一种多股流换热器综合性能优化设计方法

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：在综合考虑了体积、重量和阻力等因素的基础上, 对多股流换热器进行通道排列和优化设计, 并运用无量纲分析法, 自定义了 *syn* 因子、*syn* 线等用以评价换热器综合性能的指标。详细分析了应用 *syn* 因子综合优化翅片结构的过程, 与实际的设计结果比较表明: 该方法适用于多股流换热器的综合性能优化设计。

：　　　　；　　　　；*syn*

：TK124　　　　　　　：A

1

17 500　　/ m³,

15～20　　/t,

50

syn

syn

2

$$KA^{[2]} :$$

$$KA = h_{\mathrm{h}}A_{\mathrm{h}}\eta_{\mathrm{h}} \times \sum_{i=1}^{i=nc} h_iA_i\eta_i / (h_{\mathrm{h}}A_{\mathrm{h}}\eta_{\mathrm{h}} + \sum_{i=1}^{i=nc} h_iA_i\eta_i) \tag{1}$$

$: h—$　　　, $\mathrm{W}/(\mathrm{m} \cdot \mathrm{k})$; $A—$

1 m　　　　, m^2; $\eta—$　　　　；

h—　　　; $nc—$

ΔT

[3]:

$$\Delta T_{\mathrm{he}} = \frac{\sum_{i=1}^{i=nh} \dot{m}_i \circ \varphi_i \circ T_{\mathrm{i, in}}}{\sum_{i=1}^{i=nh} \dot{m}_i \circ cp_i} - \frac{\sum_{i=1}^{i=nc} \dot{m}_i \circ \varphi_i \circ T_{\mathrm{i, out}}}{\sum_{i=1}^{i=nc} \dot{m}_i \circ \varphi_i} \tag{2}$$

$$\Delta T_{\mathrm{ce}} = \frac{\sum_{i=1}^{i=nh} \dot{m}_i \circ cp_i \circ T_{\mathrm{i, out}}}{\sum_{i=1}^{i=nh} \dot{m}_i \circ cp_i} - \frac{\sum_{i=1}^{i=nc} \dot{m}_i \circ cp_i \circ T_{\mathrm{i, in}}}{\sum_{i=1}^{i=nc} \dot{m}_i \circ cp_i} \tag{3}$$

$$\Delta T = (\Delta T_{\mathrm{he}} + \Delta T_{\mathrm{ce}})/2 \tag{4}$$

$$L = Q/(KA \circ \Delta T) \tag{5}$$

：he—　　　；ce—　　　；nh—　　　；

$Q—$　　　, kW。

KA_{c-h}[2]、　　　　　　　　L_c

　　　　　　ΔE,

。

$$KA_{c-h} = \frac{h_c A_c \eta_c h_h A_h \eta_h (A_c / \sum\limits_{i=1}^{i=nc} A_i)}{h_c A_c \eta_c + h_h A_h \eta_h (A_c / \sum\limits_{i=1}^{i=nc} A_i)} \qquad (6)$$

$$L_c = Qc / (KA_{c-h} \times \Delta T) \qquad (7)$$

$$\Delta E = (L - L_c) / L \qquad (8)$$

:　　　c—

　　　　　ΔE　　5% ~ 10%。

　　　　　　　　　　,　　　　　　ΔP

:

$$\Delta P = 4f \times L \cdot G^2 / (d_s \cdot 2\rho) \qquad (9)$$

: G—　　　　　, kg/(m^2 · s); d_s—　　　　, m;
ρ—　　　, kg/m^3。

3

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　　　　　　　　　　,　—syn　　　（
　,　　"synthesis"　　）,　　　syn

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　　　　　, syn　　　　　　　　　　。
, syn　　　　　、　　　、
,　　　　　　。

　　　　　　4　　　　　　　　　　　,
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1　。

表 1

/K	/K	/kPa	/kW	/m^3 · s^{-1}	/ kg · m^{-3}
129.15	290.15	149	8.801 6	0.041 88	1.428 9
129.15	290.15	134.47	10.705 4	0.051 45	1.28
142.35	293.15	1294	49.618 2	0.236 44	1.292 8
129.15	290.15	134	30.111 2	0.143 12	1.256 73

