Control Loop Project with SIMCET

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TRACCIA

1) simula la risposta dinamica "ad anello aperto" a seguito di una variazione nel *controller output* a **gradino**, di un valore "a piacere" "a scendere"
2) adotta un controllore PID "ideale" ed effettua il *tuning* ottimale
3) riporta il sistema dinamico nelle stesse condizioni di partenza
4) chiudi l'anello e simula la risposta dinamica "ad anello chiuso" a seguito di una variazione nel *set point* a **gradino**, di un valore "a piacere" "a scendere"
5) raddoppia i valori scelti di K_P e τ_P
6) fai il confronto e commenta le risposte "ad anello chiuso" e quella "ad anello aperto"

DEVELOPEMENT

Using the "SIMCET" program, let's analyze the functioning of the temperature control on a reactor. The reactor is a jacketed one reactor. The reactor temperature is measured by with a sensor.

The controller has to bring the reactor temperature value as close as possible to the set point value.

For To do this job work the controller will send a flow of steam to the jacket in order to change the reactor temperature.

We consider the temperature of the external environment as a manipulated variable and the wind speed as a disturbance.

The dynamic mathematical model that describes the case in question is the following:

- Time domain: $\dot{Q}_g - U_a S(T - T_a) - C v_V = V \rho_w C p_w \frac{dT}{dt}$

We replace the deviation variable and we write the equation in canonical form:

$$V\rho_w C_{pw}\frac{dT^1}{dt} + U_a S T^1 = U_a S T_a^1 - C v_v^1$$

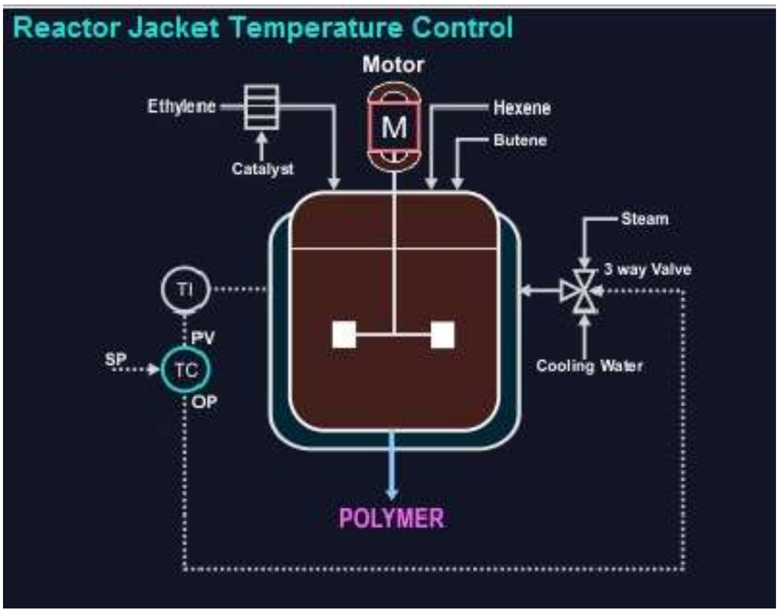
$\tau_p = \frac{V\rho_w C_{pw}}{U_a S}$; $k_{p_1} = \frac{U_a S}{U_a S} = 1$; $k_{p_2} = \frac{C}{U_a S}$

$\tau_p \frac{dT^1}{dt} + T^1 = k_{p_1} T_a^1 - k_{p_2} v_v^1$

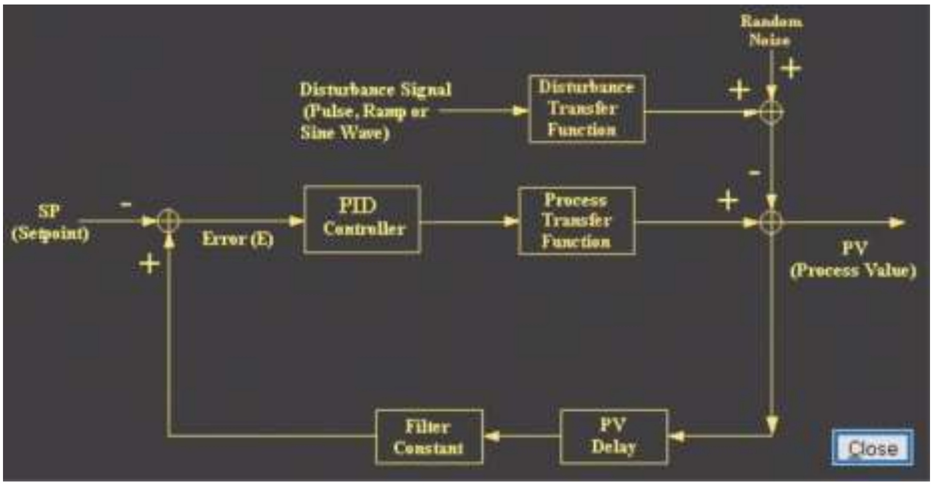
- LaPlace domain: $\tau_p[S\overline{T}^1(S) - T^1(0)] + \overline{T}^1(S) = k_{p_1}\overline{T}_a^1(S) - k_{p_2}\overline{v}_v^1(S)$

