DESIGN OF FUZZY LOGIC CONTROLLER FOR THE PUMP SUBMERSIBLE TO SAVE ELECTRIC ENERGY

Proceeding of the 2nd International Conference on Smart City Innovation
October 9th, 2019
Diponegoro University, Semarang, Indonesia

Adhi Kusmantoro[1], Mega Novita[1]

[1]*Faculty Of Engineering And Information, University Of PGRI Semarang*

Article Info:
Received: 17 September 2019
Revised: 04 October 2019
Accepted: 7 December 2019

Keywords:
Fuzzy Logic Controller, DOL Controller, Submersible Pump

Correspondence:
[1]adhiteknik@gmail.com
[2]novita@upgris.ac.id

Abstract. The use of electric power source for the use of submersible pumps greatly affect the payment of the electricity, especially if the submersible pomap used in residences. This is due to a submersible pump control for low power capacity is still via DOL (direct line). Control pumps with DOL starting current causes a high, so the consumption of electrical energy is also great. The purpose of this study was to design control submersible pump with a capacity of 1 hp single phase using fuzzy logic. In designing the fuzzy logic controller using fuzzy mamdani with two inputs that level with a limit of -3 to 3, and changes in levels with limits of up to 0.3 -0.3, respectively - each of which has five membership functions. While the output is the velocity (speed) with five membership functions to limit -3000 up to 3000. The shape of the membership function using triangular and trapezoidal membership functions. The number of rules that are used to control the submersible pump motors as many as 29 rules. Therefore, fuzzy logic controllers generate low initial flow and accuracy in filling the water in the tank, the submersible pump motor speed graph on the right is also at a speed of 3000 rpm, so the resulting efficiency of energy use.

How to cite: *Kusmantoro, A; Novita,M . 2019. Design of fuzzy logic controller for the pump submersible to save electronic energy.* ***Proceeding of the 2nd International Conference on Smart City Innovation.*** *Diponegoro University, 9 October.*

A. Introduction

Submersible pump is submerged pump type are widely used in factories, hotels, hospitals, government buildings, and homes. In the residential capacity of the pump used is usually between 0.5 Hp up to 1 Hp. The use of submersible pumps have led to the use of electrical energy to be large and the amount of electricity bills of approximately 50% due to the use of submersible pumps (Bevrani, Habibi, Babahajyani, Watanabe, & Mitani, 2012). Controller used submersible pumps with low capacity still using the system DOL (direct line). Control systems DOL motor starting current causes the pump to be high, hence the need to control that produces a low starting current. With motor starting currents are not large, the electrical energy consumption will be reduced and the impact on the electricity payment PLN (Ogata, 2010; Aravind, Valluvan, & Ranganathan, 2013).

The development of control technology progressing faster and has benefits on human life. One type controller is widely used fuzzy logic controller (FLC). The development of this controller is supported by other control devices, for example a microcontroller, PLC and microprocessor FLC (Dinesh, Manikanta, Rohini, & Prabhu, 2015). Fuzzy logic controller does not require a mathematical model of the system, the required input and output information. The more information the fuzzy logic controller will give excellent results (Aydogmus, 2009). Therefore the fuzzy logic controller is also widely used to control plant that is not linear, you can not do other controllers. Many developed countries have long used fuzzy logic controllers in industrial and electronics equipment. Research conducted designing fuzzy logic controller on a submersible pump with a capacity of 1 Hp, which aims to improve the efficiency of electrical energy consumption, lowering the submersible pump motor starting currents, and improve the quality of electricity used (Juang & Lo, 2008).

Results of research that has been done can be one of information, evaluation, and reference in improving the efficient use of electric energy. In addition, the results of this study may be one of the references in the development of submersible pump motor controllers.

