Dynamic Analysis of Absorption Column

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ABSTRACT

The absorption column is one of the essential separation processes in industrial operation, so the need arises to control absorption column by process simulation and also to analyze system by method called frequency response using MATLAB8. This work dealt with gas-liquid (air-water) absorption packed column which is analyzed by bode plot and frequency response to determine the stability of the system with or without Proportional Controller (P), Proportional Integral Controller (PI) or Proportional Integral Derivatives Controller (PID).The frequency response gives the transient response information, by defining such frequency response quantities as gain margin and phase margin. This work presents dynamic analysis of absorption column which is single input/single output (SISO) using feedback control (P, PI and PID) with the parameters of Cohen-Coon, Ziegler Nichols and Internal Model control and compares between them.

KEY WORD: absorption, control, gas, liquid, column,

التحليل الديناميكي لعمود الامتصاص

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الخلاصة

عمود الامتصاص هو واحد من عمليات الفصل الاساسية فى الصناعات البتروكيمياوية ،لذلك دعت الحاجة للسيطرة على عمود الامتصاص بواسطة عملية المحاكاة وايضا عن طريق تحليل النظام بطريقة تدعى استجابة التردد باستخدام برنامج MATLAB8. تم في هذا العمل إستخدام عمود الإمتصاص المحشو ذو نظام غاز-سائل (ماء – هواء) الذي حلل بواسطة طريقة ال (Bode) وإستجابة التردد لحساب إستقرارية النظام مع او بدون السيطرة. إستجابة التردد تعطى معلومة الاستجابة العابرة بواسطة تعريف بعض كميات استجابة التردد مثل Phase Margin And Gain Margin. هذا العمل يقدم التحليل الديناميكى لعمود الامتصاص والذى هو احادى المدخل احادى المخرج (SISO) باستخدام سيطرة التغذية الارجاعية (P,PI, and PID) مع معاملات (Ziegler - Nichols, Cohen - Coon And Internal Model Control) والمقارنة بينهم.

1-INTRODUCTION:

Gas-liquid absorption columns are largely employed in chemical industry separation units.Absorption process nonlinearities and environment variations are such that a fixed parameter conventional feedback controller cannot adequately achieve satisfactory performance [1].

Absorption is a unit operation in which an air stream containing the component intended for removal is passed upward through a packed tower while a stream of water is passed downward through the tower [2]. Contact between these streams allows for mass transfer. Packing increases the internal surface area of the tower, thus increasing the opportunity for component transfer [3].

Gas liquid absorption is a heterogeneous process, which involves the transfer of a soluble component of a gas phase into a relatively non-volatile liquid absorbent as shown Franks in 1967 [4]. Coulson in 1996 prove that gas liquid absorption could be employed in purification of waste gases [5].There are two types of absorption, first type is the chemical absorption, in which the liquid solvent reacts with the gas stream and remains in solution. Second type is the physical absorption, in which the solute in the gas is more soluble in the liquid solvent and, therefore, the solute is transferred to the liquid. Chemical is usually preferred over physical because the equilibrium for chemical absorption is much more favorable for the separation. However, physical absorption is important since it can be applied when chemical absorption is not possible [6].

Absorption equipment generally includes: stirred vessels, packed beds, and bubble columns. One of the most common and rapidly developing systems used to carry out the absorption process on an industrial scale is the packed tower. A packed tower is essentially a piece of pipe set on its end and filled with inert material or tower packing **[7].** Generally, the packed tower operates in countercurrent flow, where the liquid enters the system through the top and wets the surfaces of the packing, and the gas stream mixed with the effluent enters the bottom. As the liquid and the gas are contacted with one another, the components of the effluent can be absorbed into the liquid. Gas absorption in a countercurrent flow packed tower is dictated by the equilibrium conditions between the contaminant gas and the absorbing liquid. The overall controlling mechanisms are ruled by the solubility of the gas in the liquid and by any reactions that may be caused to occur in the liquid with the reacting chemical **[8].**Diffusion is used to move the gas to the liquid surface and the overall gas/liquid equilibrium controls the design of the tower. Since the gas is absorbed at the liquid surface, the more liquid to gas interactions that can be caused to occur, the closer the exiting streams will approach equilibrium **[7].**

The conventional method of process control is to use the feedback control loop with a controller. The control actions depend upon the control models present and at what values of gain and time constants of the model are set. A feedback system gives satisfactory control for a wide range of processes, and design of feedback loop does not demand any knowledge of the dynamic behavior of the process. Feedback can modify the natural dynamics of a system**.**Forinstance, using feedback, one can improve the damping of an under dampedsystem,or stabilize an unstable operating condition, such as balancing an inverted pendulum.Open-loop or feed-forward approaches cannot do this. For flow control applications,an example is keeping a laminar flow stable beyond its usual transition point.Classical control refers to techniques that are in the frequencydomain (as opposed to state-space representations, which are in the time-domain),and often are valid only for linear, single-input, single-output systems. Thus, in thissection, we assume that the input f and output y are scalars, denoted f and y, respectively**[9]**.

The corresponding methods are often graphical, as they were developedbefore digital computers made matrix computations relatively easy, and they involveusing tools such as Bode plots, Nyquist plots, and root-locus diagrams to predictbehavior of a closed-loop system.The most common type of classical controller, Proportional-Integral-Derivative (PID) feedback[9].

A proportional–integral–derivative controller (PID controller) is a generic control loopfeedback mechanism (controller) widely used in industrial control systems A PID controller calculates an "error" value as the difference between a measured process variable and a desired set point. The controller attempts to minimize the error by adjusting the process control inputs. In the absence of knowledge of the underlying process, a PID controller is the optimal controller**.** However, for best performance, the PID parameters used in the calculation must be tuned according to the nature of the system – while the design is generic, the parameters depend on the specific system.PI Controller (proportional-integral controller) is a feedback controller which drives the plant to be controlled with a weighted sum of the error (difference between the output and desired set-point) and the integral of that value. It is a special case of the common PID controller in which the derivative (D) of the error is not used [10].

