Dynamic Simulation and Analysis for Intelligent Vehicle Powertrain System

陳榮俊、張一屏

E-mail: 9121397@mail.dyu.edu.tw

ABSTRACT

This study is proposed to establish technology and methodology for powertrain dynamic control systems in an Intelligent Vehicle System (IVS). IVS powertrain control system integration includes the electronic ignition system, electronic fuel injection system and the electronic transmission control system. Several simulation programs were developed to evaluate and predict the real-time performance of the powertrain. The proper powertrain dynamic models establish relationship between the engine performance and the vehicle operating variables and control parameters. The simulation program was based on the specific engine test data; the related control system principles were incorporated to modify the dynamic performance response of the engine and IVS powertrain. The output of this simulation program including the engine speed and manifold pressure variation according to the variation of model input variables such as throttle position and engine load torque setting. The engine combustion output performance was tested under different operating conditions to analyze the internal correlation between performance and variables such as engine speed, intake manifold pressure, and spark advance etc. The implement of the control system dynamic models needs to find out the model constants and functions by which the dynamic performance of the engine and IVS powertrain can be predicted. With this dynamic performance simulation program, engineer can evaluate the variation in engine and powertrain dynamic performance due to design change and different control settings, reducing the corresponding trial-and—error effort, saving the research and development time and cost.

Keywords : IVS Powertrain System ; Engine Dynamic Analysis ; Driveline System Performance Simulation

Table of Contents

REFERENCES

參考文獻 [1]W. W. Yuen and H. Servati,“ A Mathematic Engine Model Including the Effect of Engine Emissions ”. SAE Paper No. 840036, 1986.

[2]R. D. Fruechte, and A. Kade,“ Transfer Function Modeling of a Gasoline Engine and Engine Actuators ”. GMR Memorandum 53-46, April 10, 1978.

[3]R. D. Fruechte, and A. Kade,“ Design of an Idle Speed Control System Using a Perturbation Engine Model ”. GMR Report EG-150, August 30, 1978.

[4]J. F. Cassidy,“ A State Variable Model for Engine Control Studies ”. GMR Report ET-180, December 7, 1978.

[5]J. F. Cassidy,“ On the Design of Electronic Automotive Engine Controls Using Linear Quadratic Control Theory ”. GMR Report ET-181, December 5, 1981.

[6]J. A. Tennant,“ Engine Characterization and Control, APE Project No. 2238 an 0verview ”. GM Engineering Staff APER-262, June 23, 1976.

[7]J. A. Tennant et.al,“ Development and Validation of Engine Model Via Automated Dynamometer Tests ”. SAE Paper No. 790178, February,

