العنوان:	Design of A Computerized Adaptive Pressure Control System
المؤلف الرئيسي:	Ebrahim, Hasan Mohammed Mahmoud
مؤلفين آخرين:	Tolbah, Farid، Abd Alghany, Samir Mohamed(super)
التاريخ الميلادي:	1990
موقع:	القاهرة
الصفحات:	1 - 93
رقم MD:	565623
نوع المحتوى:	رسائل جامعية
اللغة:	English
الدرجة العلمية:	رسالة ماجستير
الجامعة:	جامعة عين شمس
الكلية:	كلية الهندسة
الدولة:	مصر
قواعد المعلومات:	Dissertations
مواضيع:	الهندسة الميكانيكية، الطاقة، ضغط الغاز
رابط:	https://search.mandumah.com/Record/565623

TABLE OF CONTENTS :

العنوان:	Design of A Computerized Adaptive Pressure Control System
المؤلف الرئيسي:	Ebrahim, Hasan Mohammed Mahmoud
مؤلفين آخرين:	Tolbah, Farid، Abd Alghany, Samir Mohamed(super)
التاريخ الميلادي:	1990
موقع:	القاهرة
الصفحات:	1 - 93
رقم MD:	565623
نوع المحتوى:	رسائل جامعية
اللغة:	English
الدرجة العلمية:	رسالة ماجستير
الجامعة:	جامعة عين شمس
الكلية:	كلية الهندسة
الدولة:	مصر
قواعد المعلومات:	Dissertations
مواضيع:	الهندسة الميكانيكية، الطاقة، ضغط الغاز
رابط:	https://search.mandumah.com/Record/565623

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

DESIGN OF A COMPUTERIZED ADAPTIVE PRESSURE CONTROL SYSTEM

By

Hasan Mohammed Mahmoud Ebrahim

THESIS

Submitted in Partial Fulfilment of the
Requirements for the degree of
Master of Science in Mechanical Engineering

Supervised by

Prof. Samir M. Abdel- Ghany
Energy and Automotive Dept.
Faculty of Eng.
Ain Shams University.

Prof. Farid A. Tolbah
Design and Prod. Dept.
Faculty of Eng.
Ain Shams University.

Cairo - 1990

Examiners Committee :

Name, Title & Affiliation | **Signature**

1) Prof. Samir Mohammed Abdel-Ghany.

Dept. of Energy and Auto. Eng.

Faculty of Eng., Ain Shams Univ.

16/4/90

2) Prof. Sayed Desouky Hasan

Head of Aeronautical Eng. Dept.

Faculty of Eng., Cairo Univ.

3) Prof. Farid Abdel-Aziz Tolbah.

Dept. of Design and Production Eng.

Faculty of Eng., Ain Shams Univ.

4) Prof. Zakaria Ghoniem Ahmed Ghoniem

Dept. of Energy and Auto. Eng.

Faculty of Eng., Ain Shams Univ.

Date : / / 1990

STATEMENT

This dissertation is submitted to Ain Shams University for the degree of master in mechanical engineering.

The work included in this thesis was carried out by the author in the Department of Energy and Automotive Engineering, Ain Shams University, from 1985 to 1990.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

Date : / / 1990

Signature :

Name : Hasan M. M. Ebrahim.

ACKNOWLEDGMENTS

I would like to express my thanks and appreciation to Prof. Samir M. Abdel-Ghany for his continuous guidance and assistance throughout this work. Also, I would like to express my thanks and gratitude to Prof. Farid Tolbah for his valuable directions that allowed me to conceive of and carryout this work.

Chapter [3] introduces a brief description of the experimental adaptive control station, including the conventional pneumatic control contour beside the interfaces of that contour to the data acquisition- and control unite mastered by the control computer.

Chapter [4] includes the software flow chart and the implementation of the adaptation algorithm as a control program for the computer. The test procedures either for the conventional and the adaptive systems are included in this chapter. The whole set of results and a hard copy are given in the appendices and also in the text.

Chapter [5] includes the discussion of the results and the important conclusions of the presented work.

TABLE OF CONTENTS :

CHAPTER [1]

SURVEY ABOUT THE ADAPTIVE CONTROL

Progress in theory and systems applications of adaptive control is reviewed. Different approaches are discussed with particular emphasis on model reference adaptive systems and self tuning regulators, Techniques for analysing adaptive systems are discussed. This includes stability and convergence analysis. It is shown that adaptive control laws can also be obtained from stochastic control theory. Issues of importance for applications are covered. This includes parametric, tuning, and tracking as well as different ways of using adaptive control. An overview of applications is given.

