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All New 2.0L Turbo-charged GDI Engine from SAIC Motor

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Abstract

SAIC Motor has developed an all new 2.0 L 4-cylinder turbocharged gasoline direct injection engine to meet the market demand and increasingly stringent requirement of CAFE and tail-pipe emission regulations.

A series of advanced technologies have been employed in this engine to achieve high efficiency, high torque and power output, fast response low-end torque performance, refined NVH performance, all at market leading level, and low engine-out emissions. These main technologies include: side mount gasoline direct injection with 35MPa fuel injection system, integrated exhaust manifold, high tumble combustion system, 2-step intake variable valve lift (DVVL) with Miller Cycle, efficient turbo charging with electric wastegate (EWG), light weight and compact structural designs, NVH measures including balancer system with silence gear, friction reduction measures, optimized thermal management, etc. As a result of application of these technologies and optimized designs, the engine is able to achieve over 39.5% maximum brake thermal efficiency (BTE), as well as large high efficiency region in the fuel map that covers most typical customer real driving conditions. It delivers 360 Nm maximum torque from 1500RPM to 4000RPM, and 172kW rated power at 5500RPM, with fast low end torque response.

The new 2.0T engine already started the mass production in October, 2020, with its first application in ROEWE iMAX8, a MPV. Even with the weight of 2058kg, the vehicle is able to achieve 9.3s 0-100km acceleration, while meeting China VI b standard emission regulatory requirement equipped with this new 2.0T engine.

In this paper, the design/optimization of the engine systems will be described. The detailed investigations with simulations and dyno testing of effects of the core technologies will also be presented.

Introduction

To deal the global warming climate change, world wide consensus has been established, as Paris Agreement requires, carbon emissions need to be reduced and ultimately carbon neutral needs to be reached to minimize the greenhouse effect. In the transportation sector, this leads to the mega trend of electrifications to reduce CO2 emissions and achieve sustainable mobility. More strict CAFE standards have been formulated in regard to vehicle CO2 emissions, for example starting from 2020, China Market execute the stage V fuel consumption regulation GB 27999-2019, to further reduce the average fuel consumption target of light duty vehicles by roughly 20%. In the meantime, the EU legislation foresees a fleet CO2 reduction by 37.5 % for new passenger car registrations in 2030 [1].

Even though the OEMs are accelerating the introduction of vehicles with advanced electrification technologies, including HEV, PHEV, BEV and FCEV, the low price of crude oil, limited electric charging infrastructure and the gradual decline of government subsidies for electric vehicles have slowed down the market growth of electric vehicles. For example, for the year of 2020, about 94% of China's passenger car market share still has gasoline internal combustion engine. The research [2] also shows that for the electrified powertrain system with internal combustion engine, the improvement of engine thermal efficiency still plays great importance to the overall system efficiency and reductions of CO2 footprint directly.

At the same time, continuously more stringent pollutant emission regulations pose another great challenge to the powertrain system with ICE. For example, starting from July 2020, emission regulation in China Market is elevated form from China V to China VI, test cycle is also changed from NEDC to WLTC, and will be advanced to RDE in July 2023.

On the consumer side, expectations and requirements on the dynamic performance of the powertrain system would not comprise, especially on the low end transient torque response and NVH quality.

To meet needs and requirements from various aspects, the development of gasoline engine products with new generation technology is the key path to the updated powtrain system, with pursuing high efficiency, high performance, low carbon emission and environmental protection as the crucial development target.

At SAIC Motor, the previous generation of 2.0 liter turbocharged GDI engine has been developed and successfully produces 195Nm torque at 1000rpm, 285 Nm Torque at 1250rpm, reaches maximum torque of 360 Nm between 1500-4000rpm, 150 kW Power at 5300rpm. At the same time, the engine also achieves 35% faster low end torque response compared with previous generation 2.0T engine, providing good acceleration driving experience for consumers.

- The rear take down (RTD) exhaust after-treatment structure is adopted, helps to meet the China VI b emission requirement for vehicle application. The system includes close-coupled TWC and under-floor GPF. Initial screen selection of TWC is performed on engine dyno using newly developed EIL methodology.
- As a trend for the development method, considering more complex electrification of the powertrain system, and more stringent requirements from both quality and time duration in future development, the virtual simulations will be further extended to cover more aspects of the powertrain system, such as electric motor, battery, inverters, and related energy flow analysis, thermal management of the whole system besides base engine and transmission.

