SOFTWARE FOR ANALYSIS AND SYNTHESIS OF INDUSTRIAL PROCESSES

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The applications of Matlab are more than significant for the science development nowadays. Its diversity and flexibility are of important use in the domain of the automatics, more particularly to improve the time performances.

The present paper has been focused on the development of software, which models, simulates and regulates industrial systems, by executing different empirical methods. The process regulation has been made with a graphical user interface (GUI) that ranges variety of interactive windows, menus, buttons and graphical representation of the simulations, where the results are clearly displayed. Moreover the program promptly and correctly compares the methods of interest and finds the optimal solution for the system.

1. EMPIRICAL MODELS OF INDUSTRIAL PROCESES

In manufacturing, the main goal of the automatic engineers is to find the optimal regulator for the industry processes systems. For that purpose they initially strive to obtain an analytical model, which further helps them to calculate the parameters of the regulators. In some cases it is very difficult to develop a physical model of the system. For that reason Ziegler-Nichols, Strejc and Broida suggest their empirical models that are sufficiently accurate and very simple to apply since all the required information about the system, is the output transient characteristic (reponse indicielle). A brief presentation of the methods for calculation of those models is presented below (Table 1).

<table>
<tr><th>Method/ Analytical model G(p)</th><th>Description</th><th>Graphical representation</th></tr>
<tr>
<td>Ziegler-Nichols

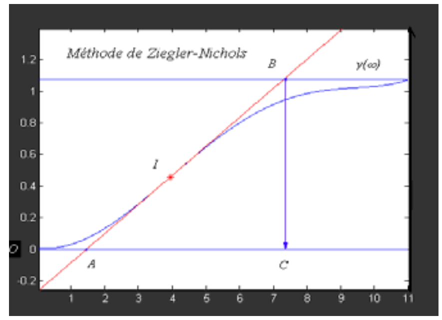
$$G(p)=\frac{Y(p)}{X(p)}=\frac{k_\infty e^{-\tau_Z p}}{T_Z p+1}$$
Equation (1)</td>
<td>Specifies the approximation of G(p) of the first range systems with delay τ, where k_∞ is the final value of the transient simulation, τ_z = OA – the delay and T_z = AC – the time constant as shown on the Fig. 1 below.</td>
<td>

Fig. 1. Ziegler-Nichols</td>
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<tr>
<td>Strejc

$$G(p)=\frac{Y(p)}{X(p)}=\frac{k_\infty e^{-\tau_s p}}{(T_s p+1)^n}$$
Equation (2)</td>
<td>Finds the parameters of the systems from first to tenth range, using the Table 2, which is empirically obtained -, where T_u, T_a et k_∞ we can find following the Ziegler-Nichols' method (Fig. 2)</td>
<td>
<table>
<tr><th>n</th><th>T_u / T_a</th><th>T_u / T_s</th><th>T_a / T_s</th></tr>
<tr><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>2</td><td>0.104</td><td>0.282</td><td>2.718</td></tr>
<tr><td>3</td><td>0.218</td><td>0.805</td><td>3.695</td></tr>
<tr><td>4</td><td>0.319</td><td>1.425</td><td>4.463</td></tr>
<tr><td>5</td><td>0.410</td><td>2.100</td><td>5.119</td></tr>
<tr><td>6</td><td>0.493</td><td>2.811</td><td>5.699</td></tr>
<tr><td>7</td><td>0.570</td><td>3.549</td><td>6.226</td></tr>
<tr><td>8</td><td>0.642</td><td>4.307</td><td>6.711</td></tr>
<tr><td>9</td><td>0.709</td><td>5.081</td><td>7.164</td></tr>
<tr><td>10</td><td>0.773</td><td>5.869</td><td>7.590</td></tr>
</table>
Table 2. T_u = OA, T_a = AC</td>
</tr>
<tr>
<td>Broida

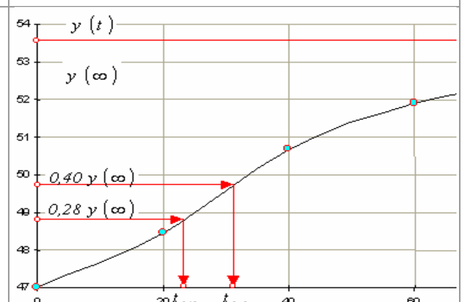
$$G(p)=\frac{Y(p)}{X(p)}=\frac{k_\infty e^{-\tau B p}}{T_B p+1}$$
Equation (3)</td>
<td>We find the value of y corresponding of 28% and 40% of k_∞:
$y_{0.28} = 0.28k_\infty$
$y_{0.40} = 0.40k_\infty$,, and we obtain the corresponding times - $t_{0.28}$ and $t_{0.40}$
$\tau_B = 2.8t_{0.28} - 1.8t_{0.40}$ et $T_B = 5.5(t_{0.40} - t_{0.28})$.</td>
<td>

