Multi-Injection Performance Optimization Study for a High Pressure Direct Injection Common Rail Diesel Engine

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ABSTRACT

The main purpose of this study is to establish the multiple injection performance optimization methodology for a high pressure Direct Injection Common Rail (DICR) diesel engine. The hardware and software of the engine control system were combined with the engine dynamometer display real-time performance parameters so that the engine control parameter tuning and multi-objective optimization rules can be integrated and the engine performance be verified at the same time by dynamometer experiments. This study has built the fuel consumption and pollution models of vehicle driving cycle which then was converted into engine torque and speed by using the real vehicle parameters. Several key points were sorted from the corresponding map data for steady state estimation measurement. The selected key points control parameters were changed to reduce the overall exhaust emissions. Experimental design optimization analysis software will emphasize three filtered driving cycle key points with both single injection and double injection analysis. The engine performance response surface functions were built and used to find optimal control parameters by using multiple targets goal-attainment optimization search program. The predicted diesel engines single and multiple injection performance, include brake torque, specific fuel consumption and four major emissions, were compared and optimized to reduce fuel consumption and emissions. The four corresponding engine control parameters include the pre-injection and main injection timings and injection durations were calculated and validated by engine dynamometer tests. The engine combustion heat release and its rate were calculated by using engine combustion pressure – crank angle data and validated with combustion analyzer under different engine operating conditions. Single injection and double injection combustion analysis were conducted and compared. The dynamic relationship between control and the response performance can be used for future reference in developing of DICR diesel engine management systems. By experimental design and multi-objective optimization search, the experiments time and expanse can be reduced and the efficiency of engine parameters calibration and adjustment can thus be improved.

Keywords : DICR diesel engine multiple fuel injection control system、Diesel engine multiple injection performance optimization 、Design of experiment Multi-objective optimization search、Diesel engine combustion analysis 相關次數:

Table of Contents

REFERENCES

[1] G.E.Corcione, M. L. Rosa, M. Lavorgna, A. Giuffrida and R. Lanzafame ” Modeling and Control of a Common Rail System for Diesel Multiple Injections, ” SAE Paper No.2001-24-0014,2001.
[2] L. Zhang, “ A Study of Pilot Injection in a DI Diesel Engine, ” SAE Paper No. 1999-01-3493,1999.
[3] F. Yan and J. Wang, ” Common Rail Injection System On-Line Parameter Calibration for Precise Injection Quantity Control, ” American Control Conference No. 978-1-4244-7427-1/10, AACC, 2010.
[4] N. R. Abdullah, R. Mamat, P. Rounce, A. Tsolakis, M. L. Wyszynski and H. M. Xu, “ Effect of Injection Pressure with Split Injection in a V6 Diesel Engine ” SAE Paper No. 2009-24-0049,2009.
[5] N.A. Henein, M-C. Lai, I. P. Singh, L. Zhong and J. Han, “ Characteristics of a Common Rail Diesel Injection System under Pilot and Post Injection Modes, ” SAE Paper No. 2002-01-0218, 2002.
[6] C. Park, S. Kook and C. Bae, “ Effects of Multiple Injections in a HSDI Diesel Engine Equipped with Common Rail Injection System, ” SAE Paper No. 2004-01-0127, 2004.
[7] Y. Mingfa, W. Hu, Z. Zunqing and Y. Yan, “ Experimental Study of Multiple Injections and Coupling Effects of Multi-Injection and EGR in a HD Diesel Engine, ” SAE Paper No. 2009-01-2807, 2009.
[8] A. Shijie , C. Hanbao, X. Hongjun, “ Examinatal Study on Common Rail Diesel Engine for Multi-Injection strategies ” 978-0-7695-4077-1/10 , 2010 IEEE.
[9] F. E. Corcione, Bianca M.Vaglieco, G. E. Corcione, M. Lavorgna, “ Potential of Multiple Injection Strategy for Low Emission Diesel Engines, ” SAE Paper No. 2002-01-1150, 2002.
[10] W. D. Ojeda, P. Zoldak, R. Espinosa and R. Kumar, “ Development of a Fuel Injection Strategy for Diesel LTC, ” SAE Paper No. 2008-01-0057, 2008.
[11] A. Vanegas, H. Won, C. Felsch, M. Gauding and N. Peters, “ Experimental Investigation of the Effect of Multiple Injections on Pollutant Formation in a Common-Rail DI Diesel Engine, ” SAE Paper No. 2008-01-1191,2008.
[12] G. M. Bianchi, P. Pelloni, F. E. Corcione and F. Luppino, “ Numerical Analysis of Passenger Car HSDI Diesel Engines with the 2nd Generation of Common Rail Injection Systems: The Effect of Multiple Injections on Emissions, ” SAE Paper No. 2001-01-1068, 2001.
[13] S. Mendez and B. Thirouard, “ Using Multiple Injection Strategies in Diesel Combustion: Potential to Improve Emissions, Noise and Fuel Economy Trade-Off in Low CR Engines, ” SAE Paper No. 2008-01-1329, 2008.
[14] Y. Lu , W. Yu and W. Su, “ Using Multiple Injection Strategies in Diesel PCCI Combustion: Potential to Extend Engine Load, Improve Trade-off of Emissions and Efficiency, ” SAE Paper No. 2011-01-1396,2011.
[15] F. Mallamo, M. Badami and F. Millo, “ Analysis of Multiple Injection Strategies for the Reduction of Emissions, Noise and BSFC of a DI CR Small Displacement Non-Road Diesel Engine, ” SAE Paper No. 2002-01-2672, 2002.
[16] D. T. Montgomery and R. D. Reitz, “ Optimization of Heavy-Duty Diesel Engine Operating Parameters Using A Response Surface Method, ” SAE Paper No. 2000-01-1962, 2000.
[17] Y. L. and R. D. Reitz, “ Optimizing HSDI Diesel Combustion and Emissions Using Multiple Injection Strategies, ” SAE Paper No. 2005-01-0212, 2005.
[18] Z. Jingqiu,and G. Guangyao, “ Optimization Design of the Electronically Controlled Injector, ” 978-1-4244-2693-5/09,2009 IEEE.
[19] Q. J. Wen, C. H. Baol, and S L. Min, ” Optimization Design Injection System Parameters of Common Rail Diesel Engine Using Response