1.1 INTRODUCTION

According to Webster,s dictionary, to adapt means "to change (oneself) so that one,s behavior will conform to new or changed circumstances". The word adaptive control have been used at least from the beginning of the 1950s. There is for example, a patent on an adaptive regulator by Caldwell (1950). Over the years there have been many attempts to define adaptive control (Truxal, 1964; Saridis, Mendel and Nikolic, 1973). Intuitively an adaptive regulator can change its behaviour in response to changes in the dynamics of the process and the disturbance. Since ordinary feedback was introduced for the same purpose, the question of the difference between feedback control and adaptive control immediately arises. A meaningful definition of adaptive control which makes it possible to look at a regulator and decide if it is adaptive or not is still missing. There appears, however, to be a consensus that a constant gain feedback is not an adaptive system. In this work I will therefore take the pragmatic approach that adaptive control is simply a special type of nonlinear feedback control. Adaptive control often has the characteristic that the states of the process can be separated into two categories, which change at different rates. The slowly changing states are viewed as parameters.

Research on adaptive control was very active in the early 1950s. It was motivated by design of autopilots for high performance aircrafts. Such aircrafts operate over a wide range of speeds and altitudes. It was found that ordinary constant gain, linear feedback can work well in one operating condition. However, difficulties can be encountered when operating point conditions change. A more sophisticated regulator which works well over a wide range of operating conditions is therefore needed. The work on adaptive flight control was characterized by a lot of enthusiasm, bad hardware and nonexisting theory. A presentation of the results is given in Gregory (1959) and Mishkin Braun (1961). Interest in the area diminished due to lack of insight and a disaster in a flight test (see Taylor and Adkins, 1965).

In the 1960s there were many contributions to control theory, which were important for the development of adaptive control. State space and stability theory were introduced. There were also important results in stochastic control theory. Dynamic programming introduced by Bellman (1957, 1961) and dual control theory introduced by Feldbaum (1960a, b, 1961a, b, 1965), increased the understanding of adaptive processes. Fundamental contributions were also made by Tsypkin (1971) who showed that many schemes for learning and adaptive control could be described in a common framework as recursive equations of the stochastic approximation type. There were also major developments in system identification and parameter estimation (Astrom and Eykhoff, 1971).

The interest in adaptive control was renewed in the 1970s. The progress in control theory during the previous decade contributed to an improved understanding of adaptive control. The rapid and revolutionary progress in microelectronics has made it possible to implement adaptive regulators simply and cheaply. There is now a vigorous development of the field both at universities and in industry.

There are several surveys on adaptive control. The early work was surveyed by Aseltine, Mancini and Sarture (1958); Stromer (1959) and Jacobs (1961).

Surveys of special areas in the field were given by Landau (1974); Wittenmark (1975); Unbehauen and Schmidt (1975); Parks, Schaufelberger and Schmidt (1980). The papers by Truxal (1964) and Tsypkin (1973) have also given enlightenment perspective. An extensive bibliography which covers more than 700 papers is given by Asher, Andresani and Dorato (1976). Three books, Narendra and Monopoli (1980); Unbehauen (1980); Harris and Billings (1981), contains representative collections of papers dealing with recent applications. When selecting the material of this survey part, I deliberately choosed to focus on the simplest types of adaptive regulators. The idea is to describe the principles behind those adaptive schemes which are now finding their way towards applications and products. This means that many interesting adaptive schemes are lift out. Self-optimizing controls were recently surveyed by Sternby (1980). Other forms of adaptations that occurs in learning systems and in biological systems are described in Saradis (1977); Mendel and Fu (1970).

1.2 APPROACHES TO ADAPTIVE CONTROL

Three schemes for parameter adaptive control-gain scheduling model reference control and self-tuning regulators-are described in a common framework. The starting point is an ordinary feedback control loop with a process and a regulator with adjustable parameters. The key problem is to fined a convenient way of changing the regulator parameters in response to change in process and disturbance dynamics. The schemes differ only in the way the parameters of the regulator are adjusted.

1.2.1 Gain scheduling

It is sometimes possible to find auxiliary variables which correlate well with the changes in process dynamics. It is then possible to reduce the effects of parameters variations by changing the parameters of the regulator as functions of the auxiliary variables figure (1.1). This approach is called gain scheduling because the scheme was originally used to accommodate changes in process gain only.

The concept of scheduling originated in connection with development of flight control systems. In this application the Mach- number and the dynamic pressure are measured by air data sensors and used as scheduling variables.
The key problem in the design of system with gain scheduling is to find suitable scheduling variables. This is normally done based on knowledge of the physics of a system. For process control the production rate can often be chosen as scheduling variable since time constants and time delays are often inversely proportional to production rate.

When scheduling variables have been obtained, the regulator parameters are determined at a number of operating conditions using some suitable design method. Stability and performance of the system are typically evaluated by simulation.
Particular attention is given to the transition between different operating conditions. The number of operating conditions is increased if necessary.

One drawback of gain scheduling is that it is an open loop compensation. There is no feedback which compensates for an incorrect schedule. Gain scheduling can thus be viewed as feedback control system where the feedback gains are adjusted by feed forward compensation. Another drawback of gain scheduling is that the design is time consuming. The regulator parameters must be determined for many operating conditions. The performance must be checked by extensive simulations. Gain scheduling has the advantage that the parameters can be changed very quickly in response to process changes. The limiting factors depend on how quickly the auxiliary measurements respond to process changes.