The control system performance can be improved by combining the feedback (or closed-loop) control of a PID controller with feed-forward (or open-loop) control. Knowledge about the system (such as the desired acceleration and inertia) can be fed forward and combined with the PID output to improve the overall system performance. The feed-forward value alone can often provide the major portion of the controller output [11]. The PID controller can be used primarily to respond to whatever difference or *error* remains between the set point (SP) and the actual value of the process variable (PV). Since the feed-forward output is not affected by the process feedback, it can never cause the control system to oscillate, thus improving the system response and stability. Feedback is a mechanism, process or signal that is looped back to control a system within itself. Such a loop is called a feedback loop [12]. In systems containing an input and output, feeding back part of the output so as to increase the input is *positive feedback*; feeding back part of the output in such a way as to partially oppose the input is *negative feedback*. Feedback is also a synonym for:

- Feedback signal - the information about the initial event that is the basis for subsequent modification of the event
- Feedback loop - the causal path that leads from the initial generation of the feedback signal to the subsequent modification of the event
- Audio feedback - the special kind of positive feedback that occurs when a loop exists between an audio input and output.

Set point is the target value that an automatic control system, for example PID controller, will aim to reach [13, 14].

The computer plays an important role in the design of modern control systems. Fortunately there is computer and software that remove the hard work from the task. With desktop computer, performance analysis, design, and simulation can be made with one program, with the ability to simulate a design rapidly, easily make changes and immediately test a new design. A computer model of the system behavior may be utilized to investigate various designs of a planned system without actually building the system itself [12, 15].

Several linear control applications for absorption columns are found in the literature. **Minorsky, in 1922** worked on automatic controllers for steering ships and showed how stability could be determined from the differential equations describing the system.**Danckwerts, in 1951 and 1954**consider the liquid surface to be composed of a large number of small elements each of which is exposed to the gas phase for an interval of time after which they are replaced by fresh elements arising from the bulk of the liquid [16, 17].**Moor, in 1970** has worked with a scalar space model, using the analytic solution of the modeling equation to predict the value of the state one delay time ahead. This analytical predictor was developed primarily for sampled data systems and hence included in its structure corrections for effect of sampling and zero-order hold [18].**Najim and Ruiz in 1995**presented first principles modeling and a long-range predictive control of an absorption packed column. This equipment was used to decrease the concentration of CO2 in a gas mixture below a desired value. A solution of diethanolamine (DEA) was used as the absorbent.The flow rate of the absorbent and theconcentration of CO2 were selected, respectively,as manipulated and controlled variables. Anextended horizon control policy, based on theminimization of a quadratic criterion function ofthe input and output tracking errors, was used forthe feedback control. The simulation studieshighlighted the applicability of this adaptivecontrol algorithm to packed columns[19].**Palú et al in 2004**studied the application of a linear dynamic matrix control (DMC) to a staged absorption column[1].**Meleiro*et al*in 2005**used neural networks for the control of the fermentation step of an alcohol production process. The internal model of the nonlinear predictive controller was represented by two Functional Link Networks (FLN). This structure presented the advantages of fast training and guaranteed convergence. The performance of the proposed controller was evaluated for servo and regulatory problems, and in both cases, it showed satisfactory results[20].**Najim K., in 2007** describesthe model and solution of the constrained optimal control problem associated with a packed absorption column. The control problem is solved using a learning automaton operating in a random environment. On the basis of physical and chemical laws, a model has been developed. It consists of three hyperbolic partial non-linear differential equations. A solution of diethanolamine (the absorbent) is used to absorb the CO_2contained in a gas mixture. The primary manipulated variables are the flow rate of the absorbent and the concentration of CO_2in the gas mixture. The control objective is to maintain the concentration of CO_2close to a desired value, subject to control limit restriction, in order to avoid the flooding of the column. It leads to a stochastic programming problem, the solution of which is closely associated with the behavior of an automaton in a random environment corresponding to the column. Detailed computer simulation results which demonstrate the performance of this automaton controller are presented [21].

The aim of the present work is Design the required controller (P, PI and PTD)to improve process response and using (P, PI and PID) as a convential control methods with tuning methods (Cohen-Coon, Ziegler Nichols)

2- THEORATICAL CONTROL ON THE ABSORPTION OF AIR-WATER SYSTEM:

In this work, a gas-liquid absorption packed column operating under a continuous mode for the absorption of air-water system. Gas absorption is usually carried out in vertical counter current packed column. The packed column is arranged to operate individually.

The liquid solvent is fed at the top of the column and is distributed over the surface of the packing either by nozzle or distribution plates. Pressure tapping is provided at the base, center and top of the column to determine pressure drops across the column. Sampling points are also provided for the gas at the same three points. The liquid outlet stream and feed solution are also equipped with sampling point. Suitable manometer measurement is included. Water/solvent is taken from a sump tank, and pumped to the column via a calibrated flow meter. Air/solute is supplied and monitored from a small compressor.

The effluent gas leaves the top of the column and is intended to be exhausted to atmosphere outside the laboratory building. The apparatus is designed to absorb air into an aqueous solution flowing down the column. Gas analysis is provided for this system shown in Figure 1 below [16]. The apparatus used in the experiments consists of a glass packed cylindrical tower filled with packing material.

The packing material used was a 3/8" glass Raschig ring randomly packed into a three inch diameter by six foot high section. A Raschig ring is simply a hollow cylinder that has an outer diameter equal to its height. The liquid and gas streams are designed to flow counter-currently past each other to obtain the greatest absorption rate. The liquid (tap water) enters the column from the top and exits out the bottom, while the gas (air) enters the bottom of the column and exits through the top. Each inlet stream has two flow meters; one mechanical and the other an electrical transmitter [14].

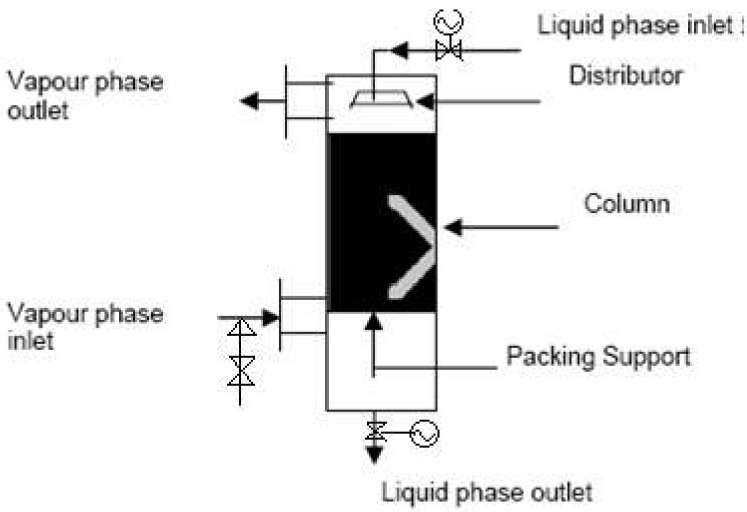

Figure (1) Gasabsorption column

P CONTROLLER:

In this type of control the output of proportional controller changes only if the error signals changes. Since a load change requires a new control valve position, the controller must end up with a new error signal; this means that proportion controller usually gives a steady state error off set. The magnitude of the offset depends on the size of the load disturbance and on the controller gain, that means the bigger gain, the smaller the offset as the gain is made bigger, however, the process becomes under damped and eventually at still higher gain, the loop will go unstable, acting like an on/off.

