應用啟發式演算法求解複合材料等厚度疊層板之疊層排序

賴志強、鄧世剛 ; 賴峰民

E-mail: 9901386@mail.dyu.edu.tw

摘 要

以複合材料取代金屬物件為現行產業的趨勢，而複合材料疊層板之疊層排序（Ply Stacking Sequence）將影響疊層間應力(Inter-Laminar Stresses)，進而造成疊層之脫層(Delamination)；因此於複合材料零組件設計過程中，疊層排序的設計佔其相當重要之角色。對於此疊層之結構排序處理，一般仍多以手動排列組合編排之方式，導致冗長之排序工作；因此，若能設計一套依據製造限制之疊層排序最佳化設計，協助相關產業進行複合材料零件開發工作，不但可節省複合材料零件開發工時，更可提高複合材料零件的可靠度。本研究以層間應力之解析解(Analytical Solution)求解複合材料疊層板之層間應力，作為最佳化之目標函數，並應用啟發示演算法(Heuristic Method)搜尋多層次之等厚度(Constant Thickness)對稱矩形疊層板之疊層排序問題，以減低整體矩形疊層板間接合面(Interface)之脫層效應，並達到縮短複合材料設計之人力及工時，進而增加複合材料疊層板之結構可靠度。

關鍵詞 : 複合材料 ; 層間應力 ; 排序 ; 啟發式演算法

目錄

參考文獻

【中文部分】 [1]. 江田貴,“ 以有限元素法研究黏結夾層對纖維加強式複合材料強度之影響 ”, 中正理工學院兵器系統工程研究所, 1988。

[2]. 張欽智,“ 以禁忌搜尋法則求解單目標考量及多目標考量之推銷員旅行問題 ”, 大葉大學工業工程研究所碩士論文, 1997。

[3]. 方崇仰,“ 以基因法改良研究分子結構的退火法 ”, 國立中山大學物理學系研究所碩士論文, 1999。

[4]. 柯義峰,“ 應用基因演算法於營建作業流程模擬 ”, 朝陽科技大學營建工程研究所碩士論文, 2000。

[5]. 柯惠雯,“ 結合模擬退火法與禁忌搜尋法在流程式生產排程之應用 ”, 大葉大學工業工程研究所碩士論文, 2000。

[6]. 陳昭仁,“ 複合材料等厚疊層板疊層排序快速最佳化設計 ”, 大葉大學工業工程研究所碩士論文,2000。

[7]. 蕭博文,“ 應用禁忌搜尋法求解營建工程專案多重資源排程最佳化之研究 ”, 朝陽科技大學營建工程研究所碩士論文, 2001。

[8]. 林師檀,“ 禁忌搜尋法與遺傳演算法混合模式在地下水復育優選問題之應用 ”, 國立中興大學環境工程研究所碩士論文, 2001。

[9]. 莊元明,“ 建立退火基因演算反算海底地因參數 ”, 台灣大學造船及海洋工程研究所碩士論文, 2001。

[10]. 駱景堯,“ 禁忌搜尋法在彈性零工型製造系統排程之探討 ”, 工業工程學刊, 16(5), pp.605-615, 1999. 【西文部分】 [11]. Aarts, E. H. L., De Bont, F. M. J., Habers, E. H. A. and Van Laarhoven, P. J. M.,“ Statistical cooling: a general approach to combinatorial optimizations ”, Philips Journal of Research, Vol.4, pp.193-226, 1985.

[12]. Ben-Daya M., and Al-Fawzan, M.,“ A tabu search approach for the flow shop scheduling problem ”, European Journal Operational Research, Vol.109, pp.88-95, 1998.

[13]. Cerny, V.,“ Thermodynamic Approach to the Traveling Salesman Problem: An Efficient Simulated Algorithm ”, Journal of Optimization Theory and Application, Vol.45, No.1, pp.223-225, 1985.

[14]. Deng, S. and Lai, H. Y.,“ The optimization of ply stacking sequence for composite laminate plate with constant thickness ”, 2001.no report.

[15]. Gantovnik, V. B., Gurdal, Z. and Watson, L. T.,“ A genetic algorithm with memory for optimal design of laminated sandwich composite panels ”, Composite and Structures, vol.58, pp. 513—520, 2002 [16]. Glover, F.,“ Future Path for Integer Programming and Links to Articial Intelligence ”, Computers and Operations Research, Vol.13, pp.533-549, 1986.

[17]. Holland, J.,“ Adaptation in Natural and Artificial System ”, Ann Arbor: University of Michigan Press, 1975.

