交叉噴流膜冷卻技術對直線與彎曲流道端壁之有效性的數值探討 = Numerical investigation of effectiveness of the film ...

陳榮良、吳佩學

E-mail: 9707381@mail.dyu.edu.tw

摘 要

本研究利用數值計算探討交叉噴流膜冷卻技術應用於直線流道與彎曲流道端壁的冷卻效果。模擬中主流雷諾數分別為62500、 125000、250000 , 主流溫度為 , 二次膜冷卻溫度為 。冷卻流體噴出方向角 , 而噴射傾斜角度為, 每一對膜冷卻孔之橫向孔距分別為0D(孔配置1)、1.5D(孔配置2)、3D(孔配置3)、4.5D(孔配置4), 而雙排孔在主流方向的距離維持在 4D ; 吹氣比變化為0.5、1、 2、3、4、5。最後也變化膜冷卻孔配對之形狀來進行數值模擬。 結果顯示, 直流道與彎曲流道中對於端壁面膜冷卻有效性最好的是孔配置1、其次是孔配置4、再來是孔配置3、最差的是孔配置2。彎曲流道在較低吹氣比條件下, 偏心交叉噴流形成之渦漩效果並不明顯, 在較高吹氣比時, 所形成右轉渦漩對端壁面之膜冷卻有效性優於左轉旋的情形, 並且兩者都已開始發生膜冷卻流抬昇現象。雖然對於上游端壁面之膜冷卻有效性大為降低, 但所形成之左轉渦漩對於靠近吸力面的冷卻是優於右轉渦漩, 而右轉渦漩所形成之薄膜冷卻則大部份覆蓋到壓力面上。再與直流道做比較可以發現到因為直流道並沒有受到橫向壓力梯度影響, 而彎曲流道在下游部分所形成之渦漩已被橫向壓力梯度破壞, 所以其下游之壁面膜冷卻有效性已漸漸超越在彎曲流道之壁面膜冷卻有效性。以上趨勢對於配對膜冷卻孔有不同形狀的情形也成立。

關鍵詞 : 偏位噴注;端壁;膜冷卻有效性;直流道;彎曲流道

目錄

參考文獻

[1] Hale, C. A., Plesniak, M. W., and Ramadhyani, S., 2000, ”Film Cooling Effectiveness for Short Film Cooling Holes Fed by a Narrow Plenum, ” ASME Journal of Turbomachinery, Vol.122, pp.553-557.

[2] Goldstein, R.J., 1971, “ Film Cooling ” in Advances in Heat Transfer, Academic Press, eds. T. F. Irvine, Jr. and J. P. Hartnett, Vol. 7, pp. 321-379.

[3] Kawaike, K., Anzai, S., Takehara, I., Sasada, T., and Matsuzaki, H., 1993, “ Advanced Cooling Design of Turbine Blades with Serpentine Cooling Passages, ” 20th International Congress on Combustion Engines, paper G12.

[4] Bell, C.M., Hamakawa, H. and Ligrani, P. M., 2000 “ Film cooling from shaped holes, ” Transactions of the ASME, VOL 122, [5] Hale, C.A., Plesniak, M.W. and Ramadhyani., S., 2000, “ Film cooling effectiveness for short film cooling holes fed by a narrow plenum, ” Journal of Turbomachinery, Vol. 122, 2000 [6] Jung, I. S. and J. Lee, S., 2000, “ Effects of orientation angles on film cooling over a flat plate: boundary layer temperature distributions and adiabatic film cooling effectiveness, ” Journal of Turbomachinery, Vol. 122, [7] Dittmar, J., Schulz, A. and Wittig, S., 2003, “ Assessment of various film-cooling configurations including shaped and compound angle holes based on large-scale experiments, ” Journal of Turbomachinery, Vol. 125, [8] Wanda Jiang, H. and Han, J.C., 1996, ”Effect of Film Hole Row Location on Film Effectiveness on a Gas Turbine Blade, ” Journal of Heat Transfer, Vol. 118, pp. 327-333.

[9] Goldstein, R.J. and Chen, H.P., 1985, “ Film Cooling on A Gas Turbine Blade Near The End Wall, ” ASME Journal of Engineering for Gas Turbine and Power, Vol. 107, pp. 117-120.

[10] Goldstein, R.J. and Chen, H.P., 1987, “ Film Cooling of A Turbine Blade with Injection Through Two Rows of Holes in The Near-Endwall Region, ” ASME Journal of Turbomachinery, Vol. 109, pp.588-593.

