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Analysis of Turbocharged Engine Driven by Pulses with Split Exhaust System and Distinct Discharge Valves

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***Abstract*— *Much effort is now being made to reduce the emissions of internal combustion engines (ICE) to comply with increasingly stringent environmental regulations. In parallel with this objective several studies are conducted with the objective of making ICE increasingly energy efficient, thus reducing the consumption of fossil fuels. This article proposes to present a new concept that can work together with others to reduce the emissions and improve the efficiency of small engines that operate in partial loads. The results that will be presented were obtained from a computer simulation using AVL BOOST software for its practicality and for being an established industrial standard.*
Keywords*— *Turbocharging, Internal combustion engine, Fuel economy.

I. INTRODUCTION

The use of a turbocharger in internal combustion engines boosts its volumetric efficiency and has been an option that is constantly used by the industry for passenger cars and heavy duty engines. However, the pressure generated by the turbine in the exhaust manifold increases the pumping work performed by the engine, thus reducing part of its energy potential. Another consequence of the use of turbocharged systems is the existence of the turbo lag that occurs due to the low volume of exhaust gases towards the turbine at low rotations, which in turn does not reach high enough revolutions to generate pressure gain in the compressor.

Turbocharged systems also have limitations in high rotations, when the turbine cannot give sufficient leakage to the exhaust gases. To solve this problem, the relief valve known as wastegate is used which releases the exhaust gases into the atmosphere and is controlled by a set-up spring to set the maximum admissible pressure in the intake manifold.

In order to overcome all of these limiting characteristics of turbocharged systems, increased back pressure, increased pumping work and a narrow operating range, this study presents a possible modification in the exhaust system to benefit the system and increase its efficiency. The modification consists in using two exhaust ducts per cylinder, where one will direct the gases to the turbine and the other after the turbine, directly to the catalytic converter. This system used in conjunction with a varied valve control in the exhaust would allow greater control of the operating point of the turbine and would make it useful in all ranges of rotation. The gains in efficiency would be due to both the increase in power over wide ranges of rotation and the reduction of pumping work.

In order to qualitatively evaluate the proposed system, simulations were performed in the AVL boost software in a standard engine provided by the software. The engine in question is a turbocharged 6-cylinder diesel engine. The performance was evaluated at a constant rotation of 2500 RPM.

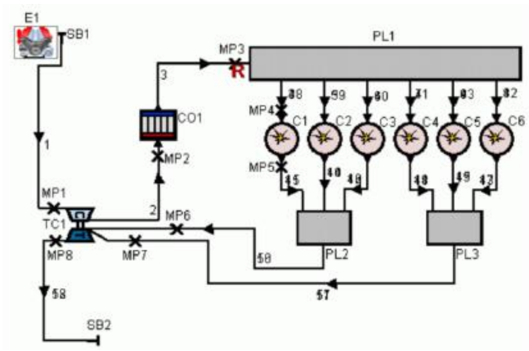

Fig. 1: AVL 6-cylinder diesel engine model.

II. METODOLOGY

In order to qualitatively evaluate the presented concepts, the 0D model of the 6-cylinder engine (6c s) in the AVL boost was used as a basis. The standard simulation data were collected and used as base parameters to evaluate the performance of the proposed system. The same model was modified to evaluate the split flow exhaust system (6c vi). To further enhance turbine efficiency under this condition a new cam profile was developed with the aim of directing a larger amount of exhaust gas to the turbine during the start of the exhaust process. This new cam profile ensures that 50% of the available energy in the exhaust gases is directed only to the turbine, then the relief valve to the atmosphere is opened to reduce pumping work.

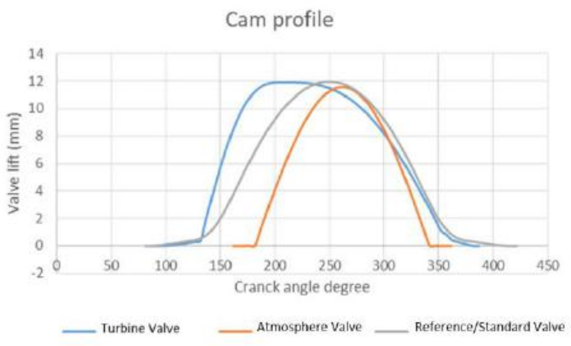

Fig. 2: Came profile

To add the new exhaust duct in the model it was necessary to restructure the exhaust system of the initial model, this was done using two exhaust valves with hydraulic diameters equal to half of the valve of the original model. The wall thickness and the lengths of the exhaust ducts were kept equal to those of the model presented by AVL. For reasons of simplification and because this was a qualitative evaluation, the loss of charge caused by the intercooler was maintained, as well as the models of heat release during the combustion process.

