鋁合金與鋁蜂巢間接觸熱阻及界面壓力之實驗研究

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摘 要

本論文分為兩部份，第一部份為螺栓接合面接觸熱阻之研究，第二部份為鋁蜂巢板熱傳特性之研究。 本文第一部份主要探討螺栓接合面接觸熱阻Al/Al、Cu/Al及SS/Al實驗結果，經由實驗量測鋁合金試片(Al6061-T6)及鋁合金和不同金屬材料(Cu/Al、SS/Al)之接觸面接觸熱阻利用螺栓接合時之接觸熱阻研究，鋁合金試片為截面積為63.5 mm × 63.5 mm，高度為50 mm。在本研究中鋁合金的試片共採用二種的螺栓組態，共分為4個螺栓以及8個螺栓，螺栓的直徑為8 mm，4個螺栓又採二種不同的表面粗糙度分別為(σ=0.16μm及σ=1.10μm)；8個螺栓分別也有二種不同的粗糙度(σ=0.25μm, σ=1.25μm)螺栓扭力的範圍為1~10 N-m。通過試片的之熱傳量約為40~100 kW/m2。在不同金屬材料的實驗中，紅銅和不銹鋼為截面積為50.4 mm × 50.4 mm，高度為50 mm的實驗試片，在不同材料之實驗中只採用4個螺栓組態，螺栓直徑為5 mm，其表面粗糙度約為1.20μm螺栓扭力的範圍為1~5 N-m。通過試片的之熱傳量約為40~100 kW/m2。研究中並利用感壓軟片的輔助來量測螺栓接合面之界面壓力，實驗的結果顯示壓力會隨著螺栓數目、扭力的增加而增加，但螺栓的數目和扭力增加到一定的數目時壓力會漸漸的趨於平緩，從感壓軟片的實驗中可觀查到表面粗糙度對壓力的影響，表面粗糙度愈佳其感壓軟片上所分佈的濃度愈均勻相對應的壓力也 就愈大，反之粗糙度愈大所相對應的壓力愈小。在界面溫度差方面，試片共分成兩種不同的表面粗糙度來比較，增加試片表面粗糙度會導致接觸面熱傳導值下降。本文最後將由實驗得知的數據，利用因次分析法整理出兩組無因次參數，並經由曲線回歸的方法找出壓力與扭力經驗關係式。 論文的第二部份，是針對鋁鋒巢之熱傳特性進行實驗研究，在上一階段實驗主要著重在不同金屬蜂巢狀結構(孔徑6.3 mm及12.7 mm)，不同材質(Al3104-H19及Al3003-H16)及不同接合條件(4個螺栓、8個螺栓)下之熱阻變化。由於上階段之壓力量測之感壓軟片的適用範圍(1-10 N-m)梢為不足使誤差偏高，導致實驗最後在壓力結果方面之經驗公式有較大的誤差，為了彌補上述實驗上的誤差本實驗選用最恰當的感壓軟片(10-50 N-m)進行壓力分析。實驗中並加入二組不同厚度的蜂巢試片以增加實驗的多樣性。實驗中發現在溫度量測方面，在相同接合條件下隨著鋁蜂巢試片厚度逐漸增加，接觸面的溫差也會增加並且熱傳效果會變差。鋁蜂巢試片之壁面溫度與孔洞中空氣溫度方面，二者的溫度十分接近，而在昇溫的過程中均保持一隱定的狀態。在有效熱傳導係數方面經由實驗的量測可得知鋁蜂巢Al3104-H19的有效熱傳導係數為6.6，從實驗結果可觀查出，增加螺栓數目會使總熱傳導值增加，總熱傳導值亦會隨著鋁蜂巢高度的增加而減小。而在接觸熱阻方面，接觸熱阻約佔總熱阻的1/8，隨著扭力的增加而下降，總熱阻會隨著鋁蜂巢高度的增加而有明顯的增加。