There is a controversy in nomenclature whether gain scheduling should be considered as an adaptive system or not because the parameters are changed in open loop. Irrespective of this discussion, gain scheduling is a very useful technique to reduce the effects of parameter-variations. It is in fact the predominant method to handle the parameter variations in flight control systems (Stein, 1980). There is a commercial regulator for process control Micro-Scan 1300 made by Taylor Instruments which is based on gain scheduling (Andreiev, 1977)

1.2.2 Model reference adaptive systems (MRAS)

Another way to adjust the parameters of the regulator is shown in figure (1.2). This schemes was originally developed by Whitaker, Yamron and Kezer (1958) for servo problem. The specifications are given in terms of a reference model which tells how the process output ideally should respond to the command signal. Notice that the reference model is part of the control system. The regulator can be thought of as consisting of two loops. The inner loop is an ordinary control loop composed of the process and the regulator. The parameters of the regulator are adjusted by the outer loop, in such a away that the error e between the model output ym and the process output y becomes small. The outer loop is thus also a regulator loop. The key problem is to determine the adjustment mechanism so that a stable system which brings the error to zero is obtained. This problem is nontrivial. It is easy to show that it cannot be solved with a simple linear feedback from the error to the controller parameters.

The MRAS was originally proposed by Whitaker and co- workers (1958). Further work was done by Parks (1966), Hang and Parks (1973), Monopoli (1973), Landau (1974) and Ionescu and Monopoli (1977). There has been a steady interest in the method (Hang and Parks, 1973). Landau,s book (Landau, 1979) gives a comprehensive treatment of work up to 1978. It also includes many references. Recent contributions are discussed in section (1.3).

The MRAS shown in figure (2) is called a direct scheme because the regulator parameters are updated directly. There are also other MRAS schemes where the regulator parameters are updated indirectly (Narendra and Valavani, 1979).

1.2.3 Self- tuning regulators (STR)

A third method for adjusting the parameters is to use the self-tuning regulator. such a system is shown in figure (1.3).

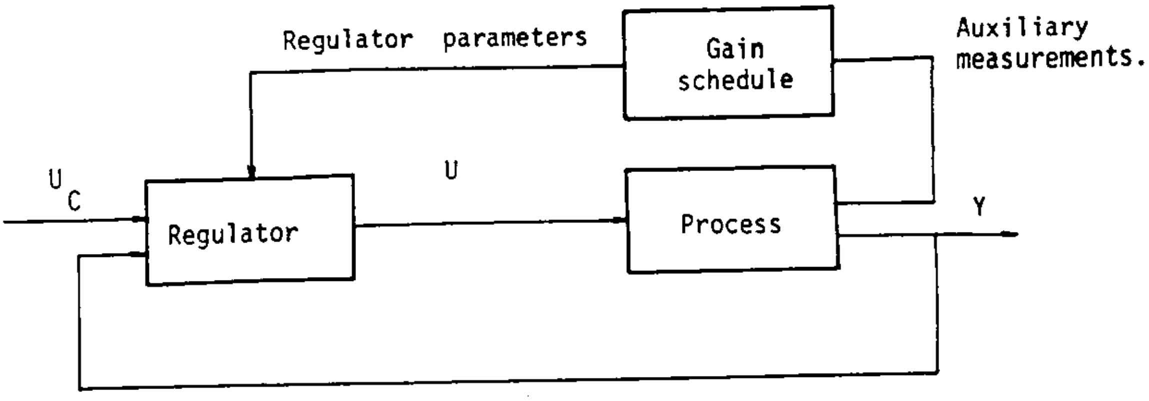


FIGURE (1.1) BLOCK DIAGRAM OF SYSTEM WHERE INFLUENCES OF PARAMETERS VARIATIONS ARE REDUCED BY GAIN SCHEDULING.

