Numerical Simulation of Flow and Heat Transfer in LPD Type Misaligned Fins

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Abstract. With the rapid development of all walks of life, heat exchangers have been used all over the various fields. Plate fin heat exchanger was concerned, because of its high heat transfer rate and the small size. Among them, the offset strip fin is called "high efficiency fin" because its special staggered arrangement structure can increase the turbulent flow of fluid and enhance heat transfer. In order to study the influence of flow and heat transfer in dislocation fins, the three-dimensional numerical simulation of LPD dislocation fins is carried out by numerical simulation. Firstly, the accuracy of the standard laminar flow model is verified by using the dislocation fins and experimental data provided by the literature. The average error between the calculated value of the heat transfer factor and the experimental value is 5.95%, and the average error between the calculated value and the experimental value of the friction factor is 2.02%. On this basis, the influence of flow parameters and structural parameters on the internal flow and heat transfer in the dislocation fins is analyzed. The results show that: (1) the smaller the fluid velocity, the lower the height of the dislocation fin; the smaller the tooth angle, the shorter the cut length; the greater the heat transfer factor \(j\), the better the heat transfer performance; (2) The higher the fluid velocity, the higher the height of the dislocation fin, the smaller the tooth angle; the shorter the cut length, the smaller the friction factor \(f\), the better the resistance characteristic; (3) the lower the fin height, the smaller the tooth angle; the shorter the cut length, the greater the temperature difference and the pressure drop with the length of the heat transfer section; the fin height has little effect on the velocity field, The flow distribution of the fluid flow in the flow channel is affected, the shorter the cutting length is, the faster the velocity field changes.

1. Introduction
The plate-fin heat exchanger is characterized by high efficiency and small volume, and is widely used in aerospace, electronic equipment, petrochemical and new energy fields. The most promising new heat exchanger equipment in the sub-industry revolution. In terms of numerical simulation, due to the difficulty in establishing the geometric model of the plate-fin heat exchanger, most of the research is two-dimensional numerical simulation, and the numerical simulation in the three-dimensional case is less. For the working fluids, most of the papers on the low-precision Prandtl number are studied. The working fluids are mostly air or water, while the literature on the high-Prandtl number media is rare. As one of the mediums of high Prandtl number, oil is used in many fields such as aerospace and...
petrochemical industry. It is of great significance to study the heat transfer of oil for the development of corresponding industries.

2. Numerical simulation of misaligned fins

2.1. Establishment of the geometric model of misaligned fins and meshing

2.1.1. Selection of geometric models. The establishment of the model is the first step in numerical simulation and a crucial step. The correct calculation model and reasonable solution area are the basic conditions for ensuring the correct results of numerical simulation. Although the experimental parts studied in this paper are simple in structure, the flow in the flow channel is complicated. If the calculation model of the complete flow channel is constructed, it will lead to the phenomenon that the calculation amount is too large and the calculation time is too long. Therefore, the corresponding simplification should be carried out when selecting the misaligned fin geometry model.

Figure 1 is a schematic view of the internal flow path of the misaligned finned plate fin heat exchanger.

Simplification of the model:
The length is selected from the total length of 12 misaligned fins, that is, 18 mm; the width is selected to be a period width; and the height is a single-layer misaligned fin height. Thus, the geometric model is built according to the literature as shown in Figures 1.1 and 1.2.

Table 1. is a table of structural dimensions of the calculation model.

| Parameter | $h_f$ (mm) | $t$ (mm) | $S_f$ (mm) | $\alpha$ (º) | $L_f$ (mm) | Total length $L$ (mm) |
|-----------|------------|----------|------------|-------------|-----------|---------------------|
| Size      | 3.2        | 0.3      | 4.93       | 80          | 1.5       | 18                  |

According to the reference experiment, the hot side fluid is air, and the cold side fluid is CD15W/40 lubricating oil. The misaligned finned plate fin heat exchanger adopts a countercurrent heat exchange method. The heat of the hot air is transferred to the working lubricant by the fins and the partition. In this paper, the model structure of the misaligned fins is relatively regular. Therefore, the hexahedral structured grid with good quality, fast calculation speed and small memory occupancy is used to mesh the fluid and solid domains of the model.