B. Literature Review

Contains Fuzzy set theory is a mathematical framework that is used to represent uncertainty, vagueness, inaccuracy, lack of information, and partial truth (Dadios, 2012). There are several reasons why people use fuzzy logic, among others:

a) Fuzzy logic concept is easy to understand. Mathematical concepts underlying the fuzzy reasoning is very simple and easy to understand.
b) Fuzzy logic can tolerate data that is not appropriate
c) Fuzzy logic is very flexible.
d) Fuzzy logic is able to model nonlinear functions are very complex.
e) Fuzzy logic can develop and apply the experiences of experts directly without having to go through the training process.
f) Fuzzy logic can work with techniques conventional control.
g) Fuzzy logic is based on natural language.

Fuzzy logic has the value of the continuous and expressed in degrees of a membership and degree of truth between 0 to 1. Therefore, something can be said to be partly right and partly wrong at the same time (An & Pei, 2012). Structur basic fuzzy inference system consists of :

a) Basis rules contain a number of fuzzy rules that map input values to output values fuzzy. This rule is often expressed by IF-THEN format.
b) The database containing membership functions of fuzzy sets used as the value for each variable system.
c) The fuzzy reasoning mechanisms that perform inference procedure. .

Fuzzy unit to process fuzzy of the input data crisp in the following manner (Berk, Stajnko, Vindis, Mursec, & Lakota, 2011):

a) Mapping firmly value the input variables corresponding to the universe of discourse
b) Conversion of the data that is mapped to the linguistic terms in accordance with fuzzy sets have been defined for these variables.

Defuzzy unit mapping of fuzzy inference output to crisp value. Fuzzy inference models commonly used is

- Model fuzzy mamdani
- Model fuzzy sugeno

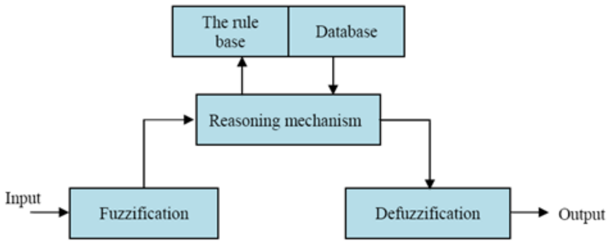

Fig. 1. The basic structure of fuzzy inference systems.

Fuzzification is the process of mapping from input to the observation of fuzzy set in the universe of discourse varied. Data mapping results are then changed to the appropriate linguistic form of a fuzzy set defined for input variables system. Input of defuzzification process is a fuzzy set obtained from the composition of fuzzy rules, while the resulting output is a fuzzy set of numbers in domain (Wu, Karray, & Song, 2005; Ahmed & Ifeanyichukwu, 2015). There are several methods defuzzification on the composition Mamdani rules on fuzzy set in the universe of discourse A Z, namely:

Method of Centroid (Composite Moment). In this method, the crisp solution is obtained by taking the center point (zCOA) fuzzy area. Generally formulated:

$$z_{COA} = \frac{\int_Z \mu_A(z) z dz}{\int_z \mu_A(z) dz}$$

Methods bisector. In this method, the crisp solution is obtained by taking the value of the domain that has a fuzzy membership value half of the total value of membership in the fuzzy area. Generally ZBOA meet:

$$\int_{\alpha}^{Z_{BOA}} \mu_A(\mathrm{z})\,\mathrm{dz} = \int_{Z_{BOA}}^{\beta} \mu_A(\mathrm{z})\,\mathrm{dz}$$

α = min {z |z ε Z}
β = min {z |z ε Z}

Mean of Maximum Method (MOM). In this method, the crisp solution is obtained by taking the average value of a domain that has a maximum membership value.

$$z_{MOM} = \frac{\int_{Z'} z dz}{\int_{Z'} dz}$$

Largest of Maximum Method (LOM). In this method, the crisp solution is obtained by taking the largest value of a domain that has a maximum membership value.

Smallest of Maximum Method (SOM). In this method, the crisp solution is obtained by taking the smallest value of a domain that has a maximum membership value.

