MIDDLE EAST TECHNICAL UNIVERSITY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

EE407
PROCESS CONTROL LABORATORY

EXPERIMENT 2
TEMPERATURE CONTROL WITH ELECTRONIC PID CONTROLLER

Date of the Experiment: 24/12/2018

Lab Group: Monday Afternoon 1

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I. <u>Results</u>

1)

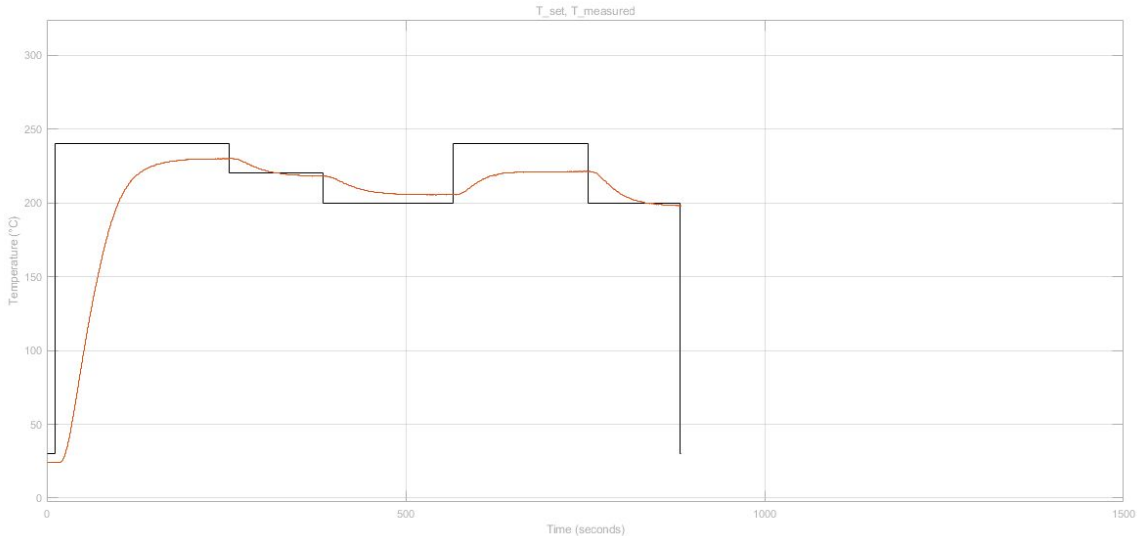

Figure 1: Step Responses for P-Controllers with $Kc = Kc,optimal$

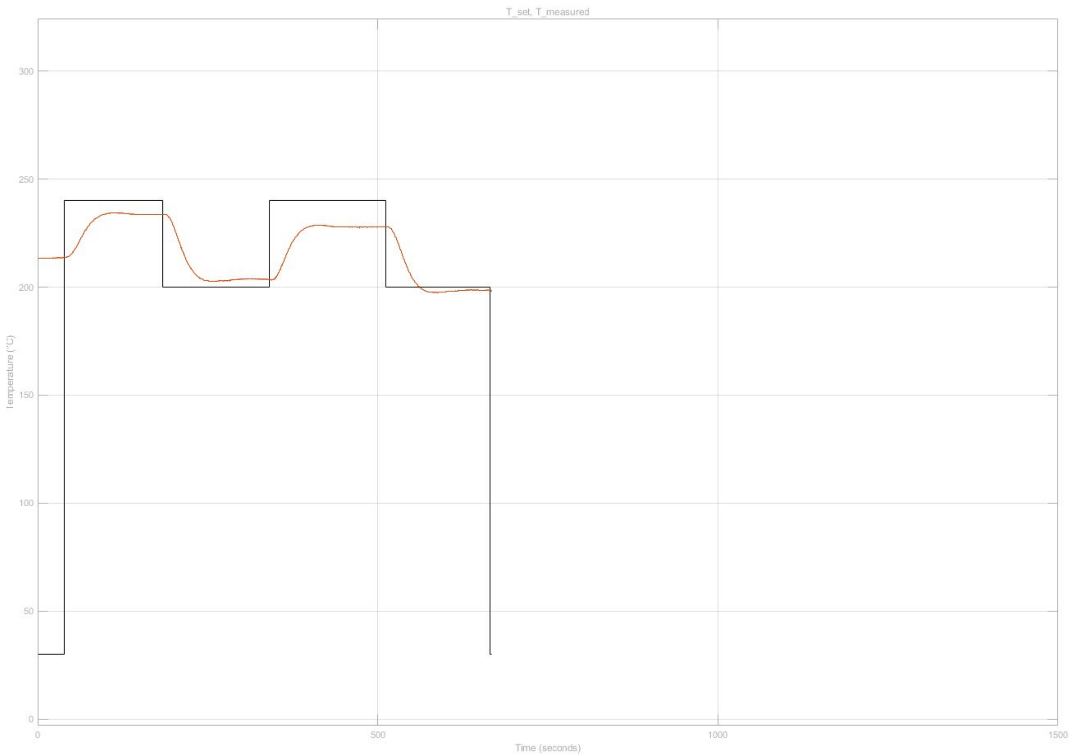

Figure 2: Step Responses for P-Controllers with $Kc = 2Kc,optimal$

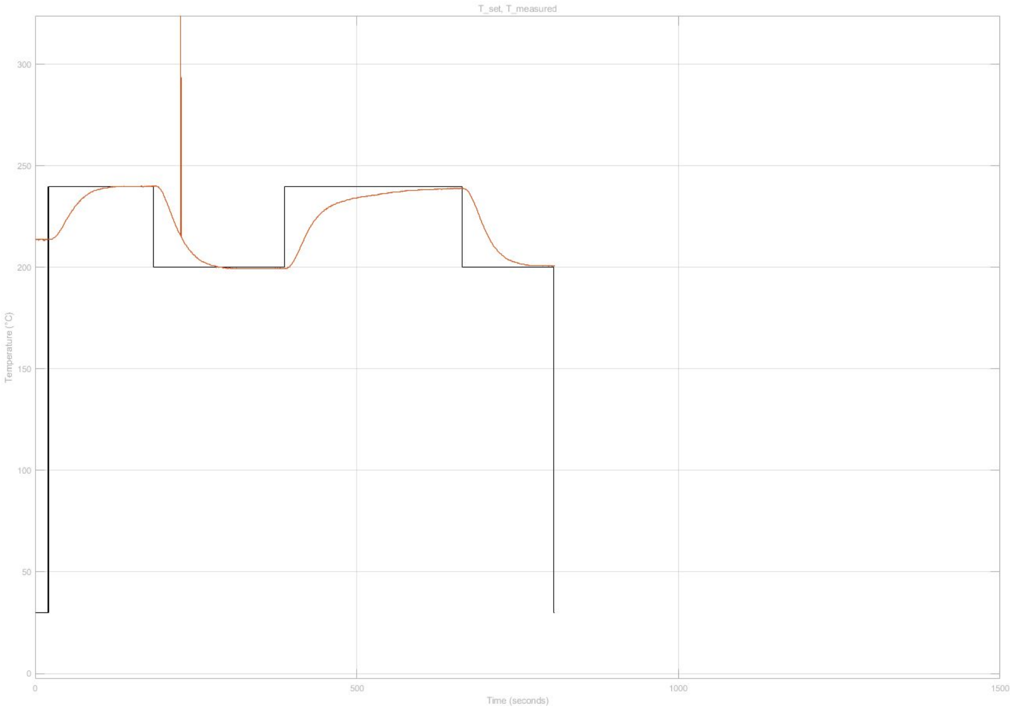

Figure 3: Step Responses for PI-Controllers with $Kc = Kc, optimal, Ti = Ti, optimal$

