1988

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AUTOMATIC PERFORMANCE CONTROL OF COMPRESSOR BY MICRO-COMPUTER

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ABSTRACT

This paper combines techniques of compressor, computer and auto-control theory. The purpose of this paper is to make a study on capacity control of compressor by means of changing the running speed of driving motor which is controlled by a micro-computer. The aim to develop this control system is to keep the pressure of gas tank to a desired, approximately constant value, i.e. the pressure deviation in the tank is limited to a narrow range over the desired value.

The closed-loop control system of compressor driven by a speed-variable motor is designed, the mathematical model and control program is also derived in this study. Many measures for reducing electromagnet interference to the computer system are introduced to ensure that the control system works successfully.

This paper compares this control system with classical intermittent switching the driving motor on or off, and presents their power consumption and performance characteristics.

INTRODUCTION

The quantity of gas supplied by compressor is required fluctuately in most situation. The pressure of gas tank will increase when the delivery capacity of compressor is greater than the quantity of gas consumed by user and vice verse. Thus, it can be seen that the pressure drop of gas tank shows the relationship between the delivery capacity of compressor and the quantity of gas consumed by user. The consumer often demands the pressure in gas tank to be kept to a desired value.

In this paper, the capacity control of compressor is carried out by varying the running speed of the driving motor through a micro-computer. The capacity of compressor follows in the track of the gas consumed, and the deviation between the pressure of gas tank and the pressure required by consumer is limited to an acceptable value.

PRINCIPLE OF THE CONTROL SYSTEM

Fig. 1 shows the closed-loop of capacity control system of compressor driven by a speed-variable electric motor.

The pressure transducer measures the pressure of gas tank, and the pressure signal is input into the micro-computer through A/D converter. The computer compares this pressure with the pressure required, and calculates the running speed whose signal is output through D/A converter and the running speed is controlled by the signal. The capacity of compressor is automatically changed with variation of the speed, the pressure in gas tank is stabilized around the desired pressure. Two regulating actions are introduced, one is proportional action (P for short), the other is proportional plus integral action (PI for short), each one has its characteristis.

SUPPRESSION OF THE ELECTROMAGNET INTERFERENCES

There are many sources of electromagnet interferences to the control system which come from the coupled electric field and coupled magnitic field of electric apparatuses, and also from the ground voltage drop and impulse current of motor. Suppression of these interferences is the key to keep the control system working properly.

The interference of power supply

In the laboratory, besides this control system, many electric apparatuses are supplied by the same power line. Owing to the existence of the internal resistence of power and the impedance of electric circuit, when the load of an apparatus varies, the voltage of the control system will fluctuate, which can make the micro-computer uncontrollable. In order to eliminate this interference, the power supply for this system is isolated by a voltage stabilizer.

The interference of ground voltage drop

As a matter of fact, the ground impedance is not zero. The micro-computer and the D/A converter both have the same ground point (see Fig.2), the voltage difference between this point and the ground point of the silicon controlled speed regulator forms a ground electric circuit which influences the computer for controlling the motor. While the computer drives the silicon controlled speed regulator through D/A converter, the computer theerfore becomes uncontrollable.

An isolating amplifier is installed between the output of D/A converter and the input of the silicon controlled speed regulator (Fig. 3), which is shown in Fig. 3. The output and input of the amplifier are completely isolated each other, so the ground voltage drop is suppressed.

The interference in measuring the pressure

The pressure of gas tank is measured by a pressure transducer and input into the computer. The transmission process of pressure signal is influenced by the electromagnet interference, so the pressure measured is not correct In order to weaken this influence, the transducer measures the average pressure in the time of sampling, then the pressure measured is more accuratelу.

The interference of impulse current of motor

If the pressure deviation is greater, the running speed increment is so greater that the impulse current influences the micro-computer through the coupled electric fields and coupled magnitic field. In order to decrease the impulse current, the running speed is increased graduately by the computer control program.