1979.
[8]D. J. Dobner, “ A Mathematical Engine Model for Development of Dynamic Engine Control ” . GMR Report EG-159, April 30, 1979.
[9]D. J. Dobner, “ Engine Characteristics for the Dynamic Engine Model ” . GMR Report EG-177, May 30, 1980.
[10]D. J. Dobner, “ A Mathematical Engine Model for Development of Dynamic Engine Control ” . SAE Paper No. 800054, 1980.
[11]D. J. Dobner, “ Introducing the Effect of Exhaust Gas Backflow in Dynamic Engine Models ” . GMR Report EG-190, May 8, 1981.
[12]R. G. DeLosh et al., “ Dynamic Computer Simulation of a Vehicle with Electronic Engine Control ” . SAE Paper No. 810447, February, 1981.
[13]Y. K. Chin and F. E. Coats, “ Engine Dynamics: Time-Based Versus Crank-Angle Based ” . SAE Paper No. 860412, 1986.
[14]R. Nishiyama, S. Ohkubo and S. Washino, “ An Analysis of Controlled Factors Improving Transient A/F Control Characteristics ” . SAE Paper No.890761, 1989.
[15]P. C. Baruah, “ A Simulation model for Transient Operation of Spark-Ignition Engines ” . SAE Paper No.9006382, 1990.
[16]W.C. Water, “ General Purpose Automotive Vehicle Performance and Economy Simulator ” . SAE Paper No.720043, 1972.
[17]P.N. Blumberg, ” Powertrain Simulation: A Tool for the Design and Evaluation of Engine Control Strategies I Vehicles, ” SAE Paper No.760158, 1976.
[18]M. Nasu, A. Ohata, and S. Abe, “ Model-Based Fuel Injection Control System for SI Engines ” . SAE Paper No.961188, 1996.
[19]I. Kolmanovsky, “ Optimization of Complex Powertrain Systems for Fuel Economy and Emissions ” . Proceedings of the 1999 IEEE International Conference on Control Applications Kohala Coast-Island of Hawaii, Hawaii, USA. August 22-27, 1999.
[20]A. Haj-Fraj and F. Pfeiffer, “ Optimization of Gear Shift Operations in Automatic Transmissions ” . Proceedings of the 2000 IEEE, AMC2000-NAGOYA, pp.469-473, 2000.
[21]H. Yamaguchi et al., “ Automatic Transmission Shift Schedule Control Using Fuzzy Logic ” . SAE Paper No.930674, 1993.
[22]Y. Narita “ Improving Automatic Transmission Shift Quality by Feedback Control with a Turbine Speed Sensor ” . SAE Paper No.911938, 1991.
[23]H. Igata et al., “ Development of New Control Methods to Improve Response of Throttle Type Traction Control System ” . SAE Paper No.920608, 1992.
[24]Y. Hojo et al., “ Toyota Five-Speed Automatic Transmission with Application of Modern Control Theory ” . SAE Paper No.920610, 1992.
[25]Y. Danno et.al, “ Powertrain Control by DBW System-Strategy and Modeling ” . SAE Paper No.890760, 1989.
[26]J. Karlsson and J. Fredriksson, “ Cylinder-by-Cylinder Engine Models Vs Mean Value Engine Models for Use in Powertrain Control Applications ” . SAE Paper No.910906, 1991.
[27]T. Morel et al., “ Integrated Engine/Vehicle Simulation and Control ” . SAE Paper No.910907, 1991.
[28]L. Mianzo, “ A Transmission Model for Hardware-in-the-Loop Powertrain Control System Software Development ” . Proceedings of the 2000 IEEE International Conference on Control Applications Anchorage, Alaska, USA. September 25-27, 2000.
[29]S. Raman et al., “ Design and Implement of HIL Simulators for Powertrain Control System Software Development ” . Proceedings of the American Control Conference San Diego, California. June 1999.
[30]B. K. Powell et al., “ Hardware-in-the-Loop Vehicle and Powertrain analysis and Control Design Issues ” . Proceedings of the American Control Conference Philadelphia, Pennsylvania. June 1998.
[31]K. R. Butts, “ An Application of Integrated CASE/CACSD to Automotive Powertrain Systems ” . Proceedings of the 1996 IEEE International Symposium in Computer-Aided Control System Design Dearborn, Mi. September 15-18, 1996.
[32]G. R. Babbitt and J. J. Moskwa, “ Implementation Details and Test Results for a Transient Engine Dynamometer and Hardware in the Loop Vehicle Model ” . Proceedings of the 1999 IEEE International Symposium in Computer-Aided Control System Design Kohala Coast-Island of Hawaii, Hawaii, USA. August 22-27, 1999.
[33]H. Hanselmann, “ Hardware-in-the-Loop Simulation Testing and its Integration onto a CACSD Toolset ” . The IEEE International Symposium in Computer-Aided Control System Design Dearborn, Michigan, USA. September 15-18, 1996.
[34]S. Toeppe, “ Specification and Testing of Automotive Powertrain Control System Software Using CACSD Tools ” . The IEEE International Symposium in Computer-Aided Control System Design Dearborn, Michigan, USA. 1998.
[35]R. E. Dorey and A. D. Scarisbrick, “ Rapid Prototyping Methodology Applied to the Powertrain Control System ” . The Institution of Electrical Engineers Printed and Published by the IEE, Savoy Place, London WC2R 0BL, UK, 1997.
[36]C. E. Hawkins and I. J. Berry, “ Rapid Prototyping Tools for Powertrain Control Systems Development ” . The Institution of Electrical Engineers Printed and Published by the IEE, Savoy Place, London WC2R 0BL, UK, 1997.
[37]R. E. Dorey and D. Maclay, “ Rapid Prototyping for the Development of Powertrain Control Systems ” . Proceedings of the 1996 IEEE International Symposium in Computer-Aided Control System Design Dearborn, Michigan, USA. September 15-18, 1996.
[38]N. Narumi et al., “ Trends of Powertrain Control ” . SAE Paper No.901154, 1990.
[39]A. Beydoun and L. Y. Wang, “ Coordination of Engine and Transmission Using Hybrid Control Methodologies ” . Proceedings of the American Control Conference Philadelphia, Pennsylvania. June 1998.