$P \propto E\ (t)$ … (1)

Where p is proportional controller;

Moreover, *E* (*t*) is the error which depends on time:

$P = G_c E(t) + P_S$ … (2)

$G_c = K_c$… (3)

$P - P_S = K_c E_{(t)}$… (4)

$P(s) = K_c E(s)$… (5)

$\frac{P(s)}{E(s)} = K_c = G_c(s)$ … (6)

Therefore, the transfer function of proportional controller is $Gc=Kc$… (7)

In the frequency response, proportional controller merely multiplies the magnitude of system at every frequency by constant *kc*. On bode plot, this means proportional controller raises the log magnitude curve by 20log *(kc)*dB but has no effect on the phase angle curve [13].

PI Controller

Proportional-integral controller is a feedback controller which drives the plant to be controlled with a weighted sum of the error (difference between the output and desired set-point) and the integral of that value. It is a special case of the common PID controller in which the derivative (D) of the error is not used.

The integral action eliminates steady state error. The smaller τ_I then the faster the error is reduced, but the system becomes more under damped as τ_I is reduced, if it is made too small, the loop becomes unstable.

$P = K_c E(t) + \frac{K_c}{\tau_I} \int_0^t E(t) \partial t + P_S$ … (8)

τ_I is the integral time constant

$P - P_S = K_c E(t) + \frac{K_c}{\tau_I} \int_0^t E(t)\partial t$ … (9)

$P_S = K_c E(s) + \frac{K_c}{\tau_I}\frac{E(t)}{s}$ … (10)

Therefore, the transfer function of proportional integral controller is:

$G(S) = K_c\left(1 + \frac{1}{\tau_I S}\right)$… (11)

In bode plot, at low frequency a proportional integral controller amplifies magnitudes and contributes -90 of phase angle lag. This loss of phase angle is undesirable from a dynamic standpoint since it moves the *Gm Gc*polar plot closer to the (-1,0)point **[12].**

Advantages and disadvantages

- The integral term in a PI controller causes the steady-state error to reduce to zero, which is not the case for proportional-only control in general.
- The lack of derivative action may make the system more steady in the steady state in the case of noisy data. This is because derivative action is more sensitive to higher-frequency terms in the inputs.
- Without derivative action, a PI-controlled system is less responsive to real (non-noise) and relatively fast alterations in state and so the system will be slower to reach setpoint and slower to respond to perturbations than a well-tuned PID system may be

PID Controller:

A **proportional–integral–derivative controller** (**PID controller**) is a generic control loopfeedback mechanism (controller) widely used in industrial control systems – a PID is the most commonly used feedback controller. A PID controller calculates an "error" value as the difference between a measured process variable and a desired setpoint. The controller attempts to minimize the error by adjusting the process control inputs. In the absence of knowledge of the underlying process, a PID controller is the optimal controller [22].However, for best performance, the PID parameters used in the calculation must be tuned according to the nature of the system – while the design is generic, the parameters depend on the specific system.

The derivative action helps to compensate for lags in the loop.

$P = K_c E(t) + \frac{K_c}{\tau_I} \int_0^t E(t)\partial t + K_c \tau_d \frac{\partial E(t)}{\partial t} + P(s)$… (12)

$P - P(s) = K_c E(t) + \frac{K_c}{\tau_I} \int_0^t E(t)\partial t + K_c \tau_d \frac{\partial E(t)}{\partial t}$ … (13)

$P(s) = K_c E(S) + \frac{K_c}{\tau_I S} E(S) + K_c \tau_d S E(s)$ … (14)

$\frac{P(S)}{E(S)} = K_c + \frac{K_c}{\tau_I S} + K_c + \tau_d S$… (15)

$G(S) = K_c\left(1 + \frac{1}{\tau_S} + \tau_d S\right)$… (16)

Two methods are used to find K_C, τ_I and τ_D **[13].**

Ziegler-Nichols Tuning

The **Ziegler–Nichols tuning method** is a heuristic method of tuning a PID controller. It was developed by John G. Ziegler and Nathaniel B. Nichols. It is performed by setting the I and *D* gains to zero. The "P" gain is then increased (from zero) until it reaches the **ultimate gain**K_u, at which the output of the control loop oscillates with a constant amplitude. K_u and the oscillation period T_u are used to set the P, I, and D gains depending on the type of controller usedThe period of the resulting oscillation is called the ultimate period, Pu (minutes per cycle).The Ziegler-Nichols settings are then calculated below for the three types of controllers. Notice that a lower gain is used when integration is included in the controller (PI) and that the addition of derivatives permits a higher gain and faster rest [9].

Cohen-Coon Tuning

The Cohen-Coon method of controller tuning corrects the slow, steady-state response given by the Ziegler-Nichols method when there is a large dead time (process delay) relative to the open loop time constant; a large process delay is necessary to make this method practical because otherwise unreasonably large controller gains will be predicted. This method is only used for first-order models with time delay, due to the fact that the controller does not instantaneously respond to the disturbance (the step disturbance is progressive instead of instantaneous).

The Cohen-Coon method is classified as an 'offline' method for tuning, meaning that a step change can be introduced to the input once it is at steady-state. Then the output can be measured based on the time constant and the time delay and this response can be used to evaluate the initial control parameters.

The advantages of this method it is used for systems with time delay and its quicker closed loop response time. But the disadvantagesits can only be used for first order models including large process delays, Offline method and approximation's for the K_c, τ_i, and τ_d values might not be entirely accurate for different systems [11].

Internal Model Control (IMC)

One of the most popular control strategies in industrial process control is the Internal Model Control (IMC) strategy, because of its simple structure, fine disturbance rejection capabilities and robustness. This control strategy can be used for both linear and non-linear systems. The IMC design is lucid for the following reasons

1- It separates the tracking problem from the regulation problem.

