Progress in Engineering Application and Technology Vol. 4 No. 1 (2023) 526-537
© Universiti Tun Hussein Onn Malaysia Publisher's Office

PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Application of PD, PI, and PID Control Mode on Vessel Ve203 at Biodiesel Pilot Plant

Ahmad Razin Syakireen Mohd Rozi[1], Bachik Abu Bakar[1]*, Rohani Rahmat[1]

[1]Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, 86400 Pagoh, Muar Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2023.04.01.056
Received 15 January 2023; Accepted 12 February 2023; Available online 12 February 2023

Abstract: This study is to apply the PD, PI and PID control mode on vessel VE203 during heating temperature process. This experiment is to aim to find the suitable parameters to use in DCS system at biodiesel pilot plant in UTHM for doing heating process. Also, this experiment is to find a low overshoot value between process value with setpoint value, and find the best rise time and cycling time. Besides that, redraw the p&id drawing also include in this experiment is to improve the p&id drawing form manufacturing to tally with the actual plant. The method that is apply in this experiment is "trial and error" method. By doing this method is easier to find the suitable parameters. The gains of a PID controller can be obtained by trial and error method. Once an engineer understands the significance of each gain parameter, this method becomes relatively easy. In this method, the I and D terms are set to zero first and the proportional gain is increased until the output of the loop oscillates [14]. As one increases the proportional gain, the system becomes faster, but care must be taken not make the system unstable. by make analysis of each response control mode. The result will compare of each control mode by looking the overshoot value and the rise time. This is because the equipment in biodiesel pilot plant at UTHM are related to the response of the control system. Such as, the quality of steam, the quality of piping, the length of piping, the loss of pressure in fraction loss, the age of temperature valve, the age of temperature transmitter, the surrounding of vessel and size of vessel. After all the data obtain, the result has been finding and it show the best parameters of PID control mode is by set the proportional is 2, integral is 500ms and derivative is 500ms. That parameters combine can get the best result of the overshoot value and rise time which is overshoot value can get 1.1 degree Celsius and the rise time is taking about 4 minutes.

Keywords: PID, Heating Temperature, Parameters

**Corresponding author: bachik@uthm.edu.my*

1. Introduction

The various sources about 408 of proportional integral derivative PID controller turning [1]. 30% of controllers permanently operate in manual mode and 25% use factory-tuning without any up-date with respect to the given plant. [2]. Hence, there is natural for effective PID controller design algorithms enabling not only to modify the controlled variable but also achieve specifies performance [3]. However, proportional integral derivative PID control is still simplest yet most effective approach in the control industry [4]. This attractive property, tuning parameters of PID controller has attracted intensive attentions in control theories and practices [5]. As a result, substantially powerful of PID tuning rules aiming at obtaining high stability and satisfied closed-loop response have witnessed a boom development since 1942. Ziegler and Nichols [6]. The delay will occur by actuator, sensor and field network while for input constraint are caused by limitation of actuator [7].

However, a controller is a device that produces an output signal based on. Process control system operation to the input signal it receives. The input signal is actually error signal, it's difference from measured value variables and desired values, or set point. This input error signal is deviation between where is the process system actually works and where the process system operating. Controller provides output signal to final control element to adjust process system to reduce this deviation. The properties this output signal is type or mode controller.

Moreover, constraint also can make control system have damaging effects on the system performance presence in the PID controller induces undesired operational difficulties that cause excessive overshoots, long settling time and loss of stability in PID controller [8].

2. Methods

This experiment has been conducting at plant biodiesel in UTHM. This experiment needs a steam at least 4 bars produced by a boiler. After a steam at a boiler reach 8 bars, the steam will supply to the plant and following the pipeline to do the heating process. To do this experiment student must understand the p&id drawing, these to ensure the loop or cascade are existing in the process before doing the experiment, also the student need to understand the proportional integral derivative PID, proportional derivative PD and proportional integral PI work.

