The Comparison of Fixed and Variable Specific Heat Parameters Based on ANSYS-CFX

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Abstract: At present, in the aerodynamic simulation calculation of turbocharger using ANSYS-CFX, we usually use a fixed constant for the gas performance parameters (including specific heat and thermal conductivity, etc.).In the whole calculation and analysis process, the selection of this constant value is defined according to the inlet temperature. This study found an appropriate, easy to operate and usable way to make the gas performance parameters in the calculation process change with different temperatures in different areas. In the calculation process, Ansys did call the temperature of different locations to calculate the specific heat value. In this study, we also checked the use of non-constant air performance parameters compared to the traditional fixed value on the turbocharger vortex end performance, the impact mainly includes flow, efficiency, and temperature.

Keywords: ANSYS-CFX; Specific Heat at Constant Pressure; Turbocharger

1. Introduction

Since turbochargers can effectively improve engine power, economy and emission, turbocharging technology has attracted more and more attention from scholars, and the development of compressors with high efficiency, high pressure ratio and wide and stable flow range has become the focus of current research on turbocharging technology. Early studies on volute internal flow were mainly based on theory and experiment, and the theoretical research and design were mostly based on invisco-free flow, runner outlet flow and axial symmetry assumption [1], and the results had significant errors with the actual situation. The eddy current flow channel model is established by Croe software, and the numerical simulation calculation is carried out by Ansys software based on finite volume method, which can accurately simulate the internal flow of the flow channel and analyze the causes of pressure loss. At the same time, the flow field inside the volute is compared and analyzed, so as to point out the direction for the optimal design of the turbocharger. Computer simulation design based on ANSYS-CFX is being used by more and more turbocharger manufacturers to reduce design costs and improve research and development efficiency [2].

Specific heat is an input parameter in ANSYS-CFX simulation analysis, which can be used in both fixed and non-fixed forms. This paper mainly studies the influence of fixed and non-fixed specific heat forms on calculation error.

2. Model Building

There are many material properties involved in CFX, including specific heat, molar mass, dynamic viscosity, thermal conductivity, etc. [3]. In this study, only specific heat C_p is considered, making C_p a variable with temperature.

For supercharger products with different platform sizes, the difference in the impact on the results will be different [4]. In this study, only products with a platform with a larger size (i.e., a turbine diameter of 80~90mm) are considered. The specific part model selected in this study is shown in Figure 1.

3. Definition of Variable C_p Values

In the usual calculation of given air performance parameters, C_p can be calculated according to the inlet temperature, which is carried out according to

$$Cp = a_1T^4 + a_2T^3 + a_3T^2 + a_4T + a_0 \quad (1)$$

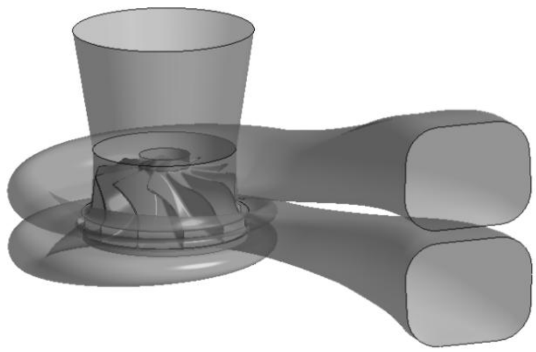

Figure 1. Selection of Vortex End Model

C_p is a power function relation with temperature, and a_1, a_2, a_3 and a_4 are the corresponding generation coefficient values.

In addition, we can also directly obtain the corresponding C_p values under different temperatures by looking up the table. Figure 2 shows the comparison of C_p values obtained by checklist method and formula method. It can be seen that the difference between them is very small.

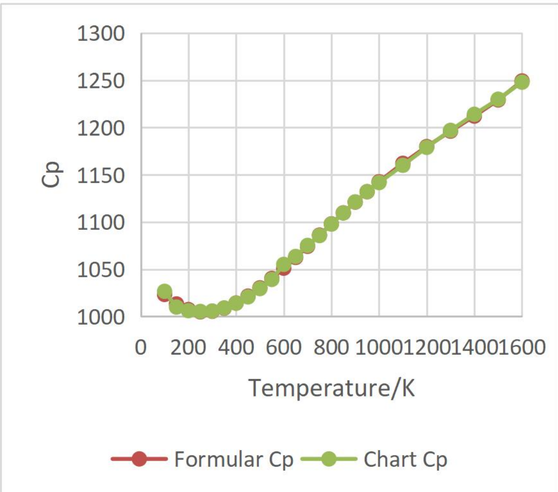

Figure 2. Comparison of C_p Values Obtained by Table Look up Method and Formula Method

In this paper, the checklist method is used to directly create expressions in Ansys, input different C_p values corresponding to all temperatures into the list, and the software can automatically perform interpolation calculation. Case 1 uses a fixed specific calorific value whose magnitude is the C_p value corresponding to the temperature at the turbine inlet. Case 2 inserts an expression in ANSYS-CFX so that C_p values can be calculated with different C_p values depending on the temperature at different fluid locations.