2- The design of the controller is relatively straightforward.

The IMC strategy is especially suitable for the design and implementation of the open-loop stable systems and many industrial processes happen to be intrinsically open-loop stable. A more elegant approach is internal model control (IMC). The premise of IMC is that in reality, we only have an approximation of the actual process. Even if we have the correct model, we may not have accurate measurements of the process parameters. Thus the imperfect model should be factored as part of the controller design. In the block diagram implementing IMC (Fig. **2**), our conventional controller G_c consists of the (theoretical) model controller G^*_c and the approximate function $\breve{G}_p$ [23]

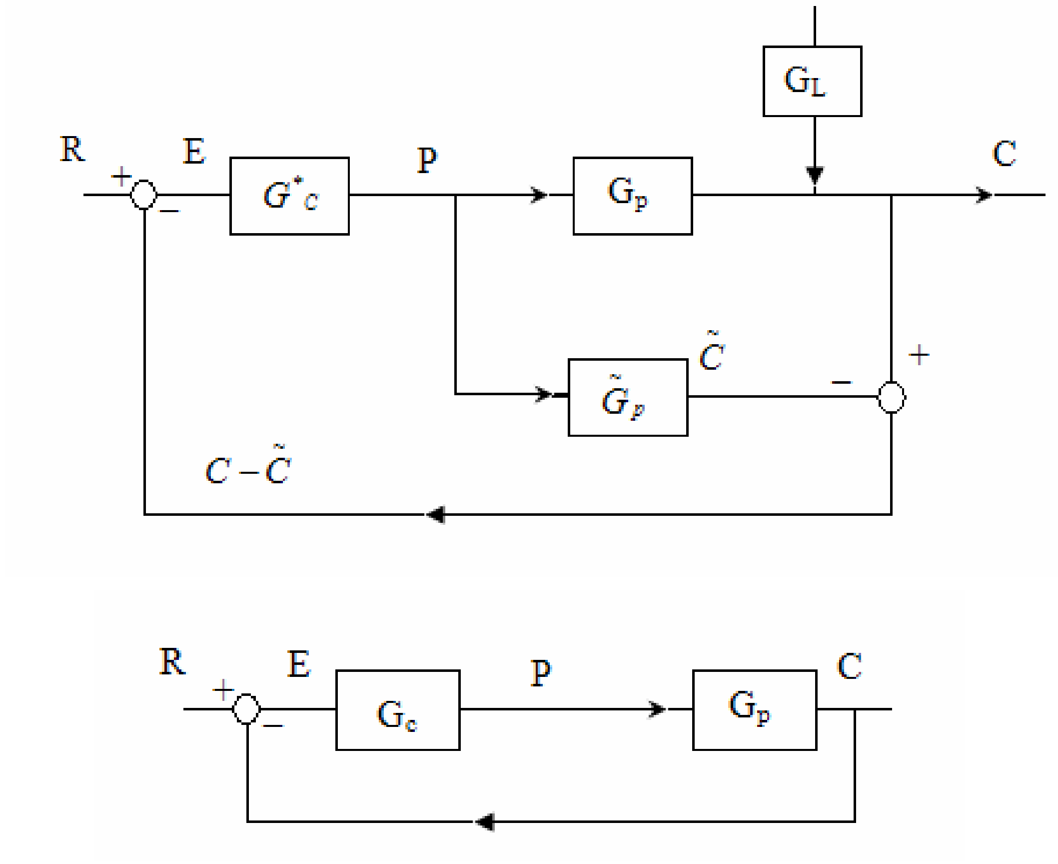

Figure (2) A system with IMC (upper panel) as compared with a conventional system

Firstly the closed-loop functions for the system must be derived based on the block diagram, the error is

$E + R - (C - \breve{C}) \ldots (17)$

And the model controller output is

$P = G_c^* E = G_c^*(R - C + \breve{C}) \ldots . (18)$

If substitute $\breve{C} = \breve{G}_p P$, then

$P = G_c^*(R - C + \breve{G}_P P) \ldots (19)$

rearrange to obtain

$P = \frac{G_c^*}{1 - G_c^* G_{\tilde{P}}} \ldots (20)$

The gist of this step is to show the relationship between the conventional controller function G_c and the other functions:

$G_c = \frac{G_{\tilde{c}}}{1 - G_c^* G_{\tilde{P}}} \ldots (21)$

This is an equation that will be used to retrieve the corresponding PID controller gains. For now, we substitute Eq.(21) in an equation around the process,

$C = G_L L + G_P P = G_L L + \frac{G_P G_c^*}{1 - G_c^* G_{\tilde{P}}} \ldots (22)$

From this step, we derive the closed-loop equation

$$C = \left[\frac{(1 - G_c^* G_{\tilde{P}}) G_L}{1 + G_c^*(G_P - G_{\tilde{P}})}\right] L + \left[\frac{G_P G_c^*}{1 + G_c^*(G_P - G_{\tilde{P}})}\right] R \ldots (23)$$

The terms in the brackets are the two closed-loop transfer function. As always, they have the same denominator---the closed---loop characteristic polynomial.There is still one unfinished business. We do not know how to choose G^*_C yet. Before we make this decision, we may recall that the poles of G_C are "inherited" from the zeros of G_p. If G_p has positive zeros, it will lead to a G_C function with positive poles. To avoid that, we "split" the approximate function as a product of two parts:

$$G_{\tilde{P}} = G_{\tilde{P}+} G_{\tilde{P}-} \ldots (24)$$

With $\breve{G}_{P+}$ containing all the positive zeros, if present. The controller will be designed on the basis of $\breve{G}_{P-}$ only. Now define the model controller function is defined as

$$G_c^* = \frac{1}{G_{\tilde{P}-}}\left[\frac{1}{\tau_c S+1}\right]^r, where\ r = 1,2, etc \ldots (25)$$

τ_C equal two-thirds the value of dead time

τ_c is the closed-loop time constant and our *only* tuning parameter. The first order function raised to an integer power of *r* is used to ensure that the controller is physically realizable.

Repeat the derivation of a controller function for a system with a first order process with dead time using IMC.