Fuzzy logic controller /FLC provides a methodology to represent, manipulate and implement ways of thinking and of human knowledge about how to control a system. The basic structure of the fuzzy logic controller (FLC) can be combined with a closed loop control system shown in figure 2 (Dey, Mandal, & Subashini, 2013). The desired plant output r (t) compared with actual output c (t). Error (error) E and error change (change of error, CE) is a variable input for FLC. FLC output is the input of plant or process inputs (input process, PI). Base rule is based on qualitative knowledge (heuristic approach) a closed loop system that aims to reduce the spike (overshoot), rise time (rise time), and oscillations, responses unit step (step function). Example of fuzzy sets for each variable input / output is expressed by the term [N, Z, P] which means Negative, Zero and Positive (Li, Fang, Song, & Wang, 2010).

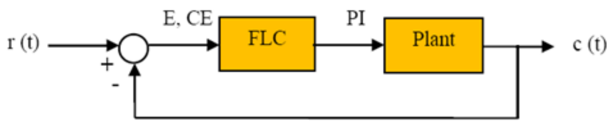

Fig. 2.Structur control system FLC.

C. Research Methods

The needs of people in residences and industries will use submersible pumps for water supply and saving in electrical energy consumption at the present time is needed. Research to be done is a kind of experimental research, which in this study will prove a hypothesis based testing of the load by using a tool in the form of an algorithm and hardware.

a) The experiments were performed using a motor load 1HP pump with a capacity of 220 V, the brand Grundfos.
b) Testing load submersible pump with fuzzy logic method compared to conventional systems / DOL.
c) Testing load changes made by changing the level of the water tank. Results are either hardware-based fuzzy logic control microcontroller arduino uno. For setting the speed using an inverter, while the load pump using a single phase induction motor with running capacitor.

Sampling was done by examining the output of the fuzzy logic controller and pump motor speed controllers. Some of the set point value assigned to the fuzzy logic controller to determine the performance or stability of the pump motor speed control. In the design of fuzzy logic controllers / FLC uses two inputs, namely water levels and changes in water levels, while output is a change in the motor speed from start up to full load speed of the motor. The process of induction motors cessation done subtly to reduce speed to the initial speed or zero speed. This process occurs when the water in the tank near full, the water level sensor detects the water level in the tank so that the induction motor submersible pump to stop working. The last stage is the stage of preparation or a research report. Phase statements made at the time the research is already running in the second of the four-month implementation study.

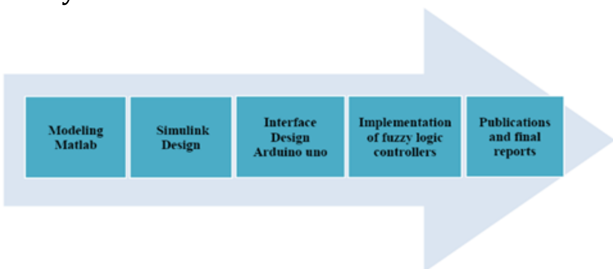

Fig. 3. Research plan.

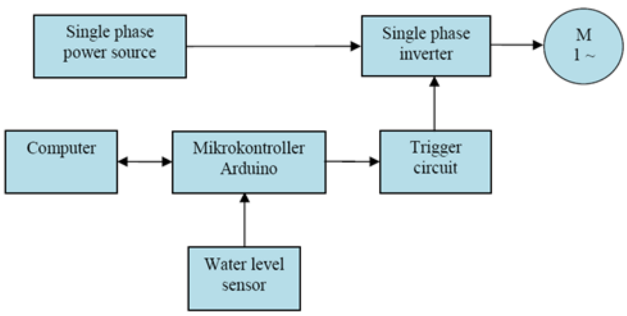

Fig. 4. Block diagram of research.