2.1.2. Boundary conditions. The studied object is the numerical simulation of flow and heat transfer performance in the oil-side single-layer fin. Therefore, the fluid domain is CD15W/40 lubricating oil, and the solid domain is SPCC (low carbon steel for cold punching). The inlet is set to speed-inlet. According to the verification literature, the inlet temperature of the oil side is 90 (363K), and the inlet flow rates are 0.12m/s, 0.24m/s, 0.36m/s, 0.53m/s and 0.72m/s, respectively. The corresponding Reynolds number is 33, 66, 100, 146, 198. The outlet is set to a pressure-outlet. The misaligned fins
have periodicity in the vertical flow direction, and the left and right end faces are set as periodic. The grid is periodically set when the mesh is divided, and the period value is 4.93 mm. The contact surface between the solid domain and the fluid domain is a fluid-solid coupling surface, and FLUENT automatically recognizes and generates a corresponding coupling shadow according to the domain setting.

2.1.3. Grid independence. The number of initial model meshes is 900,000. To find the right number of grids, re-mesh the nodes and get five grids of 750,000, 1 million, 1.3 million, 1.5 million, and 1.8 million. According to the change of the observed pressure drop value, the number of reasonable grids is judged. It is found that when the number of grids is above 1.3 million, the pressure drop value does not change with the increase of the number of grids. Therefore, 1.3 million is selected as the mesh-independent critical grid number.

2.2. Selection and verification of mathematical models
Select a variety of mathematical models that match fluid flow. According to the experimental values of the selected literature, the model with the smallest error value is selected as the research model.

In view of the high viscosity of CD15W/40 lubricating oil, poor compressibility, and strong fluid flow inertia, it is difficult to stratify. Therefore, the standard laminar flow model is selected as the model to be proved; in view of the discontinuity of the misaligned fins, the fluid boundary layer is destroyed several times and the excitation. The fluid is turbulent, so the turbulence model is used for verification. Because the flow source flow is laminar flow, the turbulence is intensified when flowing through the misaligned fins. Therefore, the RNG model suitable for forced flow is selected for demonstration; and because the fluid will generate tail vortex at the tail of the fin, the three equations suitable for the transition are selected. The model and the four-equation SST model were validated.

The comparison between the calculated results of the four models and the experimental values is shown in Figure 3. According to the verification situation, the numerical calculation value of the transition model has a large error with the experimental value. The average error value of the heat transfer factor and the friction factor of the three-equation model is 40.5% and 21.1%, respectively; the two-factor number corresponding to the four-equation SST model. The error values are larger, 108.6% and 25.7%, respectively. The numerical simulation of the laminar flow model and the RNG model differs little from the experimental values. In the heat transfer factor error, the error values of the two models are all within 6%; in the friction factor error, the error value of the RNG model is within 10%. The laminar flow model has an error value of only 2%. In general, the laminar flow model is better than the RNG model, so the laminar flow model is used as the numerical simulation model.
3. Influence of flow parameters on flow and heat transfer in misaligned fins

This chapter studies the effects of flow velocity and fluid inlet temperature on flow and heat transfer in misaligned fin flow channels.

3.1. The effect of speed on internal flow and heat transfer

When comparing the references, the trends of heat transfer factors and friction factors under different Reynolds numbers were studied. The Reynolds number characterizes the flow rate without a change in geometry. Therefore, the analysis of the influence of the velocity parameters was carried out under the operating conditions of flow rates of 0.12 m/s, 0.24 m/s, 0.36 m/s, 0.53 m/s and 0.72 m/s.