3.1

3.1.1　　　　　　　　　　　　8.5 mm,
　　　　3.0~9.5 mm,　　　　　　1.4 mm,
　0.2 mm。　　　　　　　　　　,
　1　。（　　　　　　　　,
　　　　）。
　　　　5.0~6.0 mm　　　　。　　3.0~5.0
mm　　　,　　　　,　　　　,
　。　　6.0~9.5 mm　　　　,
　　　　　,
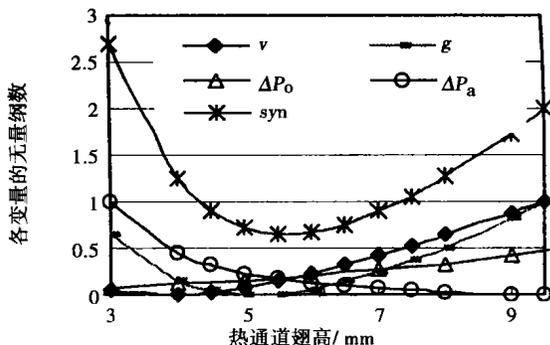
图 1　冷通道翅高为 8.5 mm, 体积、
重量、阻力与热通道翅高的关系
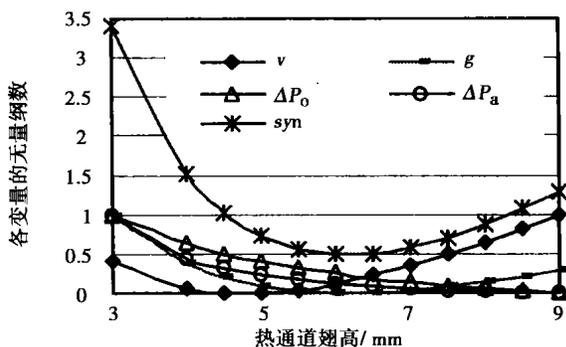
图 2　冷通道翅高为 9.5 mm, 体积、
重量、阻力与热通道翅高的关系

3.1.2　　　　　　　　　9.5 mm,
　　　　3.0~9.0 mm,　　　　　1.4 mm,
　0.2 mm,　　　　　　2　。
6.0~7.0 mm　　　　。　4.0~6.0 mm　　　,
　　,　　　　　　。　　7.0~9.0 mm　　　,
　　　,　　　　　　　　　　　。
　　: v—　　　; g—　　; ΔP_o—　　　; ΔP_a—
; syn—　　　; $gsyn$—

75％　　　syn　；$\Delta P_o syn$—　　　　　　　　，

45％　　syn　。　　　　　　　　　　　　　　　。　3. 1. 1　　　，

3. 1. 3　　　　　　　　　12. 0 mm,　　　1. 4 mm,　75％,　　　　　25％（　　　），

0. 3 mm;　　　　　　　　　　3. 0～11. 5　gsyn,　　5　。　　　　　　　　：syn

mm,　　1. 4 mm,　　0. 2 mm,　　　3　，gsyn　　　　　，

。　　　　　6. 5～7. 5 mm　　　。　，　　　，　　　　　，

3. 1. 4　　　　　　　，　　　1. 4　　　　　　（　　　）。

mm,　　0. 2 mm,　　　4　。　　45％,　　　55％（　　　），

：　　　　5. 2 mm。　　$\Delta Posyn$　　，　6　。syn　，

$\Delta Posyn$
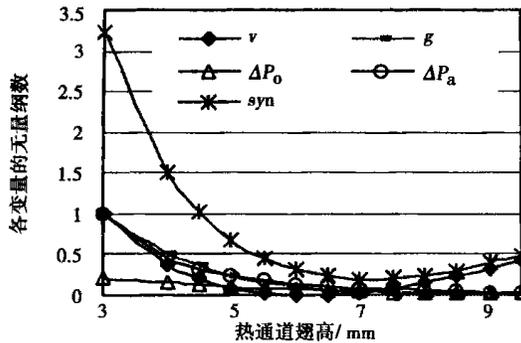
图 3　冷通道翅高为 12. 0 mm, 体积、
重量、阻力与热通道翅高的关系

