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A Noncontact Pneumatic-to-Electrical Transducer of Position

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1. Introduction

The development of modern technologies in the field of transducers has restricted, but not eliminated entirely the development and application of fluid sensors. The application of well known hydro-aerodynamic effects and phenomena [4-6] connected with the behaviour of differently shaped fluid jets, makes the fluid sensors preferred in work under extreme operating conditions, such as the presence of powerful electrical and electromagnetic fields (for example in electric welding), the presence of sparks and metal splashes (found in metal casting), or in contaminated environment full of dust, smoke and others.

The present paper discusses the results of the development and study of a noncontact pneumatic-to-electrical transducer of position [1, 3], designed on the basis of a fluid jet sensor with an annular nozzle and a pneumatic-to-electrical transducer [2], including an elastic membrane with a hard centre and a plate, an optical system and an electronic trigger scheme.

Fig. 1 shows the sensor diagram, in which the following denotations have been used: 1 is an object, moving axially with respect to the nozzle; 2 – an object, moving transversely with respect to the nozzle; 3 – a device corpus; 4 – an annual nozzle; 5 – a receiving channel; 6 – a membrane chamber; 7 – an elastic membrane with a hard centre; 8 – a plate, attached to the hard centre; 9 – an optical system.

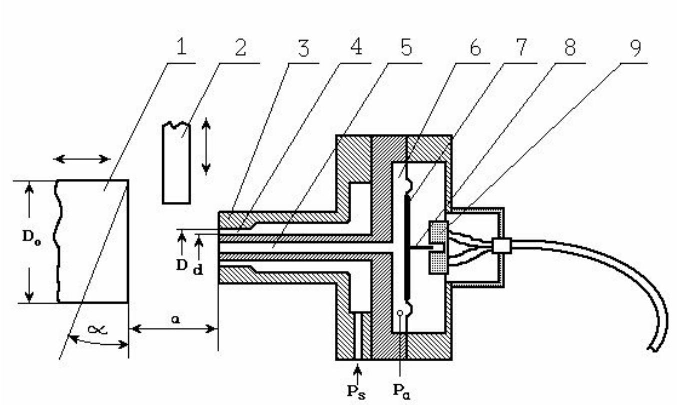

Fig. 1

Fig. 2 shows the principal diagram of the experimental equipment for static and dynamic investigations of the indicator, where 1 is the transducer studied; 2 – a mobile baffle; 3 – a platform, intended for the creation of different positions of the baffle with respect to the sensor; 4 – a direct current electric motor for the generation of dynamic input pulses, rotating the baffle; 5 – precise manual microdrives for the baffle movement; 6 – linear sensors, registering the shift and producing the respective electrical signal; 7 – inductive sensors for measuring distance and pressure, necessary for the dynamic tests; 8 – a source of compressed air with stabilized pressure; 9 – a flowmeter, 10 – a precise laboratory manometer; 11 – an amplifier of the sensors signals; 12 – a two-beam oscilloscope for visual tracing of the dynamic processes; 13 – an *X-Y* recorder.

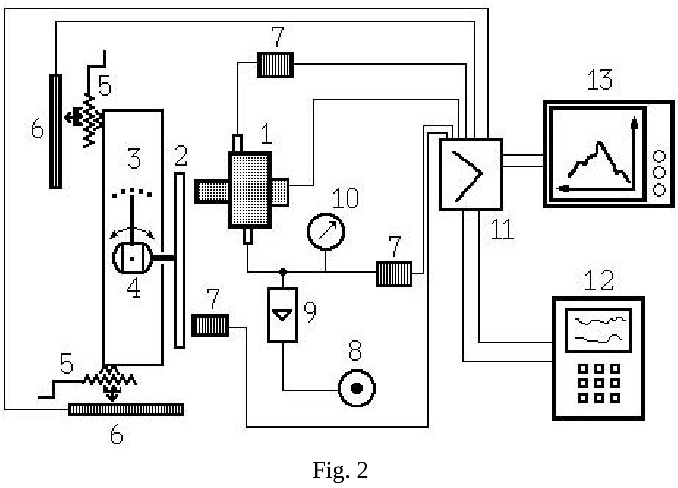

Fig. 2

2. Static and dynamic features of the transducer

The sensor investigations have been accomplished with the following parameters: $P_s = 10 \div 50$ kPa through every 10 kPa; alterations of the distance from the parallel approaching baffle to the sensor $a = 2 \div 5$ mm through every 0.5 mm; baffle slope $\alpha = 0° \div 15°$; diameter of the reflecting surface $D_0 = 4 \div 14$ mm.