$$\overline{T}^{1}(S)[\tau_p S = +1] = k_{p_1}\overline{T}_a^{1}(S) - k_{p_2}\overline{v}_v^{1}(S)$$

We show the scheme of the case in question with a screenshot.



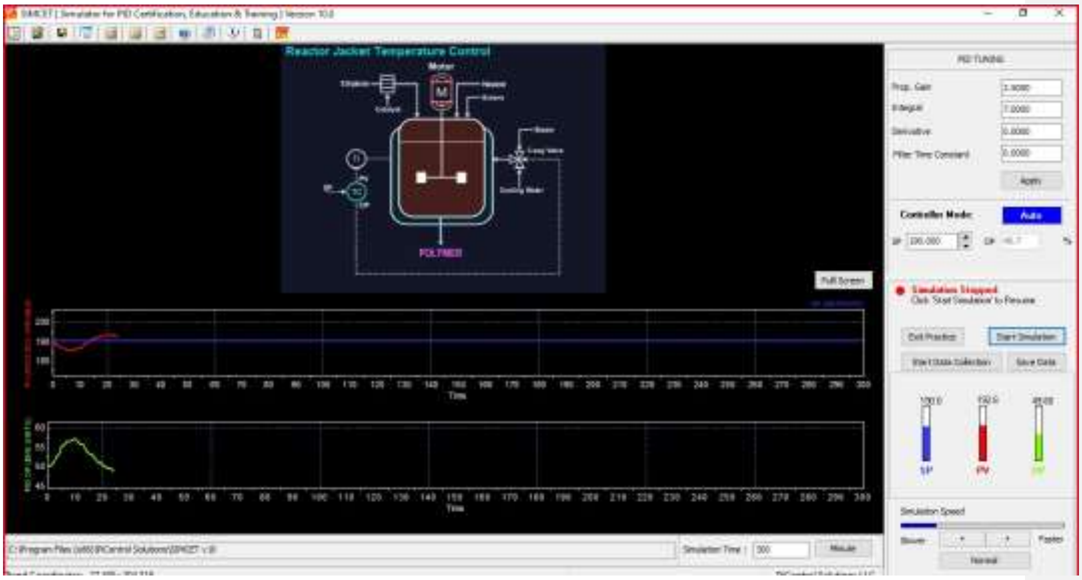
Similarly, we show the control loop with a block diagram that better explain how it works.



Proceeding with the development, we will first show a screen of the main page of the program and then, based on the actions we are going to perform, we will show focuses.

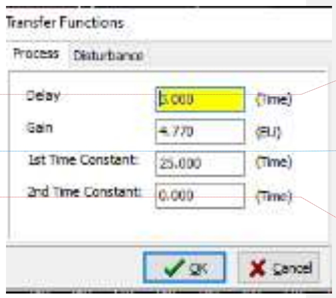
In this way we focus on changes we make to the program regarding requests.

The unit of measurement of time selected in this project-work is the minute.



$G(s) = \frac{K_p}{\tau_p s+1} e^{-t_d s}$ the parameters in the TF are Kp=4,7, τp=25, td=3

We selected these value at will according to the trace.



Commentato [MM(1]: MANCA la descrizione o l'ottenimento della TF attribuita inizialmente al *jacketed reactor*

Commentato [DC3R2]: La differenza è dovuta al fatto che abbiamo preso valori a piacere diversi da quelli dell'elaborato precedente.

