Particle Reduced, Efficient Gasoline Engines

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Publishable Summary

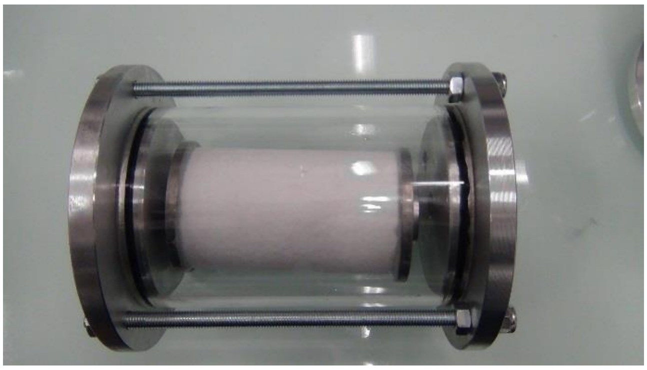
In the scope of the PaREGEn project, a new stoichiometric downsized gasoline direct injection engine is developed which should increase fuel efficiency while fulfilling Euro 6 real driving emission (RDE) restrictions. The basis for the engine development is the M270/M274 powertrain of the Daimler engine family. A reduction in CO_2 emission by 15 % from this basis is targeted. The key technologies to achieve this ambitious goal are the application of a Miller Cycle, water injection and increased compression ratio. These technologies have to be considered in the layout of the combustion system. In particular, the layout of the water injector and a combustion chamber design modification with increased compression ratio have to be designed and assessed.

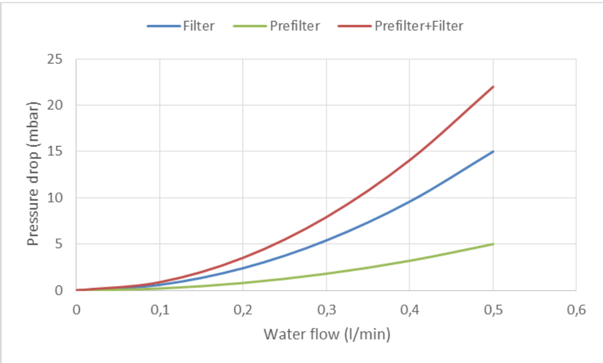
Water injection systems become more and more important for modern gasoline engines, to reduce emissions and fulfil the legal requirements. There are several possibilities to supply the water injection system with fluid. Other than filling up the system by hand, an exhaust gas condensation system to condense the available fluid in the exhaust gas and separate the liquid water from the exhaust gas after cooling, is a possibility. This approach is taken in the PaREGEn project, the system being designed by RWTH Aachen. This condensate so gained consists of water and several by-products resulting from the fuel combustion in the engine. These by-products can be acids, bases and particles, as well as unburned hydrocarbons. Before using this mixture for water injection, at least particles have to be removed to avoid clogging of injection system components, such as the pump and the injectors. Within the PaREGEn project, the particle contamination was checked by UFI Filters and a filter that could be used in a vehicle was designed.

To give some indication of the filtration needed, water harvested from the exhaust gas was analysed. The analyses performed were:

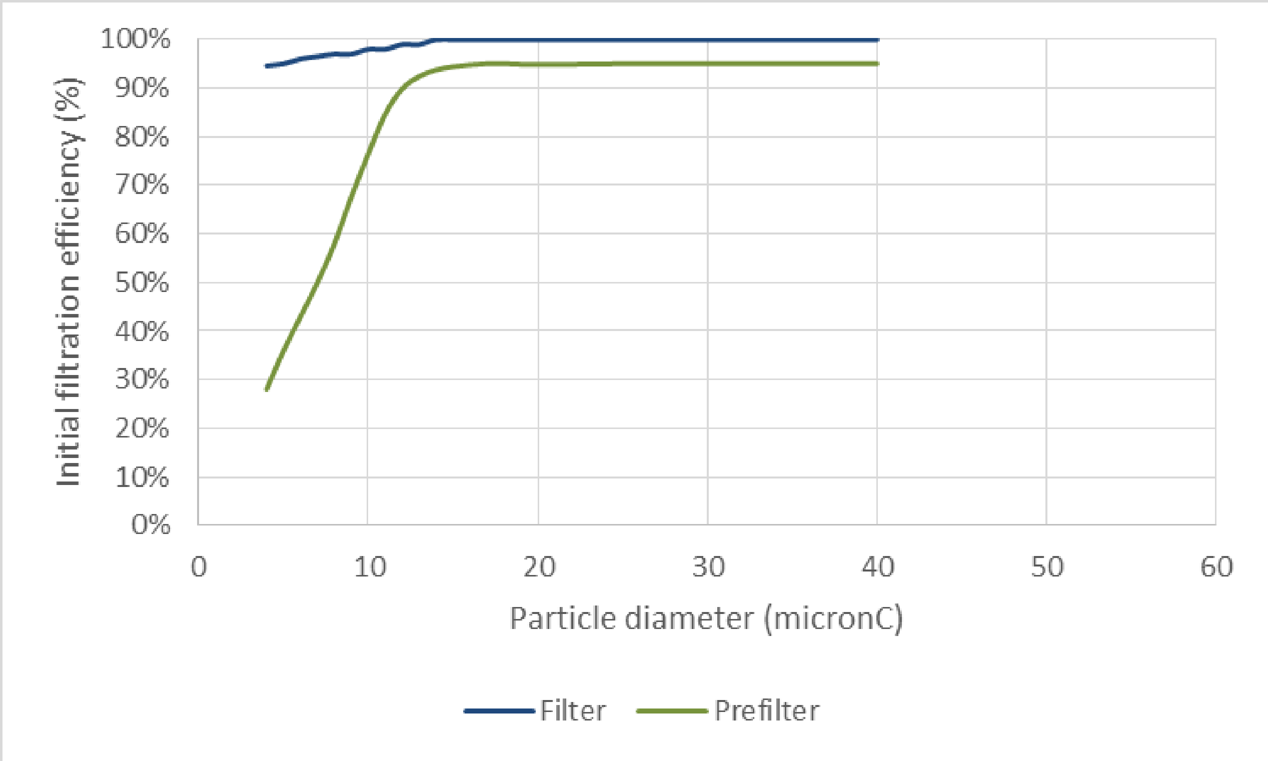
- Solid particles concentration;
- Solid particles composition;
- Solid particles morphology;
- pH value of water;
- Chemical composition.