RESULTS OF MEASUREMENT FOR THE SYSTEM

An electric control valve is introduced for modeling the consumer valve. The control system is chematically described in Fig. 4 , Fig.5 and Fig. 6 show the histories of running speed of compressor and pressure in gas tank for the P control and the PI control respectively when the mass flow rate consumed is changed.

From the diagrams above, it can be seen that the proportional action can only control the pressure appriximately to given value (never reach to it) , while the proportional plus integral regulating action can keep the pressure in gas tank to given value more accurately.

CONCLUSIONS

Comparison with classical methods

The measurement for intermittent switching the driving motor on or off is shown in Fig 7 and the results of comparison with it in Tab. 1 and Tab. 2. From the comparison, it is known that the discharge pressure is more stable and energy consumption is more economical in this micro-computer control system than classical methods.

Extending the application of this control system

1.The driving motor is a D-C motor, while the driving motor widely used in industry is A-C motor. The method for regulating the running speed of A-C motor, for instance, is to vary the friquency in many cases. The diagram of compressor control system by means of computer which can be used in industry is shown in Fig. 8.

2.According to the temperature or pressure in synthetic column, the dilevery mass flow of the boosting compressor in chemical plants can be controlled automatically , as an example, by varying the running speed or adopting other measures to change the quantity of compressed gas into the column.

3.For the compressor driven by an internal-combustion engine, the running speed is controlled by varying the injection quantity of fuel oil by means of computer control, so the capacity of compressor can fit to the need automatically.

4.In most application, the temperature of room or cold store is required to be kept in a desired value. The capacity control system in this paper can also be used in this case. According the temperature deviation of the room or cold store, the computer can automatically control the running speed of the refrigeration compressor to vary the mass flow rate of refrigerant.

REFERENCES

1. H.Holdack - Janssen H. Kruse, " Continuous and Discontinuous Capacity Control for High Speed Refrigeration Compressor", 1984 Purdue Compressor Technology Conference.

2. Reciprocating and Rotary Compressor , SNTL, Praug, 1965.

Tab. 1 Comparison of unstability of pressure

Type of capacity control \ pressure required	4.905 10^5 Pa	6.867 10^5 Pa
P control	2.4 %	1.7 %
PI control	2.4 %	1.7 %
on off control	20 %	14.3 %
closing the suction	20 %	14.3 %

Table 2 Comparison of specific work
(consumed work kJ/kg compressed air)

Type of capacity control \ pressure required	4.905 10^5Pa		6.867 10^5Pa	
	mass flow increase	mass flow decrease	mass flow increase	mass flow decrease
P control	337.45	328.47	381.12	364.69
PI control	360.88	350.89	406.01	401.05
on and off control	392.7		421.10	
closing the suction	> 392.7		> 421.10	