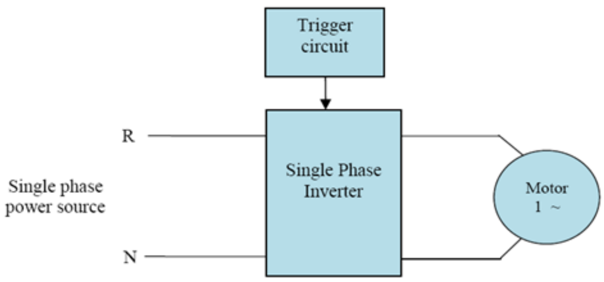

Fig. 5. Circuit power submersible pumps.

This study was conducted to improve system performance DOL (Direct On Line) in improving the efficient use of electric energy. Research that has been designed using the block diagram in Figure 4.The inverter used in this study is the Altivar of schneider electric inverter with type ATV312HU11M2. Matlab Simulink is used to control the microcontroller arduino uno and Simulink used in the fuzzy logic controller.

D. Result and Discussion

In designing the fuzzy logic controller using fuzzy mamdani with two inputs that level with a limit of -3 to 3, and changes in levels with limits of up to 0.3 -0.3, respectively - each of which has five membership functions. While the output is the velocity (speed) with five membership functions to limit -3000 up to 3000. The shape of the membership function using triangular and trapezoidal membership functions. The number of rules that are used to control the submersible pump motors as many as 29 rules. The controlling circuit in this study using a microcontroller arduino uno with water level sensors CP35MHT80 type. The water level sensor works using a laser beam. Water is pumped from the artesian well is collected in a tank with a height of 2.2 meters, 4 meters long and 3 meters wide.

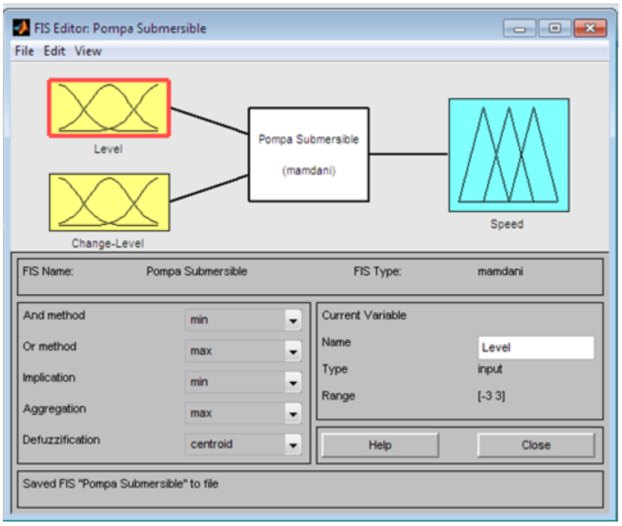

Fig. 6. The design of the input and output fuzzy.