3.1.1. The effect of speed on the flow field

(1) The effect of speed on the temperature field

The oil side fin temperature field was analyzed and the left side was the cold fluid inlet. Under the same inlet temperature ($t_h=363K$), the temperature field distribution of the above five speed conditions is shown in Figure 4.

![Temperature Cloud at Different Flow Rates](image)

Figure 4. Temperature Cloud at Different Flow Rates ($t_h=363K$)

According to the temperature profile, when the inlet temperature of the oil side is constant, the inlet flow velocity is larger, and the temperature rise of the same length is smaller. The temperature of the misaligned fins in the figure changes significantly. This is because the larger the inlet flow rate, the higher the flow rate into the misaligned fin flow path, and the greater the amount of heat exchange required, so the longer the mismatched fin heat exchange section is required to heat the same flow rate of oil.

(2) The effect of speed on the pressure field

The oil side fin pressure field is analyzed and the cold fluid inlet is on the left side. Under the condition that the inlet temperature is the same ($t_h=363K$), the pressure field distribution of the above five speed conditions is shown in Fig. 5.

The pressure profile is analyzed. Since the selected flow rate parameter is too small, the pressure drop in the figure does not change significantly. However, in the pressure distribution cloud diagrams at 0.12 m/s, 0.36 m/s and 0.72 m/s, it can be seen that when the inlet temperature of the oil side is constant, the inlet flow velocity is larger, and the pressure drop of the heat exchange section of the same length is larger.
The oil side fin velocity field was analyzed and the left side was the cold fluid inlet. Under the condition that the inlet temperature is the same (th=363K), the velocity field distribution of the above five speed conditions is shown in Fig. 6.

As can be seen from Fig. 6, along the direction of fluid flow, as the inlet flow rate continues to increase, the frequency of fluid flow rate increases. The increase of the speed increases the mass flow rate flowing into the fin flow passage, increases the fluid inertia, and increases the resistance. As can be seen in the figure, the increase in velocity causes the flow velocity in the split region to also increase, but the velocity growth rate is significantly lower than the low resistance region in the middle of the two misaligned fins. It can be seen from the comparison between Fig. 5(a) and Fig. 5(e) that as the inlet flow velocity increases, the velocity boundary layer near the wall of the fin becomes thinner.
3.1.2. Effect of speed on \( j \) factor and factor \( f \)

Figure 7 shows the variation of factor \( j \) and factor \( f \) with flow rate.

![Graphs showing the variation of \( j \) and \( f \) with flow rate.]

The working conditions were chosen as different fluid velocities to observe the effect of flow rate on heat transfer factors and friction factors. The misaligned fin geometry remains unchanged. Because the oil property parameters of the oil were previously assumed to be constant, the Reynolds number can be used to characterize the trend of the flow rate. As can be seen from Fig. 7, both the heat transfer factor \( j \) and the friction factor \( f \) decrease as the Reynolds number increases. That is, the larger the inlet flow rate, the smaller the heat transfer factor \( j \) and the friction factor \( f \). The inlet flow rate increases, so the fluid heat transfer coefficient increases. However, the increase in velocity is greater than the heat transfer coefficient, so the heat transfer factor \( j \) decreases and the fin heat transfer performance decreases. The increase in flow rate causes the pressure drop to increase. Comparing Figure 5 (a) with Figure 5 (b), the pressure drop is nearly doubled as the speed doubles. The friction factor is proportional to the pressure drop and inversely proportional to the square of the velocity. Therefore, the larger the inlet flow rate, the smaller the friction factor \( f \), and the better the resistance performance.

3.2. Effect of temperature on internal flow and heat transfer

Based on the above-described conditions in which the temperature was 363 K and the speed was 0.72 m/s, the selected speed was 0.72 m/s. The other boundary conditions are unchanged, and the four operating conditions of temperature 348K, 353K, 358K and 368K are simulated in turn. The influence of inlet temperature on the flow field and heat transfer performance of the staggered fin flow channel was analyzed.