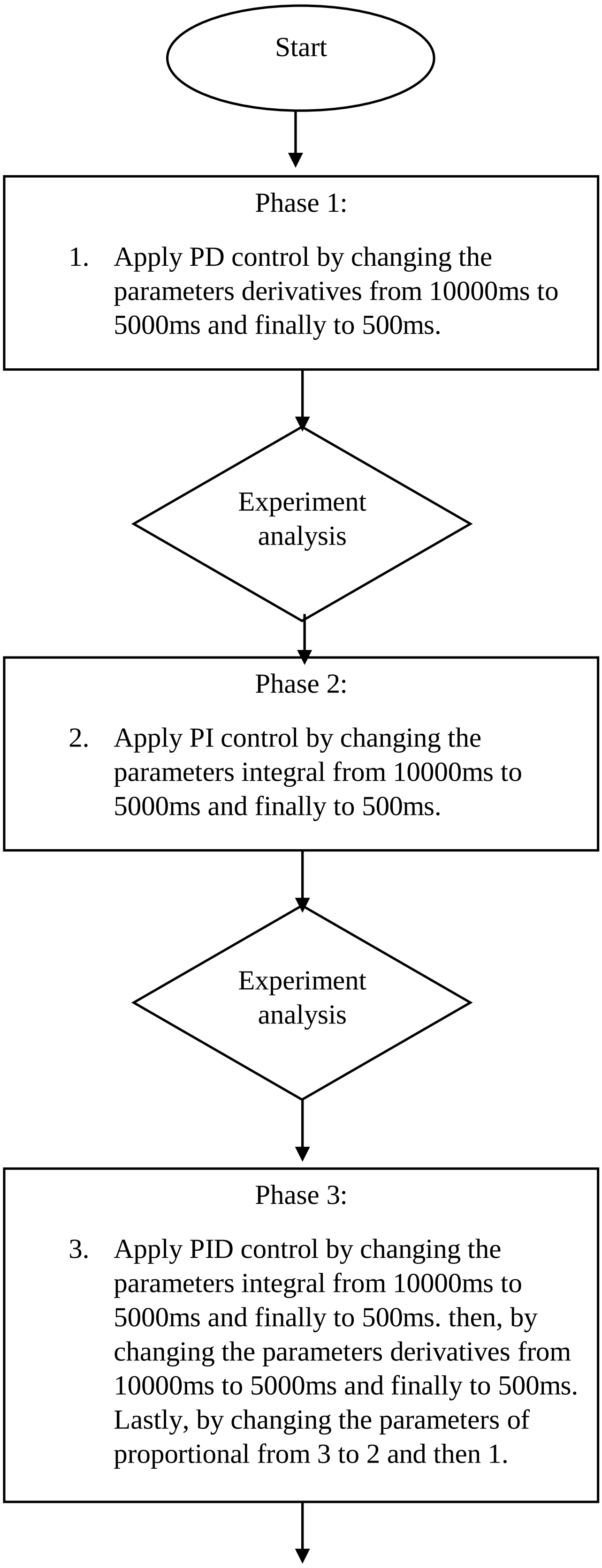
2.1 Trial and Error Method

This method is applying to identify the suitable parameters of control mode; this method was easier to make an analysis by taking the data of the graph. The data have been collected by changing the parameters one by one. Doing this experiment is consuming a lot of time to identify which parameters that are really suitable to combine with. The experiment has been testing 15 times including PD control, PI control, and PID control. Figure 1 show the flow chart of applying the control mode in this experiment to identify the parameter and find the low overshoot value and fastest rise time.

The control mode applies:

i. Test with PD control by changing the parameters of derivative and remain the proportional.
ii. Test with PI control by changing the parameters of integral and remain the proportional.
iii. Test with PID control by changing the parameters of integral, remain the proportional and derivatives.
iv. Test with PID control by changing the parameters of derivatives, remain the proportional and integral.
v. Test with PID control by changing the parameters of proportional, remain the derivatives and integral

The procedure does this experiment is:



continued

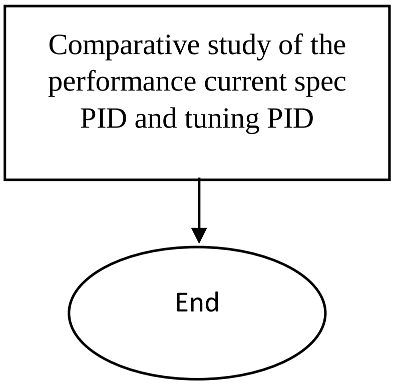


Figure 1: Flowchart of procedure doing the experiment

3. Results and Discussion

3.1 Before changing the parameters of PID.

Table 1 show the default parameters in DCS at plant biodiesel in UTHM before changing it shows the parameters of process value temperature, setpoint value temperature, overshoot value temperature, and rise time at vessel VE203 obtain by the default parameters of proportional integral and derivative PID in DCS. Then, based on the obtained parameters process in the PID parameters have changed according to the “trial and error method”. The data obtain from the default parameter will give a hint that parameter can be changed to the best parameter combination.

