Effect of Sensitive Working Gas on the Sensitivity of the Fluidic Gyroscope

Piao linhua[1, a *],Duanlei[2,b] ,Dong haoliang[3,c]

(1 Beijing Key Laboratory for sensor, Beijing Information Science & Technology University, Beijing 100101;2Sensor Technique Research Center, Beijing Information Science & Technology University, Beijing 100101，China;3Sensor Technique Research Center, Beijing Information Science & Technology University, Beijing 100101，China;a bjplh@163.com; b duanlei6688@yeah.net;)

Keywords:working gas;fluidic;sensitivity;gyroscope

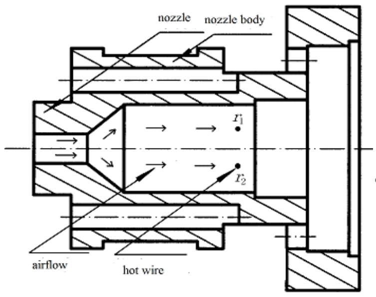
Abstract. The paper researches the dry air,nitrogen and helium and other effects of three kinds of commonly used sensitive gases on the sensitivity of the fluidic gyroscope.By using the finite element method,the flow field in sensing element of fluidic gyroscope under the effect of the input angular velocity of 20°/S, has been obtained by a series of procedure. The results are as follow:The sensitivity of different corresponding to the different working gas sensitive,K_{AIR} - - the corresponding sensitivity coefficient of dry air is10mv/(°/S), K_{N2} is 10.5mv/(°/S), K_{He} is 2.1mv/(°/S), $K_{N2} > K_{AIR} > K_{He}$,,where K_{N2} is 1.05 times of K_{AIR}, K_{He},is 0.21%of K_{AIR}This paper explained and verified the mechanism of sensitive working gas influence on fluidic gyroscope sensitivity, in order to improve the practicability of the fluidic gyroscope, meet different engineering needs to open up a new way.

Fluidic gyroscope has no rotating part of traditional gyroscope,nor solid inertial devices of piezoelectric gyro suspension components,sensitive quality of fluidic gyroscope is gas, inertia is small, not only the response time is short, and strong shock resistance, still can work normally under the impact of the 16000g.Due to the sensitive mechanism of fluidic gyroscope is based on the heat exchange between forced convection gas in sensitive element and thermal resistance wire [1],for the density, viscosity property of the sensitive working gas species in sensitive element is different, will affect the airflow speed different distribution,working gas will change in the vicinity of the thermal resistance wire flow,So species change in the sensitive working gas makes the output voltage change, lead to differences in the sensitivity of the sensor.In this paper, by using the finite element method,comparatively study of flow field in fluidic gyroscope sensitive element of dry air, nitrogen and helium and other three kinds of commonly used sensitive working gas with the input angular velocity ω_i=20°/S, explaining and verifing the mechanism of sensitive working gas influence on fluidic gyroscope sensitivity.

structure principle

Fluidic gyroscope sensitive element is mainly composed of piezoelectric pump,nozzle body, nozzle and shell body, etc. The nozzle body is the main part of the sensitive element, as shown in Figure 1.The jet of sensitive element is driven by piezoelectric pump,produce a laminar jet beam in the nozzle,then shoots to two heat resistance wire r1, r2 parallel placed in nozzle body. Once there is an angular velocity input,The jet bundle through symmetry center from two thermal resistance wire r1 and r2 formely will deviate to a direction,cause two thermal resistance wire r1, r2 different cooling, the resistance of the thermal resistance wire r1and r2 changes,cause the current to change, detection bridge loses balance,whose output voltage ΔU is corresponding to the angular velocity ω_i, as is shown in Fig.2.

The material of hot wires is platinum, which is sensitive to temperature and not easily oxidized in the air.Platinum wires diameter of 2 ~ 15 m, the resistance of the thermal resistance wire r1and r2 is same,platinum wires parallel horizontally planted in closed cavity with the diameter of 5 ~ 25mm.



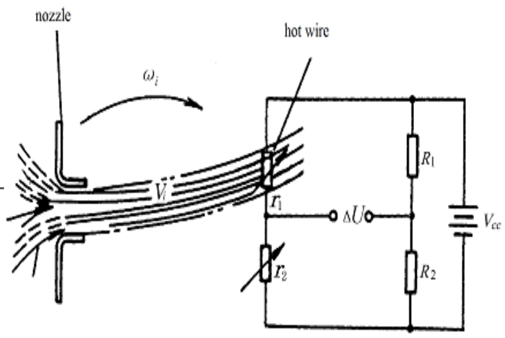


Fig.1 The frame of nozzle Fig.2 Operation principle of sensor

physical model

Due to the jet deflection of fluidic gyroscope is in the nozzle body to achieve, so the nozzle body flow channel as the object of study.In order to facilitate the modeling and calculation, two-dimensional nozzle body structure can be simplified, through the axis of symmetry nozzle body, the tw -dimensional section of airflow is obtained through the symmetry axis of the nozzle body, as is shown in Fig.3.The section of airflow has the length of 15 millimeters, of which the diameter of the entry and outlet are 2.5 millimeters and 9 millimeters respectively, with trapezoid section 5 millimeters long.Assumed that air velocity in the entrance is 1.5m/s and Reynolds Number is 900.Free convection caused by hot wires could be neglected, because its velocity is far more less than that of forced convection.

