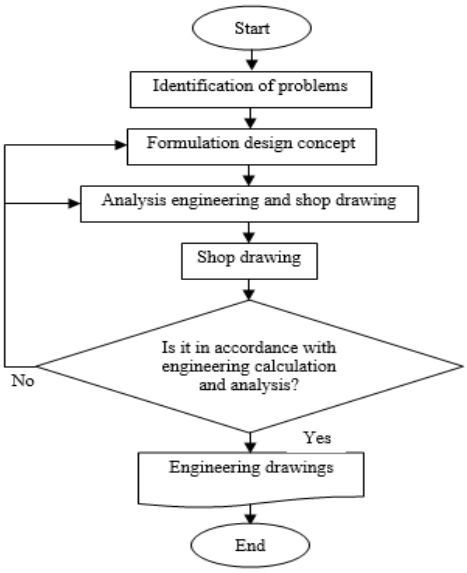
The tool used in this research is Laptop Acer Core i-5 and Solidwork 2012 software.

### Parameters of Observation

The parameters used are using factors - factors that affect the drying expressed by [6], namely

a. Surface area
b. Temperature
c. Speed of air movement
d. Long drying

### Procedure



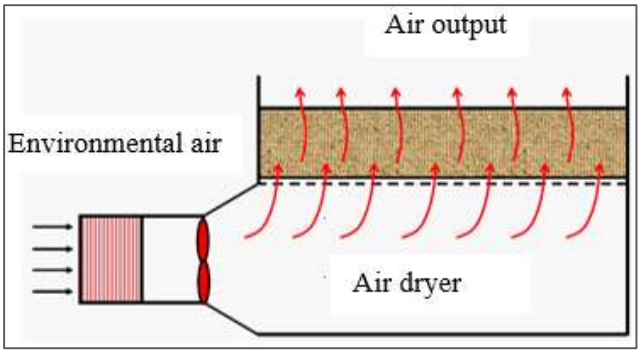



Fig. 1. Condition air dryer

**a. Environmental Air:** The ambient air temperature is 27 0C because according to [7] the average temperature environment in Indonesia amounted to 24-28 0C.

**b. Drying Temperature:** Clove optimum drying temperature is less than 65 0C, the temperature too high (above the material) is not good because it will cause water levels to drop essential oil of clove.

**c. Ratio of Temperature or Humidity (RH) of the Air Out**: According to [8] the air from drying tub types have between 85% RH to 90%, so assuming RH of 86%.

TABLE 1
CHANGES IN THE CONDITION OF THE MATERIAL PROPERTIES DURING THE DRYING PROCESS

| Condition | Dry temp ($^0$C) | Wet temp ($^0$C) | RH (%) | Water contain, H (kg/kg) | Enthalpy, h (kJ/kg) | Specific Volume (m$^3$/kg) |
|---|---|---|---|---|---|---|
| 1 | 27 | 24.26 | 80.00 | 0.0181 | 73.318 | 0.8747 |
| 2 | 60 | 31.69 | 14.28 | 0.0181 | 107.639 | 0.9711 |
| 3 | 30 | 28.00 | 86.00 | 0.0233 | 89.868 | 0.8907 |

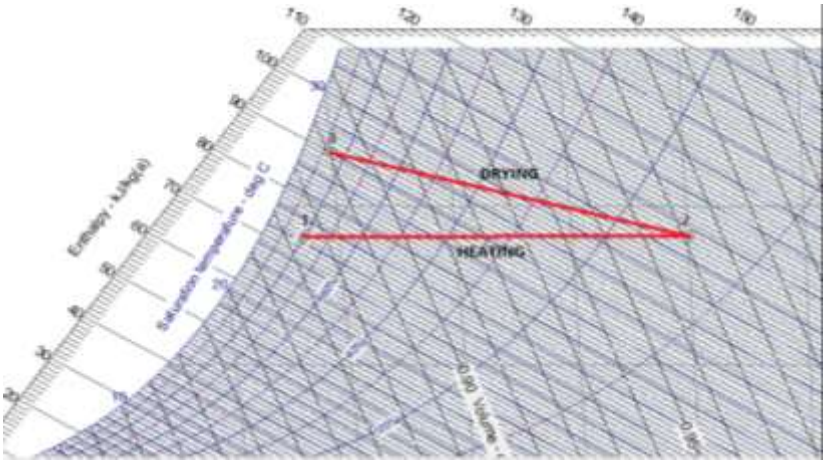



Fig. 2. Change in condition property material during dying

**1. The Specification Design of Drying Basin**

$$A_{pf} = \frac{[\frac{C}{\rho}]}{t}$$

$$= \frac{[\frac{100\ kg}{390\ kg/m^3}]}{0.3\ m}$$

$$= 0.8547\ m^2$$

Where: $A_{pf}$ is surface area of the pile (m$^2$), C is capacity of dryer (kg), ρis bulk density (density material) (kg/m$^3$), and t is thick pile (m). In the design of dryers using pile thickness 0.3 m, bulk density for clove 390 kg/m$^3$ and 100 kg capacity of dryers so that the surface area of the pile is 0.8547 m$^2$. In the draft there can be taken pile surface area of 100 cm x 90 cm = 9000 cm$^2$ = 0.9 m$^2$.