關鍵詞 : 接觸面熱傳導值、螺栓接合、界面壓力、感壓軟片、接觸熱阻、鋁鋒巢狀結構材料

目錄

參考文獻

1. Madhusudana, C. V. and Fletcher, L. S., "Contact Heat Transfer - The Last Decade," AIAA Journal, 24, 3, 510-523 (1986). 2. Fletcher, L. S., "Recent Developments in Contact Conductance Heat Transfer," Transactions ASME Journal of Heat Transfer, 110, 1059-1070 (1988). 3. Lambert, M. A. and Fletcher, L. S., "Review of the Thermal Contact Conductance of Junctions with Metallic Coatings and Films," J. Thermophysics and Heat Transfer, 7, 4, 547-554 (1993). 4. Snaith, B., Probert, S. D., and O'Callaghan, "Thermal Resistances of Pressed Contacts," Applied Energy, 22, 31-84 (1986). 5. Sridhar, M. R. and Yovanovich, M. M., "Review of Elastic and Plastic Contact Conductance Models: Comparison with Experiment," J. Thermophysics and Heat Transfer, 8, 4, 633-640 (1994). 6. Fletcher, L. S., Blanchard, D. G., and Kinnear, K. P., "Thermal Conductance of Multilayered Metallic Sheets," Journal of Thermophysics and Heat Transfer, Vol. 7, No. 1, pp. 120-126, 1993. 7. Nishino, K., Yamashita, S., and Torii, K., "Thermal Contact Conductance under Low Applied Load in a Vacuum Environment," Experimental Thermal and Fluid Science, Vol. 10, pp. 258-271, 1995. 8. Padgett, D. L., and Fletcher, L. S., "The Thermal Conductance of Dissimilar Metals," AIAA/ASME 3rd Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference, 1982. 9. Chung, K. C. and Sheffield, J. W., "Enhancement of Thermal Contact Conductance of Coated Junctions," Journal of Thermophysics and Heat Transfer, Vol. 9, No. 2, pp. 329-334, 1995. 10. Somers, R. R., Miller, J. W., and Fletcher, L. S., "Thermo Contact Conductance of Dissimilar Metals," The 2nd AIAA/ASME Thermophysics and Heat Transfer Conference, Paper No. 78-873, 1978. 11. Lewis, D.V. , and Perkins, H.C. , "Heat Transfer at the Interface of Stainless Steel and Aluminum - the Influence of Surface Condutions on the Directional Effect." Int. J. Heat Mass Transfer, Vol. 11, pp. 1371-1383, 1968. 12. M. G. Cooper, B. B. Mikic, and M. M. Yovanovich , "Thermal Contact Conductance," Int. J. Heat Mass Transfer, Vol. 12, pp. 279-300, 1969. 13. Roca, R. T., and Mikic, B. B., "Thermal Conductance in a Bolted Joint," AIAA 7th Thermophysics Conference, AIAA 72-282 (1972). 14. Bevans, J. T., Ishimoto, B. R., Loya, B. R., and Luedke, E. E., "Prediction of Space Vehicle Thermal Characteristics," Air Force Flight Dynamic Laboratory Technical Report AFFDL-TR-65-139, 1965. 15. Yip, F. C., "Theory of Thermal Contact Resistance in Vacuum with an Application to Bolted Joints," AIAA 7th Thermophysics Conference, AIAA 72-281 (1972). 16. Oehler, S. A., McMordie, R. K., and Allerton, A. B., "Thermal Contact Conductance across a Bolted Joint in a Vacuum", AIAA 14th Thermophysics Conference, AIAA 79-1068 (1979). 17. T.J. Lu, H.A. Stone, M.F. Ashby, "Heat transfer in open-cell metal foams," Acta mater. 46 (1998) 3619-3635. 18. J.S. Goodling, Microchannel heat exchange, in: A.M. Khounsary(ED), High Power Flux Engineering II, SPIE Conf. Proc., 1997. 19. R.W. Knight, J.S. Goodling, D.J. Hall, Optimal thermal design of force convection heat sink -analytical, ASME J. Electronic Packaging 133 (1991) 313-321. 20. Bejan, E Sciubba, "The optimal spacing of parallel plate cooled by force convection," Int. J. Heat Mass Transfer 35 (1992) 329-364. 21. T.J. Lu, "Heat transfer efficiency of metal honeycomb," Int. J. Heat and Mass Transfer 42 (1999) 2031-2040. 22. P.G. Collishaw, and Evans J.R.G., J. Mater. Sci., 1994, 29, 486. 23. L.J. Gibson, and M.F. Ashby, "Cellular Solids: Structure and Properties," 2nd edn. Cambridge University Press, Cambridge, 1997. 24. T.J. Lu, and C. Chen, "Thermal transport and fire retardance properties of cellular aluminum alloys," Acta mater. 47 (1999) 1469-1485. 25. R.G. Miller, and L.S Fletcher, "Thermal contact conductance of porous metallic materials in a vacuum environment," AIAA 8th Thermophysics Conference, AIAA (1973) 73-747. 26. R.G. Miller, and L.S Fletcher, Thermal Contact Conductance Correlation for Porous Metals, AIAA 12thAerospace Science Meeting, AIAA (1974) 74-114. 27. S.L. Lee, and J.H. Yang, "Modeling of effective thermal conductivity for a nonhomogeneous anisotropic porous medium," Int. J. Heat and Mass Transfer, 41, 6-7, (1998) 931-937. 28. J.H. Yang. and S.L. Lee., "Effect of anisotropy on transport phenomena in anisotropic porous media," Int. J. Heat and Mass Transfer, 42, 2673-2681 (1999). 29. J. K. Paik, A. K. Thayamballi, and G. S. Kim, "The strength characteristics of aluminum honeycomb sandwich panels," Thin-Wall Structure 35 (1999) 2.5-231. 30. C.L.Yeh, C.Y.Wen, Y.F.Chen, S.H.Yeh and C.H.Wu, " An experimental investigation of thermal contact conductance across bolted joints,"Experimental Thermal and Fluid Science 25 (2001) 349-357. 31. C.L.Yeh, Y.F.Chen, C.Y.Wen and K.T.Li "Mesurement of thermal contact resistance of aluminum honeycombs" Experimental Thermal and Fluid Science 27 (2003) 271-281. 32. 陳逸凡 "螺栓接合面接觸熱阻與鋁蜂巢板熱傳特性之研究"大葉大學機械與自動化工程學系研士論文.