By modeling our process as a first order function with time delay, and expecting experimental errors or uncertainties, our measured or approximate model function is

$$G_{\tilde{P}} = \frac{K_P e^{-t_d S}}{\tau_P S+1} \ldots (26)$$

The first order Padé approximation is used for the dead time and the positive zero term is isolated as in Eq.(24)

$$G_{\tilde{P}} = \frac{K_P}{(\tau_P S+1)\left(\frac{t_d}{2}S+1\right)}\left(-\frac{t_d}{2}S+1\right) = G_{\tilde{P}-} G_{\tilde{P}+} \ldots (27)$$

Where

$$G_{\tilde{P}+} = \left(-\frac{t_d}{2}S+1\right) \ldots (28)$$

If we choose r=1, eq.(3.6.9) gives

$$G_c^* = \frac{(\tau_P S+1)\left(\frac{t_d}{2}S+1\right)}{K_P}\frac{1}{(\tau_C S+1)} \ldots (29)$$

Substitution of Eq. (27)into Eq.((20)), and after some algebraic work, will lead to the tuning parameters of an ideal PID controller :

$$K_c = \frac{1}{K_P}\frac{\left(2\frac{\tau_P}{t_d}+1\right)}{\left(2\frac{\tau_C}{t_d}+1\right)} \ ; \tau_1 = \tau_P + \frac{t_d}{2} \ ; \ \tau_d = \frac{\tau_P}{2\frac{\tau_P}{t_d}+1} \ldots (30)$$

3- RESULTAND DISCUSSION

The process simulations are represented and explain in these figures. Before running the process simulation controllers we must test it without controllers. Figure3 and 4 represents the block and step response respectively of absorption column without any controller.

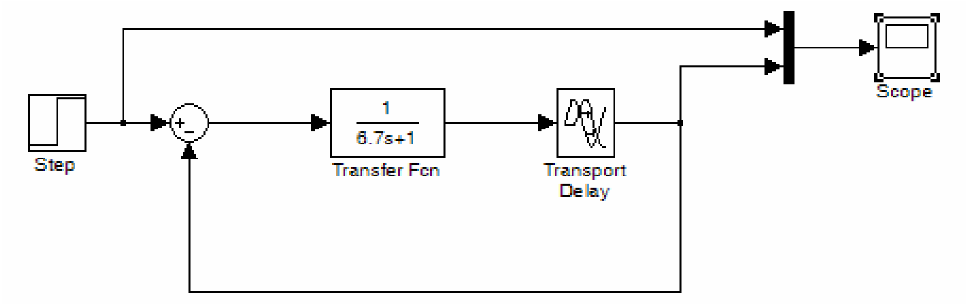

Figure (3) Block diagram of absorption column without controller

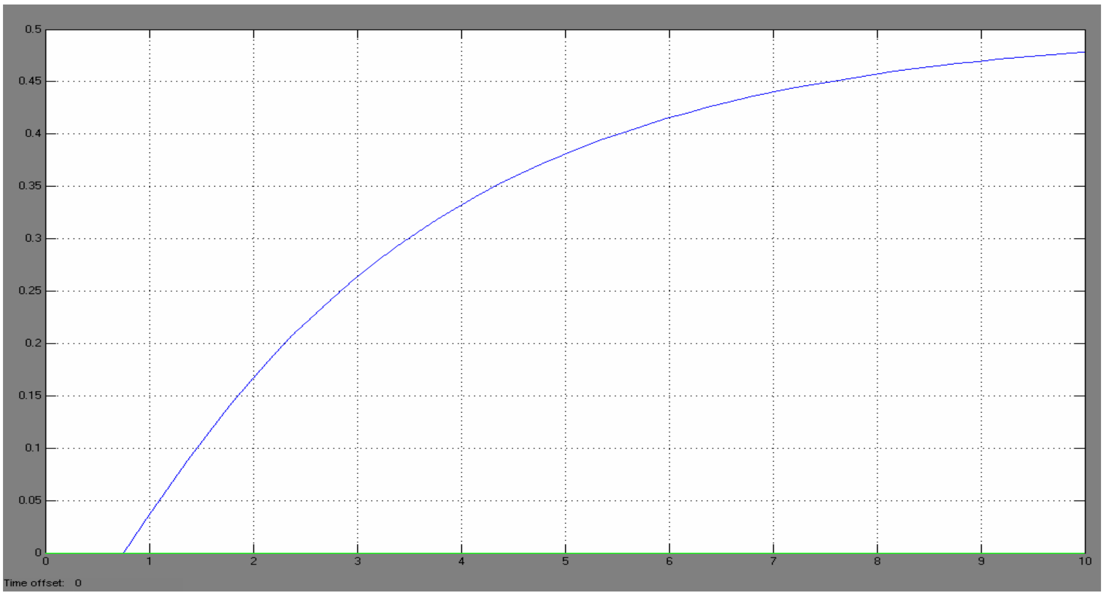

Figure (4) Response of absorption column without controller

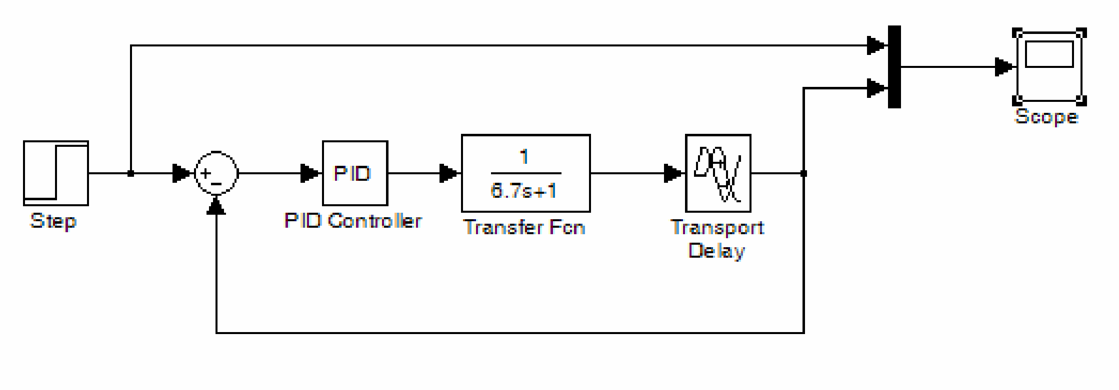

Figure (5) Block diagram with controller

Figure 4 shows the step change of system without controller, while figure 5 shown the system with controller.Comparison is made between P, PI and PID for each method used in this work via response to see which is the best value of controller setting that gives the best steady state value of control variable.When the P controller is applied to the Cohen-Coon tuning and Ziegler-Nichols tuning as represented infigure 6 and 7 which shows that when only the proportional actionwere applied, the control system is able to arrest the rise of the controlled variable and ultimately bring it to rest at a new steady-state value. The difference between this new steady-state value and the original value is called offset. The offset value of these figures is 2.5%.

