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Optimization of 1 phase induction motor speed in the process of filtering soybean pulp using PI control method

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Abstract. Tofu is one of Indonesia's special foods made from fermented soybean juice. There are several processes in making tofu. One of them is the process of filtering the juice with soybean waste. The filtering process will determine the quality and quantity of tofu. The better filtering process, the more juice are produced. The purpose of this study is to improve the results of the soybean pulp filtering process. One way is to use an induction motor for a spinner filter machine with adjustable speed. To set the speed is using VSD as a motor driver. VSD output is a frequency that can be used to regulate the speed of the induction motor. Determination of motor speed is using the PI Ziegler-Nichols oscillation tuning method so that a stable motor rotation speed is obtained. Kp value = 0.108, and Ti = 0.83 with load test conditions and 700rpm set point has the characteristics of the system response% error steady state = 7.5%, rise time = 4 sec, settling time = 4.5 sec and% over shoot = 0%.

1. Introduction

The soybean plant, Glycine soja (wild) Glycine max (cultivated), has a long history of cultivation with an estimated beginning in China around 1700-1100 years C.E [1-3]. Soybean was spread to Indonesia around in the first century. Soybeans are nuts that contain all the essential amino acids that are useful for human. This is one of the few nuts that can be consumed as complete protein. Soybean consists about 37-42% protein [4-9].

Soybeans can be processed into various food ingredients, beverages, and food flavorings. As a food ingredient soybeans are not directly cooked, but will processed first through several processes to made tempeh, tofu, soybean chips, and soybean milk powder. As a beverage ingredient that is processed, prepared, packaged in a modern way to produce water from soybeans. Tofu is been known as the one of daily food - which is very popular and has a high digestibility.

A process of making tofu in the following order is blending tofu, cooking, filtering and drying. The filtering process aims to separate the juice of soybean milk with its pulp. The filtering process uses a spinner system. The spinner is driven by a single phase induction motor.

At present day, there are many methods of control that are effective and easy to implement in a tool or system. The control system currently use is the PI control. PI control is a control system that is designed to create a stable control system according to set point. For home industry scale, the development of technology from conventional to automation is very important. Exclusive in the process of making tofu which is all done conventionally. This paper focuses mainly on the optimization of 1 phase induction motor speed.

2. Methods

2.1. Proportional control

For controllers with proportional control actions, the relationship between controller input u (t) and the error generating signal e (t) is in Equation

$$u(t) = K_p e(t) \quad (1)$$

The following are the characteristics of proportional controllers that need to be considered, when this controller is applied to a system. Experimentally, proportional controller users must pay attention to the following conditions.

- A small Kp value, the proportional controller is only able to make small error corrections (to reduce errors).
- The value of Kp is increased, the transient response shows the faster it reaches its steady state. This is important to guarantee a fast response.
- The value of Kp is enlarged, then the system will experience a response that has excessive surges and the response of the system will oscillate, making the system work unstable.

2.2. Integral control

This controller is intended to eliminate position errors in steady conditions without changing the characteristics of high frequencies and this can be achieved by providing infinite reinforcement at zero frequency at steady conditions.

In the integral controller the integral control action controller input value u (t) is changed at the proportional rate of the error generating signal e (t) can be seen in

$$\frac{du(t)}{dt} = K_i e(t) \quad (2)$$

The following are the characteristics of the integral controller when applied to a system, namely:

- If the error signal given is not zero, there will be an increase or decrease in output that is affected by the magnitude of the error signal and the value of Ki.
- The output of this integral controller requires a certain time interval, so this controller will tend to slow down the response.
- The output of the integral controller will remain at the previous value, if the error signal is worth zero.
- A large-value constant Ki will accelerate the loss of offset, but if the value of Ki is greater than there will be an increase in oscillation of the controller output signal.

2.3. Zeigler Nichols

The process of selecting parameters in the control system can produce controller tuning. Tuning control is a process that is used to minimize errors between process variables and set points and to optimize the process system.

