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RESREARCH ON FLUID CHARACTERISTIC WITHIN THE ROTATING-WING HEAT METER*

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ABSTRACT: In order to improve the performance of rotating-wing heat meter and reduce the cost of development, the three dimensions numerical calculations of the internal fluid characteristic within a heat meter are carried out based on the standard *k*-*ε* turbulent mode, the finite volume method and SIMPLE algorithm. The speed field and pressure distribution within heat meter are analyzed according to the result of numerical calculation. The flux measurement accuracy and pressure loss of basal meter are forecasted according to the calculated results. The calculated results of the impeller's rotating speed are compared with experimental results and prove the validity of the calculated results. This researches shows the calculated results can forecast the performance parameters of basal meter and can provide great help for design of the heat meter.

KEY WORDS: heat meter, numerical calculation, rotating-wing

1. INTRODUCTION

More and more Chinese enterprises begin to produce the heat meters because of high demand for heat meter after the reformation of the charging method for the winter heat consumption. But the most of Chinese homemade heat meters use the previous heat-water meter as the basal meter to measure the flux and the flux measurement accuracy can't meet the requirement. For example, the impeller of heat-water meter only rotates 6.5 turns when one liter water flows through the meter, the distinguish rate and the accuracy can't meet the 2 class Chinese standard. So designing the new type basal meter is the key of improving the measure accuracy. At present, the most heat meters are the rotating-wing heat meter, the design of basal meter mainly depend on the engineer's experiences and the relevant research of internal flow characteristic in rotating-wing machine seldom be reported. The fluid characteristic in the heat meter seriously influences the measure accuracy of flux and should be researched for improving the measurement accuracy. This research designs a new type heat meter to improve flux measurement accuracy. In order to reduce the blindness of design and improve the design efficiency, the numerical calculation based on the standard *k*-*ε* turbulent mode and the decartelization of the finite volume are carried out to forecast the performance parameter. The performance predictions of numerical method are compared with experimental results to prove the feasibility of the numerical calculation. The research shows numerical calculation can provide great help for designing the accurate heat meter.

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2. THE GRID GENERATION AND THE MATHEMETICAL MODEL

2.1 *The Generation of Grid*

The structure of the new heat meter is shown in Fig. 1. The pipe diameter of inlet and outlet is 20 mm, the operation pressure of heat meter is 1.6 MPa, and the flux measure range is from 0.05 m^3/h to 5 m^3/h. The new structure abandons the eccentricity inlet and outlet of heat-water, the inlet and outlet pipe are located at the same line for convenience of producing. A triangle deflector is located at the inlet, it changes the direction of flow and divides the water flow into two parts. The water flows into the impeller cell and pushes the impeller to rotate. The diameter of impeller cell is 49 mm, an impeller that own seven blades is assembled in the center of impeller cell. The internal structure of heat meter is complex and not symmetrical, so only three-dimension model can be used while numerical calculation is carried out. Because of the narrow and complex of the inter structure, the generation of grid is the main work of numerical calculation[1]. For decreasing the number of grids, the structural hexahedron grid is adopted to complete the discretization of computational domain. Because of complexity of structure, dividing the computational domain into eleven blocks, and then generating structural hexahedron grids for every block separately. The computational domain and grids is shown in Fig.2. It consists of the inlet pipe, impeller cell and outlet pipe. The length of inlet and outlet pipe is as seven time as the diameter of the pipe.

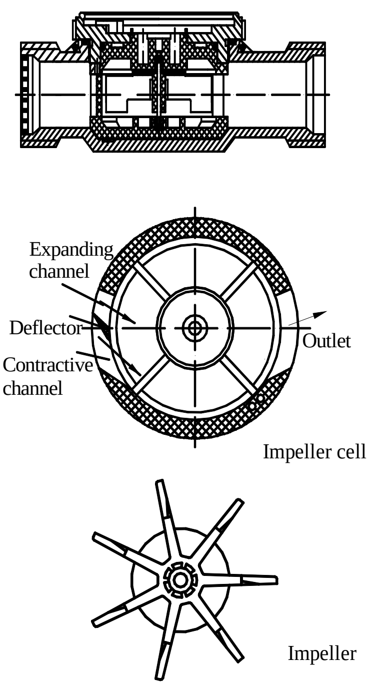

Fig.1 The Structure of heat meter

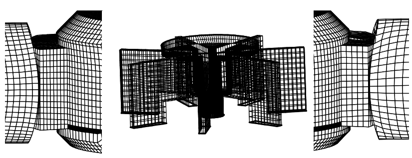

Fig.2 The computational domain

2.2 *The mathematic model*

The internal flow of heat meter is fully turbulent during the most the work time. So the standard k-ε turbulent model was compatible to implement the numerical calculation. The k-ε turbulent model consisted of continuity, momentum, k and ε equations, these equations are[2-8]:

Continuity equation:

$$\frac{\partial \overline{u}_i}{\partial x_i} = 0 \tag{1}$$

Momentum equation:

$$\frac{\partial(\rho \overline{u}_j \overline{u}_i)}{\partial x_j} = -\frac{\partial p^*}{\partial x_i} + \frac{\partial}{\partial x_j}[\mu_e(\frac{\partial \overline{u}_i}{\partial x_j} + \frac{\partial \overline{u}_j}{\partial x_i})] - 2p\varepsilon_{ijk}\omega_j \overline{u}_k \tag{2}$$

k equation:

$$\frac{\partial}{\partial x_j}[\rho \overline{u}_j k - (\mu + \frac{\mu_t}{\sigma_k})\frac{\partial k}{\partial x_j}] = \rho(p_k - \varepsilon) \tag{3}$$

ε equation:

$$\frac{\partial}{\partial x_j}[\rho \overline{u}_j \varepsilon - (\mu + \frac{\mu_t}{\sigma_\varepsilon})\frac{\partial \varepsilon}{\partial x_j}] = \rho \frac{\varepsilon}{k}(C_1 p_k - C_2 \varepsilon) \tag{4}$$

where $\overline{u}_i$ (i=1,2,3) are the average relative velocity components, ε_{ijk} is a tensor, ω is the angle-velocity of rotating region, $\mu_e = \mu + \mu_t$, μ is the viscous coefficient, μ_t the Boussinesq turbulent viscosity, is denoted by

$$\mu_t = \rho C_\alpha \frac{k^2}{\varepsilon} \tag{5}$$

p is pressure, ρ is density, p_k, produced by the turbulent kinetic energy k, is calculated by

$$p_k = \frac{\mu_t}{\rho}(\frac{\partial \overline{u}_i}{\partial x_j} + \frac{\partial \overline{u}_j}{\partial x_j})\frac{\partial \overline{u}_i}{\partial x_j} \tag{6}$$

C_μ, σ_k, σ_ε, C_1 and C_2 are the turbulent model coefficient, C_μ equals 0.09, σ_k equals 1.0, σ_ε equals 1.3, C_1 equals 1.44, C_2 equals 1.92. All the above equations form closed equations, could be solved with numerical method.

2.3 *Boundary conditions*

The ideal heat meter requires the meter factor is constant when flux changes. Meter factor is denoted