[11] Takeishi, K., Matsuura, M., Aoki, S., and Sato, T., 1990, “ An Experimental Study of Heat Transfer and Film Cooling on Low Aspect Ratio Turbine Nozzles, “ J. of Turbomachinery, Vol. 112, pp.488-496.

[12] Wilfert, G. and Fottner, L, 1996, “ The Aerodynamic Mixing Effect of Discrete Cooling Jets with Mainstream Flow on A Highly Loaded

Turbine Blade, ” ASME Journal of Turbomachinery, Vol. 118, pp. 468-478.
[13] Du, H., Han J. C., and Ekkad, S. V., 1998, “ Effect of Unsteady Wake on Detailed Heat Transfer Coefficient and Film Effectiveness Distributions for a Gas Turbine Blade, ” ASME Journal of Turbomachinery, Vol.120, pp.808-817.
[14] Yu, Y., Shih, C. H., Shih, T. I. P. and Chyu, M. K., 2002, “ Film cooling effectiveness and heat transfer coefficient distributions around diffusion shaped holes, ” Vol. 124, [15] Reiss, H. and Bolcs, A., 2000, “ Experimental study of showerhead cooling on a cylinder comparing several configurations using cylindrical and shaped holes, ” Journal of Turbomachinery, Vol. 122, [16] Sargison, J. E., Guo, S. M., Lock, G. D. and Rqwlinson, A. J., 2002, “ A converging slot-hole film-cooling geometry -part1: low-speed flat-plate heat transfer and loss, ” Journal of Turbomachinery, Vol. 124, [17] Bunker, R. S., 2002, “ Film cooling effectiveness due to discrete holes within transverse surface slots, ” Energy and Propulsion Technologies, p18, 2002.
[18] Aupoix, B., Mignosi, A., Viala, S., Bouvier, F. and Gaillard, R., 1996, “ Experimental and numerical study of supersonic film cooling, ” AIAA, [19] Azzi, A. and Abidat, M., 2001, “ Film cooling predictions of simple and compound angle injection from one and two staggered rows, ” Numerical Heat Transfer, PartA, Vol. 40, PP. 273-294, [20] 孟祥泰與劉高恩, “ 多斜孔冷卻技術分析, ” Journal of Aerospace Power, Vol. 9, No. 4, 1994.
[21] Garg, V.K. and Rigby, D.L., 1999, “ Heat Transfer on a Film-Cooled Blade – Effect of Hole Physics, ” International Journal of Heat and Fluid Flow, Vol. 20, pp. 10-25.
[22] Kim, Y.J., and Kim, S.-M., 2003, “ Influence of shaped injection holes on turbine blade leadingedge film cooling, ” Intl. J. Heat and Mass Transfer, Vol. 47, pp. 245-256.
[23] Dombrowski, N., and Hooper, P.C., 1964, “ A Study of the Sprays Formed by Impinging Jets in Laminar and Turbulent Flow, ” Journal of Fluid Mechanics, Vol. 18, pp. 392-400.
[24] Heidmann, M.F., Priem, R.J., and Humphrey, J.C., 1957, “ A Study of Sprays Formed by Two Impinging Jets, ” Technical Note NACA-TN-3835.
[25] 田智元, 2001, ”液態推進燃料噴注模擬實驗與分析”, 碩士論文, 大葉大學機械工程學系.
[26] Ahn, J., Jung, I.S., and Lee, J.S., 2003, “ Film Cooling From Two Rows of Holes with Opposite Orientation Angles: Injectant Behavior and Adiabatic Film Cooling Effectiveness, ” International Journal of Heat and Fluid Flow, Vol. 24, pp. 91-99.
[27] 吳佩學, 2005, ”利用噴注互相衝射形成冷卻薄膜之有效性的實驗探討”, 行政院國家科學委員會專題研究計畫成果報告, 計畫編號:NSC 93-2212-E-212-009 – [28] Launder, B.E., and Spalding, D.B., 1972, “ Lectures in Mathema-Tical Model of Turbulence. ” Academic Press, London, England.
[29] Kim, S.E., and Choudhury, D., 1995, “ A Near-Wall Treatment Using Wall Functions Secsitized to Pressure Gradient, ” Separated and Complex Flow, In ASME FED Vol. 217.
[30] Patankar, S.V., 1980, “ Numerical Heat Transfer and Fluid Flow. ” Hemisphere Publishing Corp., Washington DC.
[31] Krishnamoorthy, V., Pai, B.R., and Sukhatme, S.P., “ Influence of Upstrean Flow Conditions on the Heat Transfer to Nozzle Guide Vanes, ” Journal of Turbomachinery, Vol. 110, pp. 412-416, 1988.