Fig. 2. Broida</td>
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</table>

Table 1. Presentation of the methods for analysis

2. SYNTHESIS OF THE SYSTEM

After we obtain the analytical model of the system, we use it to calculate the optimal regulation P, PI or PID, this time also by implementing empirical synthesis. We apply different methods in order to observe a diversity of solutions and to choose the most advantageous one. These methods are the method of Ziegler-Nichol, Chien-Hrones-Reswick (4 cases) and Wang-Shao, shown in Table 3.

	ZIEGLER - NICHOLS - Aperiodic behaviour					
	Classic method (T_u / Tg), D1			Stabilisation limit (T_{cr} /T_{osc}), D2		
P	$\frac{T_g}{T_u\ k_{ob}}$	∞	*0*	$\frac{0{,}500\ k^*_{critique}}{k_{ob}}$	∞	*0*
PI	$\frac{0{,}900\ T_g}{T_u\ k_{ob}}$	$3{,}300\ T_u$	*0*	$\frac{0{,}450\ k^*_{critique}}{k_{ob}}$	$0{,}830\ T_{oscilation}$	*0*
PID	$\frac{1{,}200\ T_g}{T_u\ k_{ob}}$	$2{,}000\ T_u$	$0{,}500\ T_u$	$\frac{0{,}600\ k^*_{critique}}{k_{ob}}$	$0{,}500\ T_{oscilation}$	$0{,}125\ T_{oscilation}$
	CHIEN–HRONES–RESWICK (D3) - Aperiodic behaviour					
	Maintain regulation			Regulation of correspondence		
P	$\frac{0{,}300\ T_g}{T_u\ k_{ob}}$	∞	*0*	$\frac{0{,}300\ T_g}{T_u\ k_{ob}}$	∞	*0*
PI	$\frac{0{,}600\ T_g}{T_u\ k_{ob}}$	$4{,}000\ T_u$	*0*	$\frac{0{,}350\ T_g}{T_u\ k_{ob}}$	$1{,}200\ T_g$	*0*
PID	$\frac{0{,}950\ T_g}{T_u\ k_{ob}}$	$2{,}400\ T_u$	$0{,}420\ T_u$	$\frac{0{,}600\ T_g}{T_u\ k_{ob}}$	$1{,}000\ T_g$	$0{,}500\ T_u$
	CHIEN–HRONES–RESWICK (D3) - 20% overpass					
P	$\frac{0{,}700\ T_g}{T_u\ k_{ob}}$	∞	*0*	$\frac{0{,}700\ T_g}{T_u\ k_{ob}}$	∞	*0*
PI	$\frac{0{,}700\ T_g}{T_u\ k_{ob}}$	$2{,}300\ T_u$	*0*	$\frac{0{,}600\ T_g}{T_u\ k_{ob}}$	$1{,}000\ T_g$	*0*
PID	$\frac{1{,}200\ T_g}{T_u\ k_{ob}}$	$2{,}000\ T_u$	$0{,}420\ T_u$	$\frac{0{,}950\ T_g}{T_u\ k_{ob}}$	$1{,}350\ T_g$	$0{,}470\ T_u$
	k_p	T_i	T_d	k_p	T_i	T_d

Table 3. Synthesis of the system

Next we calculate the parameters of the P, PI and PID regulators and we observe whether the system satisfies the well know stability standards of Nyquist, Bode and Black-Nichols or not. Furthermore, we calculate the point of stability of the system (degree of stability), than the dynamic precision and finally the timing performance.

3. SOFTWARE FOR MODELISATION, SIMULATION AND ROBAST ANALYZE OF THE REGULATED SYSTEM

This step of our work is very important because we have managed to create software, which is easy to use and shows all the results in an attractive way. The software we use is Matlab 6.5. The resources of Matlab enable to simulate the behavior of the processes and to test the results of the modifications that we aim to examine. Once obtained with the program on Matlab, the program transfers the results and observes the behavior of the regulated system under Simulink. It enables the user to proceed with the methods of Ziegler-Nichols, Broida and Strejc, as well as the methods of synthesis of Ziegler-Nichols, Chien-Hrones-Reswick and Wang-Shao. With this regard, initially we have pursued the following steps:

- Observation of the transient characteristic (reponse indicielle) of the system,
- Validation of the optimal analytical method,
- Synthesis of the regulators P, PI and PID,
- Finally we have studied the performances of the synthesized system.