Table 1: Default parameters of PID parameters in DCS

P	I	D
3	20Kms	10Kms

Table 2: The result of default PID parameters in DCS

Setpoint Value Temperature	Process Value Temperature	Overshoot Value Temperature	Rise Time
45℃	48.5.℃	3.5℃	6 minutes

Figure 2: Default setting in DCS of the parameters proportional integral derivative PID and result of the process heating temperature at vessel VE203

3.2 Proportional plus reset (Integral) control, Integral is 400ms

The result of the Table 4 shows the process value temperature, setpoint value temperature, overshoot value temperature, and cycling time. It can observe that the cycling time was 4 minutes to cross the set point value. The overshoot value is 1.6℃. From phase 1 experiment, it shows the smallest parameter of integral from Table 3 would make a rise time of process value to cross setpoint value save a couple of times. By changing it from 10000ms to 5000ms to 500ms and lastly to 400ms. Remain the proportional to number of 3 because want to keep the default parameter. Figure 3 shows the process value temperature, setpoint value temperature, overshoot value temperature, and cycling time. It can observe that the rise time was 4 minutes to cross the set point value. The overshoot value is 1.6 ℃.

Table 3: The parameter value of proportional and integral (PI)

P	I	D
3	400ms	0Kms

Table 4: The result obtains from the experiment by using the PI control mode

Setpoint Value Temperature	Process Value Temperature	Overshoot Value Temperature	Rise Time
64℃	65.6℃	1.6℃	4 minutes

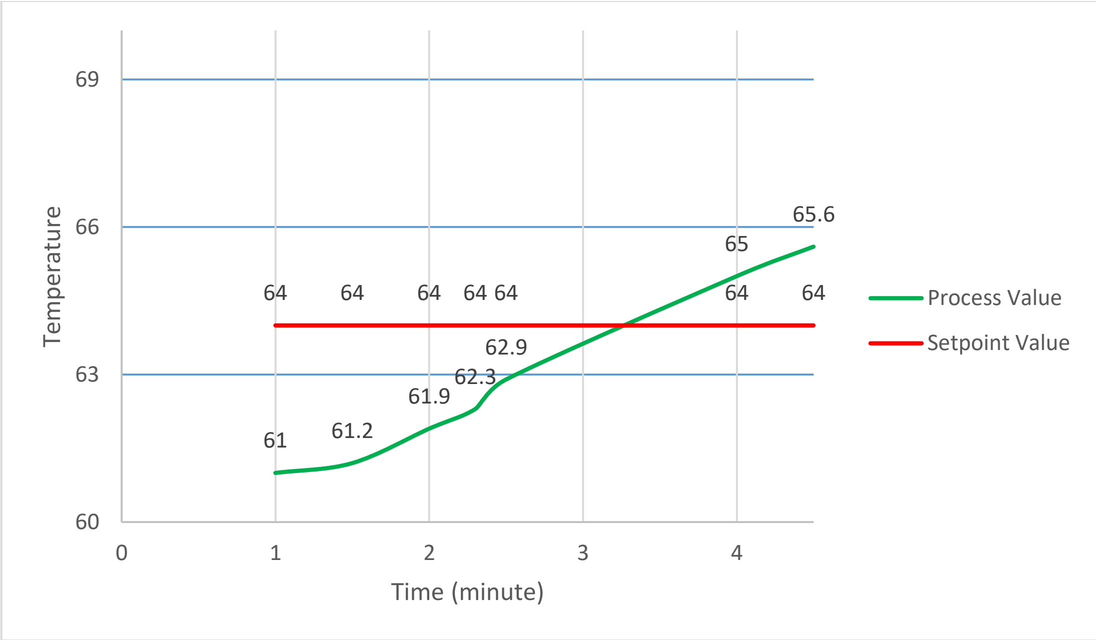


Figure 3: The response of proportional plus rate derivative (PI)