3.2.1. Effect of oil inlet side temperature on flow field

(1) Effect of temperature on temperature field

The oil side fin temperature field was analyzed and the left side was the cold fluid inlet. Under the same inlet flow rate \( (v_h = 0.72 \text{ m/s}) \), the temperature field distribution of the above five temperature conditions is shown in Figure 8.

According to the temperature profile, when the inlet velocity of the oil side is constant, the inlet temperature is larger, and the temperature rise of the same length is smaller. The inlet oil temperature continues to increase, and the temperature of the fins and separators is constantly reduced. Since the mass flow rate does not change, and the temperature difference becomes smaller, the heat exchange amount becomes smaller, so the temperature rise of the fluid in the length of the same heat exchange section becomes smaller.
Figure 8. Temperature Cloud at Different Inlet Temperatures ($v_h = 0.72$ m/s)

(2) Effect of temperature on pressure field
The oil side fin pressure field was analyzed and the left side was the cold fluid inlet. The pressure field distribution of the above five temperature conditions is shown in Figure 9 under the same inlet flow rate ($v_h = 0.72$ m/s).

Figure 9. Pressure Cloud at Different Inlet Temperatures ($v_h = 0.72$ m/s)

According to the cloud image, there is no change in pressure. Therefore, the inlet temperature has no effect on the pressure field in the staggered fin flow path.

(3) The effect of temperature on the velocity field
The oil side fin velocity field was analyzed and the left side was the cold fluid inlet. The velocity field distribution of the above five temperature conditions is shown in Figure 10 under the same inlet velocity ($v_h = 0.72$ m/s).
As can be seen from Figure 10, the temperature does not affect the velocity field in the misaligned fin flow path.

3.2.2. Effect of oil inlet side temperature on $j$ factor and factor $f$

Figure 11 shows the variation of factor $j$ and factor $f$ with temperature.

As is apparent from Fig. 2.8, as the oil inlet temperature is continuously increased, the heat transfer factor $j$ is slightly changed, while the friction factor $f$ value is kept constant. Therefore, the change of inlet oil temperature does not affect the heat transfer performance and resistance characteristics of the misaligned fin-fin heat exchanger.

4. Influence of structural parameters on flow and heat transfer in misaligned fins

With the development of technology and technology, the requirements of heat exchangers have become more detailed, and heat transfer efficiency, structural size and process shape have been continuously developed and studied. In order to obtain efficient, small and beautiful plate-fin heat exchangers. There are many fin structure parameters, such as the height, thickness, pitch, length, etc. of the fins. At present, there are few three-dimensional numerical simulations of the length of the fin cut, and the study of the fin tooth angle is almost blank. Therefore, this chapter will numerically simulate the influence of structural parameters on the flow and heat transfer in the misaligned fins. Three geometric parameters of fin height, fin tooth angle and fin cut length were simulated.
4.1. **Effect of fin height on internal flow and heat transfer**

The boundary conditions were kept constant, and the heights were 2.8 mm, 3 mm, 3.2 mm, 3.4 mm, and 3.6 mm, and the five misaligned fins with the same geometric parameters were numerically simulated.

4.1.1. **Effect of fin height on flow field.** Here, two height models of 2.8 mm and 3.4 mm are selected for analysis.

1. **Effect of fin height on temperature field**

   ![Temperature profile of transverse sections at different heights](image)

   **Figure 12.** Temperature profile of transverse sections at different heights

   The temperature field is analyzed by comparing the horizontal cross-section and the longitudinal cross-section of the misaligned fin period model.

   Figure 12 shows the temperature profile of the transverse section at different heights, with the fluid inlet direction on the left. As can be seen from Fig. 3.1, in the longitudinal direction, as the fluid flows, the fluid temperature increases. However, as the height increases, the temperature rise of the heat exchanger section of the same length decreases. The increase in height causes the flow area to increase, the mass flow rate to increase, and the amount of heat exchange when the oil is heated to the same temperature increases, and the length of the required heat exchange section increases.