[18]. Isasi, P., Sanchis, A., Molina, J. M. and Berlanga, A.,“ Hierarchical genetic algorithms for composite laminate panels stress optimization ”, Journal of IEEE, vol.4, pp.447-451, 1999 [19]. Kassapoglou, C. and Lagace, P.A.,“ An Efficient Method for The Calculation of Interlaminar

Stresses in Composite Materials ”, Journal of Applied Mechanics, Vol.53, pp.744-760, 1986.
[20]. Kirpatrick, S., Gelatt, C. D. and Vecchi, M. P., “ Optimization by simulated annealing ”, Science, Vol.220, pp.671-680, 1983.
[21]. Kolahan, F. and Liang, M., “ A Tabu Search Approach to Optimization of Drilling Operations, ” Computers Industrial Engineering, Vol.31, No.1/2, pp.371-374, 1996.
[22]. Lin, C. C., Hsu, C. Y. and Ko, C.C., “ Interlaminate Stresses in General Laminates with Straight Free Edges ”, Journal of AIAA, Vol.33, No.8, pp.1471-1476, 1995.
[23]. Lin, S., “ Computer Solution of the Traveling Salesman Problem ”, Bell System Technical, Vol.44, pp.2245-2269, 1965.
[24]. Liu, B., Haftka, T. R., Akgun, M. A. and Todoroki, A., “ Permutation genetic algorithm for stacking sequence design of composite laminates ”, Computer Methods in Applied Mechanics and Engineering, Vol.186, pp.357-372, 2000.
[25]. Lundy, M. and Mees, A., “ Convergence of an annealing algorithm ”, Mathematical Programming, Vol.34, pp.111-124, 1986.
[26]. Metropolis, N., Rosenbluth, A., Rosenbluth, M., Teller, A. and Teller, E., “ Equation of state calculations for fast computing machines ”, Journal of Chemical Physics, Vol.21, pp.1087-1092, 1953.
[27]. Mnc, A. and Gurba, W., “ Genetic algorithm and finite element analysis in optimization of composite structures ”, Composite and Structures, vol.54, pp.275—281, 2001 [28]. Niu, M. C.-Y., “ Composite Airframe Structures ”, 1992.01 [29]. Pagano, N. J. and Pipes, B. R., “ The Influence of Stacking Sequence on Laminate Strength ”, Journal of Composite Materials, January, Vol.5, pp.50-57. 1971, [30]. Park, J. H., Hwang, J. H., Lee, C. S. and Hwang. W., “ Stacking sequence design of composite laminates for maximum strength using genetic algorithms ”, Computers and Structures, Vol.52, pp.217-231, 2001.
[31]. Parmar, R. S., McClendon, R. W. and Potter, W. D., “ Farm Machinery Selection Using Simulation and Genetic algorithms ”, American Society of Agricultural Engineers, Vol.39, No.5, pp.1905-1909, 1996 [32]. Penna, T. J. P., “ Traveling salesman problem and Tsallis statistics ”, Physical Review E, Vol.51, pp.R1-R3, 1995.
[33]. Pipes, R. B. and Pagano, N. J., “ Interlaminar Stresses in Composite Laminates under Uniform Axial Extension ”, Journal of Composite Materials, Vol. 4, pp.538-548, 1970.
[34]. Rybicki, E. F., “ Approximation Three-Dimensional Solutions for Symmetric Laminates under In-Plane Loading ”, Journal of Composite Materials, Vol.5, pp.354-360, 1971.
[35]. Soremekun, G. Z., Gurdal, R. T., Haftka and Watson, L. T., “ Composite laminate design optimization by genetic algorithm with generalized elitist selection ”, Computers and Structures, vol.79, pp.131-143, 2001 [36]. Tasllis, C., “ Possible generalization of Boltzmann-Gibbs statistics ”, Journal of Statistical Physics, Vol.52, No.1/2, pp.479-487, 1988.
[37]. Tasllis, C. and Stariolo, D. A., “ Generalizes simulated annealing ”, Physical A, Vol.233, pp.395-406, 1996.
[38]. Tsai, L. R., Chang, Y. H. and Tsao, F. L., “ The Design of Optimal Stacking Sequence for Laminated FRP Plates With Inplane Loading ”, Computers & Structures, Vol.55, No.4, pp.565-580, 1995.
[39]. Tsai, L. R. and Liu, C. H., “ A Comparison between Two Optimization Methods on the Stacking Sequence of Fiber-Reinforced Composite Laminate ”, Computers & Structures, Vol55, No.3, pp.515-525, 1995.
[40]. Tsai, S. W., “ Composite Design, 4th end, Think Composites ”, Dayton. 1998 [41]. Wang, A. S. D. and Crossman, F. W., “ Some New Results on Edge Effect in Symmetric Composite Materials ”, Journal of Composite Materials, Vol.11, pp.92-106, 1977.
[42]. Wang, B. P. and Costin, D. P., “ Optimum Design of a Composite Structure with Three Types of Manufacturing Constraints ”, Journal of AIAA, Vol.30, pp. 1667-1669, 1992.
[43]. Wen, U. P. and Yeh, I. C., “ Tabu search methods for the flow shop sequencing problem ”, Journal of Chinese Institute of Engineers, 20(4), 465-470, 1997.