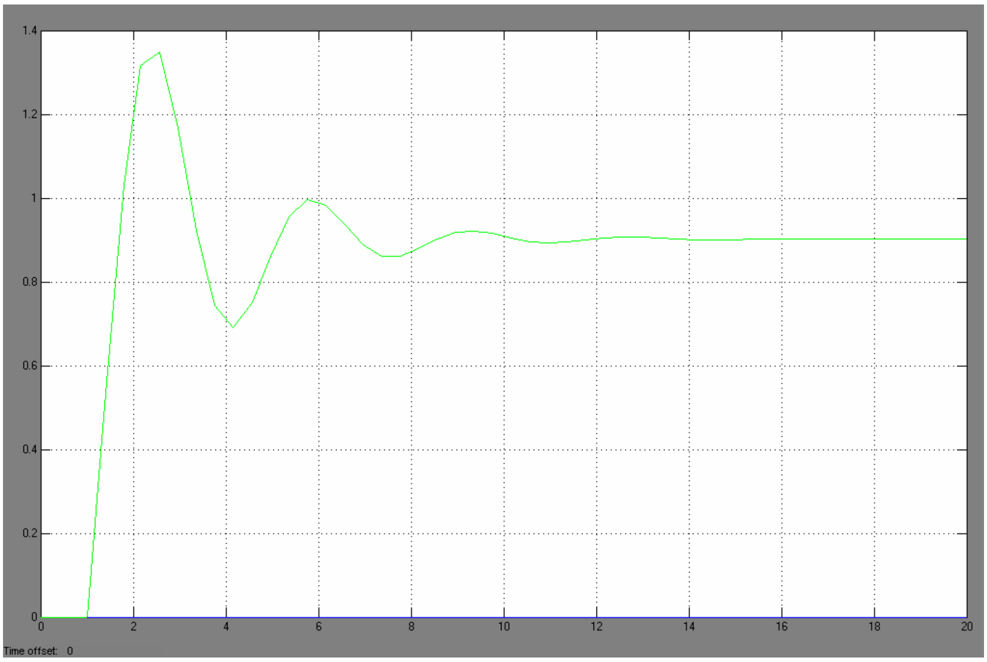

Figure (6) Response of control variable using P controller with Cohen-Coon tunin

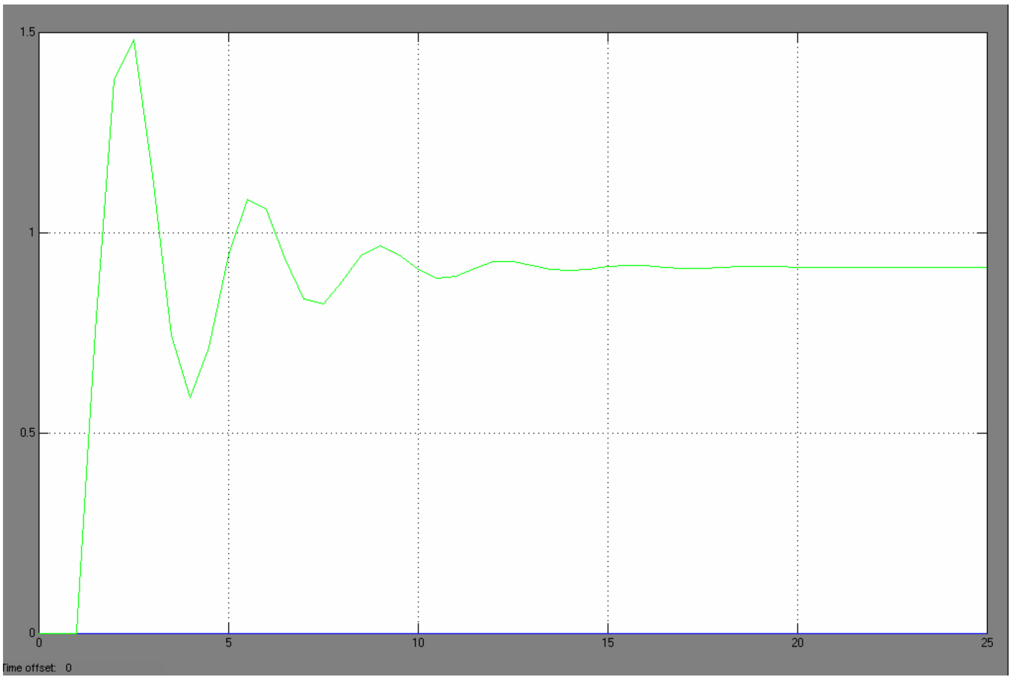

Figure (7) Response of control variable using P controller with Ziegler-Nichols tuning

In the PI controller when it is applied to the Cohen-Coon tuning, Ziegler-Nichols tuning and internal model control as shown in figure 8, 9 and 10. Figure (8) shows the too much oscillation so the system in Internal Model Control with PI controller is unstable. On the other hand in Figures (9) and (10) applying the proportional-integral will eliminate the offset and the controlled variable ultimately returns to the original value.

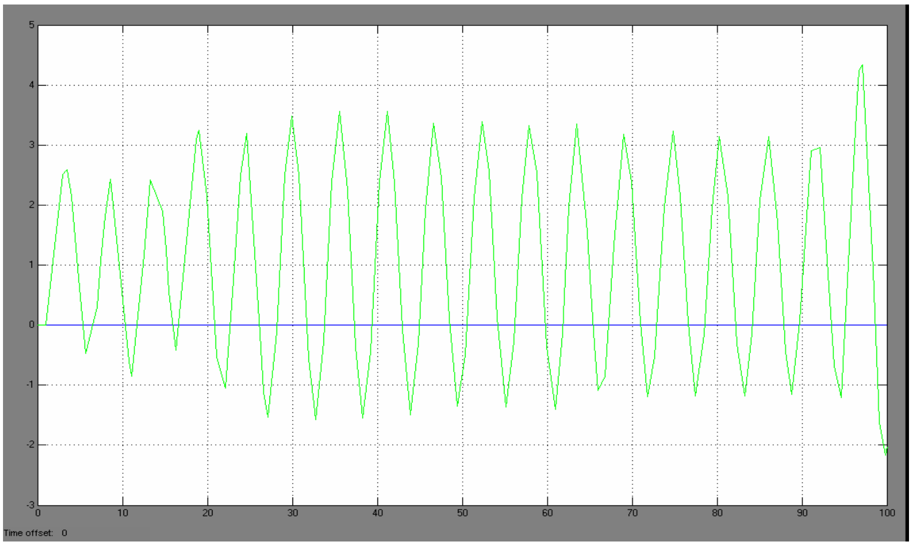

Figure (8) Response of control variable using PI controller with Internal Model Control tuning

