БЪЛГАРСКА АКАДЕМИЯ НА НАУКИТЕ • BULGARIAN ACADEMY OF SCIENCES

ПРОБЛЕМИ НА ТЕХНИЧЕСКАТА КИБЕРНЕТИКА И РОБОТИКАТА, **61**
PROBLEMS OF ENGINEERING CYBERNETICS AND ROBOTICS, **61**

София • 2009 • Sofia

A Fluidic System for Parts Checking and Sorting in Explosiveness Environment

Vlayko Peytchev, Bogdan Stoyanov, Yordan Beyazov

Institute of Information Technologies, 1113 Sofia

1. Introduction

In a production with explosive nature, the checking of parts' size can be done with the help of an automatic device based on fluidic sensors, fluidic logic, and pneumatic actuators. Thus the risk of accidents associated with sparking and heating, which is possible in electrical systems, is eliminated. Modern electronic logic schemes operate with low voltage and the electrical actuators are safe proof, but the advantages of the air-driven devices under low pressure are that they are spark-proof, can be easily reconstructed under changing requirements and because of their technical simplicity are easy to handle and maintained by a personnel with low qualification.

The creation of such a system is necessary for military plants in the production of small explosiveness parts. The requirement is to measure linear sizes of the parts in two points A and B and according to the measurement to rank them into five size categories: A-norm B-norm; A-small B-small; A-norm B-big; A-big B-norm; A-big B-big. The cases of combination of normal and small sizes are ranked as good because of their use. The technology is corrected only if a machine produces parts with inadmissible sizes that are returned to be completed and the machine is tuned.

2. Structure and operation of the system

The solution of checking sizes is to use fluidic sensors of a “nozzle-flapper” type because of their high sensitivity – resolution of hundreds of a millimeter and their ability for self-cleaning under dusty conditions. Another advantage is the possibility for their easy tuning. The characteristic of these sensors is not linear but the condition requires simple reading of three threshold values and not their absolute measurement. Two equal range adjustable sensors are applied for the two points of measurement. The sensors’ adjustment is done by calibres or testing parts. The signals from the sensors are processed by an elementary logic, they are amplified by fluidic pressure and flow converters and are applied to air-driven actuators.

The principle of operation of the fluidic system for checking and sorting is discrete (Fig. 1).

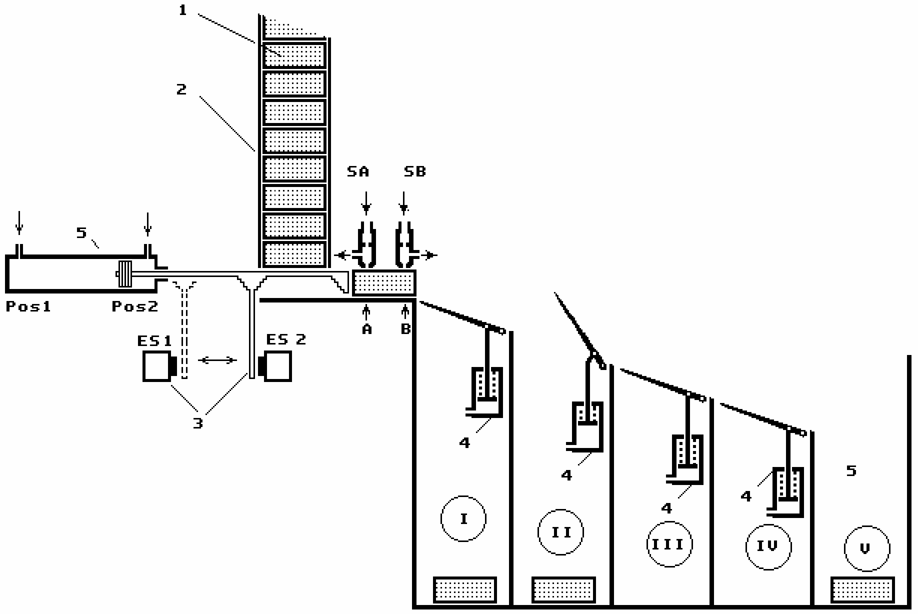

Fig. 1

The parts (1) come through a conveyor (2) and stop in front of a plunger (3), starting from position 1 (Pos1). The next part is pushed from the conveyor and positioned for measurement under the sensors SA and SB in position 2 (Pos2) for checking as it reaches the end switch (ES 2). The signal received from ES 2 turns the motion of the plunger that turns back to position 1, leaving the checked part in position 2. The next part comes from the conveyor in front of the plunger. A signal to power on the sensors is received when the plunger reaches the end position 1 via the end switch 1 (ES 1). The received signals from the sensors, through a logic scheme, open the respective bunker (4) that stays open. In the meantime, the plunger starts to push a new part from position 1 to position 2. The new part pushes down the measured part and it falls down either into the open bunker I, II, III, IV, or into a bunker without a hatch (5). When the plunger positions the new part under the sensors, the end switch ES 2 issues a signal to close all bunkers and to move back the plunger.