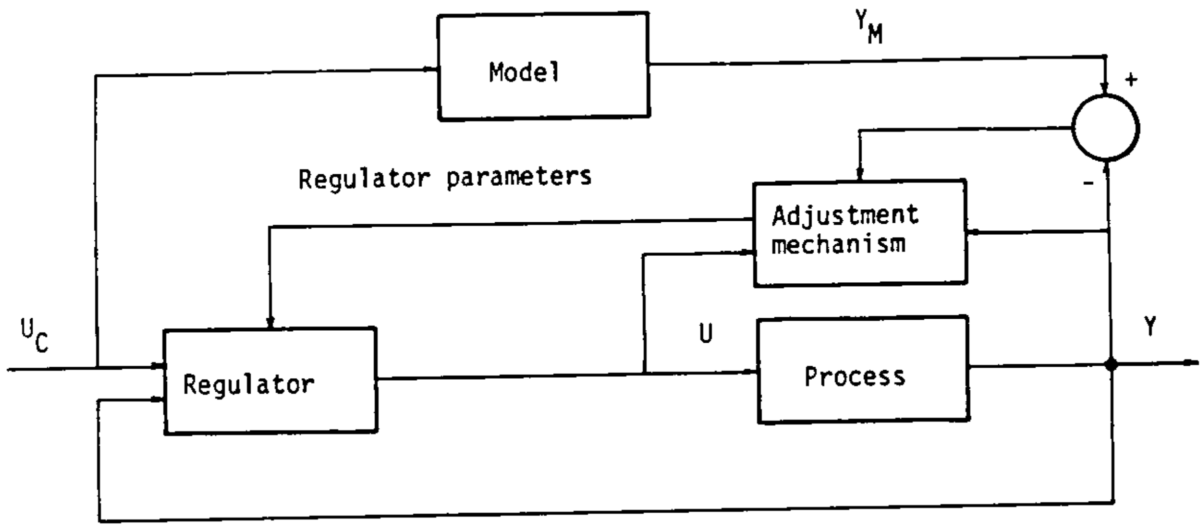


FIGURE (1.2) BLOCK DIAGRAM OF MODEL REFRENCE ADAPTIVE SYSTEM (MRAS).

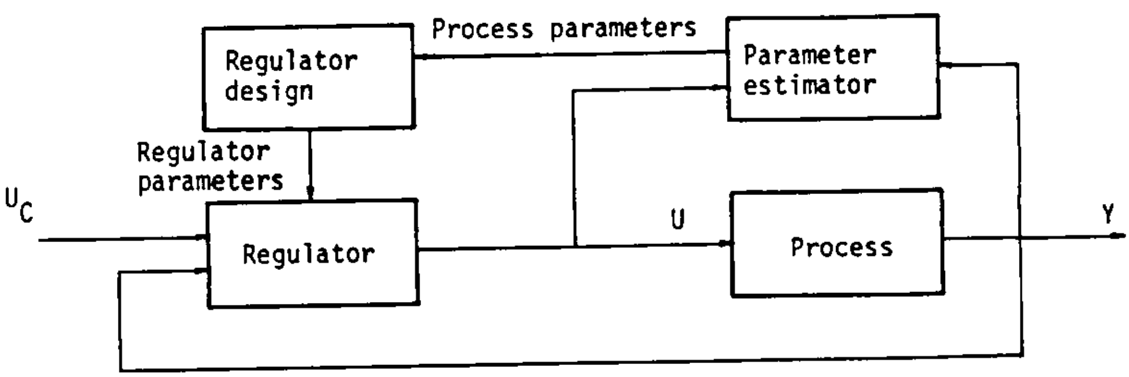


FIGURE (1.3) BLOCK DIAGRAM OF A SELF TUNING REGULATOR (STR).

The regulator can be thought of as composed of two loops, the inner loop consists of the process and an ordinary linear feedback regulator. The parameters of the regulator are adjusted by the outer loop, which is composed of a recursive parameter estimator and a design calculation. To obtain good estimates it may also be necessary to introduce perturbation signals. This function is not shown in figure 3 in order to keep the simple.

The self-tuning regulator was originally developed for the stochastic minimum variance control problem (Astrom and Wittenmark, 1973). Since the approach is very flexible with respect to the underlying design method many different extensions have been made. self-tuners based on phase and amplitude margins are discussed in Astrom (1982).
Pole-placement self-tuners have been investigated by many authors : Edmunds (1976); Wouters (1977); Wellstead and co-workers (1979); Wellstead, Prager and Zanker; Astrom and Wittenmark (1980). Minimum self-tuners with different extensions are treated in Peterka (1970, 1982); Astrom and Wittenmark (1973, 1974); Clark and Gawthrop (1975, 1979); Gawthrop (1977). The LOG design method is the basis for the self-tuners presented in Peterka and Astrom (1973); Astrom (1974); Astrom and Zhao- ying (1982); Menga and Mosca (1980).

The self-tuner also contains a recursive parameter estimator. Many different estimation schemes have been used, used, for example stochastic approximation, least squares, extended and generalized least squares, instrumental variables, extended Kalman filtering and the maximum likelhood method

The self-tuning regulator was originally proposed by Kalman (1958), who built a special purpose computer to implement the regulator. Several experimental investigations were carried out as digital computers became available. the self-tuning regulator has recently received considerable attention because it is flexible, easy to understand and easy to implement with microprocessors (Astrom, 1980a; Kurz, Isermann and schumann 1980; Isermann, 1980a).

The self-tuner shown in figure (1.3) is called an explicit STR or an STR based on estimation of an explicit process model. It is sometimes possible to re-parameterize the process so that it can be expressed in terms of the regulator parameters. This gives a significant simplification of the algorithm because the design calculations are eliminated. Such a self-tuner is called an implicit STR because it is based on estimation of an implicit process model.