图 5　重量权重为 75％与等权重时的比较
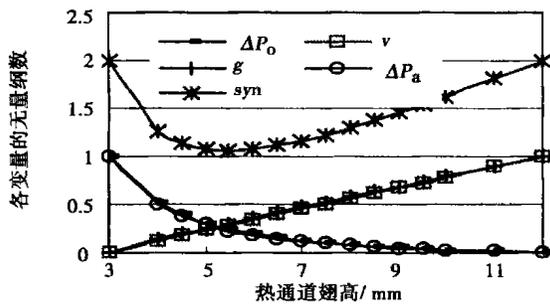
图 4　冷通道翅高 相等时, 体积、
重量、阻力与热通道翅高的关系
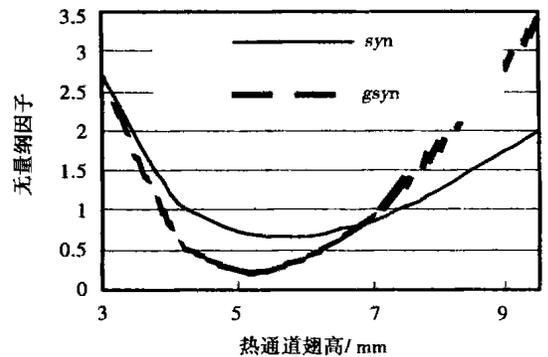
图 6　氧气阻力权重为 45％与等权重时的比较

，
，　　2　。　　　　　　　　　　　9.

5 mm,　　　　6. 5 mm　，　　　、

，　　　。　，syn

，　　　1～　4　syn

，　　syn

。

：　　　　　9. 5 mm,　　　6. 5 mm,

3. 1. 2　　　　。

3. 2

syn

表 2

/mm	/mm	/m³	/kg	/Pa	/Pa
	5. 0	0. 194 005	177. 992	1 453. 007	1 230. 741
8. 5	5. 5	0. 195 544	178. 067	1 436. 581	998. 243
	6. 0	0. 197 390	178. 450	1 422. 993	828. 373
	6. 0	0. 217 23	191. 167	1 206. 205	848. 105
9. 5	6. 5	0. 218 628	191. 196	1 193. 178	715. 054
	7. 0	0. 220 318	191. 505	1 182. 159	612. 588
	6. 5	0. 252 890	243. 537	1 047. 091	706. 190
12. 0	7. 0	0. 253 457	242. 609	1 034. 318	603. 185
	7. 5	0. 254 396	242. 070	1 023. 402	522. 394
5. 2	5. 2	0. 135 390	140. 295	3 322. 031	1 053. 660

4

（1）　　　、

（2）

（3）*syn*　　　　　　　　　　　　　、　　　　、

　　　　　　，　　　　　　　　　　　*syn*

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[1]　　　　．　　　　　　[M] ．　　：　　　　　　　，1984.
[2]　　　，　　．　　　　　　　[M] ．　　：　　　　　，
　　1993.
[3]　PRASAD B S V, GURUKUL S M K A. Differential methods for the
　　performance prediction of multi-stream plate-fin heat exchangers[J] .
　　ASME J Heat Transfer, 1992, **114**（1）41－49.
[4]　　　　，　　　，　　　．
　　　　　　[J] ．　　　　　　　，2002, **17**(6), 611－613.
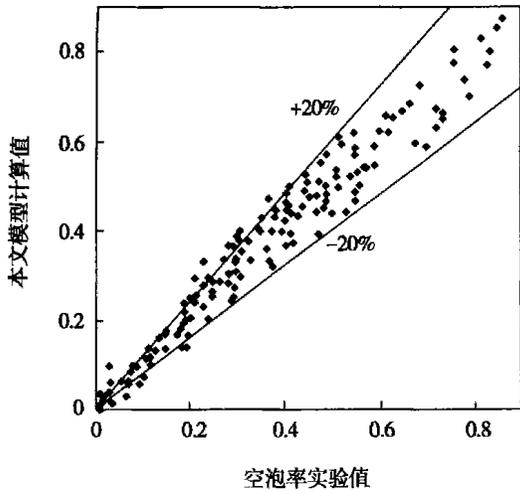
（渠　源　编辑）

（　　　　　126　　）

图 3　分布拟合模型与较低流速数据比较

图 4　分布拟合模型与较高流速数据比较

1

（$G > 900$ kg/（$m^2 \cdot s$））　　　　　　　4　　　　，

（$G > 900$ kg/（$m^2 \cdot s$）），

。

5

[1]