The value of parameters is test with proportional is 3 and integral is 400ms, this combination shows that there were suitable for combine with it because an integral is not too big for proportional. By making these constants larger or smaller, it can make the contribution of one of the controls more dominant or subtle in the system. One system might need only light integral control, some proportional and strong derivative, while another system might need strong integral and proportional controls, but not much derivative, while still another system might need roughly equal measures of each. [13]. This make a rise time is getting higher and the overshoot value is getting smaller. After this result show up this will consider the best combination of proportional and integral because overshoot value is low.

3.3 Proportional Plus Rate Derivative (PD) Control Derivative is 500ms

The Figure 4 shows the process value temperature, setpoint value temperature, overshoot value temperature, and cycling time. It can observe that the cycling time was 2 minutes to cross the set point value. The overshoot value is 1.3 ℃. For phase 2 experiment which is changing the parameter of derivatives from 10000ms to 5000ms and lastly to 500ms. Still remain a parameter to number 3 because want to keep the default parameter with this experiment it shows on Table 5. By changing to smallest parameter of proportional it will give response towards rise time and overshoot value shows on Table 6.

Table 5: The parameter value of proportional and derivative (PD)

P	I	D
3	0ms	500ms

Table 6: The result obtains from the experiment by using the PD control mode

Setpoint Value Temperature	Process Value Temperature	Overshoot Value Temperature	Rise Time
70.9℃	72.2℃	1.3℃	2 minutes

The value of parameters is test with proportional is 3 and derivative is 500ms, this combination shows that there were not suitable for combine with because derivative is too big for proportional. This make a rise time is getting shorter and the overshoot value is getting smaller. The higher the error signal rate of change, the sooner the final control element is positioned to the desired value. Several important things to keep in mind when working with PID control loops [13]. Error is the difference between the level you want and the level that is measured, and control loops work to correct error and derivative control detects and resists abrupt changes in the system [13].

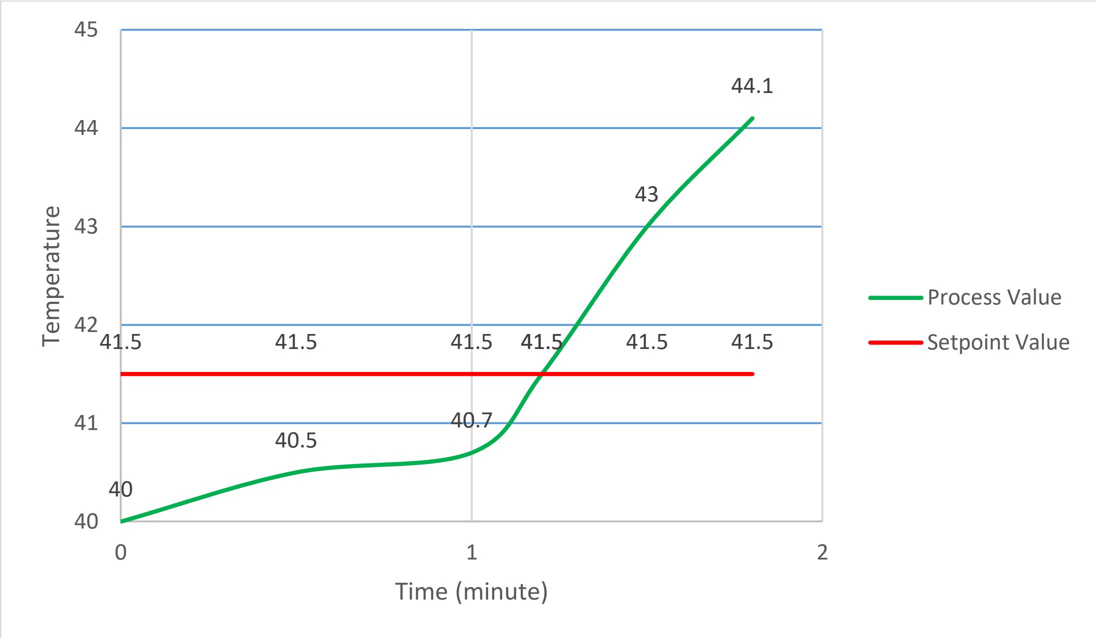


Figure 4: The response of proportional plus rate derivative (PD)

