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THE MICROCOMPUTOR MEASUREMENT AND CONTROL SYSTEM FOR PERFORMANCE TEST OF COMPRESSOR

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ABSTRACT

According ISO1217 standard and metheds of performance test for general dis-placement air compressor of China, a microcomputor measurement and control system for performent test of compressor has been set up. All the test can be carried out without manual interference,it has been realized collecting and treating data automatically.Using some hardward and softward steps,the accurary and repetition of directly collected datum were keeping with the standard.The compressor discharge pressure was controled by 6522 parallel input-and-output interface, step-by-step motor and governing valve.Because manual adjusting,artificial collecting and manual treating have been avoided, the system has saved manual work and time.the accurary and reliability of the test got better.

NOMENCLATURE

M_i:instantaneous change rate of mass flowing into the recerive
M_o:instantaneous change rate of mass flowing out the receiver
$\frac{dM}{d\tau}$:intantaneous change rate of mass in the receiver
K_g:constant related with the work condition of the receiver
K_p:constant related with the stable pressure
K_f:constant related with the opening of the throtting valve
ΔF:variation quantity of the opening of the throtting valve
ΔU:control quantity of adjustment
T_i:accumulative time
T:sampling time of microcomputor
Ts_1, Td_1:suction and discharge temperature of primary stage
Ts_2, Td_2:suction and discharge temperature of secondary stage
Pd_1: discharge pressure of primary stage
Ps_2, Pd_2:suction and discharge pressure of secondary stage
T_1:temperature before the flow measurement orifice plate
H:pressure difference of the flow measurement orifice plate

INTRODUCTION

according to ISO-1217 standard, the performance test of compressor would be carried out with convension method, all the test result would be read and treat by manual. These would waste manual work and time, it is very difficult to measure the datum simultaneity and accuratly. With improvement of measurement technology and using of computor,we have researched and produced a microcomputor measurement and control system for performance test of compressor. So the test can proceeded with automatically controlling of microcomputor without manual interference. When the test end, we can get the measurement result and all kind of tables that were demanded.

CONSISTING OF THE SYSTEM

The system mainly consisted with four parts: Apple - 11(E) microcomputor, transduce - amplifier part, input-output channels and work condition control part. The transduces included semi-conductor P-N model temperature transduces, silicon pressural-resistance pressductor, magnet-electrical rotating torque and speed tranduce. The signal of temperature and pressure were amplified and conducted to A/D converter, the signal of torque and revolution were send out from the digital quantity output channel of PYIA rotating torque and speed meter, than they were conducted to microcomputor through Mn card. The control system was consisted by 6522 parallel input-output card,step-by-step motor and power of step-by-step motor, governing valve. The sketch of system shown in Fig 1.

CONTROL OF DISCHARGE PRESSURE OF COMPRESSOR

In the standard, the compressor discharge pressure was controled with the receiver pressure, the maximum relative deviation between measured pressure ratio and set pressure ratio must be less than 1.0%, the maximum allowable fluctuation from average must be less than 0.5%. In conventional test, we must adjust the fine adjustment valve of discharge system by manual to keep the measurement datum in accessible range. And now, we have researched and produced a goverment system to control the pressure, it can satisfy the demand of the standard.

1: Adjustment dynamic character of the receiver

In Fig 2, there is a receiver, the gas was discharged by compressor and send into the receiver, the receiver delivered the gas through the throtting valve. Since the pressure(P) of the receiver must be constant ,the pressure was adjustment quantity.