## 2. The Specification Blower

Air flow rate, drying temperature and water vapor dispersion affect drying time. For tub-type dryers, air flow rate is generally between 0.8 - 1.0 $m^3$/s/ton of dried [8]. In the draft drawn 1.0 $m^3$/s/ton, then for a capacity of 100 kg required air flow rate for $V_{blower}$ is 0.1 $m^3$/s. so the rate of the air mass ($G_{blower}$) of

$$G_{blower} = \frac{\mathbf{V_{blower}}}{\mathbf{Volume\ spesifik_2}}$$

$$= \frac{\mathbf{0.1\ m^3/s}}{\mathbf{0.9711\ m^3/kg}}$$

= 0.103 kg/s

a. Pressure drop

$$\Delta p_{grain/m} = \frac{\mathbf{a\ V_s^2}}{\mathbf{Ln\ (1+b\ V_s)}}$$

$$= \frac{\mathbf{6.11\ x\ 10^4\ (0.117\ m/s)^2}}{\mathbf{Ln\ (1+2.24\ 0.117\ m/s)}}$$

= 3593.37 Pa/m

$\Delta p_{grain/m}$ is the pressure drop per depth (Pa/m), superficial velocity (m/s), a and b are coefficients obtained from the experiments, in order to get $\Delta p_{grain/m}$ is 3593.37 Pa/m.

For the design of the dryer $V_s = V_{blower}/A_{pf}$ = 0.1 $m^3$/s / 0.8547 $m^2$ = 0117 m/s. The value of a and b for the cloves are not so approachable using clover alike namely a = 6.11 x 104 and b = 2.24 [11]. To a depth of 0.3 m piles, piles pressure loss after going through is 3593.37 Pa/m x 0.3 m = 1078.01 Pa. Pressure loss due to ducting and floor dryers tub estimated 100 Pa. So the blower should be able to maintain a static pressure of 1078.01 Pa + 100 Pa = 1178.01 Pa = 120.2 mm$H_2O$ (1 mm$H_2O$ = 9.8 Pa).

### b. Blower Power

Blower power needed (efficiency 90%) is

$P_{udara} = V_{blower}\ \Delta p_{grain/m}$

= 0.1 $m^3$/s x (1178.01 Pa)

= 117.801 W

= 0.118 kW

In the range of high pressure, axial type blower generally manufactured total efficiency ($Eff_{udara}$) of about 75%, so it used the power blower that needed:

$P_{motor} = P_{udara}/Eff_{udara}$

= 0.118 kW/ 0.75

= 0.157 kW

= 0.208 HP

So selected electric motor used is single-phase electric motor of 0.5 HP = 0.378 kW.

## 3. Specifications Furnace

Furnace power is

$P_{furnance} = G_{blower}\ (h_2 - h_1)$

= 0.103 kg/s (107.639 kJ/kg - 73.318 kJ/kg)

= 3.535 kJ/s

= 12.726 MJ/hr

Firewood as fuel has a calorific value (q) of 16.8 MJ/kg [9] and assuming that the total efficiency of the furnace is 20% (Eff), the fuel consumption is:

$$G_{fuel} = \frac{\mathbf{P_{furnance}}}{\mathbf{q\ x\ Eff}}$$

$$= \frac{\mathbf{12.726\ MJ/hour}}{\mathbf{16.8\ MJ/kg\ x\ 0.20}}$$

= 3.788 kg/hour

## 4. The Calculation of the Drying Time

Carrying capacity of water for every kilogram of dry air is shown by the difference between RH conditions 1 and 3, which stated:

$\Delta H = H_3 - H_1$

= 0.0233 kg/kg – 0.0181 kg/kg

= 0.0052 kg/kg

When connected to the mass flow rate of air from the blower blowing Gblower (kg/s), the water vapors that can be carried by air are:

$D_{H2O} = \Delta H\ x\ G_{blower}$

= 0.0052 kg/kg x 0.103 kg/s

= 0.0005356 kg/s

(Every second, air flow is carrying out 0.0001607 kg $H_2O$)