Relations between MRAS and STR

The MRAS was obtained by considering a deterministic servo-problem and the STR by considering a stochastic regulation problem. In spite of the differences in their origin it is clear from figures (1.2) and (1.3) that the MRAS and the STR are closely related. Both systems have two feedback loops. The inner loop is an ordinary feedback loop with a process and a regulator. The regulator has adjustable parameters which are set by the outer loop. The adjustments are based on feedback from the process inputs and outputs. The methods for design of the inner loop and the techniques used to adjust the parameters in the outer loop may be different, however.
The direct MRAS is closely related to the implicit STR and the indirect MRAS to the explicit STR.

1.3 Theory

The closed loop systems obtained with adaptive control are nonlinear. This makes analysis difficult, particularly if there are random disturbances. Progress in theory has therefore been slow and painstaking. Current theory gives insight into some special problems. Much work still remains before a reasonably complete theory is available. Analysis of stability, convergence, and performance are key problems. Another purpose of the theory is to find out if control structures like those in Section (1.2) are reasonable, or if there are better ways to do adaptive control.

1.4 Uses and abuses of adaptive techniques

Before going into the details of applications of adaptive control some different ways to use adaptive techniques will be discussed.

1.4.1 Auto-tuning

It is possible to tune regulators with three to four parameters by hand if there is not too much interaction between adjustments of different parameters. For more complex regulators it is however necessary to have suitable tuning tools. Traditionally tuning of more complex regulators have followed the route of modelling or identification and regulator design. This is often a time-consuming and costly procedure which can only be applied to important loops or to systems which are made in large quantities.

Both MRAS and the STR become constant gain feedback controls when the estimated parameters are constant. Compare figures

(1.1) and (1.3). The adaptive loop can thus be used as a tuner for a control loop. In such applications the adaptation loop is simply switched on, perturbation signals may be added. The adaptive regulator is run until the performance is satisfactory. The adaptation loop is then disconnected and the system is left running with fixed regulator parameters. Auto tuning can be considered as a convenient way to incorporate automatic modelling and design into a regulator. It widens the class of problems where design methods can be used cost effectively.

Automatic tuning can be applied to simple PID-controllers as well as to more complicated regulators. For minimum variance control the performance evaluation can be done simply by monitoring the covariances of the inputs and outputs (Astrom, 1970). Tuning can then be initiated when there are indications that a loop is badly tuned.

It is very convenient to introduce auto-tuning in a DDC-package. One tuning algorithm can then serve many loops. Since a good tuning algorithm only requires a few kbytes of memory in a control computer substantial benefits are obtained at marginal cost.

1.4.2 Automatic construction of gain schedules

The adaptive control loop may also be used to build a gain schedule. The parameters obtained when the system is running in one operating condition are then stored in a table. The gain schedule is obtained when the process has operated at a range of operating conditions, which cover the operating range.

There are also other ways to combine gain scheduling with adaptation. A gain schedule can be used to quickly get the parameters into the correct region and adaptation can then be used for fine tuning.

1.4.3 Adaptive regulators

The adaptive techniques may of course also be used for genuine adaptive control of systems with time varying parameters. There are many ways to do this.

The operator performance is important, since adaptive regulators may also have parameters which must be chosen. It has been the experience that regulators without any externally adjusted parameters can be designed for specific applications, where the purpose of control can be stated as a priori. The shipsteering autopilot is such an example.

In many cases it is, however, not possible to specify the purpose of control a priori. It is at least necessary to tell the regulator what it is expected to do. This can be done by introducing dials that give the desired properties of the closed loop system. Such dials are called performance related. New types of regulators can be designed using this concept. For example, it is possible to have a regulator with one dial, which is labelled with the desired closed-loop bandwidth. Another possibility would be to have a regulator with a dial, which is labelled with the weighting between state deviation and control action in a LQG problem. A third possibility would be to have a dial labelled with the phase margin or the amplitude margin.

Abuses of adaptive control

An adaptive regulator, being inherently nonlinear, is more complicated than a fixed gain regulator. Before attempting to use adaptive control it is therefore important to first examine if the control problem cannot be solved by constant gain feedback. Problems of this type have only rarely been investigated. Two exceptions are Astrom (1980b) and Jacobs (1980). In the vast literature on adaptive control there are many cases where a constant gain feedback can do as well as an adaptive regulator. A typical examples is the very ambitious feasibility study of adaptive autopilots for autopilots for air crafts (IEEE, 1977). The aircraft used in the experiments could easily be controlled with conventional methods.

Notice that it is not possible to judge the need for adaptive control from the variations of the open loop dynamics over the operating range. Many cases are known where a constant gain feedback can cope well with considerable variations in system dynamics (Astrom, 1980d). There are also design techniques for constant gain feedback that can cope with considerable gain variations (Horowitz, 1963).

1.5 Applications

There are over 1500 papers on adaptive control, several hundred simulations have been performed, and more less number experiments on laboratory processes have been made. Adaptive techniques are also starting to be used in commercial products. An overview of the applications is given in this section.

