Advances in emission control technologies

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Highlights

- After-treatment systems continue to advance in response to tightening regulations globally
- Specifically to gasoline vehicles, addition of particulate filters is expected to meet the PN limits
- We review the advances in emission control technologies and specifically the performance aspects of gasoline particulate filters (GPFs)

1. Introduction

Tailpipe regulations on criteria pollutants continue to get tighter across the world. Driven by global warming considerations, major countries have also adopted targets on tailpipe CO_2 or fuel consumption. There is an increased emphasis on meeting the above regulations under practical real-world driving conditions. Both engine-based and after-treatment solutions are advancing accordingly to address the challenging regulations [1]. This talk will provide an overview of some of these technologies.

We further take a specific example, the broad market adoption of gasoline direct injected (GDI) engines, and the specific after-treatment solution being developed. GDI engines have gained popularity for their improved fuel economy compared to traditional port fuel-injected (PFI) engines. However, GDI engines emit many more particulates, even higher than diesel engines fitted with diesel particulate filters (DPFs) [2]. This has prompted the development of GPFs to meet the particulate number (PN) regulations in Europe and China. With the introduction of GPFs, the gasoline after-treatment will be modified to one of the options below:

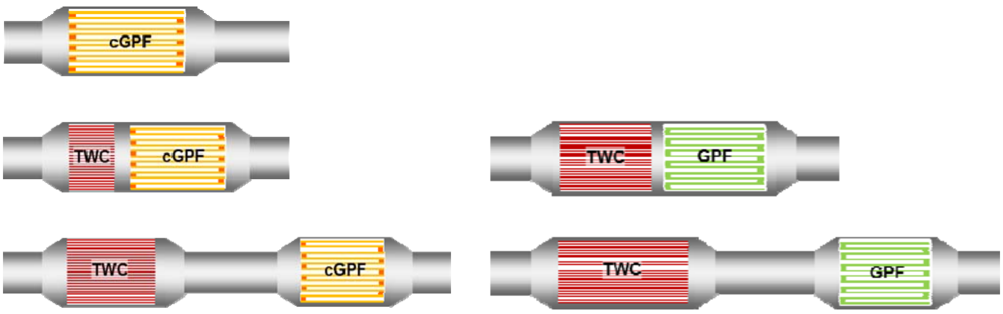

Figure 1. Gasoline after-treatment including TWC coated ("cGPF") and bare GPFs.

GPFs are expected to be deployed in either the close-coupled or under-floor position, and used purely for filtration or for added functionality of gas conversion through the application of a three-way catalyst (TWC) coating. The design of a robust product which meets the needs in these various configurations is the topic of this talk.

2. Methods

We will provide a summary of the broad regulatory trends driving the need for advanced engine and after-treatment solutions, and touch upon the relevant technologies being developed to address these regulations. The main focus here will be to discuss various design considerations to meet the various needs that GPFs must satisfy: high filtration efficiency, low pressure drop (clean and soot loaded), adequate soot and ash capacity, soot regeneration and thermo-mechanical robustness.

3. Results and discussion

Two product families, GC HP 300/8 and GC 200/8, have been developed to meet the various performance requirements expected of GPFs. The porosity has been tailored to offer high filtration and low pressure drop, while also providing pore volume to accommodate TWC washcoat. The channel geometry has been designed to ensure adequate volume for soot and ash accumulation (the latter over lifetime). We have done vehicle testing which shows that regeneration of soot can proceed passively. But we also offer thoughts on scenarios including high rates of soot accumulation.

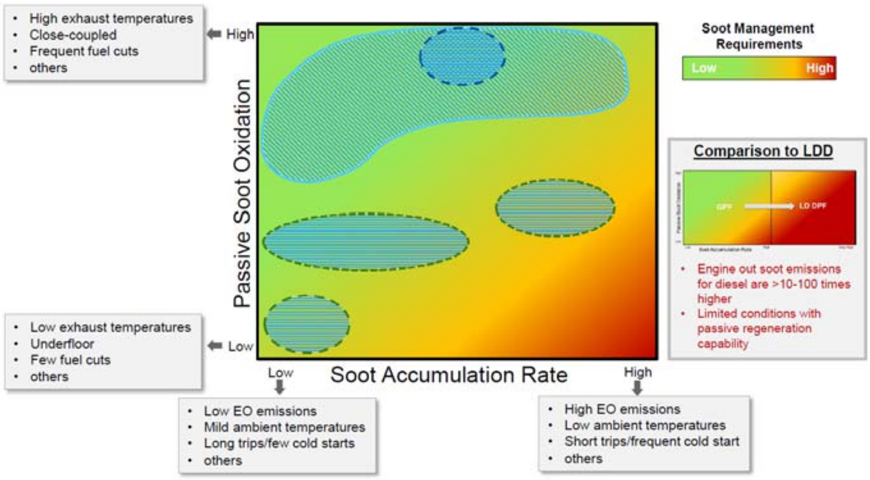

Figure 2. Soot management within a GPF, its dependence on factors such as exhaust temperatures & engine out soot levels

Finally, we find that with proper design, the substitution of an existing TWC with a coated GPF can be done at minimal fuel penalty.

4. Conclusions

GPFs have been developed to meet the most stringent of particulate reduction needs of modern gasoline vehicles. We have demonstrated through vehicle testing that properly designed GPFs can help meet the PN limit without affecting the fuel economy. The combination of high exhaust temperatures along with fuel-cut events during real world driving suggests the possibility of passive regeneration being adequate, while we discuss other extreme conditions which may require active management. Ash accumulation helps drive the filtration efficiency, although with a pressure drop penalty.

References

[1] Johnson, T. and Joshi, A., "Review of Vehicle Engine Efficiency and Emissions," SAE Technical Paper 2017-01-0907, 2017, doi:10.4271/2017-01-0907

[2] Platt, S. M., El Haddad, I., Pieber, S. M., Zardini, A. A., Suarez-Bertoa, R., Clairotte, M., Daellenbach, K. R., Huang, R.-J., Slowik, J. G., Hellebust, S., Temime-Roussel, B., Marchand, N., de Gouw, J., Jimenez, J. L., Hayes, P. L., Robinson, A. L., Baltensperger, U., Astorga, C. and Prévôt, A. S. H. "*Gasoline cars produce more carbonaceous particulate matter than modern filter-equipped diesel cars*" Scientific Reports | 7: *4926*A. Bianchi, N.C. Jones, Chem. Eng. J. 157 (2019) 326–337

Keywords
Gasoline particulate filters (GPF), GDI, light-duty vehicles