The amount of water that must be removed from the material ($GH_2O$) is calculated from the weight of the wet ingredients ($G_{wet\ cloves}$). Here it is 30 kg cloves with m1 = 70.83% and the desired moisture content $m_2$ = 14% [10].

$$G_{H2O} = G_{wet\ cloves}\ x\ \frac{\mathbf{m_1 - m_2}}{\mathbf{100\ \% - m_2}}$$

$$= 100\ kg\ x\ \frac{\mathbf{70.83\ \% - 14\ \%}}{\mathbf{100\ \% - 14\ \%}}$$

= 66.0814 kg $H_2O$

So, drying time is

$G_{H2O} / D_{H2O}$= 66.0814/0.0005356

= 123 378 s

= 34.27 hours

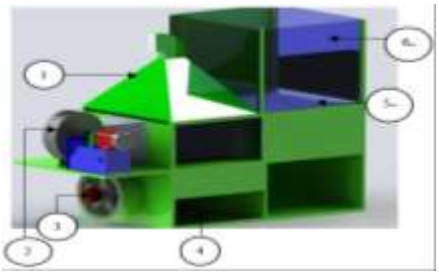


Fig. 3. Design machine dryer

**Description:**

1. The chimney
2. Blower
3. Fan blower
4. Biomass furnace
5. Plenum dryer
6. Basin dryer.

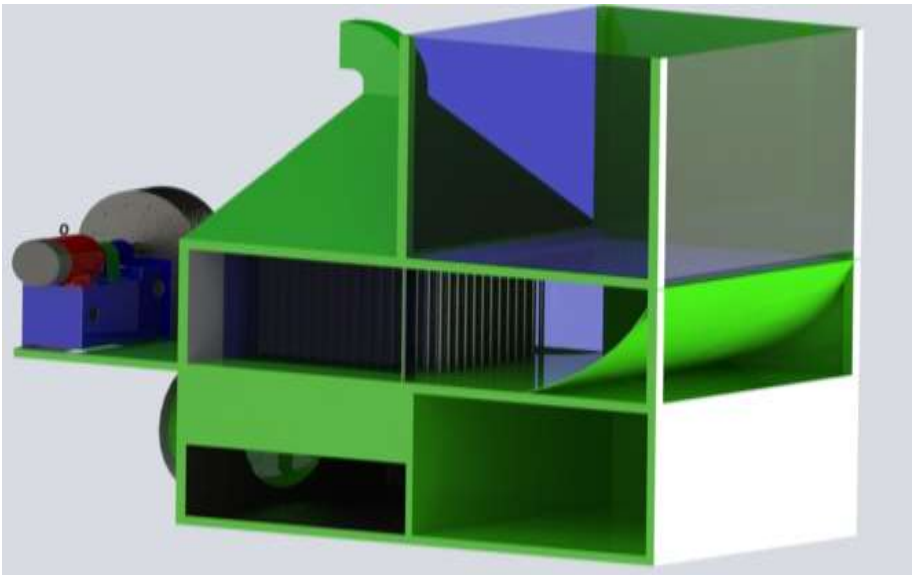


Fig. 4. Sightings of the plate in the open air passageway
Description: 1. Plumbing pipe smoke (heat exchanger).