   ![Temperature profile of longitudinal section at different heights](image)

   **Figure 13.** Temperature profile of longitudinal section at different heights

   Figure 13 shows the temperature distribution of the longitudinal section at different heights. Observing the temperature distribution of the individual misaligned fins, it can be seen from Fig. 13 that the fin temperature gradient of 2.8 mm in height in the height direction of the staggered fin is larger than 3.4 mm. Compare the temperature contours in Figure 13(a) with Figure 13(b). The temperature gradient at the near wall of the fin with a height of 2.8 mm is larger than that of the 3.4 mm fin, indicating that the gradient of the temperature boundary layer at the near wall of the low fin is larger than that of the fin.

   2. **Influence of fin height on pressure field**

   Analysis of the cloud diagram in Figure 14 shows that when the fluid flows to the front end of the fin, the blockage pressure area of the high fin is smaller than that of the low fin. From the pressure change value of the full fin, it can be obtained that as the height increases, the pressure drop value of the heat exchange section of the same length becomes smaller.
3 Influence of fin height on velocity field

The left side is the fluid inlet direction, and Figure 15 is the velocity cloud diagram of the longitudinal section of the height of 2.8 mm and 3.4 mm, respectively, and the velocity variation trend on the longitudinal section is observed.

According to Figure 15, as the height increases, the high-speed region of the center of the fin flow gradually decreases, and the streamline at the near wall of the fin becomes thin. The change in the velocity field is due to the increase in height, increasing the fluid flow area, and the fluid is not simply squeezed into the intermediate low pressure region. The increase in the flow rate simultaneously causes the velocity boundary layer of the fin wall to be thinned, so the height is increased, and the flow line near the longitudinal cross-section fin is thinned.

4.1.2 Effect of fin height on $j$ factor and factor $f$. The effect of fin height on the heat transfer performance and resistance characteristics of the misaligned fins was investigated. In the case of $Re = 100, 200$, the curve of $j$, $f$ as the fin height changes is shown in Fig. 16.

As the height increases, the overall trend of the heat transfer factor $j$ is small. According to Fig. 16(a), it can be seen that the overall trend of $j$ with height is reduced. Although the increase in height increases the secondary heat exchange area of the misaligned fins, the flow cross section of the flow...
path also changes accordingly. The amount of heat exchange required at the same temperature difference increases, resulting in a decrease in the heat transfer factor $j$. As the height increases, the flow passage cross section becomes larger, and the fluid flow resistance becomes smaller, so that the friction factor $f$ decreases as the height increases.

4.2. Influence of fin tooth angle on internal flow and heat transfer

In order to keep the fin spacing constant, the control fin angle is varied between 90º and 80º. Keep the other boundary conditions unchanged, and select the 90º, 88º, 85º, 83º, 80º five angle parameters for numerical simulation. A single misaligned fin was selected for analysis. Because the spacing was constant, the angle change was small, but the change law was the same. Therefore, the misaligned fins with angles of 90º and 80º were selected for each flow field analysis.

4.2.1. Effect of fin tooth angle on flow field

(1) Effect of tooth profile angle on temperature field

The longitudinal section of a single misaligned fin is selected for temperature field variation analysis.

It can be seen from Fig. 17 that the 80º fin has a larger temperature gradient and the temperature contour of the fluid near the wall is denser than the 90º misaligned fin.

![Figure 17. Temperature profile of longitudinal profile of different tooth angles](image)

(2) Influence of tooth profile angle on pressure field

On the left side is the fluid inlet, and the model transverse section pressure map is selected for analysis. As shown in Figure 18. As the angle increases, the pressure drop of the same length increases. The reason for the increase in pressure drop is that when the angle is 90º, the fluid at the rectangular corner is easily blocked and the resistance characteristics are increased.

