IDENTIFICATION AND OPTIMAL CONTROL OF BLOWING SYSTEM

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Obiectivul important al lucrării de constă în dezvoltarea unor algoritme privind controlul fluxului şi al temperaturii precum şi optimizarea acestora. Prezentul studiu tratează regimul stabil de funcţionare.

Analizele efectuate, analize numerice si calcule, se referă la tipuri importante de comenzi privind fluxul aerului şi temperatura. Obiectul pricipal al acestui articol este de a controla unele caracteristici importante ale unui proces chimic folosind unui dispozitiv automat de identificare şi optimizare a sistemelor, prin care se intenţionează controlarea fluxul aerului şi a gradulului temperaturii în acelaşi timp, începând cu un aparat mecanic conectat la un calculator, în care sunt instalate programele respective; acest aparat permite reglarea valorii temperaturii la o anumită presiune de aer specificată ce urmează să producă aer cald.

The major efforts regarding this analysis, on algorithmic development, and on computations deal with the flow and temperature control and their optimization. This study treats the steady state in order to avoid the unsteady problems.

The paper's analyses, i.e. the numerical analyses, and computations have addressed two important types of controls which are the air flow and the temperature. The principal object of this paper is to control several important characteristics of a chemical process by using an automatic device for optimization and system identification; in each case one intends to control the temperature degrees and the air pressure values in the same time, starting from a mechanical apparatus connected at a computer where there are installed the respective control software; this apparatus gives the possibility to set the temperature values at a specified pressure which can produce cold air.

Keywords: air flow control, temperature control, ELWE, ADAPTECH, optimization

1. Introduction

The LTR710 is a small controlled air flow and temperature system which was made by ELWE the German company to be used in automatic control applications of the ACPC laboratory. This device has the following I/O variables:

- two measurable output variables (pressure/flow rate and temperature)
- two input variables (speed of the fans and power of the heater)

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These variables allow us to determine the properties of controlled systems, in which the controlled variables are the temperature and the pressure or the flow, and to examine the performance of different controller structures [7]. The manually adjustable angle of the throttle can, for example be applied as an external interference signal.

The heater in this plant can only be operated when 10% of the ventilator power has been reached. At this point the value for the pressure sensor signal is measured and stored as an (analog) reference point (zero). Later on the measured value is subtracted from the test results to compensate for the varying air pressure and a drift over time of the pressure sensor, the LTR710 is demonstrated in the figure (1). When external controllers (industrial controller or PC) are connected, the following control loop structures can be set up with the controlled air and temperature system LTR701:

- Simple control loops
- Cascade control systems
- Multi-variable control system

Fig. 1. LTR 710

2. Mathematical models

Two different methods are used to mathematically describe the static and dynamic properties of the controlled service. Therefore it seems to be appropriate to use the much easier method of experimental analysis [4]. All the inputs of the controlled system are successively energized in steps and the reaction of the controlled system is measured as a step response on its outputs. Then each step response is described with a mathematical model, whose step response corresponds well with the measured response. In the simplest case, the mathematical model represented by figure (2) is a first-order time delay element, whose characteristic variables, amplification and time constant can be directly read off the measured step response. Additional time delays can then easily be described with a lag element. The transfer function of such a model would be:

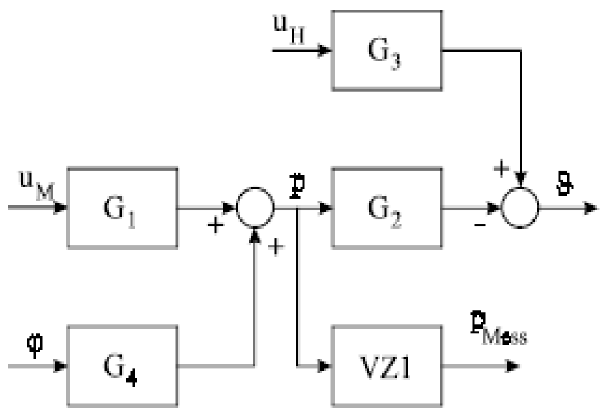

Fig. 2. Block diagram for controlled pressure and temperature systems

Additional time delays can then easily be described with a lag element. The transfer function of such a model would be:

$$G(s) = e^{-T_i s} \frac{k}{1 + Ts}$$

where:

k: the gain factor

T: the time constants

T_i: the dead time

Due to the non-linearity of the described controlled system, the input and output signals are displayed as deviations from previously determined operating points. Accordingly determined transfer functions only apply to this area of operation. The approach for the measured step responses leads to the following structure for the controlled system:

u_M describes the manipulated variable for the motor of the fan;

u_H the manipulated variable for the heater and φ the manually adjustable angle of the throttle valve as an interference signal. The output variables which are measured via the respective sensors are the pressure *P* at the end of the pipe and the air temperature ϑ on one of the four possible measuring points. The measured pressure will additionally be filtered via a first-order time-delay element (VZ1, realised in the PC program). As illustrated further below, P_{mess} is preferably used for the measurement of step responses or control loop performances instead of the directly measured pressure [5].

3. PIM and PCREG software

The two French softwares PIM and PCREG are made by ADAPTECH Company. They consist of an important laboratory addressing students in the domain of automatic control and system engineering, who are eager to develop their knowledge about the system in the computer-assisted design for numerical applications of control. [1]. The system identification methods are based on a linear model and have been well developed and applied in wide areas of control engineering [2].

This application is done on line by using the identification software the PIM and the control software the PCREG, by which one can find the most valid transfer function by identifying the recorded data. This transfer function can be introduced to the PCREG to find the controller polynomials. PIM makes it possible to identify parametric models of process starting from experimental data; those can be limited of very low amplitude, thus making it possible to carry out identification without disturbing the normal operation of the installations. Moreover, as an operation in open loop is very often proscribed in practice, PIM provides a methodology of identification to leave experiments carried out in loop closed, very useful to improve the performances of an existing controller, using the complementary software PCREG.

4. Problem statement

The main objective of this research is to control the temperature and the flow of the air resulted from the LTR701 apparatus which is connected to the computer; the recorded data will be processed by the two software that are already installed in this computer; the purpose is to find the transfer function of this system then to use this mathematical model in order to specify the controller polynomials. To test the efficiency of this application we have to use the validity test in the identification menu then we have to use the robustness test in the control menu [6].

5. Simulation

Greater attention has been focused on the identification of process models in recent years, in part due to the variety of controller design methods that rely on an explicit process model. The first step in the use of many of the techniques is to obtain a model of the process to be controlled. Unfortunately, theoretical models of most chemical processes are often quite difficult to calculate. In these situations models must be identified from the actual process data.

The PIM software application is used for identifying the system, with the optimized parameters values in order to find the most valid model. This model must be controlled with the help of an RST controller; for this the paper appealed at the PCREG control software; its input is the identified model. With the presence of the unstable zeros, one chooses the poles placement method to specify the performances on proceeding and control. one follows the results after setting the sampling period, command, noise, SPAB, register and devisor. In this section the procedure of identification used is described so that the model class to identify the system is of class ARX.

One saves the two I/O data files where the continuous values are centered [3]. Each value from these two files is represented in a register, where n=8 bits. The period of sampling and of data registration is 3s in the temperature processing; then in the pressure the sampling period must be equal to 0.2s, in the absence of apriori information, ARX model structure, the recursive least square method and the decreasing gain in which the delay 0 and it is the same for the initial values of the estimation parameters.

The polynomials of this model can construct the transfer function which was tested by the validity test to verify the efficiency of the chosen model. The step response of this system is demonstrated in figure (3) in which one sees that the pressure operation is a valid one.

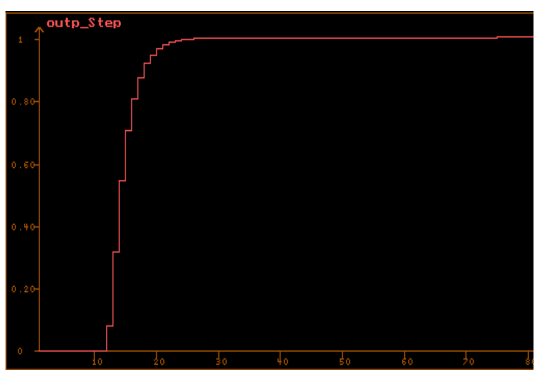

Fig. 3. Step response of the pressure function

Now, one tries to find the controller which is corresponding to this identified system, by introducing firstly the sampling period which equal in this case to 0.2s then the model name and pole and placement algorithm which gives the three polynomials of the RST controller.