If the receiver was in a equilibrium state, the gas fluid flowing into the receiver (Mi) would be equal to the gas fluid flowing out the receiver (M_o). In time T , the Mi suddenly increased a quantity Mi, the gas fluid flowing into the receiver would be more than the flowing out, the recriver pressure also increased. In the result of increaseing of pressure, the fluid flowing through the valve M_o would increase, and the fluid Mi would decrease. Just shown in Fig 3. The pressure P increase, the difference between Mi and M_o would be less, the variation in speed of pressure (P) would become less. At end, Mi would be equal to M_o, and the pressure (P) would be stability. In this describe, the pressure (P) was adjustment quantity, the change of the pressure influence Mi and M_o, that is, both flowing into portion and flowing out portion, there are self-equilibrium.

we can also describe the receiver with mathematic method. The receiver volume is control volume, the mass conservation equation of a variable-mass system is:

$$M_i - M_o = \frac{dM}{dt} \qquad (1)$$

the mass fluid M_o could be decribed with relation of a mesurement orifice plate. M_o related with the valid flowing area and the thermodynamic state of the receiver, it was non-linear relation between them. but in vicinity of stabity pressure, we can express the non-linear relation with linear relation, and write into Taylor series expension; the change rate of mass in the receiver was depended on the variation of the pressure (P), that can caculated from the state equation. So equation (1) could be:

$$\frac{K_g}{K_p} \cdot \frac{d(\Delta P)}{dt} + \Delta P = - \frac{\Delta M_i}{K_p} - \frac{K_f}{K_p} \qquad (2)$$

The equation express; the variation of ΔMi and ΔF would cause the change of the pressure,the relation both them is index number mode.

2: Action of regulator

The input signal of the regulator was the difference between adjustible quantity and the set pressure, the out-put signal of the regulator was remove of the regulator system (in that, it is throtting valve). these is a relationship between the output and input. The general relationship are double-bit-acting, proportion-acting, intergal-acting, differential-acting or multiplicity of them.

For the relation shown as equation 2, it would be a satisified result using a proporation(P)-intergal(I) regulator.

PI regulator is a kind of linear regulator, the difference between the set quantity(S) and pratical output quantity(Y) will be control quantity(E=S-Y). It will be realized PI regulating with linear composed of proportion and intergal relation. the control law of the regulator just like that;

$$\Delta U = K\left(E + \frac{1}{T_i}\int_0^t E\,dt \right) \quad (3)$$

computor control is a kind of sampling control, and the governing part is step-by-step motor, so the additional quantity of the regulator can be caculated like that;

$$\Delta U = U_i - U_{i-1} = K\left(E_i - E_{i-1} + \frac{T}{T_i} E_i \right) \quad (4)$$

To determand the control quantity Ui, we must decide the proportion facter sampling period time T and intergal time Ti. With many times field expermant, we can get the three parameter, the result of adjustmant would be satisified.

3: Conposition of control system

The sketch picture of receiver pressure control system shown in Fig 4. In the picture , the CPU of microcomputor take the role of digital regulator, the 6522 card is a programible interface and it worked in out-put state. With control of microcomputor, the out-put electrical level "1" or "0" were pluse signal that control rotation of the step-by-step motor.

The procedure of control was that; the pressductor on the receiver measured the pressure P' , and conducted to the microcomputor through A/D converter, the microcomputor would compare the quantity P' with set pressure P, got the difference (E=P-P'). If the difference was more than accessible, the digital regulator would caculated the signals of direction and amound of rotary motion steps. The signals and null shift signal would conducted to the step-by-step motor. When receiverd the signals, the motor would rotary and the throtting valve would be moved, the opening of the throtting valve varied. At end, the difference (E=P-P') would be less than the franchise. With circling, it would be realized control and adjustment of pressure. The sketch of program of discharge pressure control shown in Fig -5.

ACCCRACY ANALYSIS OF DIRECTLY MEASUREMENT DATUM

We had taken practical test in 3W--0.75/14 air compressor to compary the result of the conventional test in the standard with the system measurement result. Before measurement, we had calibrated the pressductor and temperature with piston piezometer and water constant temperature oven, the calibration was static.In practical test, the microcomputor system was calibrated in field with the general standard meter to cancel the system deviation and zero shift of the transduce, then the compressor performance were measured automatically.