GUI - Graphical User Interface in Matlab

To make all calculations and show the results, we have created the "user friendly" interface, which comprises of attractive menus, buttons and graphical plots (Fig. 3).

Furthermore, we have applied the program to model, analyze and find the optimal regulation of the temperature of a steam generator and we have proved its rapidity and reliability.

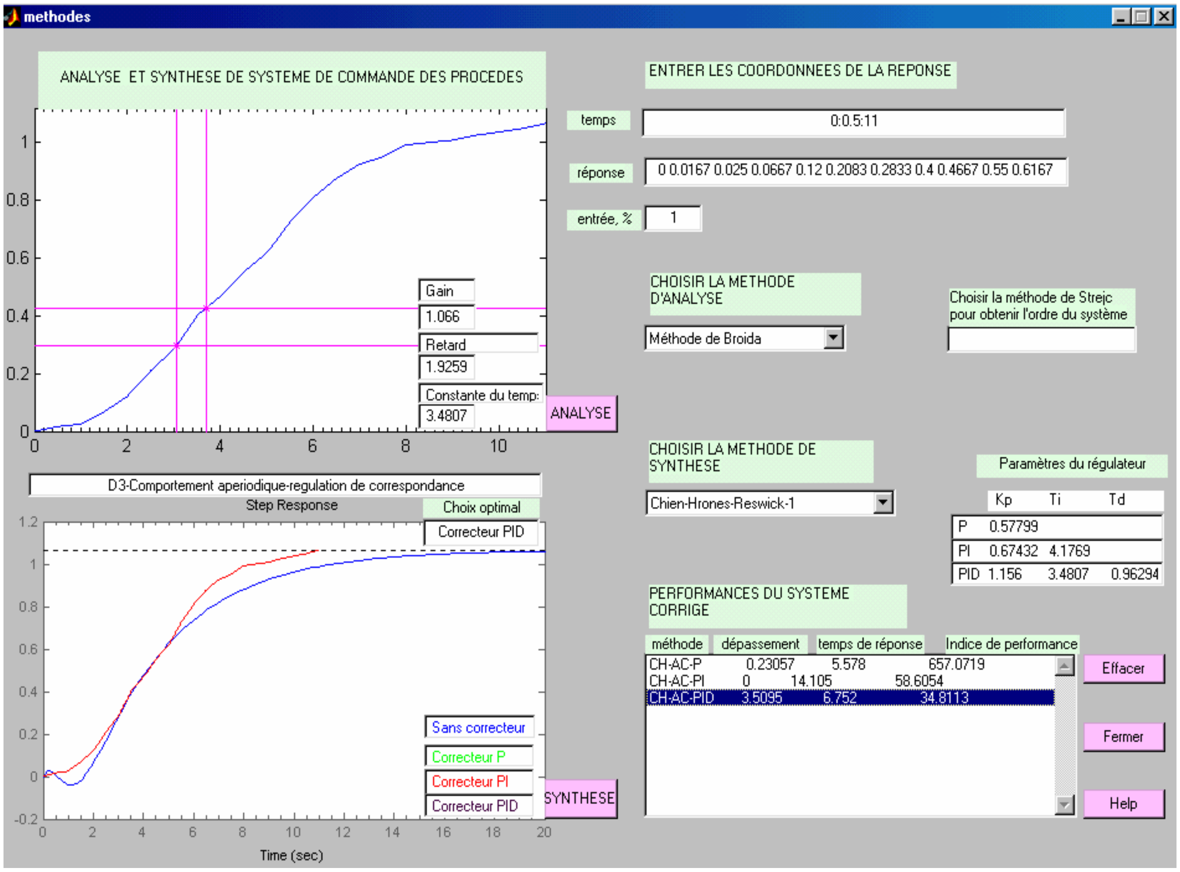

Fig. 3. Graphical User Interface

4. PERSPECTIVES

The presented software could be reorganized according to the user needs. For instance, in order to pursue future calculations, we suggest the results to be transferred to Excel.

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