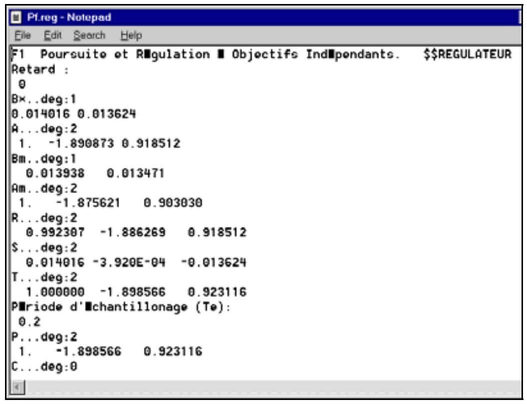

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Fig. 4. The pressure controller and model polynomials

One follows the same previous steps in the temperature control to find the estimated model. By testing this transfer function, one confirms that the system is a valid one. Now, one uses these results like an input of the PCREG software to find the controller of this model. Thus one chooses the damping coefficient $\xi=0.8$, curves of responses this normalization demonstrates that, in this case the relation between the frequency proper w_0 and the growth time t_M is $w_0.t_M=3$. If one want to find that $t_M=100s$, one must choose $w_0=0.03rad/s$, the model and its controller are shown in figure (5).

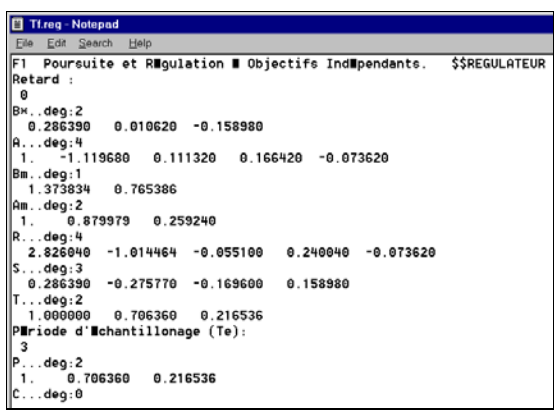

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Fig. 5. Temperature identification and control results

To test the controller robustness, one must verify the Nyquist diagram, which is shown in figure (6). From which one find that the margins robustness are defined under some conditions of the gain, the phase, the delay and the modulus margins values.

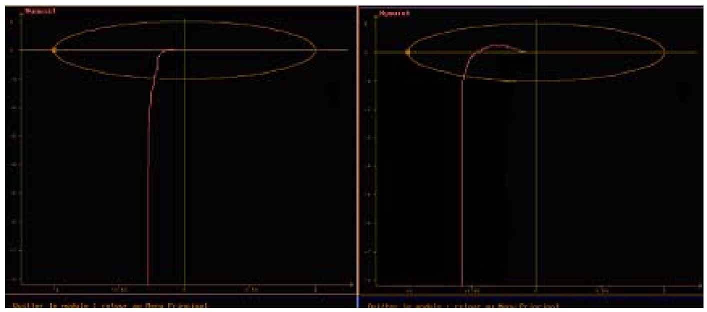

Fig. 6. Nyquist diagram of the pressure respectively the temperature

Here one verifies the sensitivity function which confirms the stability of this system. From the figure (7) one can remark that the closed loop being asymptotically stable, the integral of the logarithm of the modulus of the output sensitivity function from 0 to $0.5f_s$ is equal to 0 for the case of the stable open loop.

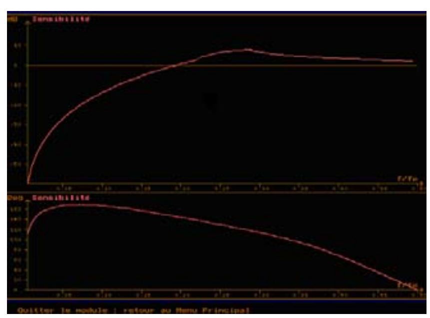

Fig. 7. Temperature sensitivity function

6. Conclusion

After these two software applications, from which one found the new model and its controller of the pressure and the temperature, one introduce to this model with its controller a value of reference. It is shown in the figure (8) that the output has the same trajectory of the reference, which implicates that the model and the found controller are the closest system to the real process.

Fig. 8. Processing output

- A known method of optimization based on software PCREG was applied in this example, by using the outputs of a system well identified by another program, the PIM.

- The control procedure of any temperature and pressure can be used in vast industrial fields especially in chemical and petrochemical applications.

- The temperature and the pressure are two characteristics of an industrial process, each one is influenced by the other which can result a nonlinear system.

R E F E R E N C E S

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