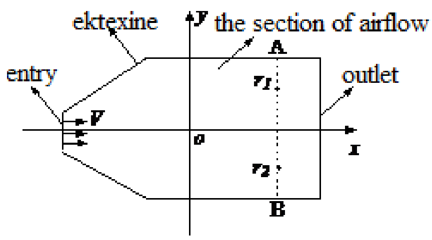


Fig.3 two-sensing enclosure map

Solving, results and discussion

ANSYS-FLOTRAN CFD is an advanced facility to analyses the flow field of two-dimensional and threedimensional fluid.The process always includes three steps:
modeling, loading, and calculating.

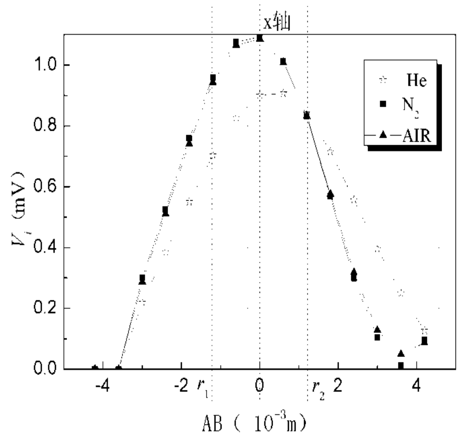


Fig.4 Distribution of the flow velocities along line AB

Table1 Different airvelocity sensitive workinggas corresponding to the two heatresistance wire R1and R2.

	V_{r1} (m/s)	V_{r2} (m/s)	ΔV (m/s)
AIR	0.3192	0.9429	0.624
N_2	0.2980	0.9591	0.661
He	0.5571	0.7035	0.146

Line AB plumbed to x-axis is made through hot wires so as to observe the distribution of jet flow velocities clearly, as it is shown in Fig.3.As Fig.4 shows, the flow velocities distribute along line AB according to the results of FEA.As you can see from Figure 4, the airflow velocity V_i along line AB corresponding to the two heat source center line is the asymmetric distribution while the angular velocity ω_i=20 /S,the airflow velocity V_{r1} and V_{r2} along the thermal resistance wire r1and r2 respectively with the difference ΔV as shown in Table 1. Seen from table 1, the airflow velocity along the two heat resistance wire r1 and r2 corresponding to sensitive working gas is inequality,the difference ΔV_{N2} between V_{r1} andV_{r2} corresponding to N_2 is is the maximum,ΔV_{AIR} between V_{r1} andV_{r2} corresponding to dry air take the second,ΔV_{He} between V_{r1} andV_{r2} corresponding to He is the minimum.Where ΔV_{N2} is 1.05 times of ΔV_{AIR},ΔV_{He} is 0.21%of ΔV_{AIR}.The difference ΔV of airflow velocity along two thermal resistance wire r1and r2 change will inevitably lead to the difference of current flow through the two thermal resistance wire r1 and r2 change,the bridge loses its balance,and outputs a voltage signalΔU[1,2] corresponding to sensitive working gas,therefore, according to the detection of bridge output voltage ΔU, indirect verification the difference ΔV of flow velocity along the thermal resistance wire r1 and r2. Relationship between bridge output voltage ΔV corresponding to different sensitive working gasand the angular velocity is shown in Fig5.As can be seen from the graph,The sensitivity coefficient K_{AIR} of dry air is 10mv/(°/S), K_{N2} is 10.5mv/(°/S), K_{He} is 2.1mv/(°/S).The different sensitivity corresponding to the different sensitive working gas , $K_{N2} > K_{AIR} > K_{He}$,,where K_{N2} is 1.05 times of K_{AIR}, K_{He},is 0.21%of K_{AIR}.The above and finite element numerical results are consistent

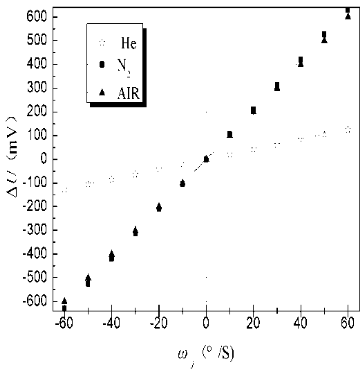


Fig.5 Curves of relationship between $\Delta U$and ω_i

Conclusion

The paper researches the dry air, nitrogen and nitrogen effects of three kinds ofcommonly used sensitive gases on the fluidic gyroscope sensitivity. By using the finite element method,using ANSYS FLOTRAN CFD program,the flow field in sensing element of fluidic gyroscope under the effect of the input angular velocity of 20°/S, has been obtained by a series of procedure, such as model building, meshing, loads applying and equation solving. The results are as follow:

(1)The different sensitivity correspondingtodifferent working gas sensitive,The sensitivity coefficient K_{AIR} of dry air is 10mv/(°/S), K_{N2} is 10.5mv/(°/S), K_{He} is 2.1mv/(°/S).Thedifferent sensitivitycorresponding to the different sensitive working gas , $K_{N2} > K_{AIR} > K_{He}$,,where K_{N2} is 1.05 times of K_{AIR}, K_{He},is 0.21%of K_{AIR}.

(2)N_2 is corresponding to the highest sensitivity, the thermal resistance wiresantioxidant, stability is better, but the cost is high; sensitivity of dry air, the thermal resistance wires easily oxidized, poor stability; $H_e$corresponding to theminimum sensitivity, thermal resistance wire is not easy to be oxidized, the best stability.

This paper explained and verified the mechanism of sensitive working gas influence on fluidic gyroscope sensitivity, in order to improve the practicability of the fluidic gyroscope, meet different engineering needs to open up a new way.

Acknowledgement

BeijingNatural Science Fund Project&Beijing City Board ofEducation Science and technology key project (KZ201511232034); Key Laboratory of Beijing open projects funded project;Modern Control Technology funded by Ministry of Education Key Laboratory;

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