1.5.1 Industrial feasibility studies

There have been a number of industrial feasibility studies of adaptive control. The following references covers some of the major studies, [19], [27], [30], [31], [33] and [48]. The references above and recent books on applications of adaptive control, Narendra and Monopoli (1980) and Unbehauen (1980), contain more details and many additional references.

new or changed circumstances(adaptation). The controller was supplied with a stepping motors unit connected to its adjustable dials (PB %, T(i)). The HP-computer, using the attached software, would drive the stepping motors to change the parameters with the predefined values. Of course the problem was to minimize the system steady state error. The proposed adaptive scheme has led to some important recommendations which are discussed and given in chapter [5].

CHAPTER [2]

ADAPTIVE CONTROL SYSTEM CONFIGURATION AND ANALYSIS

2.1 Introduction :

The industrial pneumatic process, in the present work, is assembled in the lab., and contains two vessels connected by an air supply and a disturbance valve. The problem is to maintain constant pressure in vessel (II), irrespective the variation of the disturbance valve opening. Thus, a feedback control loop has been built. The feedback system layout is illustrated in chapter [3].

The pressure in vessel (II) is controlled by using the pneumatic PI- controller in figure (3.7). The parameters of the controller are adjusted for driving the control valve trying to maintain constant pressure in vessel (II). The plant model is usually an approximation to the actual dynamic behavior, and even then the parameter values in the model are often not precisely known and may also vary widely with the operating conditions.

The process at a certain pressure (in vessel II) responds differently to the disturbance changes than at any other pressure. Then the parameter variation of the plant and also the existing nonlinearity will force the system to operate far from the desired conditions. For very wide parameter variations, the adaptive control schemes which adjust the controller parameters may be necessary.

The adaptive control schemes can take a number of forms but as the name suggests, they are intended to provide improved performance by adapting themselves to changing conditions. The most common successful approach to adaptive control is a preprogrammed or scheduled scheme in which the system measurements (set point and disturbance valve opening) that are causing the changes in the controlled system's parameters and continuously adjusts the controller parameters to accommodate the current situation.

In the present work the adaptive algorithms based on the integral criterion are used. The ITAE criterion was chosen and used for determining the controller parameters for several operating conditions.

2.2 Modeling of the plant :

In this chapter, the mathematical model of the proposed industrial process is derived.
The state of any physical plant may be disturbed by the effect of all signals and disturbances applied on it.

The signals and disturbances may be classified as follows :

a- Disturbances (external uncontrolled signals) which may be classified into observable (can be measured) and unobservable (can't be measured) signals.

b- Control actions which may be generated by the controller and fed to the plant to correct its controlled parameters.

The methods which may be used to determine plant model can be classified into :

a- Analytical methods.
b- Experimental methods.
c- Methods using both the analytical and the experimental techniques (engineering method).

The process under consideration represents a prototype model of two air vessels connected in series as shown in figure (2.1). They are filled with air by means of a control valve whose opening represents the control action ,the disturbance signal in this process is the disturbance valve opening.
The two vessels are of the same volume, and it is assumed that the air inside the vessels flowing isothermally (see figure 2.3).

The two vessels can be represented by a block diagram of two channels as shown in figures (2.1) and 2.2) :

a- Channel (I) which relates the disturbance valve opening and the process variable (P).

b- Channel (II) which relates the control valve opening and the process variable (P).

The analytical methods are to be used for determining the skeleton of the mathematical model, while the experimental techniques are used to get the parameters of the analytically obtained skeletons.

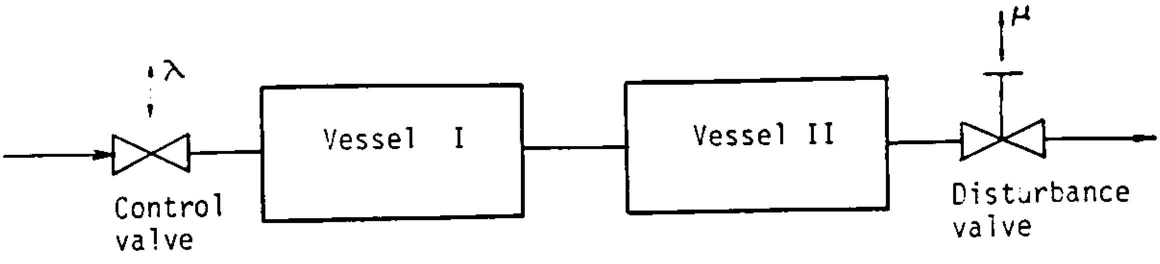


Figure (2.1) Plant schematic diagram.