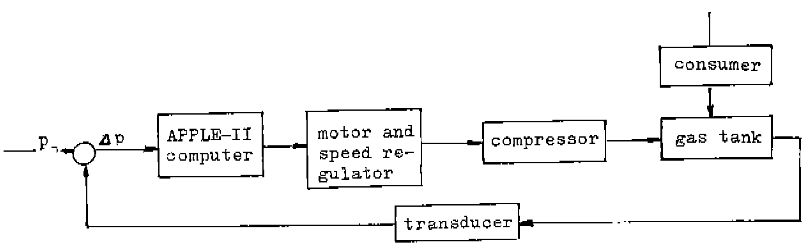


Fig. 1 The closed-loop of control system

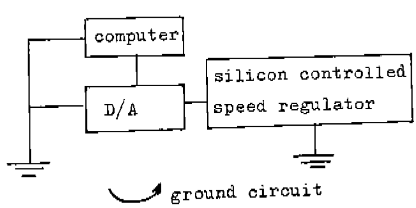


Fig. 2 Interference of ground voltage drop

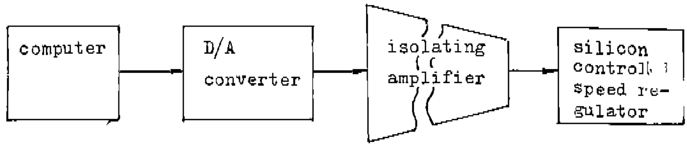


Fig. 3 Suppression of ground voltage drop

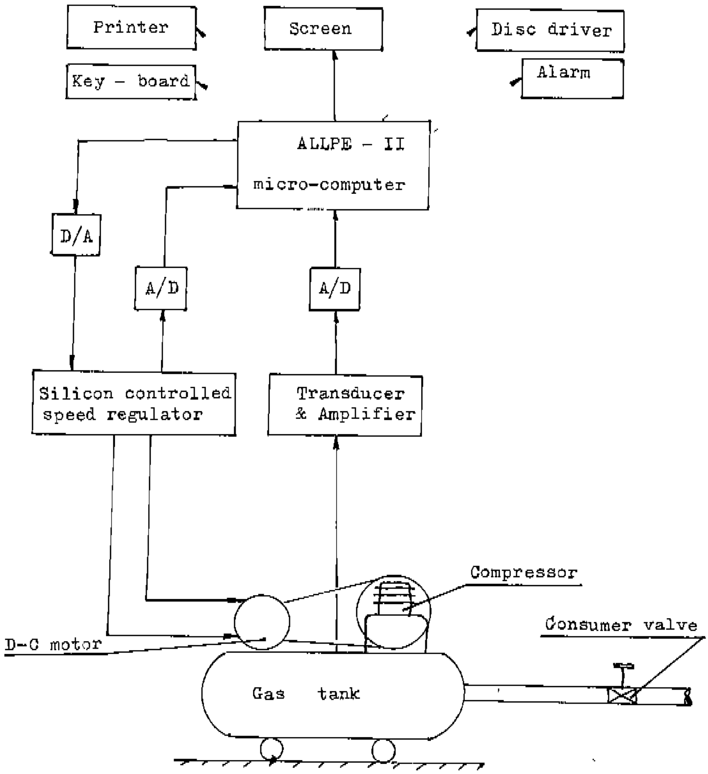


Fig.4 Compressor control system through micro-computer

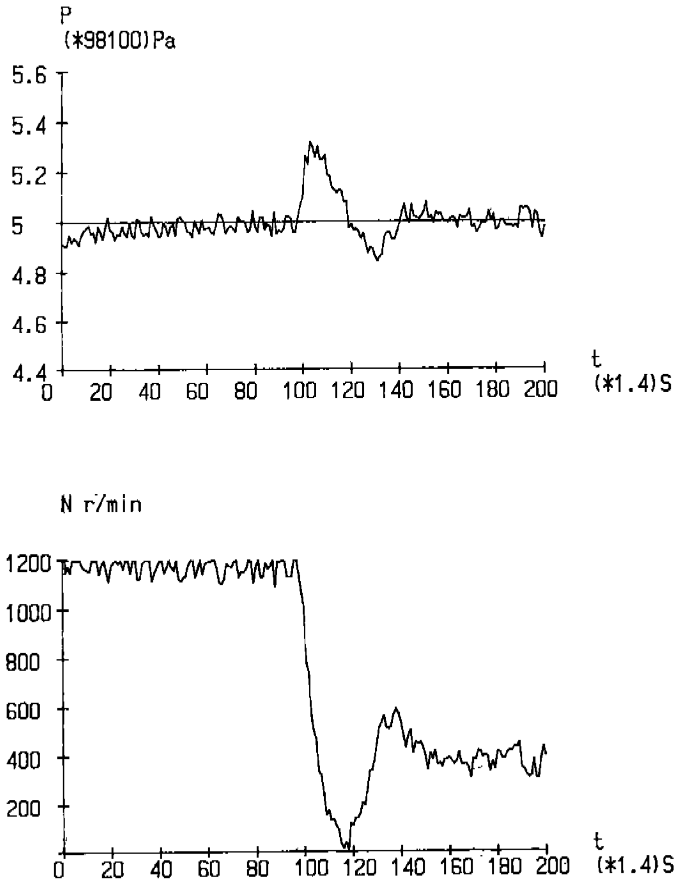


Fig. 6 Histories of rotation speed and pressure for PI control (required pressure $P_o = 4.905 \quad 10^5$ Pa)