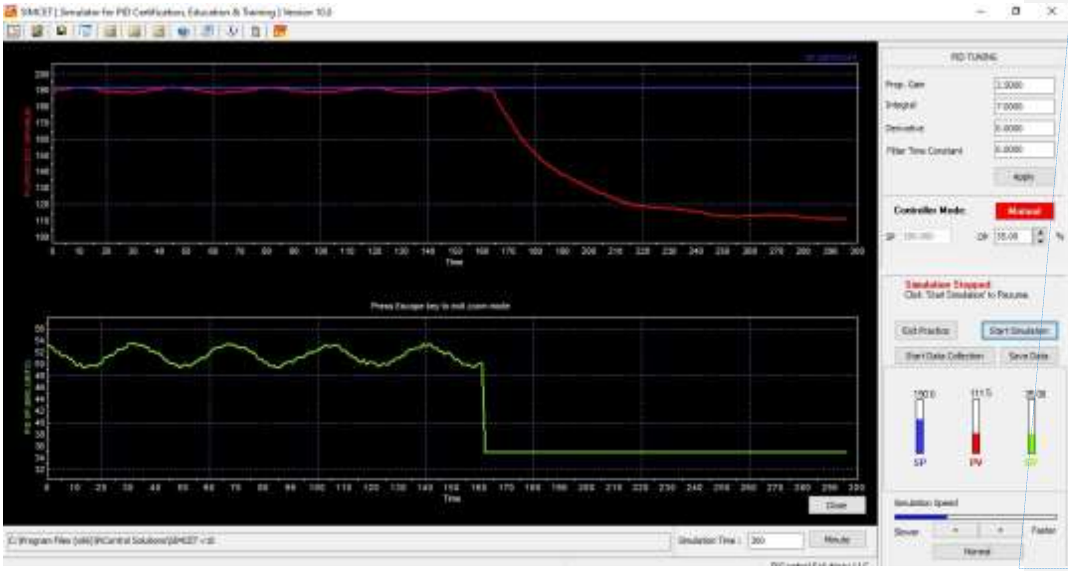
Commentato [MM(2]: Comunque,
mi sembra dalla figura finale che la TF ha:
Kp=4.7
tauP=25
mentre Adinolfi aveva:
Kp= -0.403 (sist. ad azione inversa)
tauP=2.38 min
Perché questa differenza?

Initially the program starts with a set point of 190 ° C and controller mode in automatic. Let's set the program to “open loop”, then we change the controller mode from automatic to manual.

Now we can change the OP value and modify the opening of the three-way valve. To have a downward trend, we close a valve by decreasing OP from 50% to 35%.

The program starts to graph the dynamic step response due to the change just made.

The response is shown in the next figure.



Commentato [DC5R4]: Per quanto riguarda il salvataggio non so perché ma ci dà errore oppure ci dice che non siamo abilitati a farlo.

In this simulation it is possible to register and save data, to obtain a new FOPDT model and tuning PID controller.

Commentato [MM(4]: DOMANDA:
da questa simulazione, che è in pratica uno “step test”, è possibile:

1.salvare i dati in un file?
2.ottenere un nuovo modello FOPDT di fitting dei dati dinamici?
3.fare un nuovo tuning del controllore PID?

To make the PID optimal, let's configure the parameters by clicking the fourth icon at the top left “PID Configuration”.

By setting the PID Execution Period as low as possible, we ensure that the PID responds with a high speed and therefore is faster in carrying out its action.

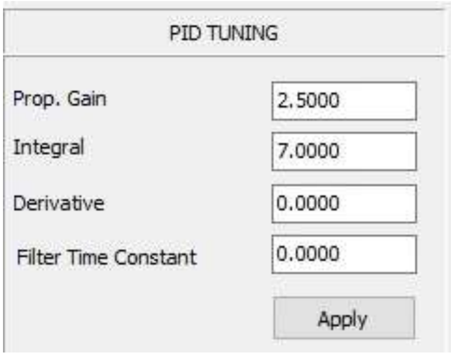
The parameters are already optimal, in fact the curve of the process variable is quite precise.

Otherwise we would have had to modify the parameters of the PID to be able to have a precise curve.

The upper figure shows the PV Noise value, i.e. the noise value. Noise is a common interference in all equipment. On average the noise is around 4%, so to have a very realistic case we should bring PV Noise to at least 4%.

Commentato [MM(6]: MANCA
la spiegazione circa il valore dei parametri:
sono già "ottimi" ?
Come sono stati ottenuti ?