4. Parameter Values of the Boundary Conditions

Two cases are given different C_p values, and other parameters are consistent with each other.

Table 1. Parameter Values of Two Cases

	Case1	Case2
Inlet temperature K	373	373
Molar mass Kg/kmol	28.96	28.96
Specific heat capacity J / (kg K)	1011.01	F(t) Interpolate by looking up the table
Reference temperature [C]	25	25
Reference pressure atm	1	1
Density Kg/(m s)	1.831e-05	1.831e-05

5. Comparision of Results

By extracting and comparing the C_p value in the calculation results, we can find that the C_p value of case 2 in Ansys changes with the flow of fluid. The temperature at the exit is low and the C_p value is low. The heat shield and the entrance have a higher fluid temperature and the corresponding C_p value is high.

By comparing the flow and efficiency values of Case 1 and Case 2, it can be found that there is little difference between the flow values of Case 1 and Case 2, and the results are similar, but there is an obvious difference between the efficiencies. The efficiency of Case 1 is significantly higher than that of Case 2, with a difference of about 2%.

6. Conclusion

In the aerodynamic simulation calculation of supercharger using ANSYS-CFX, tables can be created in the software by checklist method, and different specific calorific values under different temperatures can be written into the software. ANSYS-CFX can use interpolation method to obtain C_p parameter values of different positions for calculation and processing of results. There is no significant difference between the fixed C_p and the variable C_p value depending on the location in the calculation of traffic, but there is a significant difference in the calculation of efficiency. The variable C_p value can better approximate the real situation and reduce the calculation error.

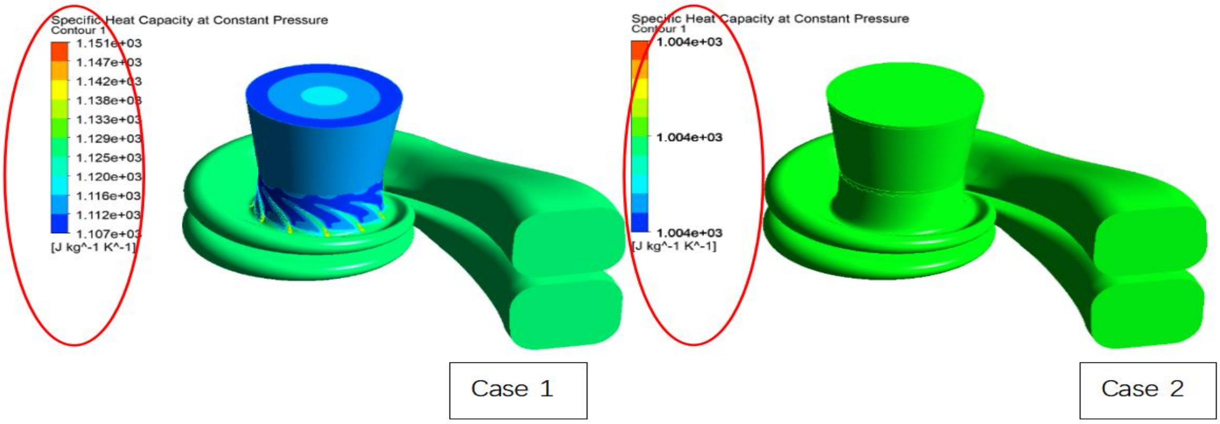

Figure 3. Comparison of C_p Results

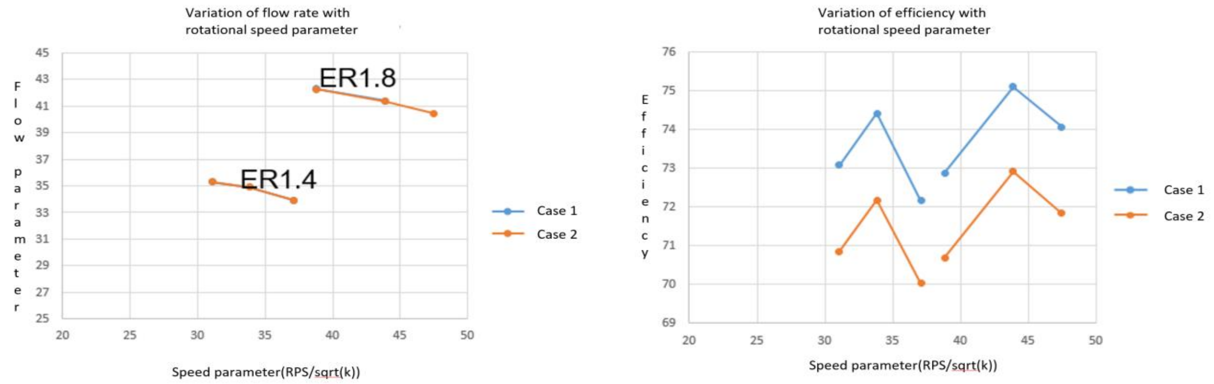

Figure 4. Comparison of Flow Rate and Efficiency Results

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