The working static characteristics of the sensor with an annular jet at axial and parallel relocation of the baffle are shown in Figs. 3 and 4, where P_a is the output pressure, acting on the membrane of the pneumatic-to-electrical transducer.

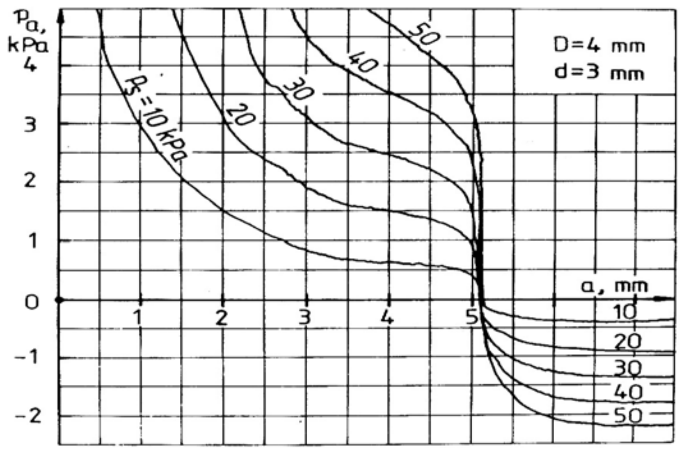

Fig. 3

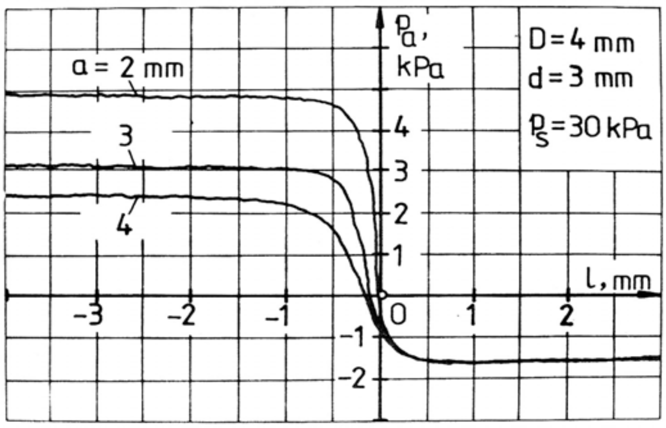

Fig. 4

The relations obtained show that a “singular” output signal (gauge pressure) is obtained and it relocates the membrane with the plate towards the optical system, when the distance *a* is smaller than 5 mm, while in case the distance is bigger, the output signal becomes negative (underpressure) and the membrane is detached from the optical system up to its leaning against the rear wall. It is important to note that the supply pressure does not influence the distance *a* up to the extent when switching over would take place, but it influences only the magnitude of the output pressure and the steepness of the sensor characteristic.

Keeping constant parameters, the behaviour of the transducer is studied with respect to the diameter of the reflecting surface of the object (Fig. 5). The output gauge pressure drops down considerably at $D_0 \leq 2D$, which can be seen in Fig. 6.