In table 1 shown the result and difference of the test in different test condition.

In table 1, except the discharge temperature of secondary stage exceed the franchise, other measurement datum were in the rang of accessible. The resean was the discharge tempreature of secondary stage over the range of water constant temperature oven and the datum were got with heterodyme method. when the tempreature over 100℃, we can calibrate the tranduces with oil constant temperature oven, the accuracy of the temperature would keep in the range. The signal of torque and revolution were transited to microcomputor in digital quantity, the accuracy only depond on the torque-speed meter.

PROGRAM DESIGN OF MICROCOPMUTOR

MEASUREMENT AND TREATING PROCESS

The program was designed in moduiar structure, the main-program call some sub-programs. The sub-program included; control program of work condition, collect and store datum program, manage and print program for initiative measured datum, treat program for test result, program for matrixing to standard work condition. program for print the tables of all test result. The process would carried out with controling of computor, at end of the test, the tables or result which were demanded would be got.

CONCLUSION

The microcomputor measurement and control system for performance of compress satisifyied the standard ISO-1217 and GB3853-83, realized automatical weasurement and work condition control. The system consistant was easy, the accuracy and reliability of result satisified the requrement,so it is valuable to spread it.

REFERENCE

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Tabel. 1 comparison of directly measurement results

discharge pressure	piezometer data	4.61	4.58	8.66	8.89	11.13	11.23
of secondary stage	computor collected data	4.58	4.57	8.65	8.88	11.15	11.20
MPa ×10	difference	-0.03	-0.01	-0.01	-0.01	+0.02	-0.03
discharge pressure	piezometer data	2.35	2.33	2.491	2.54	2.54	2.54
of primary stage	computor collected data	2.36	2.33	2.48	2.55	2.54	2.55
MPa ×10	difference	+0.01	0.00	-0.01	+0.01	0.00	+0.01
differential pressure	manoment data	367.5	371.3	354.8	342.4	345.2	349.3
of orifice plate	computor collected data	366.0	370.0	353.5	341.0	345.0	348.0
mm$H_2$0	difference	-1.5	-1.3	-1.3	-1.4	-1.2	-1.3
tempreature before	thermometer data	40.52	40.19	37.42	39.41	40.02	40.60
orifice plate	computor collected data	40.55	40.30	37.60	39.45	40.00	40.75
℃	difference	+0.03	+0.11	+0.18	+0.04	-0.02	+0.15
suction gas temperature	thermometer data	31.47	31.39	31.50	31.24	31.33	31.90
of primary stage	computor collected data	31.35	31.45	31.50	31.35	31.50	31.75
℃	difference	-0.12	+0.06	0.00	+0.11	+0.17	-0.15
discharge gas temperature	thermometer data	87.67	86.30	87.32	88.25	88.44	88.76
of primariy stage	computor collected data	87.60	86.30	87.40	88.35	88.49	88.90
℃	difference	-0.07	0.00	-0.08	-0.10	+0.05	+0.14
suction gas temperature	thermometer data	57.00	56.28	56.70	56.83	57.32	57.84
of secondary stage	computor collected data	57.05	56.25	56.80	56.90	57.40	57.90
℃	difference	+0.05	-0.03	+0.10	+0.07	+0.08	+0.06
discharge gas temperature	thermometer data	86.73	80.71	111.02	112.42	120.48	124.53
of secondary stage	computor collected data	86.80	80.90	110.40	111.70	122.10	125.25
℃	difference	+0.07	+0.19	+0.62	+0.72	+1.52	+1.52