3.4 Proportional Integral Derivative PID, Integral is 500ms

The Figure 5 shows the process value temperature, setpoint value temperature, overshoot value temperature, and rise time. It can observe that the rise time was 11 minutes to cross the set point value. The overshoot value is 0.3 ℃. For this phase 3 experiment will be used the data from phase 1 and phase 2 data obtain and apply with combine it. Example on the Table 7 shows the parameter of integral was the lowest others than 2 parameters. by changing of that parameter, it will give a response for the heating process show on Table 8.

Table 7: The parameter value of proportional and derivative (PID)

P	I	D
3	500ms	10000ms

Table 8: The result obtains from the experiment by using the PID control mode

Setpoint Value Temperature	Process Value Temperature	Overshoot Value Temperature	Rise Time
65℃	65.3℃	0.3℃	11 minutes

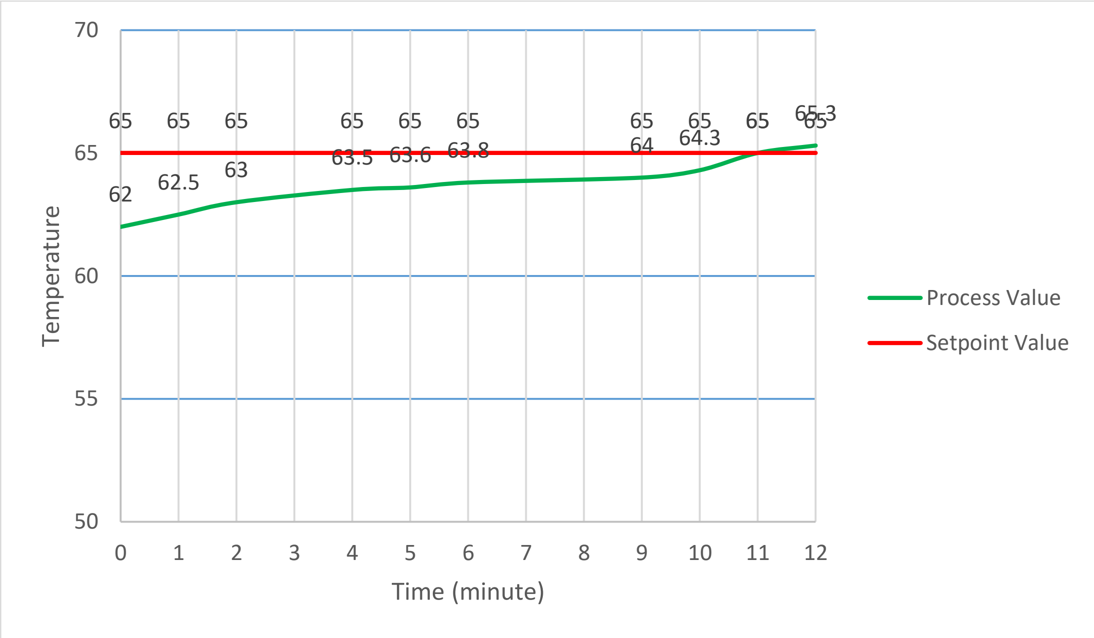


Figure 5: The response of proportional integral derivative (PID)

The value of parameters is test with proportional is 3, an integral is 500ms and derivative is 10000ms, even a small error term will cause the integral component to increase slowly. The integral response will continually increase over time unless the error is zero, so the effect is to drive the Steady-State error to zero. Steady-State error is the final difference between the process variable and set point [14]. This make a rise time is getting longer and the overshoot value is getting slower. the value of an integral can be considered because it can make the overshoot value is getting lower.