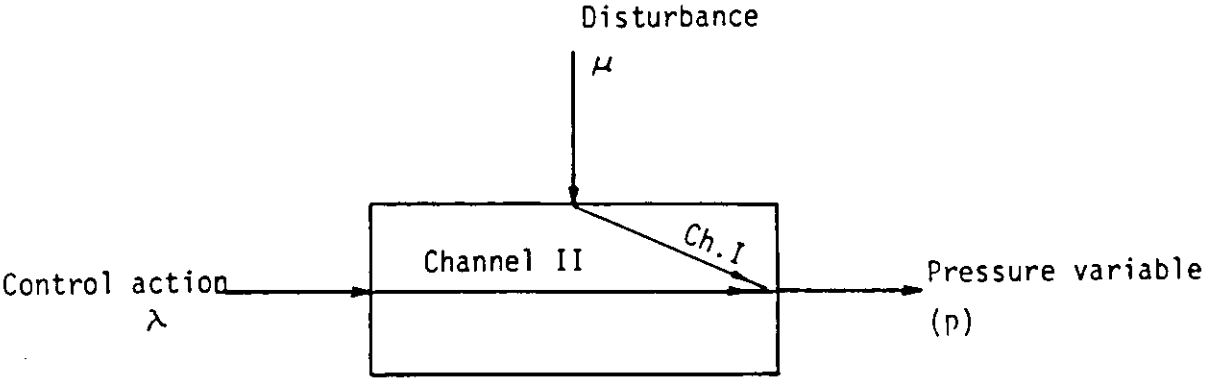


Figure (2.2) Plant block diagram

2.3 Process Model For Channel [I] :

From figure (2.3); for vessel [I]

The mass balance equation of vessel [I] can be written in the form :

$$\frac{d M_1}{d t} = - m_2^{\circ} \qquad (2.1);$$

The air in this process is treated as a perfect gas, i.e.:

$$P V = M_1 R T$$

Assuming that the temperature is constant, then :

$$V \frac{d P_1}{d t} = R_g T \frac{d M_1}{d t}$$

$$\frac{d M_1}{d t} = c \frac{d P_1}{d t} , \qquad (2.1a)$$

$$\text{where} \quad c = \frac{V}{R_g * T}$$

The mass balance for vessel [II] is :

$$\frac{d M_2}{d t} = m_2^{\circ} - m_3^{\circ} \qquad (2.2);$$

As in the previous case we get :

$$\frac{d M_2}{d t} = c \frac{d P}{d t} \qquad (2.2a)$$

But $m_3^\circ = f(p, \mu)$

$$= m^\circ_{3,o} + \frac{\partial m_3^\circ}{\partial t}\bigg|_{p_o,\mu_o} \Delta p + \frac{\partial m_3^\circ}{\partial t}\bigg|_{p_o,\mu_o} \Delta \mu$$

$$= m^\circ_{3,o} + K_1 \Delta p + K_2 \Delta \mu \qquad (2.3)$$

where $\Delta \mu$ = small change in the disturbance valve opening
ΔP = small change in the pressure in vessel [II].

The partial defferintial terms are substituted by constants when all the variables change with small perturbations around the normal operating conditions, i.e.

$$m_2^\circ = f(p_1, p)$$

$$= m^\circ_{2,o} + \frac{\partial m_2^\circ}{\partial p_1}\bigg|_{p_{1,o}, p_o} \Delta p_1 + \frac{\partial m_2^\circ}{\partial p}\bigg|_{p_{1,o}, p_o} \Delta p$$

$$= m^\circ_{2,o} + K_3 \Delta p_3 + K_4 \Delta p \qquad (2.4)$$

By summing equations (1.1) and (1.2) :

$$c \frac{d p_1}{d t} + c \frac{d t}{d t} = - \Delta m_3^\circ$$

From equation (1.3), we have :

$$c \frac{d p_1}{d t} + c \frac{d p}{d t} = - K_1 \Delta p - K_2 \Delta \mu$$

Taking the Laplace transformation for both sides of the last equation [assuming zero initial condition], we get :

$$c S P_1(s) + c S P(s) = - K_1 P(s) - K_2 \mu(s) \qquad (2.5)$$

Eleminating $P_1(s)$ from equations (1.1) and (1.4), we have:

$$c S P_1(s) = - K_3 P_1(s) - K_4 P(s)$$

$$\therefore \quad P_1(s) = - \frac{K_4}{c S + K_3} \qquad (2.6)$$

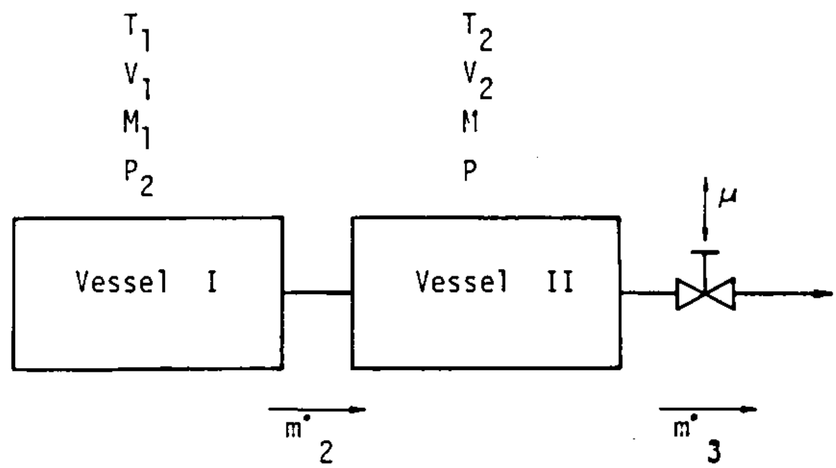
From equation (1.6) in equation (1.5)