![Figure 18. Pressure profile of transverse section of different tooth angles](image)

(3) Effect of tooth profile angle on velocity field

On the left side is the fluid inlet direction, and Figure 19 is the longitudinal profile velocity profile of the different tooth angles. The longitudinal section of the central region of a single fin is selected for velocity field analysis.
In the middle flow channel of a single fin, the velocity flow field in the flow channel is unevenly distributed due to the influence of the previous misaligned fin. The uneven distribution of internal flow in the 80° fin causes the flow velocity to show two elliptical triangle flow diagrams of different sizes, and the trapezoidal flow channel region causes the high velocity region to be lower. The flow distribution of the 90° fins is relatively uniform, and the flow lines are two almost equal elliptical shapes. The 80° fin flow rate is significantly higher than the 90° fin.

4.2.2. Effect of fin tooth angle on j factor and factor f

The influence of the fin tooth angle on the heat transfer performance and resistance characteristics of the misaligned fin was investigated. Keep the boundary conditions unchanged and analyze the Reynolds number of 100 and 200 respectively. Figure 20 shows the effect of the tooth profile on the factor j and the f factor.

According to the numerical calculation results, as the tooth angle increases continuously, the heat transfer factor j is continuously decreasing, and the friction factor f is continuously increasing. Within the range studied, the 80° misaligned fins have the best heat transfer characteristics and the best resistance characteristics.

4.3. Effect of fin cutting length on internal flow and heat transfer

This section will simulate the effect of the length of the fin cut on the internal flow and heat transfer of the misaligned fins. Geometric parameters such as wing height, wing thickness, and tooth angle remain unchanged. According to the previous cut length of 1.5mm, the numerical simulation was carried out by selecting 1mm, 2.5mm, 3.5mm and 5mm.
4.3.1. Effect of fin cutting length on flow field

(1) Effect of cutting length on temperature field

![Figure 21. Temperature profile of transverse section of different cut lengths](image)

The left side is the fluid inlet direction and the total length is fixed at 12mm. The temperature distribution of the transverse section analyzes the effect of the length of the cut on the temperature field. The cloud map of the temperature field in the transverse section of each cut length is shown in Figure 21.

According to the analysis in Figure 21, the effect of different cut lengths on the temperature field is roughly the same. The fluid Reynolds number $Re$ remains unchanged, and when the fin cut length is short, the fluid boundary layer is not fully developed, and only a single fin flows through the initial section of the boundary layer. Effectively utilize the initial segment effect of the boundary layer to reduce the thermal resistance effect caused by the increase in the thickness of the fluid boundary layer. In the range where the length of the cut is appropriate, the shorter the cut length, the larger the temperature difference of the heat exchange section of the same length.

(2) Influence of cutting length on pressure field

![Figure 22. Pressure profile of transverse section of different cut lengths](image)

The change of pressure field in the same length heat exchange section is selected. As the length of the cut increases, the pressure drop of the heat exchange section of the same length is continuously reduced. The shorter the length of the misaligned fins, the more the flow of the fluid is destroyed, the fluid turbulence effect is increased, and the wake vortex is easily formed. The generation of the wake vortex not only increases the partial pressure of the tail of the fin, but also increases the pressure value...
of the front section of the downstream fin, and promotes the pressure drop value of the heat exchange section of the same length.

(3) Effect of cutting length on velocity field

The left side is the fluid inlet direction, and Figure 23 is the different section length transverse section velocity distribution cloud map. The transverse section velocity distribution cloud map and the fluid flow diagram are selected for the analysis of the slit length versus the velocity field. The fluid flow diagram is shown in Figure 23

![Figure 23. Different section length transverse section velocity cloud map](image)

It can be seen from Fig. 23 that as the length of the cut increases, the flow of the fluid gradually develops and the frequency of destruction is reduced. The flow in the common channel of the two misaligned fins is closer to laminar flow.