However we are considering a more or less ideal case in which we are able to greatly reduce the noise and therefore we keep the starting value of PV Noise equal to 0.3%.



PID CONTROLLER LAW:

Time domain

$$o(t) = K_c \left[\varepsilon(t) + \tau_D \frac{d\varepsilon}{dt} + \frac{1}{\tau_I} \int_0^t \varepsilon(t^*) dt^* \right] + c_s$$

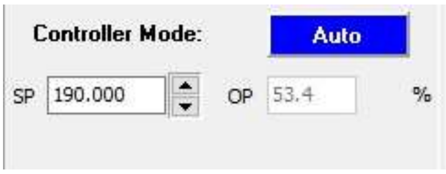
Laplace domain

$$G_{PID} = K_c \left(1 + \tau_D s + \frac{1}{\tau_I s} \right)$$

We can change the constants in the PID controller equation. If we excessively modify a parameter, this will result in a change in both the PID OP diagram and the PV diagram.

In Automatic mode, excessively increasing the derivative parameter means that the action of this term is too high, causing a jagged response. While excessively decreasing the value of the integral parameter, its action causes the PID OP to oscillate.

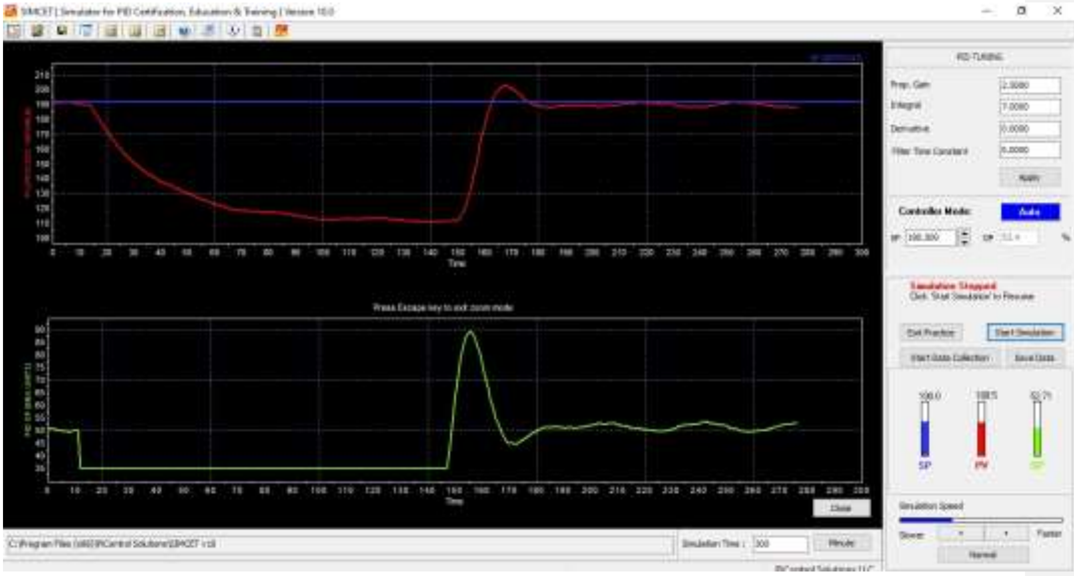
To bring the dynamic system back to the starting conditions, we move the controller mode from manual to automatic, so that the automatic control loop is restored. We will obtain that through an automatic variation of the OP, the process variable will be as close as possible to the set point value.



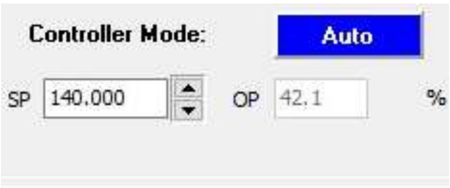
From the next focus, it is possible to see how the dynamic response changes.

Firstly it changes due to the switch in manual mode, where the response is step-down.

Then it changes when we set the program in automatic mode, where the response oscillates approaching the set point.