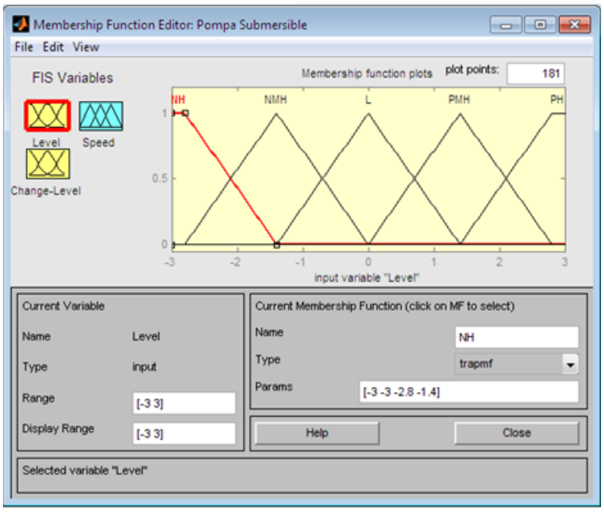

Fig. 7. The design of the membership function of input level

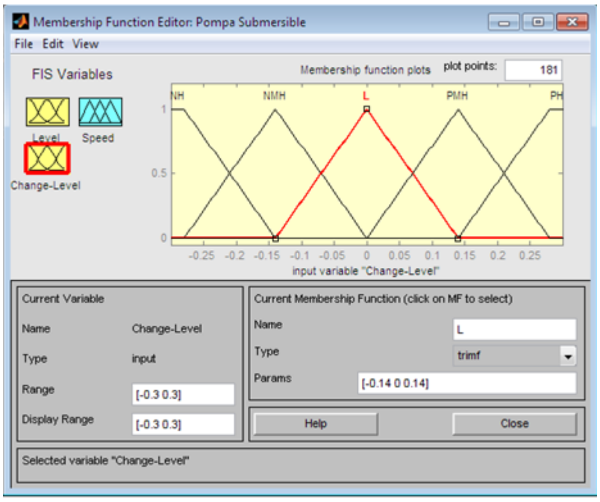

Fig. 8. The design of the membership function of input level changes.

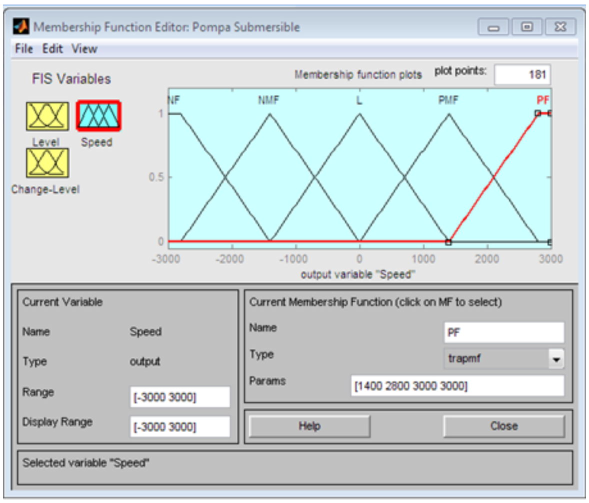

Fig. 9. The design of the output membership function of speed.

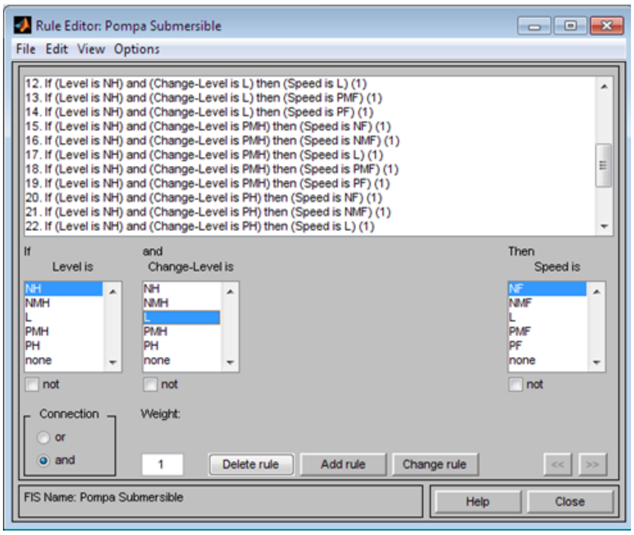

Fig. 10. The design of fuzzy rules.

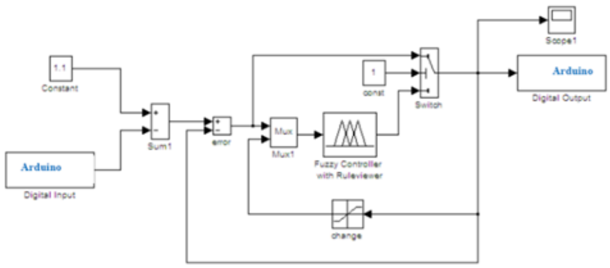

Fig. 11. Results of the draft simulink matlab.

