Development of control systems on vacuum evaporators with 50 l capacity to reduce honey water content accordance to sni 01-3545-2004

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Abstract. Riau still has many protected forests and nature reserves. One of the wealth of protected debt is the forest's Honey. One of the weaknesses of forest honey is the high water content in honey. The permissible water content in honey is 22% based on SNI 01-3545-2004. This paper presents a vacuum evaporator of control system design as a tool for reducing the water content in Honey. The control system design is made such that the honey temperature in the evaporation process is no more than 40°C. There are three quantities that are controlled in this process, namely vacuum chamber pressure, temperature and screw rotation. Temperature control system and pressure control system use close loop system, while the control system for screw rotation uses open loop system. The three main components of this control system are the VE 115N vacuum pump, the stirring screw motor with 1 HP power, 2 heaters with 250 watts of power each, Temperature Control (Eliewell IC901 thermostat and thermistor sensor), 35x25 panel box. To meet the quality of honey, the control system is set with a maximum temperature of heating water 40°C and vacuum pressure at 7.4 kPa and screw rotation at 60 rpm.

1. Background

One of the forest products in Riau Province is honey bee. One of the favorite trees for nesting is the Sialang Tree [1]. The lack of honey quality in Indonesia is partly due to the high water content in the honey [2]. The water content makes it easy to ferment honey. Therefore we need a tool to reduce the water content. The quality of honey as a food ingredient has been regulated in SNI 01-3545-2004. The maximum water content is permitted at 22% and honey heating should not exceed 40°C [3].

Research on the tools used in order to reduce the water content in honey has been widely studied. The condenser evaporator [4], the effect of thickening honey by using a vacuum evaporator on the quality of honey produced, and to increase the variant of honey products [5]. The energy performance of vacuum evaporators for liquid digestate treatment[6], scale up production indonesian liquid propolis from raw propolis and wild beehive using bubbling vacuum evaporator[7], experimental study on water separation process in a novel spray flash vacuum evaporator with heat-pipe[8], analysis of the residual gases in several types of high-vacuum evaporators[9] and changes in properties of palm sugar syrup produced by an open pan and a vacuum evaporator during storage[10] are some other recent examples of research on vacuum evaporators that can be used as a reference for this research.

Designing a vacuum evaporator that we do with a capacity of 50 liters [11]. The results of the design and manufacturing review [12] were taken to suit the conditions of people in areas with low electricity...
consumption. This design is made in such a way, where the water used as a heating medium is placed around the walls of the vacuum evaporator. The hot water that comes from two heaters is conduction through the vacuum evaporator wall. Honey in the evaporator room is conditioned under 1 atm. Stirring in a vacuum evaporator chamber using a screw.

To get better results, the evaporator must be equipped with a control system [13]–[15]. In this paper we will present the design of the control system used in the vacuum evaporator we have made. There are three components that are controlled on this evaporator, namely temperature, pressure and screw rotation. The temperature is maintained below 40°C, the pressure is about 7.4 kPa atm and the screw rotation of the electric motor is at a certain speed. The control system for temperature and pressure will use a closed loop system, while the screw rotation with an open loop system

2. Methods
In the previous two papers we have presented about this vacuum evaporator which is about the design and manufacturing process. The design results can be seen in Figure 1(a) and the manufacturing results can be seen in Figure 1(b). The design of this vacuum evaporator based on pressure vessel principle refers to ASME section VIII Boiler and Pressure Vessel code standards.

![Design result](image1.png)

(a)
![Results of making vacuum evaporators](image2.png)

(b)

**Figure 1.** (a) Design result[11]. (b) Results of making vacuum evaporators[12]

In this paper is to make a control system of the engine vacuum evaporator which consists of three main process control, temperature control, pressure control and rotation control screw. The control system of each process has a different purpose is certainly the type of control system used and application methods are also different. The following are the planning and control system making process of each instrument (figure 2).
The purpose of the planning and manufacturing of a temperature control system that is in accordance to the principle of vacuum evaporator. Evaporating the water at low temperatures with pressures below 1 atm. Who wants to be controlled is the temperature at 40°C figures, which needed a system that can regulate a constant temperature in the Honey. The system can be ordered working electric heaters and provide temperature information processing.

The purpose of the planning and manufacturing of pressure control system is to determine and set the pressure to be achieved and can be controlled during the process is underway. Machine working vacuum evaporator under vacuum, which is under a pressure of 1 atm. The pressure to be achieved is 7.4 kPa using a vacuum compressor.

Engine vacuum evaporator equipped with a stirrer and a screw that serves as a tool to condition the Honey that is in the vacuum chamber in order to keep it moving. So that the screw rotation honey continues to flow from the bottom to the top to make the Honey will be faster uneven heating and evaporation process. The control system in the round screw using a type of open control system.