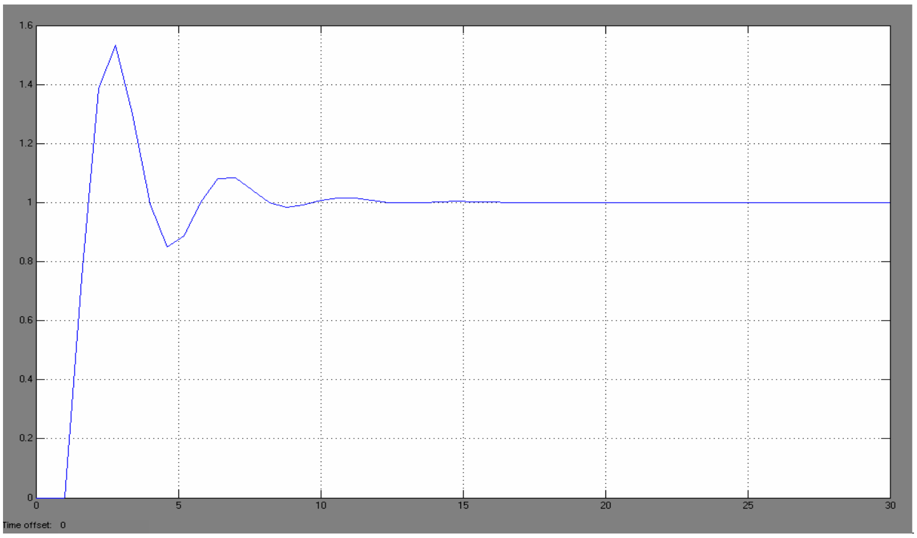

Figure (9) Response of control variable using PI controller with Cohen-Coon tuning

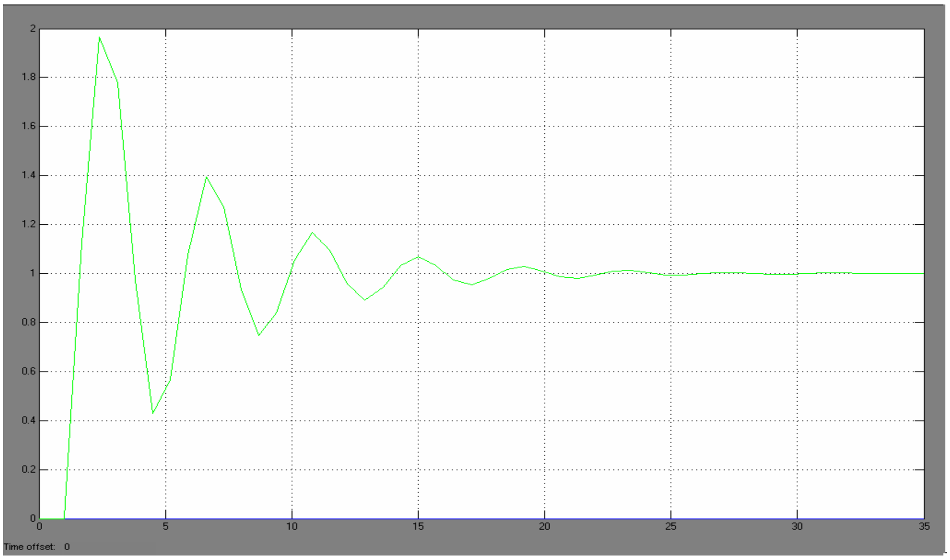

Figure (10) Response of control variable using PI controller with Ziegler-Nichols tuning

When the PID controller is applied to the Cohen-Coon tuning, Ziegler-Nichols tuning and Internal model control we get the following diagrams:

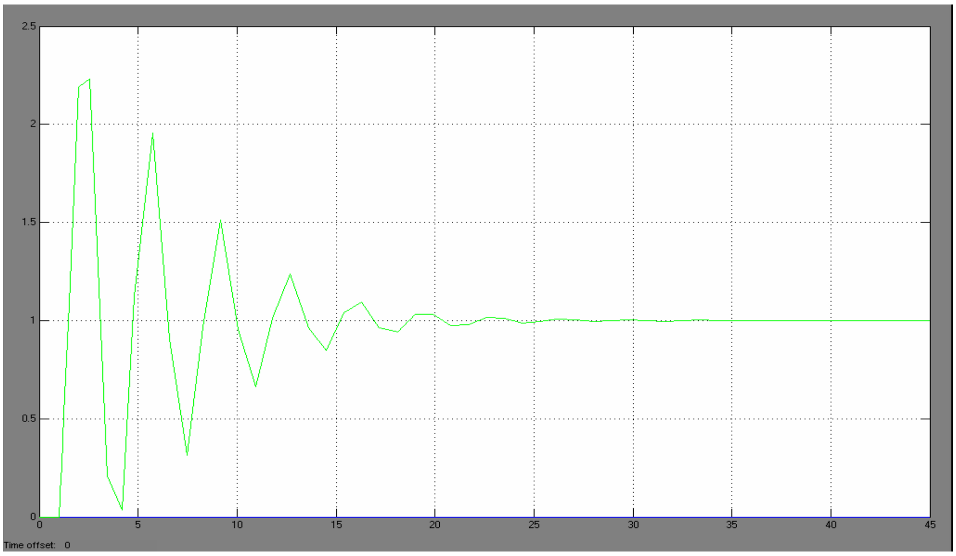

Figure (11) Response of control variable using PID controller with Internal Model Control tuning