$$c S \left[- \frac{K_4}{c S + K_3} P(s) \right] + c S P(s) = - K_1 P(s) - K_2 \mu(s)$$

$$\left[- \frac{K_4 c S}{c S + K_3} + c S + K_1 \right] P(s) = - K_2 \mu(s)$$

$$\left[c^2 S^2 + (K_1 + K_3 - K_4) cS + K_1 K_3 \right] P(s) = - K_2 (cS + K_3) \mu(s)$$

Then the transfer function for channel [I] is



$T_1 = T_2 = T$: (Temperature).

$V_1 = V_2 = V$: (Volume).

M_1 , M : (Mass of air inside vessels I , II) .

$\dot{m}_2$, $\dot{m}_3$: (Mass flow rate) .

P_2 , P : (Pressure) .

Figure (2.3) Schematic diagram for channel I

$$W_I(s) = \frac{P(s)}{\mu(s)} = - \frac{K_2\ (c\ S + K_3)}{c^2\ S^2 + (\ K_1 + K_3 - K_4\ )\ c\ S + K_1 K_3} \quad (2.7)$$

2.4 Process Model for Channel [II] :

Refering to figure (2.4), the mass balance equation for vessel [I] is :

$$\frac{d\ M_1}{d\ t} = m_1^\circ - m_2^\circ$$

$$\frac{d\ M_1}{d\ t} = c\ \frac{d\ p_1}{d\ t} = m_1^\circ - m_2^\circ \quad (2.8)$$

For vessel [II], the following expressions can be obtained :

$$\frac{d\ M}{d\ t} = m_1^\circ - m_3^\circ = c\ \frac{d\ p}{d\ t} \quad (2.9)$$

$$m_1^\circ = f\ (\ \lambda,\ p_1)$$

$$m_1^\circ = m_{1,o}^\circ + K_5\ \Delta\lambda + K_6\ \Delta p_1 \quad (2.10)$$

$$m_2^\circ = m_{2,o}^\circ + K_7\ \Delta p_1 + K_8\ \Delta p \quad (2.11)$$

$$m_3^\circ = m_{3,o}^\circ + K_9\ \Delta p + K_{10} \Delta\mu \quad (2.12)$$

Summing equations (1.8) and (1.9), we have :

$$c\ \frac{d\ p_1}{d\ t} + c\ \frac{d\ p}{d\ t} = m_1^\circ - m_2^\circ$$

$$= K_5 \Delta\mu + K_6 \Delta p_1 - K_9 \Delta p - K_{10} \Delta\mu$$

العنوان:	Design of A Computerized Adaptive Pressure Control System
المؤلف الرئيسي:	Ebrahim, Hasan Mohammed Mahmoud
مؤلفين آخرين:	Tolbah, Farid، Abd Alghany, Samir Mohamed(super)
التاريخ الميلادي:	1990
موقع:	القاهرة
الصفحات:	1 - 93
رقم MD:	565623
نوع المحتوى:	رسائل جامعية
اللغة:	English
الدرجة العلمية:	رسالة ماجستير
الجامعة:	جامعة عين شمس
الكلية:	كلية الهندسة
الدولة:	مصر
قواعد المعلومات:	Dissertations
مواضيع:	الهندسة الميكانيكية، الطاقة، ضغط الغاز
رابط:	https://search.mandumah.com/Record/565623

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

DESIGN OF A COMPUTERIZED ADAPTIVE PRESSURE CONTROL SYSTEM

By

Hasan Mohammed Mahmoud Ebrahim

THESIS

Submitted in Partial Fulfilment of the
Requirements for the degree of
Master of Science in Mechanical Engineering

Supervised by

Prof. Samir M. Abdel- Ghany
Energy and Automotive Dept.
Faculty of Eng.
Ain Shams University.

Prof. Farid A. Tolbah
Design and Prod. Dept.
Faculty of Eng.
Ain Shams University.

Cairo - 1990

جامعة عين شمس
كلية الهندسة

تصميم منظومة تحكم متأقلم فى ضغط غاز
مع
إدخال حاسب آلى فى المنظومة

مهندس / حسن محمد محمود إبراهيم

رسالة مقدمة للحصول على
درجة الماجستير فى الهندسة الميكانيكية (طاقة)

تحت إشراف

الأستاذ الدكتور / سمير محمد عبد الغنى
قسم هندسة الطاقة والسيارات
كلية الهندسة – جامعة عين شمس

الأستاذ الدكتور / فريد عبد العزيز طلبة
قسم التصميم وهندسة الإنتاج
كلية الهندسة – جامعة عين شمس

القاهرة : ١٩٩٠