NVG　　　　　　　　　，

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[1]　SUN QI, YANG RUICHANG, ZHAO HUA. Predictive study of the
　　incipient point of net vapor generation in low－flow subcooled boiling
　　[J] . **Nucl Engrg Des.** 2003, **225**(2－3): 249－256.
[2]　VIJAYAN P K, MARUTHI RAMESH N, PILKHWAL D S, et al. An
　　assessment of void fraction correlations for vertical upward steam－wa-
　　ter flow[R] . India: Bhabha Atomic Research Center, 1997. 1－12.
[3]　ROUHANI S Z, AXELSSON E. Calculation of void volume fraction in
　　the subcooled and quality boiling region[J] . **Int J Heat Mass trans-**
　　fer, 1970, 13(2): 383－393.
[4]　LEVY S. Forced convection subcooled boiling prediction of vapor volu-
　　metric fraction[J] . **Int J Heat Mass transfer**, 1967, **10**(4): 951－
　　965.
[5]　MAROTI L. Axial distribution of void fraction in suncooled boiling
　　[J] . **Nuclear Technology**, 1977, **34**(1): 8－17.

（渠　源　编辑）
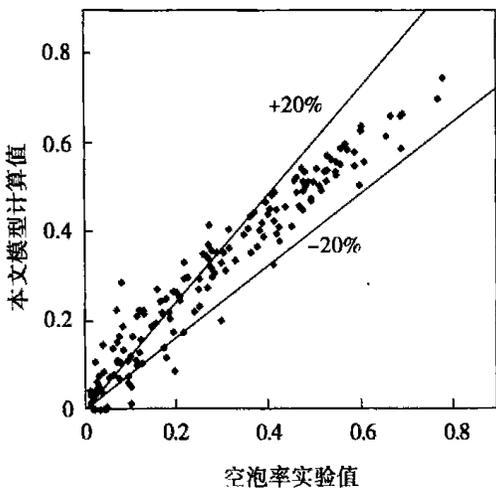
film， compact heat exchanger

＝A Preliminary Study of the Performance of a Porous-medium Evaporative Cooling-based Intercooler [，] / ZHANG Zhen-yi， ZHANG Yan， SUN Yu-feng （College of Power and Nuclear Energy Engineering under the Harbin Engineering University， Harbin， China， Post Code： 150001） //Journal of Engineering for Thermal Energy &Power. － 2004， 19（2）. －163～166

The theory and construction of an evaporation-cooled intercooler is briefly described. By way of wind tunnel tests the resistance and temperature-reduction characteristics of various packings were verified， resulting in the selection of proper packing media. It is shown that the evaporation-cooled intercooler is simple in theory and can be installed at the inlet of a diesel and gas turbine and employed on a ICR （intercooled recuperative） marine gas turbine. It is feasible to use the intercooler under discussion to replace an originally installed intercooler. **Key words**： evaporative cooling， intercooler， packing

Navier—Stokes **＝Optimized Aerodynamic Design of Turbine Cascades Based on Composite Evolutionary Algorithms and Navier-Stokes Equation Solution Techniques** [，] / LI Jun， REN Bin， FENG Zhen-ping （College of Energy &Power Engineering and Institute of Turbomachinery under the Xi' an Jiaotong University， Xi' an， China， Post Code： 710049） //Journal of Engineering for Thermal Energy &Power. － 2004， 19（2）. －167～170

The optimized aerodynamic design of turbine cascades is presented， which has been based on composite evolutionary algorithms and Navier-Stokes equation solution techniques. By combining evolutionary algorithms with a Simplex method the resulting composite evolutionary algorithms can enhance the search efficiency of evolutionary hereditary algorithms through a reform of the worst individuals in a population by using the Simplex method. The design objective of turbine cascade aerodynamic optimization is to minimize the total pressure loss. The coordinates of the control points of Bezier curves for the cascade profile parametrization serve as the optimized design variables. Reynolds-averaged Navier-Stokes equation solution techniques were used to calculate the total pressure loss. Baldwin-Lomax algebraic turbulent model is used as a turbulent model. The optimized design has reduced the total pressure loss of the cascades by 20%. The design results demonstrate that the optimization techniques used by the authors for the turbine-cascade aerodynamic design proved to be an effective approach. **Key words**： composite hereditary algorithm， turbine cascade， optimization， design