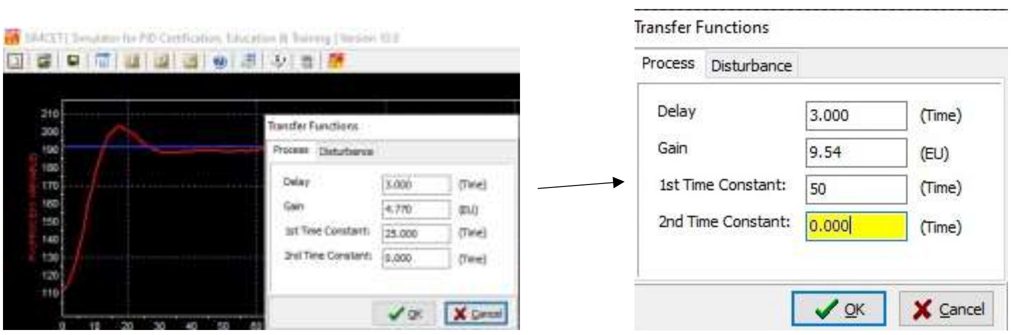
To simulate the step response downward in closed loop, we vary the value of the set point from 190 ° C to 140 ° C.



From the next focus, it is possible to see the step down dynamic response due to the variation of the set point. The response will then oscillate to get as close as possible to the new set point value.

To double the selected values of KP and ĩP, we click the icon "T" in the upper left.

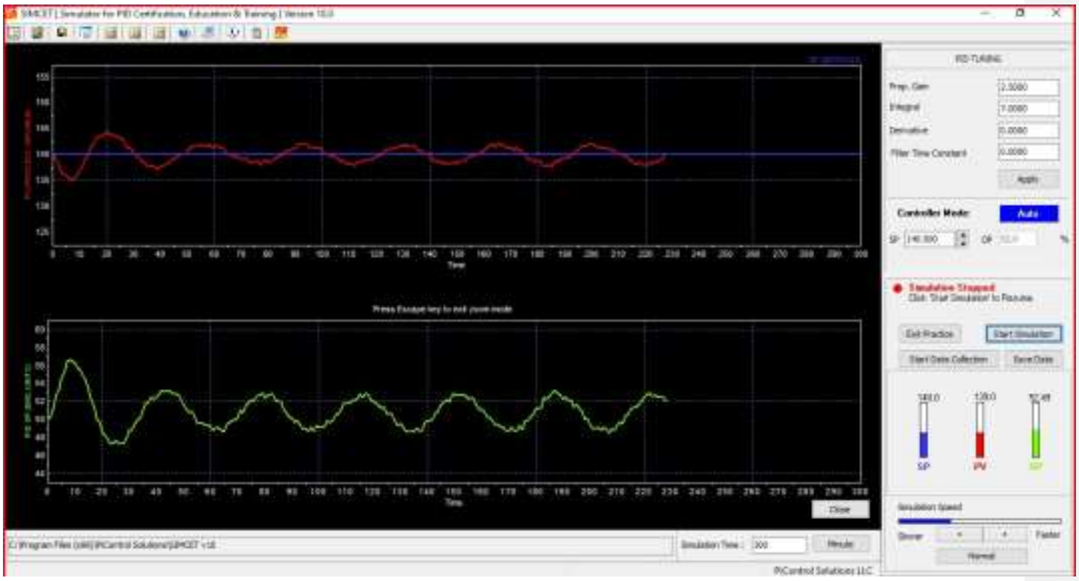
A window will open and we can change the values of the terms of the transfer function.



From the next focus it is possible to see the variation of the dynamic response following the variation of the values of KP and ĩP. We note that the dynamic response fluctuates continuously with the same period. This makes us deduce that we are in the case where Kc = ku.

Graphically we can calculate the amplitude and the period of oscillation. Pointing the cursor on the points of the graph, we can read the coordinates of the point at the bottom left. We point the cursor on the beginning and the end of the oscillation, we make the difference between the abscissa of the two points, we calculate the period of oscillation. Similarly, if we point the cursor on a peak and make the difference with the set point, we obtain the amplitude of the oscillation.

The period of oscillation is ĩ0 = 40 min, while the amplitude of the oscillation is T = 3.



In conclusion, we compare the open loop response with the closed loop response.

The closed loop response, due to a variation of KP and τP, has shown an oscillatory trend around the set point value of both the controller output and the processed variable without reaching a constant value. [see the above Fig. ~~up~~]

The open loop response has shown that the observed system corresponds to a FOPDT model, self-regulating with dead time equal to 3 minutes with positive static gain because the "downward" variation of the controller output involves a decrease in the process variable measured. [see the Fig. below ~~under~~].


Integral
Filter Time Constant
Apply
Controller Mode:
Start Data Collection
Save Data
SP
PV
Faster
Normal