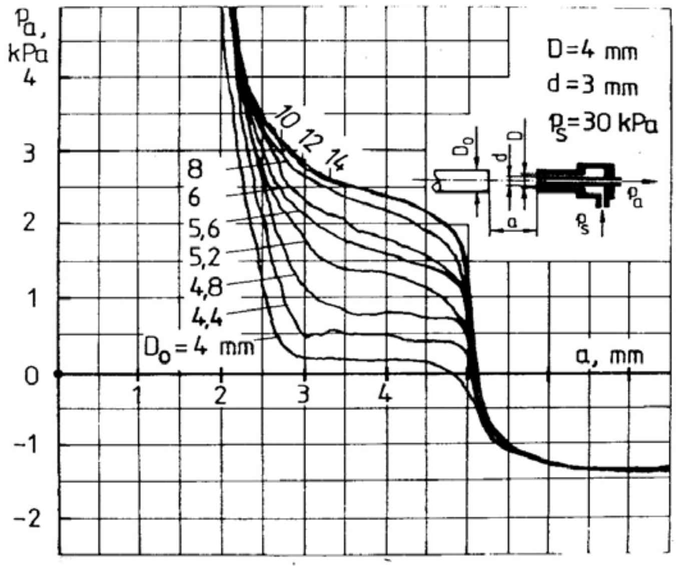

Fig. 5

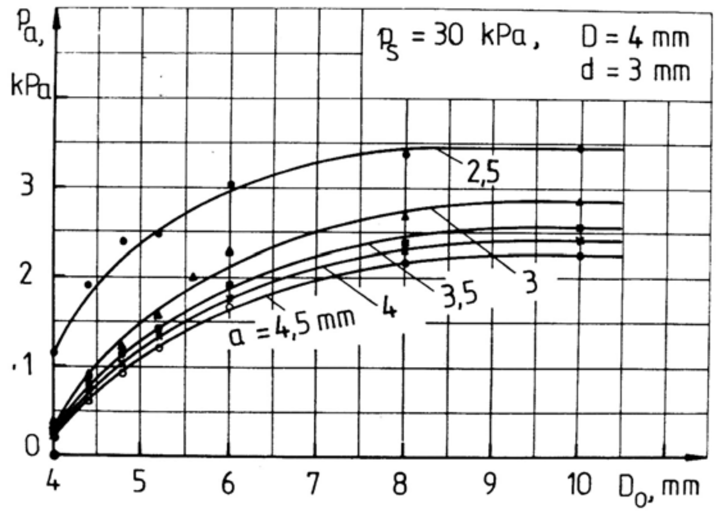

Fig. 6

Some example results from the investigations of the baffle non parallelity in relation to the annular dozzle are shown in Figs. 7 and 8. It appears that the dependence of the pressure P_a on the slope of the reflecting surface is approximately linear (Fig. 8).

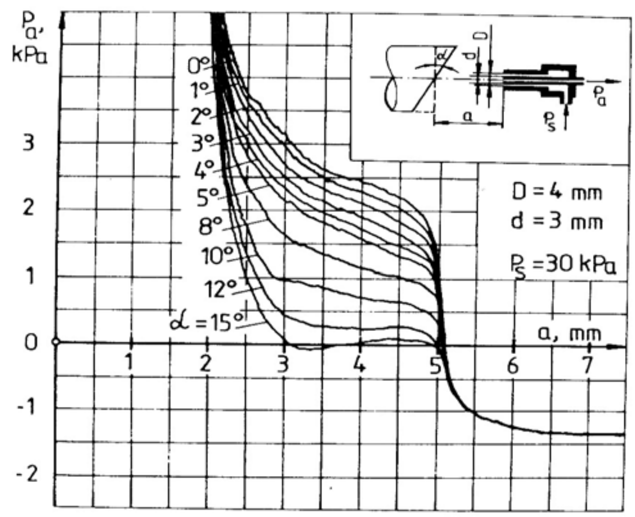

Fig. 7

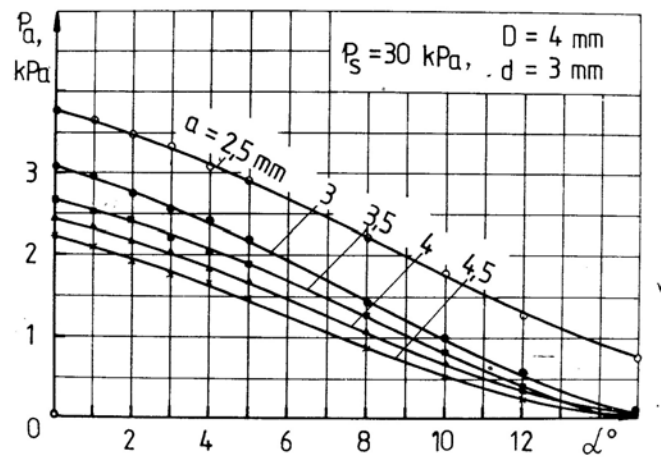

Fig. 8

The gauge pressure obtained P_a in the presence of an object (baffle) acts on the membrane, which is relocated and thanks to the plate attached to it, the beams of the optical system are cut off. For this purpose a shift of 1.5 mm of the plate is necessary, due to which the membrane in its end position leans against the membrane wall.