Fig. 12. The circuit controller with microcontroller arduino uno.

Fig. 13. Location of research.

In the use of controllers DOL demonstrate the inappropriateness of replenishing water in the tank, causing the excess electrical energy use at the pump, while the use of fuzzy logic controller produces precision limits of replenishing water in the sump. Besides controlling DOL generate initial surge large enough compared to the fuzzy logic controller.

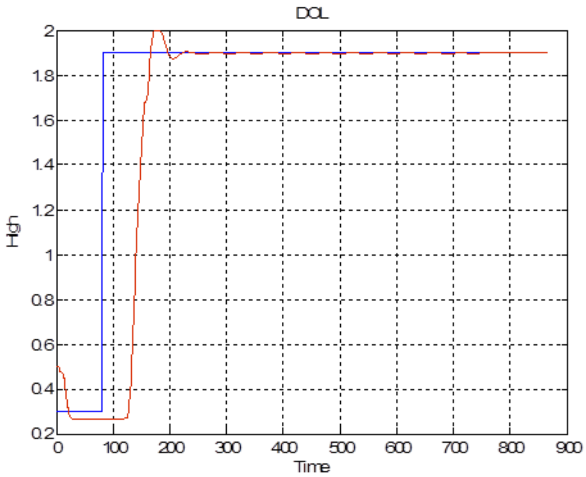

Fig.14. Graph of filling the watertank withDOL

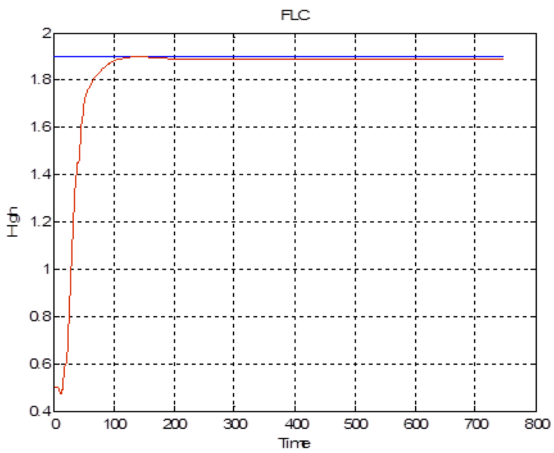

Fig.15. Graph of filling the water tank with FLC

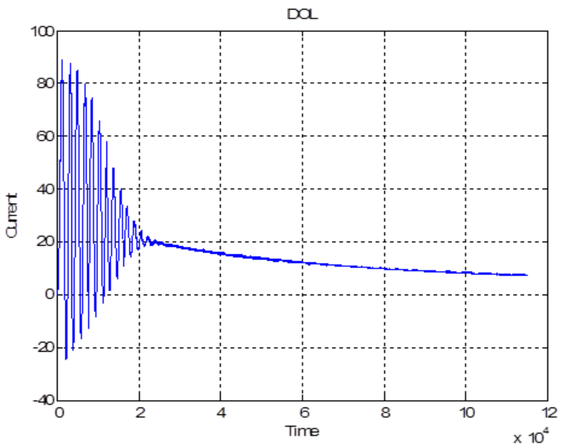

Fig. 16. Graph current motors with DOL

Therefore, fuzzy logic controllers generate low initial flow and accuracy in filling the water in the tank, the submersible pump motor speed graph in Figure 19 are also right at a speed of 3000 rpm, so the resulting efficiency of electrical energy use when compared to the speed graph in Figure 18.