The logic scheme (Figs. 2 and 3) is built on the basis of fluidic discrete logic elements without moving parts that operate with air under low pressure. It is necessary to perform the logical operations shown in Table 1:

Table 1

Case	Size	Signal from sensor	Output signal from threshold element	Opens bunker
1	A-small B-small	SA-0 SB-0	TR1 – 0 TR2 – 0 TR3 – 0 TR4 – 0	no open bunker, parts fall into bunker without hatch
2	A-norm B-norm	SA-low SB-low	TR1 – 1 TR2 – 0 TR3 – 1 TR4 – 0	bunker I
3	A-norm B-big	SA-low SB-high	TR1 – 1 TR2 – 0 TR3 – 1 TR4 – 1	bunker II
4	A-big B-norm	SA-high SB-low	TR1 – 1 TR2 – 1 TR3 – 1 TR4 – 0	bunker III
5	A-big B-big	SA-high SB-high	TR1 – 1 TR2 – 1 TR3 – 1 TR4 – 1	bunker IV

The fluidic signal from the sensors’ outputs is sent to the control input of non-symmetric threshold elements from trigger type (TR1, TR2, TR3, TR4). They represent a non-symmetric Coanda element with adjustment of the flow in passive control channel by screws, thus achieving the required switching level. When the control signal is zero, the trigger goes back to the initial state. The two groups have two identical elements each and are set up in such a way that, upon respective values of the linear part sizes, the received sensor signal generates an output signal 1 or 0 according to the size.

The cyclic movements of the plunger are determined by the repetitive activation of ES 1 and ES 2. The time for one cycle depends on the friction of the parts to the slanting line and the parts’ weight. This time could be trimmed by chocking of cylinder’s outlets that triggers the plunger. To control the plunger’s movement, a logic scheme is used as well, that is built of fluidic pneumatic elements.

The actuators of the system are pneumatic cylinders operating at standard low pressure. The low-level signal from the logic elements is amplified by pneumatic amplifiers. In the scheme, a switch is intended for starting and stopping, that is also pneumatic.