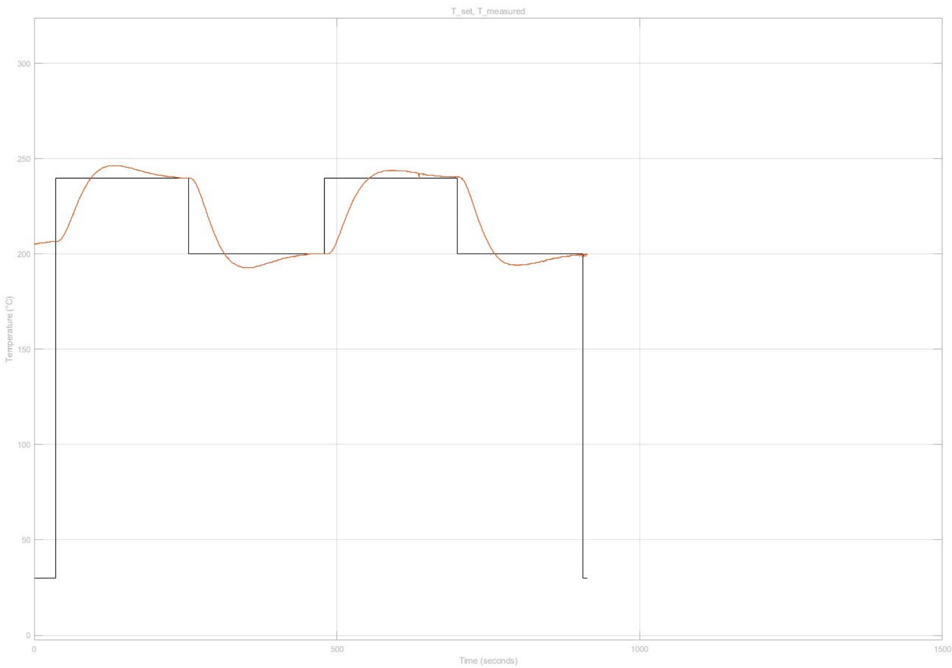

Figure 4: Step Responses for PI-Controllers with $Kc = Kc, optimal, Ti = 0.5Ti, optimal$

2) The steady state error is proportional with 1/Kc for the P-only Controllers. We obtain non-zero steady-state error when T_{set} = 220℃ with fan airflow at its minimum when we use P-only controllers. When the airflow is at its maximum, the disturbance which is energy lost due to air flow increases. Then, this result in the rise at the steady state error as can be seen from the figures.

3)

Table 1: Time Constants and Steady State Errors for P-Controllers for Minimum Air Flow

P only controllers	Set Point (Degree)	Time Constants	The Steady State Error
$K_c = K_{c,optimal}$, $T_i = 0$	**240**	**64.2 secs**	**4.25 %**
$K_c = K_{c,optimal}$, $T_i = 0$	**220**	**29.9 secs**	**0.7727 %**
$K_c = K_{c,optimal}$, $T_i = 0$	**200**	**44.4 secs**	**2.91 %**
$K_c = 2K_{c,optimal}$, $T_i = 0$	**240**	**27.7 secs**	**2.375 %**
$K_c = 2K_{c,optimal}$, $T_i = 0$	**200**	**32 secs**	**1.38 %**

As we can see by increasing the proportional gain the steady state error decreases. The time constants also decrease. However, there will be oscillations for large Kcs.

4)

Table 2: Rise Time, Settling Time and Percentage Overshoot Values for PI-Controllers for Minimum Air Flow

PI only controllers	Rise Time (90 %)	Settling Time (3 %)	Percent Overshoot
$K_c = K_{c,optimal}$, $T_i = T_{i,optimal}$	**65.7 secs**	**85.8 secs**	**0**
$K_c = K_{c,optimal}$, $T_i = 0.5T_{i,optimal}$	**53 secs**	**190.8 secs**	**2.83**

As we can see the rise time is smaller for the second case with smaller T_i, hence it shows more aggressive behaviour. The settling time increases and we also see the overshoot for the second case whereas no overshoot exist in the first case.

5) In manual reset, there is an operator manually changes the bias of the controller's output to eliminate the offset. It could be said that the controller is manually reset by the operator. The method is using for P Controller in the experiment. The value of bias is set according to 220 Degree. Hence, we observed more error at other set point values.

Automatic reset is the integral action of the controller known today. Integral action is used to increase or decrease of the controller’s output to reduce the error when there is any error. The method is using for PI and PID Controller in the experiment.

The speed of the integral action is set by the integral time setting (Ti). A large value of Ti results in a slow integral action, and a small value of Ti results in fast integral action.

II. Conclusions

In this experiment, we observed the P controller and PI controller behaviours under the different disturbance conditions while changing the set point. We used FOPDT approximation for finding the parameters.

In P controllers, the systems are self-regulating. They stabilize themselves without any corrective action. The error is nonzero except u(bias)=SP and the change of the set point makes error bigger. By increasing the gain controller the steady state error will be decreased. However, when maximum disturbance is available the steady state error will increase.

In PI controllers, we observed that the steady-state error becomes zero which means the process variable equal to the setpoint. However, when Tii is less than Ti,optimal then an overshoot occurred. When we decrease Ti, the system behaves more aggressively due to reduced rise time.