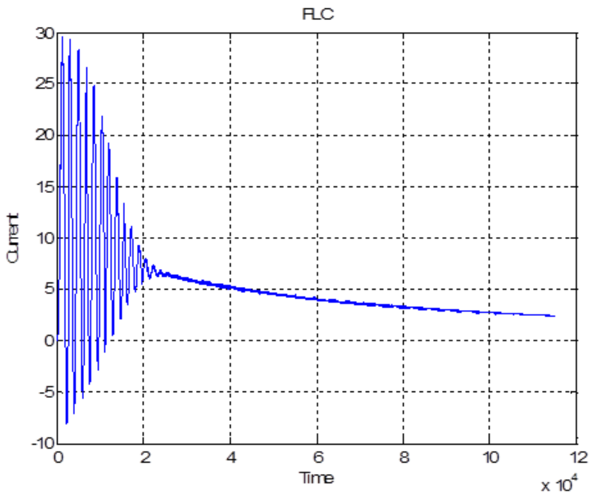

Fig. 17. Graph current motors with FLC.

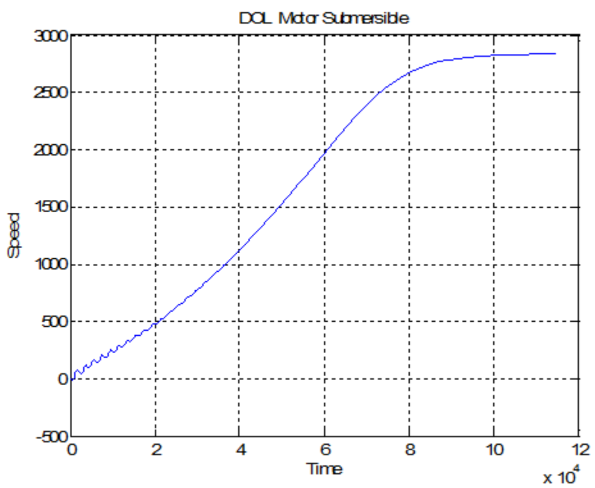

Fig. 18. Graph motor speed with DOL.

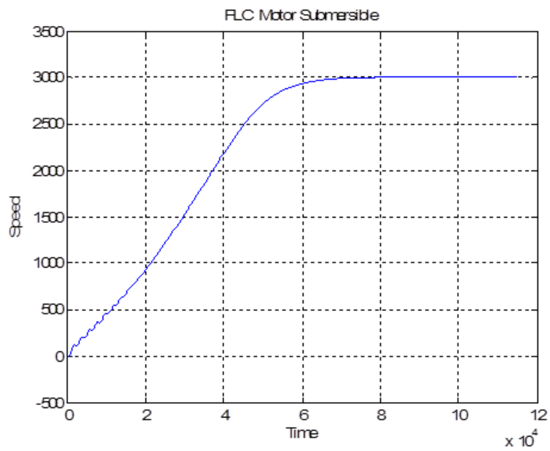

Fig. 19. Graph motor speed by FLC.

E. Conclusion

In the use of DOL controller shows the inappropriateness of replenishing water in the tank, causing the excess electrical energy use at the pump, while the use of fuzzy logic controller produces precision limits of replenishing water in the sump. Besides controlling DOL generate initial surge large enough compared to the fuzzy logic controller. Fuzzy logic controller generates a low initial flow and accuracy in filling the water in the tank, the submersible pump motor speed graph is also right at a speed of 3000 rpm, so the resulting efficiency of electrical energy use when compared to the graph speed controller called DOL. The shape of the membership function in this study using triangular and trapezoidal membership functions. The number of rules that are used to control the submersible pump motors at 29 rule. Number of rules produce the most excellent process control.

F. Acknowledgment

This article was presented at the 2nd International Conference on Smart City INNOVATION (ICSCI) 2019, jointly held by Universitas Indonesia and Universitas Diponegoro. ICSCI Conference have been supported by the United States Agency for International Development (USAID) through the Sustainable Higher Education Research Alliance (SHERA) Project for Universitas Indonesia's Scientific Modelling, Application, Research, and Training for City-centered Innovation and Technology (SMART CITY) Center for Collaborative Research, administered through Grant #AID-497-A-1600004, Sub Grant #IIE-00000078-UI-1.

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