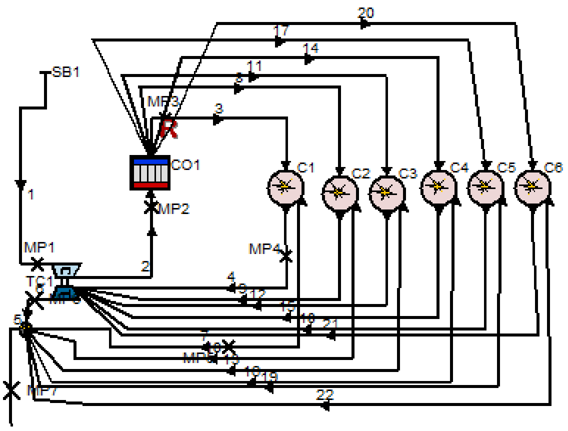

Fig. 3: Double relief valve system proposed

Multiple measurement points were used to obtain a better understanding of the exhausting process in this presented configuration. To increase the robustness of the process, several interactions were required by the software to satisfy the system governance equations and maintain their coherent values.

III. RESULTS

The simulation presented several results that when evaluated were shown to be consistent with the expected. The presented model obtained a nominal power lower than the base model presented by the AVL boost, but the fraction of unburned fuel increased drastically, since the fuel mass injected per cycle was maintained as a static parameter in all simulations. This suggests that this model could operate with an injected fuel volume much lower than the base model and have a higher overall efficiency.

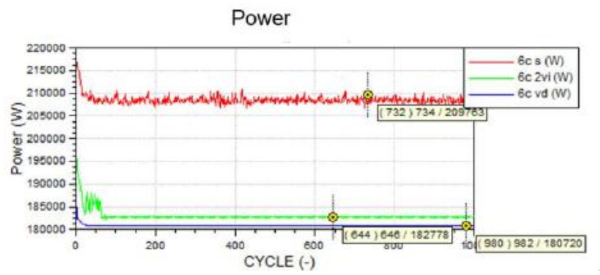

Fig. 3: Power of each model

Another relevant result to be highlighted was the enthalpy flux measured in the turbine, the camshaft model proposed by this study and divided flow, presented intermediate values to the other models, which makes it consistent with the expected and evidences that the proposed system can operate at multiple partial turbine operation points only by modifying the cam profile or the opening and closing phase of the cam.

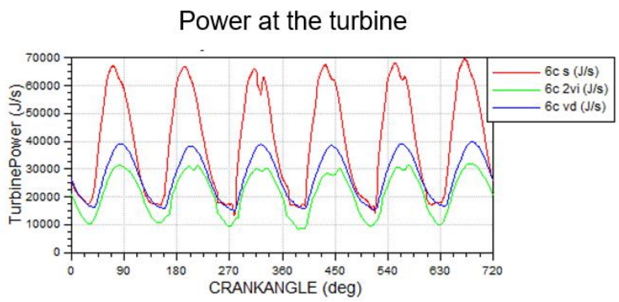

Fig. 4: Power at the turbine

IV. CONCLUSION

The preliminary results presented in this paper were satisfactory and consistent with that shown in the literature. This system should be studied in greater depth to have a broader understanding of its capabilities and applications.

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REFERENCES

[1] Heywood, J. B. (1988); Internal Combustion Engine Fundamentals; McGrawHill Book CO.; New York.
[2] Williams, A.M. Baker, A.T. Garner, C.P (2016),"Turbo-Discharging for improved engine torque and fuel economy", in 10th international conference of turbocharger and turbocharging.
[3] Pulkrabek, Willard W. Engineering fundamentals of the internal combustion engine. 1. ed. Upper Saddle River, N.J.: Prentice-Hall, Inc.
[4] Van Basshuysen R., Schafer F. (eds.) Internal Combustion Engine Handbook: Basics, Components, Systems, and Perspectives. Part 1.
[5] Taylor, C.F. (1976); Análise dos Motores de Combustão Interna; Trad. Por Mauro Ormeu C. Amorelli. 2ª ed.; São Paulo, Edgar Blücher e Edusp.; Vols. 2.
[6] Watson and Janota, M, Turbocharging the Internal Combustion Engine, MacMilan, GreatBritain, 1982.