Reference

1. EU Regulation 2019/631 of the European Parliament and of the Council, "2019 Setting CO2 Emission Performance Standards for New Passenger Cars and for New Light Commercial Vehicles, and Repealing Regulations (EC) No 443/2009 and (EU) No 510/2011."
2. Uhlmann, T., Balazs, A., et al., "High Efficient Gasoline HEV Meeting 2030 CO2 Targets - The Road towards 59 g/km Fleet CO2," in *10th Aachen Colloquium China Sustainable Mobility* 2020.
3. Qian, C., Xin, J., Ping, Y., Cai, D., et al., "A New 2.0L and 1.8L Medium Size Turbocharged GDI Engine Development," in *4th Aachen Colloquium China Automobile and Engine Technology*, Beijing, 2014.
4. Xu, Z., Zhou, Z., Wu, T., Li, T. et al., "Investigations of Smoke Emission, Fuel Dilution and Pre-Ignition in a 2.0L Turbo-Charged GDI Engine," SAE Technical Paper 2016-01-0698 (2016). https://doi.org/10.4271/2016-01-0698.
5. Hitomi, M., Sasaki, J., Hatamura, K., and Yano, Y., "Mechanism of Improving Fuel Efficiency by Miller Cycle and its Future Prospect," SAE Technical Paper 950974 (1995). https://doi.org/10.4271/950974.
6. Al-Hasan, N., Beer, J., Ehrhard, J., Lorenz, T. et al., "Charging Technologies for CO2 Optimization by Millerization," SAE Technical Paper 2015-01-1250 (2015). https://doi.org/10.4271/2015-01-1250.
7. Sellnau, M. and Rask, E., "Two-Step Variable Valve Actuation for Fuel Economy, Emissions, and Performance," SAE Technical Paper 2003-01-0029 (2003). https://doi.org/10.4271/2003-01-0029.
8. Kreuter, P., Heuser, P., Reinicke-Murmann, J., Erz, R. et al., "Variable Valve Actuation - Switchable and Continuously Variable Valve Lifts," *SAE 2003-01-0026*. https://doi.org/10.4271/2003-01-0026.
9. Grimaldi, F., Gervais, D., Marchal, A., and Floch, A., "Single-cylinder Experiments for Downsizing-Oriented SI Concepts: GDI and VVL Thermodynamic Comparison," SAE Technical Paper 2007-24-0013. https://doi.org/10.4271/2007-01-0013.
10. Pauer, T., Yilmaz, H., Zumbrägel, J. et al., "The New Generation Bosch Gasoline Direct-injection Systems," *MTZ Worldwide* 78, no. 7-8 (2017): 16-23.
11. Zhu, D., Pritchard, E.G.D., and Silverberg, L.M., "A New System Development Framework Driven by a Model-Based Testing Approach Bridged by Information Flow," *IEEE Systems Journal* 12, no. 3 (2016): 2917-2924, doi:10.1109/JSYST.2016.2631142.
12. Heywood, J.B., *Internal Combustion Engine Fundamentals [M]* (New York: McGraw-Hill, 1988), 184-186.
13. Xu, Z., Ping, Y., Cheng, C., Zhang, X. et al., "The New 4-Cylinder Turbocharged GDI Engine from SAIC Motor," SAE Technical Paper 2020-01-0836 (2020). https://doi.org/10.4271/2020-01-0836.
14. Prakash, A., Nelson, E., Jones, A., Macias, J. et al., "Particulate Mass Reduction and Clean-up of DISI Injector Deposits via Novel Fuels Additive Technology," SAE Technical Paper 2014-01-2847 (2014). https://doi.org/10.4271/2014-01-2847.
15. Joedicke, A., Krueger-Venus, J., Bohr, P., Cracknell, R. et al., "Understanding the Effect of DISI Injector Deposits on Vehicle Performance," SAE Technical Paper 2012-01-0391 (2012). https://doi.org/10.4271/2012-01-0391.
16. Steimle, F., Kulzer, A., Richter, H., Schwarzenthal, D. et al., "Systematic Analysis and Particle Emission Reduction of Homogeneous Direct Injection SI Engines," SAE Technical Paper 2013-01-0248 (2013). https://doi.org/10.4271/2013-01-0248.
17. Dadam, S., Jentz, R., Ienzen, T., and Meissner, H., "Diagnostic Evaluation of Exhaust Gas Recirculation (EGR) System on Gasoline Electric Hybrid Vehicle," SAE Technical Papers 2020-01-0902 (2020). https://doi.org/10.4271/2020-01-0902.

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Definitions/Abbreviations

BSFC - brake specific fuel consumption

BTE - brake thermal efficiency

COP - conformity of productions

DVVL - discrete variable valve lift

EIL - engine-in-loop

EWG - electric wastegate