＝ Comprehensive-performance Optimization Design Method for Multi-stream Heat Exchangers [，] / ZHAO Yong-qin， CUI Guo-min， LU Hong-bo， LI Mei-ling （Research Institute of Thermal Engineering under the Shanghai University of Science and Technology， Shanghai， China， Post Code： 200093） //Journal of Engineering for Thermal Energy &Power. － 2004， 19（2）. －171～174

On the basis of a comprehensive consideration of such factors as volume， weight and resistance， etc a flow-channel layout and an optimized design were carried out for a multi-stream heat exchanger. Moreover， a dimensionless analytical method is applied to define a synthesis （syn） factor and synthesis line， etc in order to evaluate the comprehensive performance of the heat exchanger. A detailed analysis is performed of the process of fin-structure comprehensive optimization by making use of the synthesis factor. A comparison of the analysis results with design ones indicates that the method under discussion is suitable for the comprehensive-performance optimization design of the multi-stream heat exchangers. **Key words**：

multi-stream heat exchanger，dimensionless analytical method，synthesis factor

= **Nonlinear-oscillating Meshless Boundary Element Method for the Prediction of Blade Reliability** [，] / YANG Jian（Research Institute of Chemical Machinery under the Zhejiang University，Hangzhou，China，Post Code：310027）// Journal of Engineering for Thermal Energy & Power. — 2004，19（2）. —175～178

On the basis of a nonlinear fluid vibration-excitation theory a direct solution scheme for boundary integral equations of fluid structure coupling analysis has been set up to predict the fluid-excited vibration reliability of turbomachine blades. By using the linearization treatment of equivalent mean values and deviations a reliability index is evaluated，and a nonlinear meshless boundary element method proposed to analyze the reliability of blades. The results of numerical calculations indicate that the proposed method can be employed to realize a speedy and effective prediction of blade performance and to conduct an optimized probability design for a new type of turbomachinery. **Key words**：rotating machine，blade，reliability prediction，boundary element method

BP   = **On-line Computation Method for Steam Turbine Exhaust Enthalpy Based on BP Neural Network** [，] / GUO Jiang-long，ZHANG Shu-fang，CHEN Hai-ping（Power Engineering Department，North China University of Electric Power，Baoding，China，Post Code：071003）// Journal of Engineering for Thermal Energy & Power. — 2004，19（2）. —179～181

The steam exhaust point of a steam turbine is located in a wet steam zone. Due to a lack of steam-wetness measuring instruments on-site it is difficult to determine directly the enthalpy of turbine exhaust steam. The calculation of this enthalpy has long been one of the difficult issues in the on-line analysis and diagnosis of thermal economics of a thermal power plant thermodynamic system. There exist numerous factors，which can affect the turbine exhaust enthalpy. The relationship between these factors and the exhaust steam enthalpy is a typical nonlinear one. With a NK200-12.7/535/535 type of air-cooled plant serving as an example the authors have recommended a method for setting up a model for calculating the turbine exhaust enthalpy by using a BP neural network. The method has been successfully put into use on an on-line diagnosis system of thermal economics for a power plant. **Key words**：turbine exhaust enthalpy，BP neural network，steam turbine，model

= **A Study of Two-phase Flow-pattern Identification Method Based on a Dynamic Clustering Algorithm** [，] / JIA Zhi-hai，NIU Gang，WANG Jing（College of Mechanical and Power Engineering under the Shanghai Jiaotong University，Shanghai，China，Post Code：200030）// Journal of Engineering for Thermal Energy & Power. — 2004，19（2）. —182～185

Differential pressure signals of three flow patterns in a horizontal pipe，i.e.，vapor/water two-phase laminar flow，agitation flow and elastic flow，have been collected. Through the use of a probability density function（PDF）method an analysis was conducted of the signal characteristics. The four eigen parameters reflecting PDF function variation，namely，peak number k_1, maximum peak value k_2, peak position k_3 and variance k_4, have been defined. Then，by making use of a dynamic clustering algorithm a classification/identification was conducted for the above-mentioned three flow patterns. It can be shown that the use of PDF in conjunction with the dynamic clustering algorithm makes it possible to realize a speedy and accurate identification of the vapor/water two-phase flow pattern，testifying to the feasibility of the method under discussion. **Key words**：two-phase flow，flow pattern identification，probability density function，dynamic clustering