3.5 Proportional Integral Derivative PID, Derivative is 500ms

The Figure 6 shows the process value temperature, setpoint value temperature, overshoot value temperature, and rise time. It can observe that the rise time was 4 minutes to cross the set point value. The overshoot value is 1.1 ℃. The Table 9 shows the changed of parameter, after been changed from 10000ms to 5000ms and lastly to 500ms. By that parameter it will give a different of the result of experiment which is show on Table 10.

Table 9: The parameter value of proportional and derivative (PID)

P	I	D
2	500ms	500ms

Table 10: The result obtains from the experiment by using the PID control mode

Setpoint Value Temperature	Process Value Temperature	Overshoot Value Temperature	Cycling Time
75.8℃	76.9℃	1.1℃	4 minutes

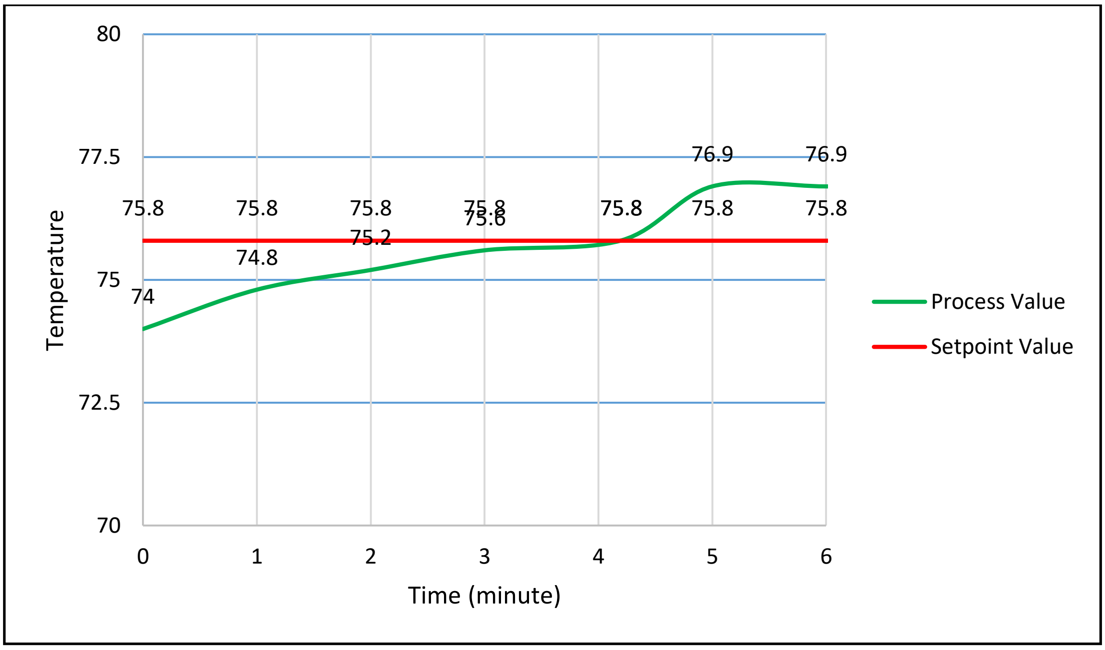


Figure 6: The response of proportional plus rate derivative (PID)

The value of parameters is test with proportional is 2, an integral is 500ms and derivative is 5000ms, this combination shows that there was considered suitable for combine with it. This is because a rise time took 4 minutes to cross the setpoint and the overshoot value is getting smaller with 1.1℃

3.6 Proportional Integral Derivative PID, Proportional is 2

The value of parameters is test with proportional is 2, an integral is 500ms and derivative is 5000ms, this combination shows that there was considered suitable for combine with it. This is because a rise time took 4 minutes to cross the setpoint and the overshoot value is getting smaller with 1.1℃. Table 11 shows the changed of parameter proportional before this the experiment have been testes with parameter 3 after changed it to 2 it gives a response toward heating temperature on Figure 7. Table 12 shows the result of response after changed the parameter.