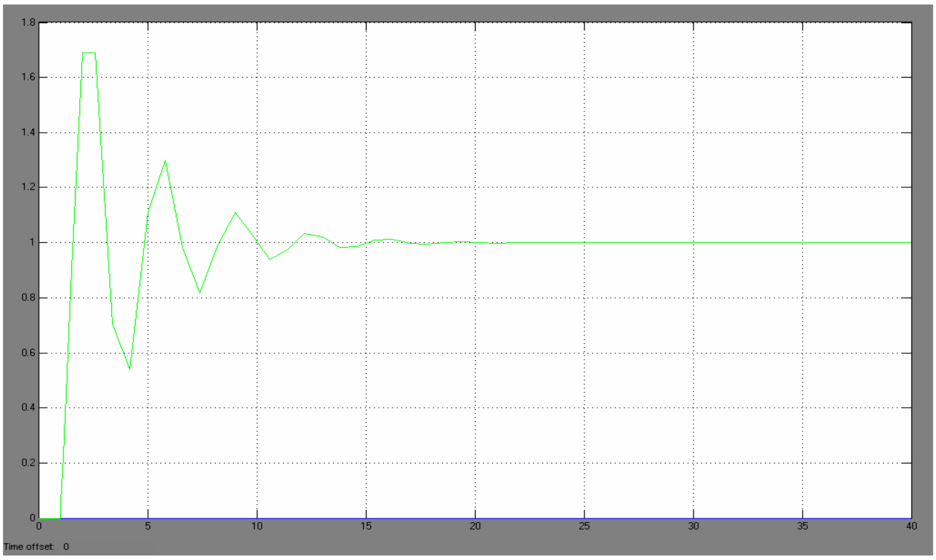

Figure (12) Response of control variable using PID controller with Cohen-Coon tuning

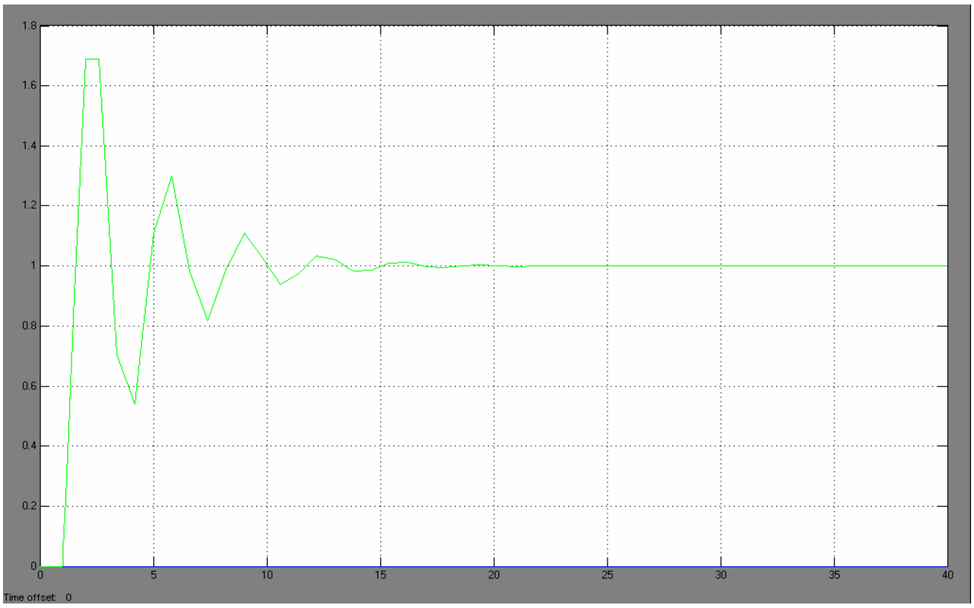

Figure (13) Response of control variable using PID controller with Ziegler-Nichols tuning

Figure (11) shows that the oscillation in Internal Model Control with PID controller is more than that of Cohen-Coon tuning and Ziegler-Nichols tuning.On the other hand Figures (12) and (13) show that when the proportional-integral is applied, it will eliminate the offset and the controlled variable ultimately returns to the original value, so they are stable. The all times responses for all figures from (6) to (13) are presented in Table (1) below

Table 1: Times Responses

Method	**Controller**	**Settling time(sec.)**	**Rise time (sec.)**	**Steady state**
Cohen-Coon	P	5.70	0.56	0.905
	PI	9.20	0.589	1
	PID	2.32	0.267	1
Ziegler-Nichols	P	6.65	0.979	0.916
	PI	6.35	0.539	1
	PID	—	N/A	Inf.
Internal Model Control	—	—	—	—
	PI	21.8	3.42	0.334
	PID	—	N/A	N/A

In Table 1 it can be noticed that the Cohen-Coon tuning with PID controller is the best method for reaching stability in the open loop system compared with other methods using other kinds of controllers, this is because the Cohen-Coon tuning with PID controller has the lowest settling time and rise time of all the others.

4- CONCLUSIONS

The present work was carried out to study the "real time" process simulation in process control and process control for different control strategies. The time response which includes settling time, rise time and steady state show that Cohen-Coon method in PID controller has the lowest settling and rise time with steady state equal to one. This means that the Cohen-Coon method is the best to get stability. To improve process response we must use P, PI and PID controller and compare between them.

The response Figure for the system without controller is unstable but when controller is used the system is more stable. From these figures it can be seen clearly that Cohen-Coon tuning with PI controller is more stable and the controlled variable ultimately returns to the original value.

5- NOTATION:

A Cross sectional area of the column m^2
A The packing area per volume m^{-1}
C State Space -
E Experimental error -
F Feed Rate Kmol/s
$|G_{(jw)}|$ Magnitude of the open loop system -
$G_{(jw)}$ The open loop transfer function -
G^*_C Theoretical transfer function -
G_C Transfer Function of Controller -
G_m theMolor Flow rates of The Gas and Liquid Kmol/s
$\sim G_P$ Approximate transfer function -
H Henry's law constant -
K_C Controller Gain -
K_G Mass transfer coefficient of gas phase -
K_s Steady State Gain -
L_m The Molor Flow rates of The Gas and Liquid Kmol/s
P Total pressure which is constant $N\ m^{-2}$
r Integer power -
s Laplace Form -

Greek Letters

τ Time constant s
τ_D Derivative time s
τ_I Integral time s

Subscripts

i Number of component
j Number of component

Abbreviations

ADC Analog to digital converter
DAC Digital to analog converter
MIMO Multi-input/Multi-output
ODE's Ordinary differential equation
P Proportional controller
PI Proportional integral controller
PID Proportional integral derivatives controller

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