Tools and materials used include (figure 3):

a. Vacuum Compressor VE 115N
b. Electric Motor 1 HP
c. Pressure Gauge Vacuum
d. Panel boxes 35x25 and electrical cables
e. Heater (2x250 watt) and Temperature Control (Eliwell thermostat IC901 and sensor termistor)
f. Measuring instrument

Figure 2. Flow chart of control system
3. Result and Discussion

3.1 Temperature control system block diagram

The block diagram of the evaporator vacuum engine temperature control can be seen in Figure 4 where feedback occurs in a system that has automatic control. To measure the temperature of Honey using an appropriate sensor. The sensor will send the temperature measurement results to be read by the controller, then the controller will calculate through a certain algorithm to produce a signal which is then used as a relay contact action on the controller.

Changes in temperature read will affect the controller command of the relay. Temperature measurement by a sensor below 40°C, the controller will give the relay command to be an NC circuit so that the flow of electricity is connected to the electric heater. Conversely, if the temperature is above 40°C, the relay will become a NO circuit and the electricity will be cut off. Figures 40°C according to the setpoint value that has been adjusted on the controller.

The work of the temperature control system with the feedback method has functions such as measuring, comparing, calculating and acting. The temperature control function can be explained in the following table 1:

| Measure                  | Compare with                  | Increase Temperature               | Action |
|--------------------------|-------------------------------|------------------------------------|--------|
| Honey temperatur (Output)| Honey temperatur setpoint (input 40°C) | If output > 40°C heater OFF         | NC     |
|                          |                               | If output < 40°C heater ON          | NO     |

The following will explain the circuit in the temperature control system components can be seen in Figure 5.
The picture above explains the process of assembling the control system instruments and electrical components in the vacuum evaporator engine control system panel box.

### 3.2 Block Diagram for Pressure Control System

The block diagram of the evaporator vacuum machine pressure control can be seen in Figure 7. where there is feedback in a system that has manual control by humans. To measure the pressure of a vacuum chamber seen or read by humans through a vacuum pressure gauge. The human eye as a sensor to read the pressure gauge and the brain as a controller will command the hand to press the on or off button so that the actuator will work.
The pressure to be achieved in the processing process using a vacuum evaporator is 7.4 kPa. Vacuum compressors that function as air suction in the vacuum room to be removed are selected as actuators in the pressure control system. And the electrical components used are PTM and PTB as contact on and off the pressure control system. Humans as an act of feedback or also called manual control will take action by reading a pressure gauge.

### 3.3 Block Diagram for Screw Rotation Control

The block diagram of the evaporator vacuum machine screw control can be seen in Figure 8 where the control system used is an open control system.

The screw rotation which is controlled on the vacuum evaporator machine uses an electric motor as an actuator, the same as the previous control using the electrical components and the actuator, the process will take place. However, the screw rotation control output is not measured, because it uses an open type control system. So with the PTM contact and PTB control system will be active during the process, the control will be deactivated after the process is complete. The screw rotation speed has been determined to be 60 rpm.

After the three control systems have been prepared, the electrical system is designed to assemble the control system and the vacuum evaporator can function. The electrical system can be seen in Figure 9.
Figure 9. Electrical circuit for support the control system of vacuum evaporator

The working principle of the control system and the electricity system is as follows: (1) In the first position the main switch is activated to activate the control system of the water-lowering machine in honey. (2) Next the green button on the screw mover motor is activated, then the motor will rotate. And there will be stirring in a vessel that has been filled with honey. During this process the motor will always move to do stirring (3). The green button on the vacuum pump motor is activated so that the vacuum pump operates to suck the pressure inside the vessel. This process lasts until the pressure in the vessel reaches 7.4 vacuum pressure. Pressure figures can be seen on the gauge pressure. After the pressure in the honey reaches 7.4 cmHg. Stirring continues but the red button on the vacuum pump is turned off and on. (4) The process of heating in honey begins by pressing the green button on the temperature of the controller in this system has been set the standard temperature of honey heating according to SNI maximum 40°C. The heater will start working on heating the water on the wall of the vessel. In this system there is a temperature sensor placed in the vessel to directly measure the temperature of honey when the temperature of the honey reaches 40 °Celsius. to heat the water so that the honey is maintained.

Further research that can be done is to study an experimental vacuum evaporator. These experimental results can be validated with a number of similar studies with this research, especially in terms of use to reduce water content in certain fluid content. It is hoped that the research can be useful especially for communities around the forest with honey bee farmer income. The final goal is that the quality of honey in accordance with SNI standards can be of export quality and also in the process of storing honey with low water content can last a long time.

4. Conclusion

After carrying out the making and testing of research with the title review of making a temperature control system, pressure and screw rotation of the vacuum evaporator machine to reduce the honey content of 50 liters of honey. The author can draw the following conclusions:
1. The control system used is of three types, namely a temperature control system, a control system for vacuum pressure and a control system for the honey stirrer screw rotation in the vacuum evaporator chamber.

2. The temperature control system and pressure control system use the close loop system, while the control system for screw rotation uses the open loop system.

3. The three main components of this control system are the VE 115N vacuum pump, the stirring screw motor with 1 HP power, 2 heaters with 250 watts of power each, Temperature Control (Eliwell IC901 thermostat and thermistor sensor), 35x25 panel box.

4. To meet the quality of honey in accordance with SNI 01-3545-2004 the control system is set with a maximum temperature of honey 38.5°C and in heating water 40°C and vacuum pressure at 7.4 kPa and screw rotation at 60 rpm.

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