![Figure 24. Fluid local streamline diagram](image)

The speed variation of the local velocity streamline diagram with the difference in the length of the cut fins and the velocity streamline characteristics is selected. In the paper, the same length flow passages with cut lengths of 1 mm fins and 5 mm fins were selected for analysis. According to the streamline diagram, the velocity field of the short misaligned fins is continuously destroyed, and the tail vortex is generated at the tail of the fin. The velocity line of the long misaligned fins is gentle, the frequency of the broken ring is reduced, the eddy current at the tail of the fin is not obvious, and the fluid disturbance effect is significantly reduced.

### 4.3.2. Effect of fin cutting length on j factor and factor f.

The effects of fin cut length on heat transfer performance and resistance characteristics of misaligned finned plate fin heat exchangers were investigated. The Reynolds number is selected as 100 and 200 respectively, and other boundary conditions are kept unchanged, and the influence law is summarized. Figure 25 shows the effect of the cut length on the factor j and the f factor.

![Figure 25. Effect of cut length on j factor and factor f](image)
It can be clearly seen from Fig. 3.14 that as the length of the misaligned fins increases, the heat transfer factor $j$ and the friction factor $f$ are both reduced. The longer the length of the fin cut, the longer the flow length of the fluid depending on the wall surface, and the boundary layer at the near wall has a good development foundation, so that the boundary layer is continuously thickened, and the corresponding thermal resistance is also increased, thereby reducing the surface of the fin. Heat transfer coefficient. Therefore, as the length of the fin cut increases, the heat transfer factor $j$ decreases. The longer the cut length, the worse the fluid disturbance effect. As the length of the cut increases, the pressure drop of the overall model increases. This is because when the model is selected, the number of misaligned fins is constant, and the cut length of the individual fins is changed, resulting in an increase in the total length of the entire model. This leads to an increase in pressure drop as the length of the cut increases. Therefore, as the numerical value shows, as the length of the cut increases, the friction factor $f$ decreases and the resistance characteristics become superior.

5. Main conclusions
In this paper, ANSYS series software is used to simulate the performance of the misaligned fins in three dimensions. The effects of flow parameters and structural parameters on the flow and heat transfer performance of the misaligned fins were analyzed. The main conclusions are as follows:

(1) Comparing the experimental values of the heat transfer factor $j$ and the friction factor $f$ with the calculated values of different calculation models. In the four computational models of the standard laminar flow model, the RNG model, the three-equation transition model and the four-equation SST model, the calculated values of the standard laminar flow model agree well with the experimental values. The average error between the calculated value of the heat transfer factor $j$ and the experimental value is 5.95%. The average error of the calculated value of the friction factor $f$ and the experimental value was 2.02%. Therefore, the numerical simulation of such problems should choose the standard laminar flow model.

(2) The heat transfer characteristics of the misaligned fins show that the fluid inlet temperature has little effect on the heat transfer factor $j$. The greater the fluid inlet velocity, the smaller the heat transfer factor $j$. The lower the fin height of the misaligned fin, the smaller the tooth angle, the shorter the cut length, the larger the heat transfer factor $j$, and the better the heat transfer performance;

(3) The simulation of the resistance characteristics of the misaligned fins shows that the fluid inlet temperature has no effect on its resistance characteristics. When the inlet flow rate increases, the friction factor $f$ decreases. The higher the fin height of the misaligned fin, the smaller the tooth angle, and the longer the cut length, the smaller the friction factor $f$, the better the resistance characteristics;

(4) The flow field distribution in the misaligned fin flow channel shows that the lower the fin height, the smaller the tooth profile angle and the larger the temperature gradient near the fin. The shorter the length of the fin cut, the greater the temperature difference between the same length. The lower the fin height, the shorter the cut length and the greater the pressure drop over the same length. Height has little effect on speed. The change of the angle only affects the distribution of the split flow when the flow is split. The shorter the cut length, the higher the frequency field changes.

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