[40]Keum-Shik Hong and Kyung-Jinn Yang, “ An Object-Oriented Modular Simulation Model for Integrated Gasoline Engine and Automatic Transmission Control ”. SAE Paper No.990750, 1999.
[41]J. W. Anthony, J. J. Moskwa and E. Danielson, “ Powertrain Simulation of the M1A1 Abrams Using Modular Model Components ”. SAE Paper No.980926, 1998.
[42]Z. J. Rubin, S. A. Munns and J. J. Moskwa, “ The Development of Vehicle Powertrain System Modeling Methodologies: Philosophy and Implementation ”. SAE Paper No.971089, 1997.
[43]M. Pettersson and L. Nielsen, “ Driveline Modeling and RQV Control with Active Damping of Vehicle Shuffle ”. SAE Paper No.970536, 1997.
[44]B. Klages, R. J. Woermann and H. J. Theuerkauf, “ An Improved Real-Time Model of a Planetary Gear Train ”. SAE Paper No.970970, 1997.
[45]V. Krishnaswami et al., “ Application of Sliding Mode Observers to Automobile Powertrain Diagnostic ”. Proceedings of the 1996 IEEE International Conference on Control Applications Dearborn, Michigan, USA. September 15-18, 1996.
[46]K. M. Connair et.al, “ Development of a Common Vehicle Model for Chassis Control Design ”. SAE Paper No.990732, 1999.
[47]J.J. Moskwa, “ Automotive Engine Modeling Real Time Control ”. M.I.T. Ph.D. thesis, May, 1988.
[48]J.J. Moskwa and W.W. Robert, “ Automotive Engine Modeling Real Time Control Using MATLAB/SIMULINK ”. SAE Paper No. 950417, 1995.
[49]M. Peter, “ Multivariable PI Tuning and Application to Engine Idle Speed Control ”. Proceedings of the American Control Conference San Diego. Califomia, 1999.
[50]L. Kjergaard and S. Nielsen, “ Advanced Nonlinear Engine Idle Speed Control Systems ”. SAE Paper No. 940974, 1994.
[51]H. P. Geering et al., “ Measurement of the Wall-Wetting Dynamics of a Sequential Injection Spark Engine ”. SAE paper No.940447, 1994.
[52]C. R. Turin and H. P. Geering, “ On-Line Identification of Air/Fuel Ratio Dynamics in a Sequentially Injected SI Engine ’. SAE paper No.930857, 1993.
[53]T. Sekozawa et al., “ Development of a Highly Accurate Air/Fuel Ratio Control Method Based on Internal State Estimation ”. SAE paper No.920290, 1992.
[54]C. R. Turin and H. P. Geering, “ Model-based adaptive fuel control in an SI engine ”. SAE Paper No.940374, 1994.
[55]D. J. Powell et al., “ Engine Air-Fuel Ratio Control Using an Event-Based Observer ”. SAE paper No.930766, 1993.
[56]U . Kiencke and L . Nielsen “ Automotive Control Systems For Engine Driveline and Vehicle ”. Springer ISBN 3-540-66922-1, pp.47-52, 2000.
[57]M. Nishda et al., “ Closed Loop Control of the EGR Rate Using the Oxygen Sensor ”. SAE Paper No. 880133, 1988.
[58]A. W. Olbrot et al., “ Robust parameterized controller design with an application to exhaust gas recirculation (EGR) system ”. Proceedings of the 34th Conference on Decision and Control New Orleans, LA December, 1995.
[59]Y. Kaneko et al., “ The Effect of Exhaust Gas Recirculation and Residual Gas on Engine Emission and Fuel Economy ”. SAE Paper No. 750414, 1975.
[60]M. Fujieda et al., “ Development of Electronic EGR Control System for Gasoline Engine Part 2 Study on Control Accuracy and Specific fuel consumption ”. JSAE Paper No. 9437043, 1994.
[61]R. K. DuPuy, “ Fuel System and Emission Control ”. HarperCollins 3rd edition ,1994.
[62]M. G. Daniel and P. D. Timothy, “ Engineering, Quality and Experimental Design ”. Longman Scientific & Technical. London, 1992.
[63]G. E. P. Box and J. S. Hunter, “ Multifactor Experimental Designs for Exploring Response Surfaces ”. Ann. Math. Stat. 28, pp.195-241. 1957.
[64]L.R. Foulds, “ Optimization Techniques An Introduction ”. Springer Verlag Inc., New York, 1981.
[65]R. H. Myers and D.C Montgomery, “ Response Surface Methodology ”. John Wiley & Sons Inc., 1995.
[66]G. Derringer and R. Suich, “ Simultaneous Optimization of Several Response Variables ”. J. of Quality Technology, Vol. 12, pp. 214-219, 1980.
[67]J. Y. Wong, “ Theory of Ground Vehicle ”. John Wiley & Son, second edition, pp. 3-72, 1993.
[68]小林久德等著、賴耿陽編譯, “ 電子控制式汽油噴射技術 ”. 台灣復文興業公司,1995。
[69]S. A.Munns, “ Computer Simulation of Powertrain Components with Methodologies for Generalized System Modeling ”. University of Wisconsin-Madison, M.S. Thesis, 1996.