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Mechanical Analysis Model of the Turbine Flow-meter

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Abstract

A mechanical behavior model of the turbine flow-meter is established and improved to transform the binary nonlinear equations by the substitution element elimination method, and to solve the equations by using the right-point search method. After the operation parameters are inserted into the improvement model calculation, and compared with the Monte Carlo method used in the existing literature, the operation efficiency greatly improves when ensuring that the results meet the error requirements, which proves the success of the algorithm improvement.

Keywords

Turbine Flow-meter; Mechanical Analysis Model; Nonlinear Equations; Monte Carlo Method; Segment Search Method.

1. Introduction

Turbo flow-meter is a kind of speed flow measuring instrument, which has the advantages of high accuracy, good repeatability, wide range and small volume, so it is widely used in military, petrochemical, agriculture, light industry and many other industrial fields [1]. Due to the different fluid flow conditions of the measured in turbine flow-meter in different fields, the application conditions of turbine flow-meter are different. Therefore, the study of the measurement performance under different conditions is of great practical significance for the extensive expansion of the application field of turbine flow-meter.

At present, the theoretical basis of turbine flow-meter model are angular momentum change theory, boundary layer theory and wing theory. Related scholars have established different mechanical analysis models based on the above several theories. Hochreiter Based on momentum analysis and one-dimensional calculation, the relationship between the turbine flow-meter instrument coefficient and the dimension parameters is analyzed, but ignoring the influence of the measured fluid velocity, density and viscosity. According to its experimental comparison, the maximum deviation of the model is 10% [2].Lee et al. established the mathematical model of the turbine flow-meter based on the momentum theory [3], but the parameters of this model depend on the experimental data, so it is difficult to generalize to the general situation. Thompson And other applied wing theory to propose a calculation formula of the driving torque of the turbine flow-meter, and establish a mathematical model of the turbine flow-meter [4], but it simplifies the working condition of the turbine flow-meter to a certain extent, including the inlet velocity profile only considering the full development of turbulence state and the influence of the fluid viscosity.Tsukamoto[5] Combine the boundary layer theory and the momentum theory to derive the calculation formula of various resistance moments. C. L. Tegtmeier and other [6] use a typical turbine flow-meter size parameter to build a 3 D grid model considering the flow rate, density and viscosity, and use CFD to analyze the stable rotation state of the turbine flow-meter and present a calibration result. Z. Dzemic and other have considered the transition state based on the steady-state operation of the turbine flow-meter [7], and studied the relationship between the Reynolds number and the dynamic response of the turbine flow-meter by using the hot-line wind speed measurement method.

Based on the research of Lee, Thompson and others, Zhao et al. uses the boundary layer theory to deduce the numerical relationship between the viscous resistance moment and viscosity and flow [8], gives a new mathematical model, and calculate the critical Reynolds number to distinguish the turbine flow meter according to the model. Weng Yan et al. [9] considered the existence of the viscous boundary layer, added a correction coefficient to the mathematical model of Thompson, and applied the boundary layer theory to calculate the relationship between the blade resistance coefficient and the viscosity, but the correction coefficient was determined according to the experiment.Stuzhong [10] introduces Osee equation on the basis of wing theory, and applies the conformal transformation method to obtain a more accurate calculation formula of blade lift and resistance. On the basis of wing theory, Sun Lijun [11] fully considered the influence of blade limited wingspan, established a turbine flow-meter analysis model that does not depend on experimental parameters and does not need human intervention, and proposed to apply the Monte Carlo method to the potential flow solution part of the model. Later, researchers used this model to optimize the size parameter of turbine flow-meter [12-14] from the aspects of flow and viscosity, or broaden the application [15-17] of turbine flow-meter [15-17], but there were few improvements to the model.In this paper, in the process of applying the model calculation and solution, it is found that the Monte Carlo method successfully solves the problem of difficult convergence of nonlinear equations, but because the randomness of the algorithm can be difficult to predict the operation time. If the mathematical model of bearing turbine structure size parameters is optimized, this problem will cause the overall operation time due to the superposition of iterations.

In order to shorten the operation time, this paper improves the nonlinear equations in the mechanical analysis model of the turbine flowmeter and its solution algorithm, which lays a foundation for the subsequent optimization of the key size parameters of the bearing turbine structure.

2. Algorithm Improvement

On the basis of wing theory, Sun Lijun fully considered the influence of blade limited wingspan, established a turbine flow-meter analysis model that does not depend on experimental parameters and does not need human intervention, and proposed to apply the Monte Carlo method to the potential flow solution part of the model. Later, researchers used this model to optimize the size parameter of turbine flow-meter from the aspects of flow and viscosity, or broaden the application of turbine flow-meter, but there were few improvements to the model. In this paper, in the process of applying the model calculation and solution, it is found that the Monte Carlo method successfully solves the problem of difficult convergence of nonlinear equations, but because the randomness of the algorithm can be difficult to predict the operation time. If the mathematical model of bearing turbine structure size parameters is optimized, this problem will cause the overall operation time due to the superposition of iterations.

Thompson And other applied wing theory to propose a calculation formula of the driving torque of the turbine flow-meter, and establish a mathematical model of the turbine flow-meter but it simplifies the working condition of the turbine flow-meter to a certain extent, including the inlet velocity profile only considering the full development of turbulence state and the influence of the fluid viscosity.Combine the boundary layer theory and the momentum theory to derive the calculation formula of various resistance moments.use a typical turbine flow-meter size parameter to build a 3D grid model considering the flow rate, density and viscosity, and use CFD to analyze the stable rotation state of the turbine flow-meter and present a calibration result.have considered the transition state based on the steady-state operation of the turbine flow-meter, and studied the relationship between the Reynolds number and the dynamic response of the turbine flow-meter by using the hot-line wind speed measurement method.Turbo flow-meter is a kind of speed flow measuring instrument, which has the advantages of high accuracy, good repeatability, wide range and small volume, so it is widely

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3. Conclusion

Based on the wing theory and the fluid boundary layer theory, the mechanical model of turbine mechanical meter and improve the Monte Carlo method for solving nonlinear equations in the mathematical model. In order to verify the effect of the improved algorithm, in this paper, the parameters are replaced into two algorithms to prove the effectiveness of the running time and the convergence success rate in a certain time.

For two different structural parameters, the instrument coefficient under different flow rate is calculated and analyzed with the improved model, compared with the test results of the literature, and the accuracy and effectiveness of the numerical algorithm used in solving the model.

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