In the plant oscillation method is arranged in series with the PID controller. Initially, the value of Ti is set to infinity and the value of Td is set to the value of 0 (Ti = ∞ and Td = 0). Then the value of Kp is increased gradually from zero to a critical value of Kcr, this will result in the reaction of the system going to oscillate continuously (if the output does not have continuous oscillations for the Kp value or has been taken, then this method does not apply). From oscillating output on an ongoing basis, the critical strengthening of Kcr and Pcr can be determined.

Rules for determining the Kp and Ti values based on the formula shown in Table 1

Table 1. Number of Kp and Ti

Specification	unit
Kp	0.45 Kcr
Ti	1.2 Pcr

2.4. Electronics system

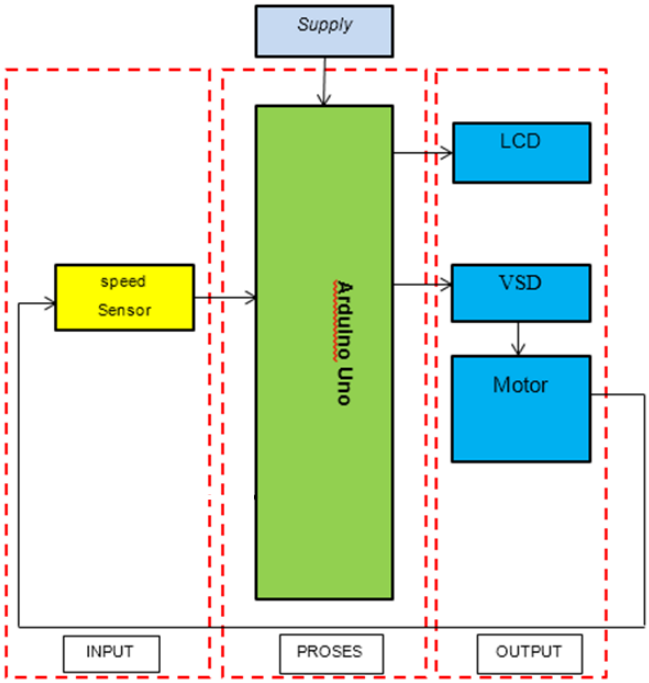

Figure 1. Diagram block diagram

Based on Figure 1, the speed sensor is used as system feedback, Arduino Uno as a controller, Variable Speed Driver (VSD) as a motor driver, and a single phase induction motor as a plan system.

3. Result and discussion

The system was tested at a set point of 700 rpm with conditions weighing 10 liters of soy milk with Kp = 0.108 and Ti = 0.83. System response from the plan can be seen in Figure 2 below.

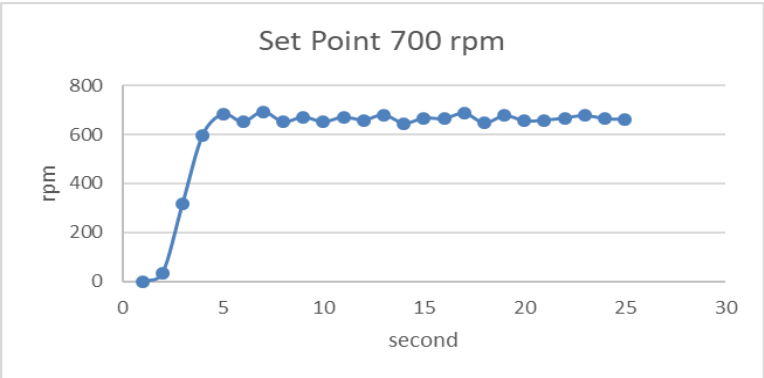

Figure 2. System response

Based on Figure 2, the results of the system response analysis are shown in Table 2

Table 2. System response analysis.

Specification	**unit**
%Error steady state	7.5%
Rise time	4 sec
Settling time	4.5 sec
% over shoot	0%

4. Conclusion

The PI control of the system is Kp = 0.108, and Ti = 0.83 when tested with a 700rpm set point with load conditions having system response characteristics% error steady state = 7.5%, rise time = 4 sec, settling time = 4.5 sec and% over shoot = 0%.

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