Surface Methodology, ” 978-1-4 577-0246-4/11/$26.00,2011 IEEE.
[20] H. Hiroyasu, H. Miao, T. Hiroyasu, M. Miki, J. Kamiura, and S. Watanabe, “ Genetic Algorithms Optimization of Diesel Engine Emissions and Fuel Efficiency with Air Swirl, EGR, Injection Timing and Multiple Injections, ” SAE Paper No. 2003-01-1853,2003.
[21] Y. Sun, and R. D. Reitz, ” Modeling Diesel Engine NOx and Soot Reduction with Optimized Two-Stage Combustion, ” SAE Paper No. 2006-01-0027,2006.
[22] 陳榮俊, ” 智慧型車輛動力系統之動態模擬與分析, ” 大葉大學車輛工程學系碩士班碩士論文, 2002.
[23] 章文堯, “ 混合動力車輛反向性能模擬與分析, ” 大葉大學 車輛工程學系碩士班 碩士論文, 2003。
[24] 蘇筵壬, “ 直接噴射共軌式柴油引擎管理系統控制最佳化之研究, ” 大葉大學 機械與自動化工程學系碩士論文,2011.
[25] M. G.Daniel and P. D. Timothy, “ Engineering, Quality and Experimental Design, ” Longman Scientific & Technical. London, 1992.
[26] G. E. P. Box and J. S. Hunter, “ Multifactor Experimental Designs for Exploring Response Surfaces, ” Ann. Math. Stat. 28, pp.195-241. 1957.
[27] L. R. Foulds, “ Optimization Techniques An Introduction, ” Springer Verlag Inc., New York, 1981.
[28] R.H. Myers and D.C Montgomery, “ Response Surface Methodology, ” John Wiley & Sons Inc., 1995.
[29] G. Derringer and R. Suich, “ Simultaneous Optimization of Several Response Variables, ” J. of Quality Technology, Vol. 12, pp. 214-219, 1980.
[30] R. Stone原著、梁乃文譯, “ 內燃機(第二版) , ” p.527~p.532,文京圖書有限公司,1999