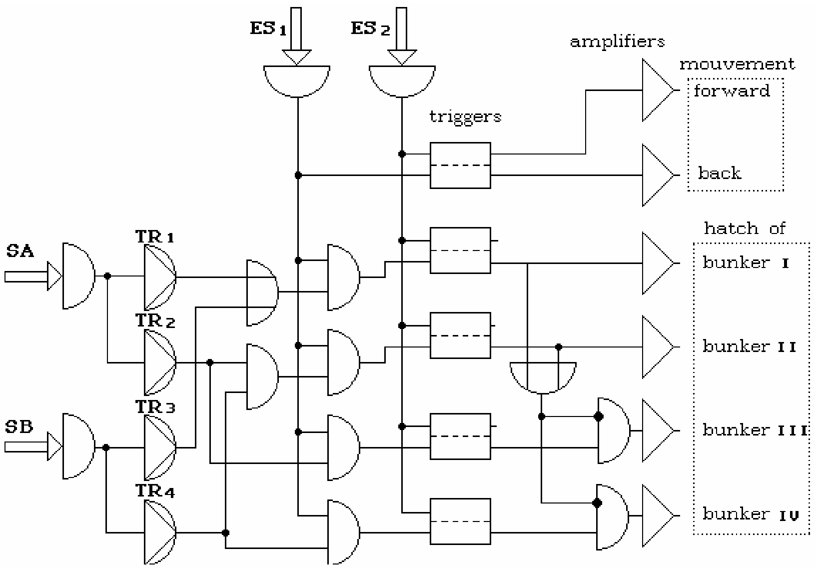

Fig. 2

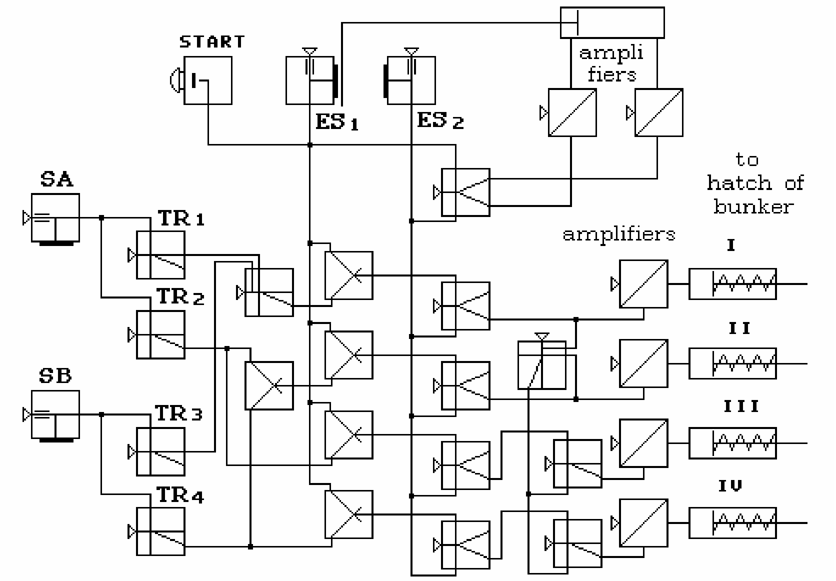

Fig. 3

The system is supplied with compressed air, prepared by filtering, drying, and regulating to the required pressure done by a standard air conditioning group. To supply the logic scheme, an additional reducer for very low pressure is used.

The actuators for opening the bunker's hatches are single-acting pneumatic cylinders. The plunger is triggered by a double-acting pneumatic cylinder. All cylinders’ sealing does not require maintenance and lubrication, which makes the preparation of the air under pressure simpler.

3. Characteristics of the fluidic sensor

3.1. Operational principle of the sensor

The general scheme of the fluidic sensor of “nozzle-flapper” type, used in the system, is shown in Fig. 4.

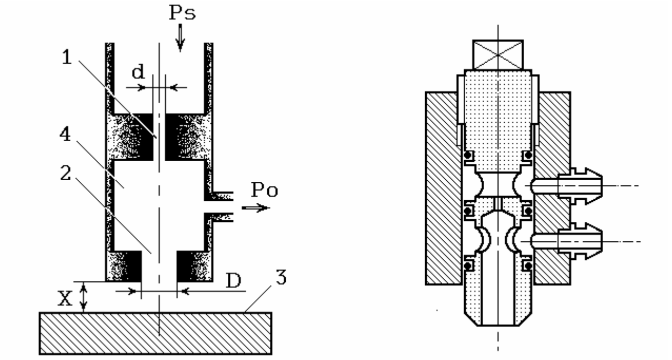

Fig. 4

Its basic elements are: permanent choke (1), emitting nozzle (2), intermediate chamber (4) and changeable choke formed between the emitting nozzle and the “flapper” – detail (3). The permanent choke has a non section (*F*) determined by the diameter *d*, and the changing choke has a section (*f*) representing a cylindrical surface determined by the diameter (*D*) of the emitting nozzle and the distance *X* to the detail. The reception of an information signal P_0 for the change of distance *X* is a result of the change of the static pressure in the intermediate chamber (4) caused by alteration of the section *f* of the changing choke. The change in that pressure (P_0) according to the distance (*X*) between the emitting nozzle and the detail represents the operational characteristic of the sensor.

3.2. Operational characteristic of the sensor

The equation of the operational static characteristic of the considered pneumatic sensor, at subcritical flowing through both chokes, is derived [5] using the equation for the flow of the air

$$P_0 = \frac{P_S C_1^2 f^2}{C_1^2 f^2 + C_2^2 \pi^2 D^2 X^2}, \tag{1}$$

where f is the area of the cross section of the permanent choke; C_1 and C_2 are the corrected coefficients of the air flow through the permanent and the changing choke, respectively, determined by the equations:

$$C_1 = 0.8329 - 0.4334 f + 0.4519 f^2, \tag{2}$$

(3) $$C_2 = 0.8329 - 0.4334F + 0.4519F^2 .$$

In Fig. 5 the graphical image of the characteristics of the sensor are shown with the most common diameters of the permanent (d = 1 mm) and a changing choke (D = 3 mm), with supply pressure P_S = 140 kPa, obtained actually $[P_0 o = f(X)]$, and according to the semi-empirical equation $[P_0 e = f(X)]$. The results confirm the correctness of the accepted approach for more accurate analytical determination of the operational characteristic of the sensor.