Table 11: The parameter value of proportional and derivative (PID)

P	I	D
2	500ms	500ms

Table12: The result obtains from the experiment by using the PID control mode

Setpoint Value Temperature	Process Value Temperature	Overshoot Value Temperature	Rise Time
75.8℃	76.9℃	1.1℃	4 minutes

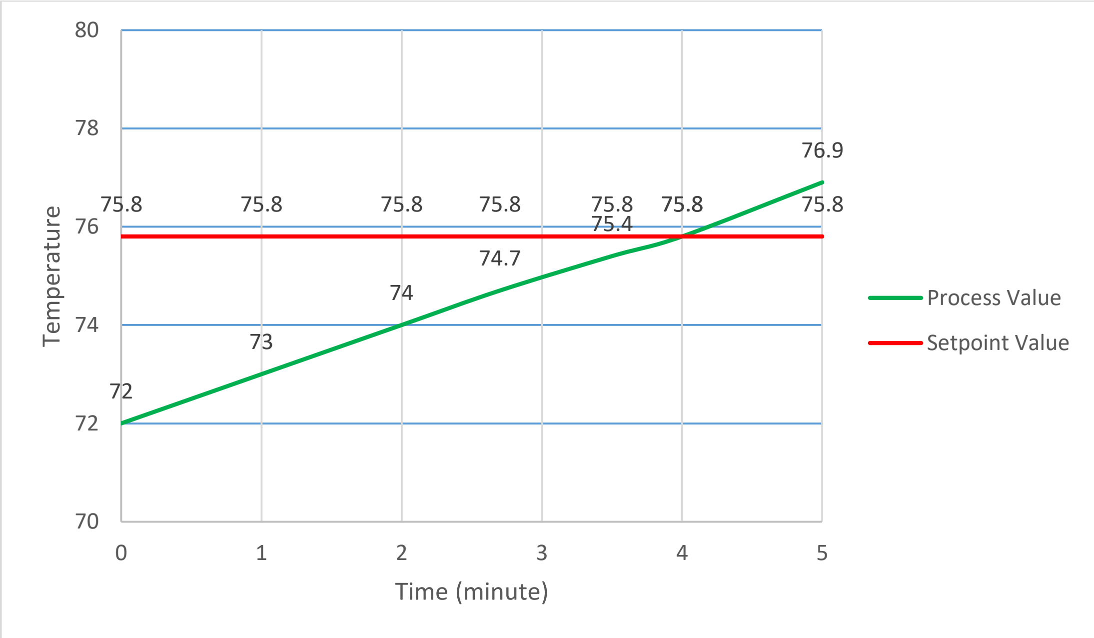


Figure 7: The response of proportional integral derivative (PID)

The value of parameters is test with proportional is 2, an integral is 500ms and derivative is 500ms, this combination shows that there were suitable for combine with it because the derivative and an integral is not too big for proportional. This make a rise time is adding one minute and the overshoot value is getting slower.

3.7 Discussions

Comparing Table 2 and Table 4 for VE203 revealed that integral action is useful for eliminating offset caused by load variations and process self-regulation. In the presence of lags and/or dead time, integral action will cause oscillation if sufficiently aggressive. In purely integrating processes, any amount of integral action guarantees overshoot following setpoint changes. Besides that, derivative action is useful for cancelling lags but useless on its own. Each action has limitations, and the derivative action dramatically amplifies process noise, causing oscillations in fast- acting processes. Each action has a unique application. Derivative action works exceptionally well for speeding up the response of processes dominated by long lag times and for assisting in the stabilization of runaway processes. The aims are to provide the parameters that can implement in DCS at plant biodiesel in UTHM is achieved because before changing the parameters the overshoot was runaway far from setpoint value and the rise time was taking long.

Table 13 show the low overshoot and fastest rise time by using the parameter for PID, proportional is 2, integral is 500ms and derivatives is 500ms to compare others parameters of control mode. The green highlight is the best result for this experiment with overshoot value with 1.1 degree Celsius and rise time taking 4 minutes

Table13: The three-control mode result of the experiment

Control Mode	P	I	D	Result
PD	2	0ms	500ms	Overshoot value: 1.3℃ Rise time: 2 minutes
PI	2	400ms	0ms	Overshoot value: 1.6℃ Rise time: 4 minutes
PID	2	500ms	500ms	Overshoot value: 1.1℃ Rise time: 4 minutes

This is not good situation for production plant for an example a recovery process at VE203, because the process is using a methanol during the heating, the properties of methanol in SDS (Safety Data Sheet) was shown a boiling point for methanol was at 64.7 degree Celsius. This can be one of safety precaution for heating process to not overshoot the process value. As we know the production plant are one of the highest demand plantations in global. Then, time management are very important for production plant, if the time is taking long for any process it can delay the production and it can give a bad feedback for the company.

