A Design of the Variable Crank and the Flywheel with Variable Mass Moment of Inertia Applied on the Stirling Engine

江俊杉、陳照忠

E-mail: 9707248@mail.dyu.edu.tw

ABSTRACT

Internal-combustion engines have been used for over one hundred years. Though high-performance internal-combustion engines have been developed constantly, but their thermal efficiency is unable to break through the limit of innate restriction. Combining the Stirling engine and the internal-combustion engine might be able to attain the goal of reducing pollution. The Stirling engine is one kind of heat machinery with a fixed amount of output power. It is very difficult to control its output power. The design of applying the variable crank and the flywheel with variable mass moment of inertia on the Stirling engine makes its output power can be easily controlled. This study made an analysis of dynamics by using different types of variable crank and stroke. Getting result curves of position, velocity and acceleration. According to the analysis curve, we can see the advantage and the faults of this machinery, and using the result compare to a reciprocating engine as a standard. This study use the reciprocating engine as a standard and made an analysis of dynamics by using different types of variable crank and stroke. Getting the result curves of position, velocity and acceleration. According to the analysis curves, we can see the advantage and the faults of this machinery. Design flywheel with variable mass moment of inertia to increase stirling engines environmental adaption. Using the spring control the clutch, and set the clutch into high speed and low speed two steps of mass moment of inertia. Flywheel function is set by rotational speed. When the speed is low, the variable mass moment of inertia is bigger than the high speed. This study uses ADAMS for simulate analysis. By high speed computing, we can find the problems and solved them before the products has been completed.

Keywords : Stirling engine ; design ; Variable crank ; Flywheel with variable mass moment of inertia

Table of Contents

封面內頁 簽名頁 授權頁..iii 中文摘要..iv 英文摘要..v 誌謝..vi 目錄..vii 圖目錄..ix 表目錄..xiii 第一章 緒論..1 1.1 前言..1 1.2 研究動機..1 1.3 文獻回顧..2 1.4 研究目的..6 1.5 論文架構..6 第二章 機構之應用設計..8 2.1 α Type 史特靈引擎設計..8 2.2 可變曲柄機構設計..12 2.3 可變質量慣性矩飛輪設計..17 第三章 分析與討論..20 3.1靜態分析..20 3.1.1飛輪運轉時向心加速度對飛輪之影響................21 3.1.2材料熱膨脹對功能尺寸的影響..........................26 3.1.3向心加速度對曲柄組件影響...............................32 3.2曲柄滑塊動態分析..35 3.3可變曲柄之動態分析..45 3.4可變質量慣性矩飛輪動態分析..................................70 第四章 結論與未來展望..75 4.1 結論..75 4.2 未來展望..76 參考文獻..78

REFERENCES

參考文獻 【1】 曾玉泉，“ 極速引擎的魅力-史特靈引擎（Stirling Engine） ”，生活科技教育月刊，三十九卷，第五期，2006年。【2】 林育煌，使用菱形驅動機構之同軸是史特靈引擎研究，大同大學機械工程研究所碩士論文，2005年。【3】 施長江，史特靈引擎菱形驅動與熱流分析，大同大學機械工程研究所碩士論文，2004年。【4】 許世宗，利用史特靈引擎回收焚化爐廢熱之熱傳分析，成功大學機械工程學系碩士論文，2002年。【5】 Lung-Wen Tsai, Mechanism Design Enumeration of Kinematic Structures According to Function, CRC

Press, 2002. 【6】 張弘政，可變慣性飛輪之概念與構形設計，崑山科技大學機械工程系碩士論文，2007年。 【7】 George W. Crise, Variable Displacement Internal Combustion Engine Having Automatic Piston Stroke Control, U.S. Patent No. 4131094, 1978. 【8】 S. T. Hsu, F. Y. Lin, and J. S. Chiou, “ Heat Transfer Aspects of Stirling Power Generation Using Incinerator Waste Energy, ” Renewable Energy, Vol. 28, pp. 59-69, 2003. 【9】 Can Cinar, and Halit Karabulut, “ Manufacturing and Testing of a Gamma Type Stirling Engine, ” Renewable Energy, Vol. 30, pp. 57-66, 2005. 【10】 H. Karabulut, H. S. Yucesu, and C. Cinar, “ Nodal Analysis of a Stirling Engine with Concentric Piston and Displacer, ” Renewable Energy, Vol. 31, pp. 2188-2197, 2006. 【11】 J. Boucher, F. Lanzetta, and P. Nika, “ Optimization of a Dual Free Piston Stirling Engine, ” Applied Thermal Engineering, Vol. 27, pp. 802-811, 2007. 【12】 Bancha Kongtragool, and Somchai Wongwises, “ Optimum Absorber Temperature of a Once Reflecting Full Conical Concentrator of a Low Temperature Differential Stirling Engine, ” Renewable Energy, Vol. 30, pp. 1671-1687, 2005. 【13】 Feng Wu, Linger Chen, Chih Wu, and Fengruisun, “ Optimum Performance of Irreversible Stirling Engine with Imperfect Regeneration, ” Energy Convers, Vol. 39, No. 8, pp. 727-732, 1997. 【14】 Bancha Kongtragool, and Somchai Wongwises, “ Performance of a Twin Power Piston Low Temperature Differential Stirling Engine Powered by a Solar Simulator, ” Solar Energy, Vol. 81, pp. 884-895, 2007. 【15】 D. G. Thombare, and S. K. Verma, “ Technological Development in the Stirling Cycle Engines, ” Renewable and Sustainable Energy Reviews, Vol. 12, pp. 1-38, 2008. 【16】 M. Kuosa, J. Kaikko, and L. Koskelainen, “ The Iimpact of Heat Exchanger Fouling on the Optimum Operation and Maintenance of the Stirling Engine, ” Applied Thermal Engineering, Vol. 27, pp. 1671 – 1676, 2007. 【17】 Zhaolin Gu, Haruki Sato, and Xiao Feng, “ Using Supercritical Heat Recovery Process in Stirling Engines for High Thermal Efficiency, ” Applied Thermal Engineering, Vol. 21, pp. 1621-1630, 2001. 【18】 Dar-Zen Chen, and Wei-Ming Pai, “ A Methodology for Conceptual Design of Mechanisms by Parsing Design Specifications, ” ASME, Vol. 127, pp. 1039-1044, 2005. 【19】 Jehad A. A. Yamin, and Mohammad H. Dado, “ Performance Simulation of a Four-Stroke Engine with Variable Stroke Length and Compression Ratio, ” Applied Energy, Vol. 77, pp. 447-463, 2004. 【20】 許正何，創造性機構設計學，高立圖書有限公司，2006年。 【21】 Masaki Ota, Hisakazu Kobayashi, Youichi Okadome, and Masaru Hamasaki, Variable Displacement Compressor, U.S. Patent No. x578503, 1998. 【22】 簡國祥和柳立明，可變衝程之史特靈引擎，中華民國專利公報565652，2002年。 【23】 山田義和佐藤義一，可變衝程引擎，中華民國專利公報200415301，2005年。 【24】 Otto Georg, Working Machine with Flywheel of Variable Inertia Moment, U.S. Patent No. 2301943, 1946. 【25】 Yasunari Kimura, Takao Tsuboi, and Tesuneo Endoh, Variable Flywheel Mechanism and Flywheel Apparatus, U.S. Patent No. 20070179012A1, 2007. 【26】 楊泰和，主動驅動或依離心力線性隨動之動態飛輪效應原理及結構，中華民國專利公報175512，1991年。