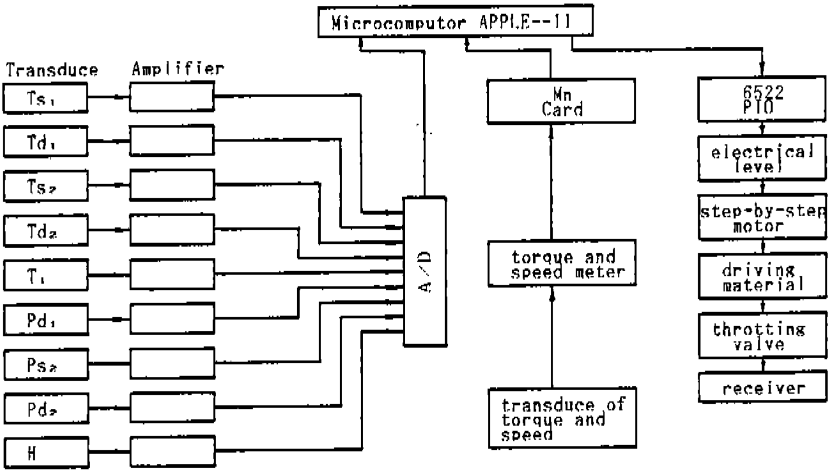

Fig. 1 Sketch of the measurement and control system

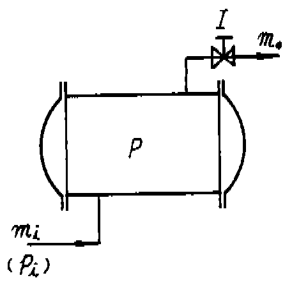

Fig.2 The fluid flowing into and out the receiver

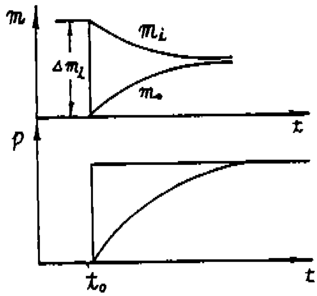

Fig.3 Process of pressure change in the receiver

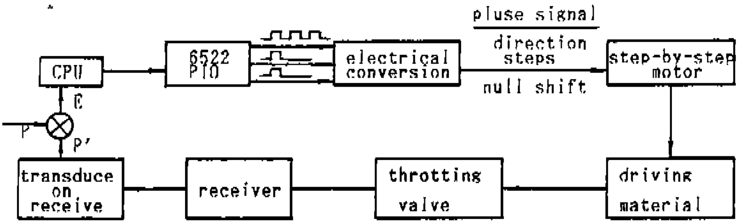

Fig.4 Sketch of pressure control process in the receiver

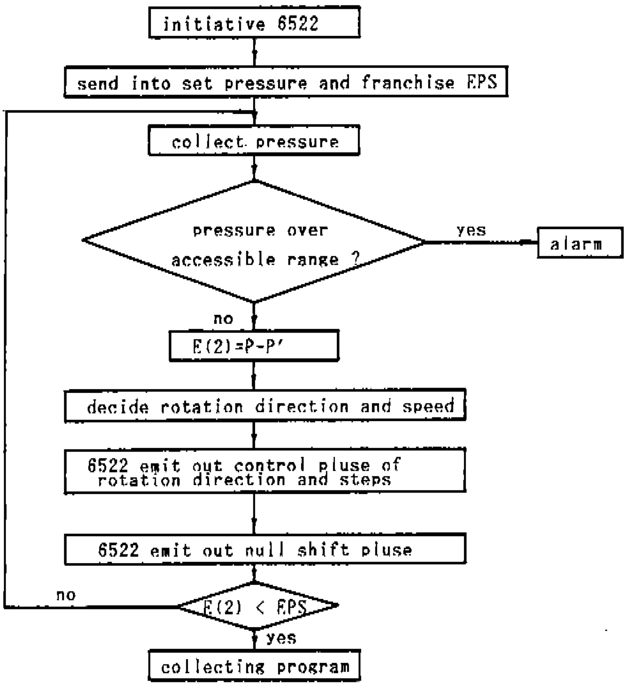

Fig.5 Sketch of pressure control program