4. Conclusion

The experiment result demonstrates that the PID controller is very effective and suitable for heating temperature for improving the domain characteristic of system response, such as rise time, and overshoot. In order to overcome some problems that faced by students about losses of resources about PID in subject plant control and instrument. The testing in several controller mode has been implementation on heating temperature at vessel plant biodiesel have comes out with kind of response of the controller mode. It can give easier to identify which is more suitable parameters to use for heating process at vessel especially for polishing process at plant biodiesel. According to the experiment about result and analysis. The response of PID towards heating process are related many factors such as the quality of steam, the quality of piping, the length of piping, the loss of pressure in fraction loss, the age of temperature valve, the age of temperature transmitter like RTD, the surrounding of vessel and size of vessel. This is affected the response of the controller mode, but for this experiment it achieves to overcome the overshoot value and the rise time to make it faster with currently plant biodiesel in UTHM condition.

Acknowledgement

The author would like to thank the Faculty of Engineering and Faculty of Mechanical and Manufacturing Engineering. Universiti Tun Hussien Onn Malaysia for its equipment, technical and expertise support.

References

[1] O'Dwyer, A. (2012). An overview of tuning rules for the PI and PID continuous-time control of time-delayed single-input, single-output (SISO) processes. PID control in the third millennium, 3-44.

[2] Yu, C. C. (2006). Autotuning of PID controllers: A relay feedback approach. Springer Science & Business Media

[3] O. Akan, I. Akyildiz, V.C. Gungor, A real time and reliable transport protocol for wireless sensor and actor networks, IEEE/ACM Transactions on Networking 16 (2) (2008) 359–370.

[4] Na, W. (2009, May). A new fuzzy pid controller for time delay systems. In 2009 WRI Global Congress on Intelligent Systems (Vol. 2, pp. 191-194). IEEE.

[5] Wu, Z.-Q., Xu, C.-H., Yang, Y.Hide details Adjustable PID control based on adaptive internal model and application in current shared control of multi inverters Journal of the Franklin Institute, Volume 354, Issue 7, 1 May 2017

[6] Wu, Z.-Q., Xu, C.-H., Yang, Y.Hide details Adjustable PID control based on adaptive internal model and application in current shared control of multi inverters Journal of the Franklin Institute, Volume 354, Issue 7, 1 May 2017

[7] Zhou, Y.et al. Global asymptotic stability of uncertain nonlinear system with state and input constraint,2012Bejing: IEEE

[8] Bak. M., Control of System with Constraints, in Automation, 2000, Technical University of Denmark, p.170

[9] A. Mohamed, M.A. Imran, P. Xiao, R. Tafazolli memory-full context-aware predictive mobility management in dual connectivity 5G Networks IEEE Access (2018),

[10] A.A. Abbasi, M. Younis, A survey on clustering algorithms for wireless sensor networks, Computer Communications 30 (2007) 2826–2841

[11] B. L. Chua, "Pid Tuning With Input Constraint : Application on Food,." vol. 6,no. 2, pp. 83-89, 2009.

[12] Bucz, Š., & Kozáková, A. (2012). PID controller design for specified performance. Introduction to PID Controllers: Theory, Tuning and application to frontier areas.

[13] S. L. A. V. O. J, I. E. K. (2004). Learn.parallax.com. Proportional, Integral, and Derivative | LEARN.PARALLAX.COM. Retrieved February 11, 2023, from https://learn.parallax.com/tutorials/language/pbasic/pid-control/proportional-integral-and-derivative#:~:text=Proportional%20control%20resists%20error%20by,abrupt%20changes%20in%20the%20system.

[14] Goodwin, G. C. (n.d.). The PID Controller & Theory explained. NI. Retrieved February 11, 2023, from https://www.ni.com/en-my/innovations/white-papers/06/pid-theory-explained.html#:~:text=Rise%20Time%20is%20the%20amount,percentage%20of%20the%20final%20value.