The amount of solid particles found in the water is about 1.5 g/l: that can be considered as an high concentration. UFI designed a particle filtration system that can remove solid contaminant from water. This assembly has a pressure drop lower than 20 mbar at 0.45 l/min. The system and the pressure drop results are shown here:



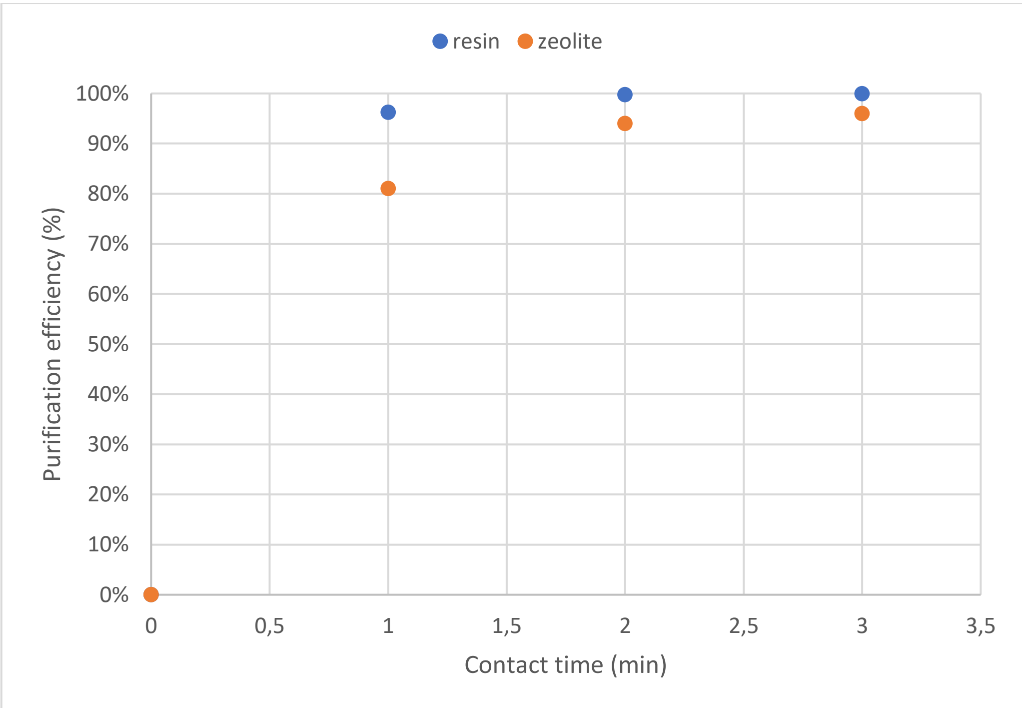


The filtration efficiency, measured on a proprietary test rig, was found to fulfil the requirements. In this case, filtration efficiency was measured using a dispersion of 10 mg/l of ISO 12103-1 A3 Medium Test Dust. See the measurement results below:



The prefilter (green line in the graph above) gave a separation efficiency of 75% for 10 micron particles, while the filter (blue line) can block more than 95% of particles of 10 microns. The series arrangement of prefilter and filter enabled a particle retention of 28 g, with an incremental pressure drop of 80 mbar (although this value depends on the type of dust, so could be different in real application). Furthermore, the contribution of dust settling could also be used, if the filtration system were installed in a vertical position, with water flowing down to up.

A purification system for ammonia removal was designed, with ion exchange resins being used, which were found to give a very good removal efficiency, see the figure below:



Further steps should be made, in particular for the definition of filtration system suitable for a car installation. In such a case, more parameters should be considered:

- Maximum working temperature: all materials used for the filtration system must work at high temperatures, since they could be close to the engine. The proper materials shall be used in order to avoid fast ageing or melting.
- Minimum working temperature: temperatures below zero degrees are a problem for water systems. Water icing must be avoided at first because ice cannot be injected into the engine. Then we have the problem of water expansion during icing, which could lead to high pressures and cracking of pipes and housings.
- Purging system: it could be necessary to completely or partially empty the water lines after engine switch-off. This could avoid icing problems and reduce bacterial growth, with the effect of increased water consumption.
- Electrical heating system: probably an electrical heating system is necessary to heat up the ice after freezing should the system not be purged. Electric power must be defined, considering vehicle onboard power limitations.

A draft design validation (DV) plan for the filtration system was derived and is included in the report.

8 Appendix A – Acknowledgement

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Project partners:

#	Partner	Partner Full Name
1	RIC	RICARDO UK LIMITED
2	DAI	DAIMLER AG
3	JLR	JAGUAR LAND ROVER LIMITED
4	BOSCH	ROBERT BOSCH GMBH
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6	JM	JOHNSON MATTHEY PLC
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15	RWTH	RWTH AACHEN UNIVERSITY
16	UFI	UFI FILTERS SPA
17	UOB	UNIVERSITY OF BRIGHTON

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