Fig. 9 shows graphically the characteristic of the sensor switching over, expressed in the alteration of the electric voltage U_a by the optical system, depending on the axial relocation *a* of the object. The electric voltage is formed as a discrete signal with the help of an electronic trigger scheme, enabling the setting of the desired value of U_a and of the hysteresis of the switching characteristic.

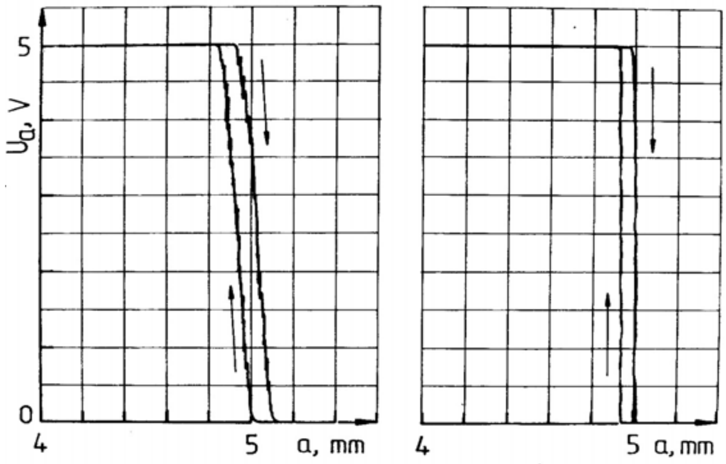

Fig. 9

Fig. 10 presents the frequency characteristic of the transducer at different distances between the baffle and the annular nozzle. The operating frequency of the sensor is highest about 200 Hz, with a distance between the baffle and the nozzle within the range of 2.5 mm up to 3.5 mm.

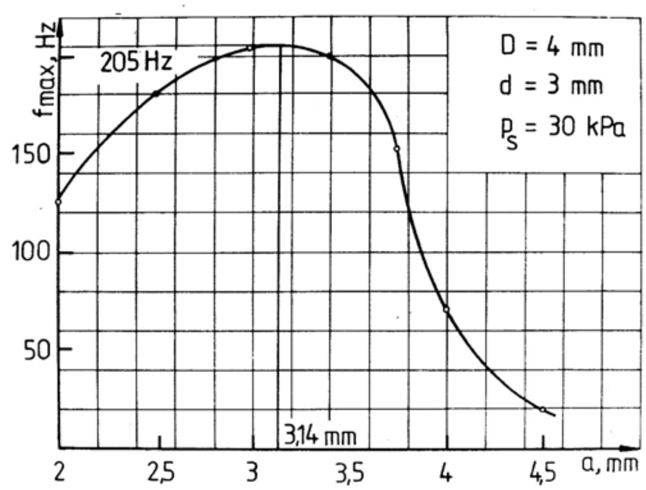

Fig. 10

3. Conclusion

From the analysis of the results of the investigations of the developed noncontact pneumatic-to-electrical transducer of position, the following more significant conclusions can be done:

– the magnitude of the supply pressure does not influence the distance *a*, at which gauge pressure is obtained at the sensor output, but it does influence its magnitude and intensity of growing;

– the output gauge pressure reduces significantly for a diameter of the baffle, smaller than twice the diameter of the annular nozzle of the sensor ($D_0 \leq 2D$);

– the dependence of the gauge pressure P_a on the slope of the reflecting plate with respect to the surface of the annular nozzle is approximately linear, at that with the increase of the slope angle, the pressure drops down;

– the electronic trigger scheme allows the setting of the output signal U_a at a desired value and the magnitude of the switching characteristic hysteresis after reaching a definite distance *a* of the baffle with respect to the output cross section of the annular nozzle;

– the maximal frequency of the transducer switching over depends on the distance *a* and it takes place at *a* = 3 mm.

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Безконтактный пневмо-электрический преобразователь позиции

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(Р е з ю м е)

Представлены результаты исследований безконтактного пневмо-электрического преобразователя позиции, который построен на основе струйного датчика с кольцевой дюзой и пневмо-электрического преобразователя. Статические храктеристики струйного датчика определены для разных геометрических и динамических характеристик пневмо-электрического преобразователя. Устройство предназначено для работы в экстремных условиях – при наличии пыля, ударов и вибраций, в электричиских и радиоактивных полях, при променливой температуре окружающей среды и др.