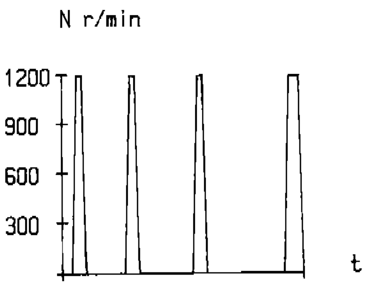
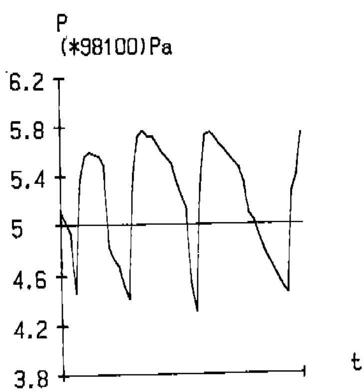


Fig. 7 N & P histories for the motor switch on or off

(required pressure $P_o = 4.905 \pm 0.490\,5 \quad 10^5$ P_a)



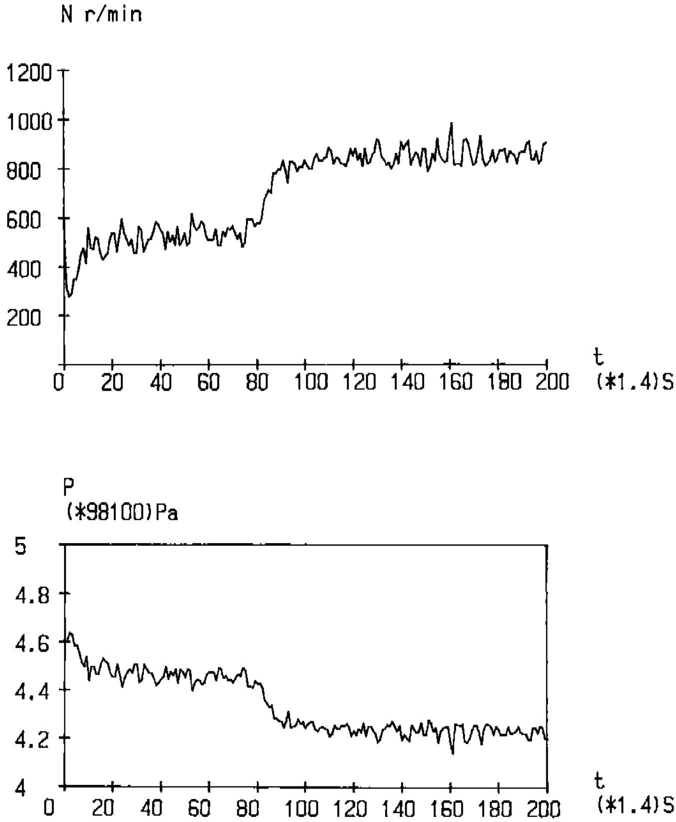


Fig. 5 Histories of rotation speed and pressure for P control
(required pressure P_o = 4.905 10^5 P_a)

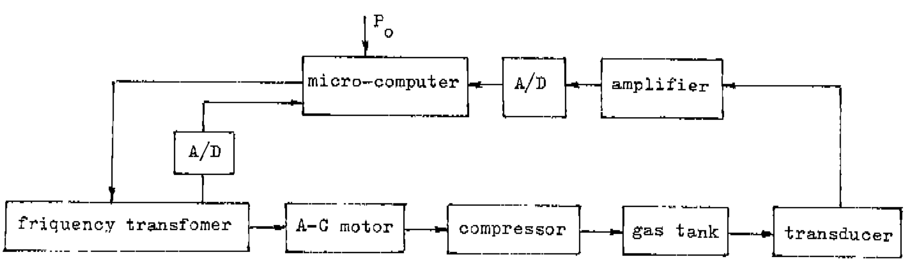


Fig.8 Real compressor auto-control for industry