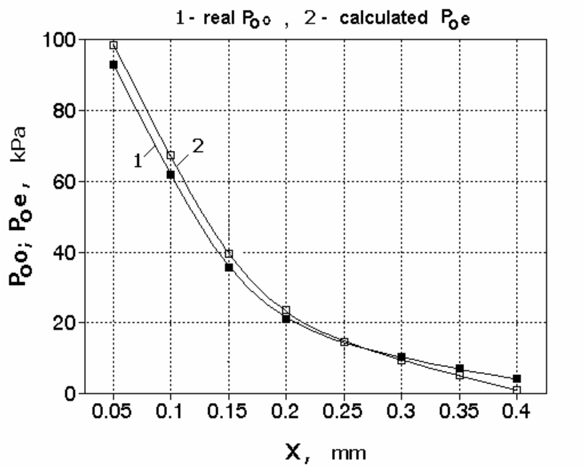

Fig. 5

3.3. Sensibility of the sensor to input signal

Sensibility of sensors of the type “nozzle-flapper”: with respect to the input signal is determined by the declivity S $(S = \Delta P_0 / \Delta X)$ of the static characteristic in its operational sector. In a number of papers [1, 3, 4] algorithms and methods are proposed to increase the sensibility (the ratio coefficient) of the sensors of the considered type with the help of change of the sizes and the form of the chokes and the intermediate chamber (4). In cases of already built pneumatic sensor, its sensibility can be increased by increasing the supplying pressure P_S . An empirical equation is derived [5] to determine sensibility of the sensor to the input signal:

(4) $$S = \frac{\Delta P_0}{\Delta X} = 6.29 P_S \cdot$$

As it can be seen by equation (4), the changing sensibility of the output signal with respect to the change of the distance X between the sensor and the barrier is changing proportionally to the supplying pressure value. This fact should be considered when choosing the operational supply pressure of the sensor, as well as the fact that it should have a constant value stabilized in the course of operation by suitable means.

4. The characteristics of a sorting system

The laboratory model of the sorting system has shown a sufficient for the practice accuracy. In its realization the parameters would improve with the use of appropriate materials and processing. Fastness is not big because of the cyclic mode of operation – about 100 measurements per minute. A system with a rotary mode would be more efficient. The implemented materials and the air supply provide high explosiveness proof. The construction is simple and easy to tune and maintain.

5. Conclusions

Based on the theoretic and experimental results obtained from the conducted research, the following more important conclusions can be drawn:

- A prototype is built of a fluidic sorting system for explosiveness parts with small size that is applicable for passive checking of parts in the products of some military production.
- A logic scheme is developed for automation of the sorting process based on fluidic elements.
- A pneumatic sensor of a “nozzle-flapper” type is developed and a semi-empirical relation is proposed to determine its static characteristic, where corrected coefficients of the flow are introduced for subcritical air flow through the permanent and changing choke of the sensor. Thus a bigger confidence is achieved in the determination of the output information signal in the sector of sensor triggering.

References

1. Jork Rainer. Pneumatische und hydraulische Bauelemente und Baugruppen der MSR-Technik. Berlin, Verlag Technik, 1982.
2. Алимов, О. Д., М. М. Гохберг. Пневмопривод и пневмоавтоматика с нестандартными схемами. Фрунзе, Илим, 1970.
3. Дмитриев, В. Н., В. Г. Градецкий. Основы пневмоавтоматики. М., Машиностроение, 1973.
4. Ибрагимов, И. А., Н. Г. Фарзане, Л. В. Илясов. Элементы и системы пневмоавтоматики. М., Высшая школа, 1975.
5. Стоянов, Б. П., В. С. Пейчев. Теоретико-експериментално определяне на коефициентите на дебита и общото съпротивление на пневматични турбулентни дросели. –Техническа мисъл, **XXXIII**, 1996, №1, 75-85.
6. Stoyanov, B., Y. Beyazov, V. Peichev. Static Characteristics of a Fluid “Flapper-and-Nozzle” Sensor. – Cybernetics and Infomation Technologies, Vol. **1**, 2001, No 2, 86-92.

Флюидная система для контроля и сортирования деталей в эксплозивной среде

Влайко Пейчев, Богдан Стоянов, Йордан Беязов

Институт информационных технологий, 1113 София

(Резюме)

Рассматривается система контроля и сортирования маленьких деталей в эксплозивной среде. Система включает конвейер, измервательное оборудование, два оригинальные флюидные сенсора типа „дюза-вентиль” и пять контейнеров для готовых частей. Проверка размеров и логика базируются на флюидных логических элементах. Привод системы на основе воздуха ниского давления.