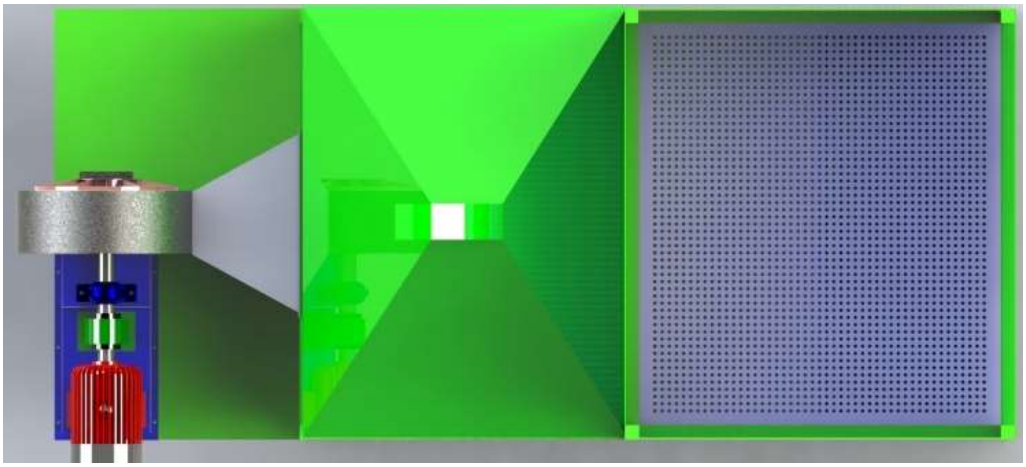


Fig. 5. Top view

TABLE 2
SPECIFICATION MACHINE DRY

| Parameter | Specification |
|---|---|
| Capacity | 100 kg (*recommended*) |
| Drying time | ± 35 jam (100 kg) |
| Dimension | 2.5 x 1 m |
| Dimension basin base | 1 x 0,9 m |
| Blower power | 0.5 HP |
| Fuel | Biomass (wood) |
| Necessary wood | 3.8 kg/jam |
| Dimensional framework | 4 cm x 4 cm |
| Thick plate | 4 mm |
| Smoke conduit diameter | 2 cm |
| Input voltage (blower & fan) | 220 V |

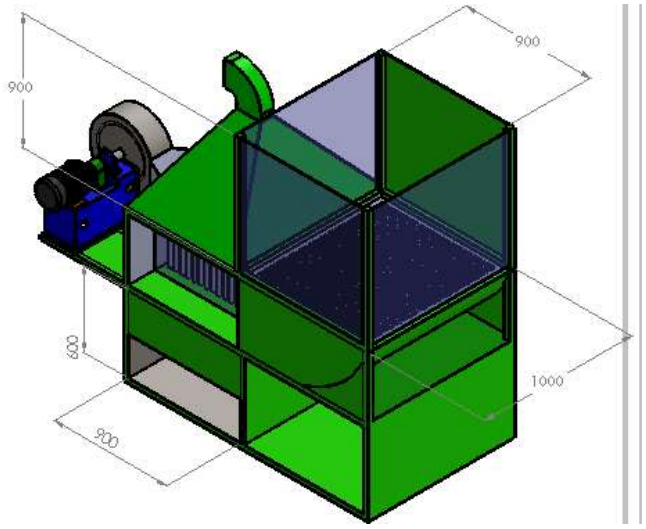



Fig. 6. Isometry view with dimension

## DISCUSSION

This drying machine is specifically designed for the commodity cloves. Fuel (heating) derived from biomass (wood) is burned at a rate of 3.8 kg/hour. Smoke hot combustion products will be channeled towards the chimney through small pipes (diameter 20 mm). Blower will be blowing air with a volumetric rate of 0.1 $m^3$/s. Blowing air blower will hit small pipes channeling the smoke resulting in forced convection heat transfer. Based on this research, the optimum pile high on bath-type dryer is 0.3 m, so it is recommended to fill the cloves in the tub just as high as 0.3 m, equivalent to 100 kg of clove. The temperature of the air entering the heating bath is controlled at 60 °C through the ON-OFF control on the furnace blower fan. It is based on research which shows that clove at temperatures above 65 °C will have decreased levels of essential oils. Turn down the hall dryers (lower pedestal basin) with designed curved in order to reduce head loss as a result of the turn.

In the design of cloves drying machine of 100 kg capacity, desired moisture content will come down from 70.83% to 14%. Some parameters that must be specified include air condition dryer, dryer tub specifications, specifications fan, furnace specifications, and the drying time. Ambient air temperature is set at 27ºC with relative humidity (RH) of 80%. Air heaters are set at 60ºC, while the air out of the tub is 30ºC. The drying process can be seen in the diagram in Figure 2. The specification psychometric draft dryer tub is calculated on the basis of capacity, bulk density, and height of a pile of cloves. Through the calculation, resulting tub surface area is 0.9 $m^2$. The rate is calculated based on the air mass flow rate of air and the specific volume of air heaters. The specific volume of air heater is searched using psychometric diagram. The value of the specific volume of air heaters contained in table 1 is equal to 0.9711 $m^3$/kg. So that through the calculation, the rate of air mass is 0103 kg/s. Blower power is needed to calculate the value of pressure drop and flow rate of air. Air flow rate obtained is amounted to 0.1 $m^3$/s while its pressure drop is at 1178.01 Pa. So the blower power can be obtained. Furthermore, the motor power is generated through blower power ratio of the blower efficiency. Motor power required to design cloves drying machine is 0.5 HP. Furnace power is determined by the difference in enthalpy of the air heater with ambient air with the furnace power of 12 726 MJ/kg consumption of fuel (wood) required by 3.78 kg/hour. By using this design of the dryer, the drying time becomes faster whereas to drain 100 kg of cloves, it takes 34 hours.

## CONCLUSION AND RECOMMENDATIONS

Engine design is feasible to be used for drying the cloves with the sun on sunny weather takes about six days whereas with this machine it only takes 35 hours with operational costs relatively low.

### Declaration of Conflicting Interests

There are no conflicts of inetrest.

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