Comparison of gasolines with different distillation curves: effect of the temperature on a GDI spray opening angle

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Introduction

A GDI multihole injector was used to investigate the effect of the fuel composition and temperature on the spray angle. Three pure mono-component fuels, and six different kinds of gasoline were tested in a quiescent bomb. The injector and the fuel were heated-up at at different temperatures ranging from 20 to 120 °C. Back light photography was used to capture still images of the spray from which geometrical parameter of the spray image could be extracted. The spray spreading, its initial and far field angles could be compared to infer information on the effect of the fuel composition on the spray macroscopic parameters.

Material and methods

A GDI injector with six holes, whose pattern is present in figure 1 was used in this study. The study is focused on the spray shape at quasi-steady condition, that is when the spray head is already out of the field of view, only its quasi-steady conical part is visible, and its angle has reached a steady value; this allow to enhance the effect of the single plumes coalescence and spray collapse under the effect of the increasing fuel temperature, and to highlight the initial spray widening due to flash boiling.

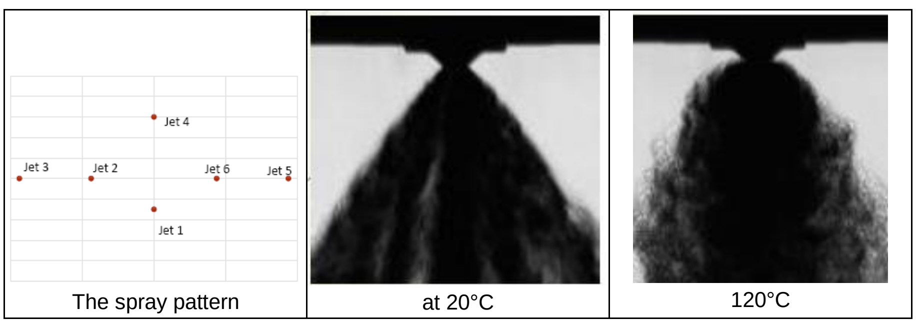

Figure 1. The sray pattern and two examples of spray images at different gasoline temperatures

Different fuels were tested, to investigate the effect of the fuel distillation curve. Three were pure mono-component fuels, namely Normal-hexane, Normal-heptane and Iso-octane. Five were different kinds of gasoline with the distillation curves in the range of commercial gasolines, with different percentage of light components and different final distillation temperature. One was a very light fuel, a blend of light component around five atoms of carbon, with the distillation curve comprised between 25 and 35°C. One was a real commercial gasoline bought at a random petrol station, for which the distillation curve is unknown.

The injector with its holder and the fuel were heated-up at different temperatures ranging from 20 to 120 °C, and the fuel spray was injected in quiescent air at ambient pressure and temperature.

Back light photographies were captured on a schlieren bench, so no perspective distortions were present in the spray images..

Standard procedure of image analysis were adopted to extract simple information on the spray shape.

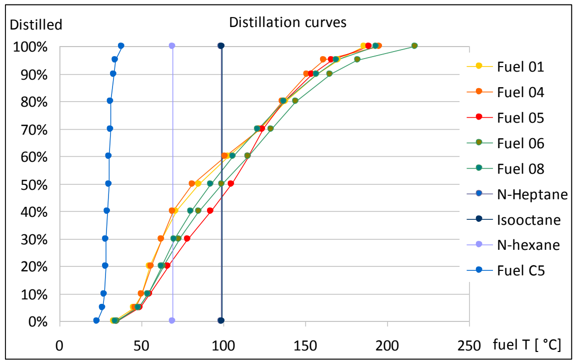

Figure 2. Distillation curves of the fuels used. Fuel 95 not available

Results and Discussion

Attention was focused on the spray spreading by measuring the spray width very close to the injector tip, and a global spray angle in the far field, between 20 and 60 millimeters of distance from the injector tip. No effects are evident when the fuel temperature is below the distillation curve. Evaporation and flash boiling effects are immediately visible when the fuel temperature increases above the initial point of the distillation curve: the spray width close to the injector widens, while the spray narrows in the far field.

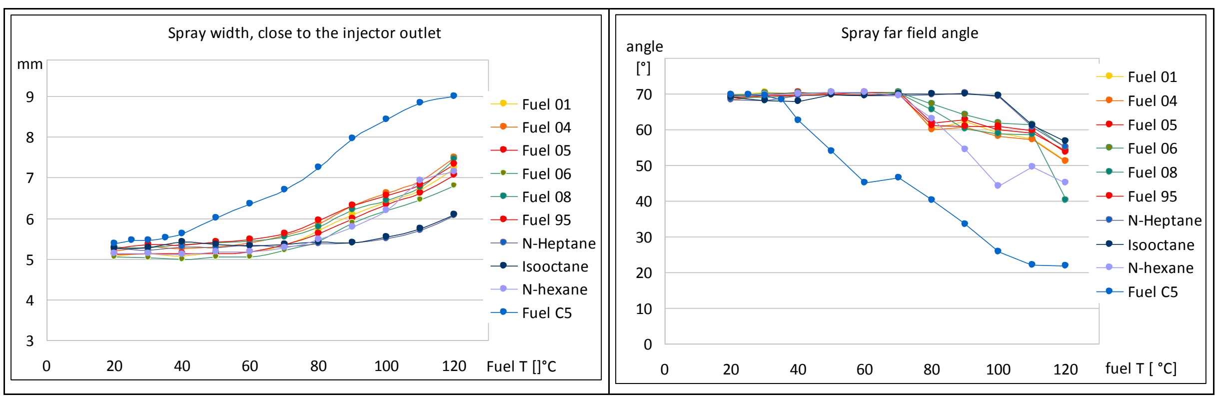

Figure 3. Spray initial width and far field angle, as a function of the fuel temperature, for the tested fuels

The main result of the study are the following.

Iso-octane and N-heptane are very similar among them, it is nearly impossible to appreciate a difference..

N-hexane have a similar behavior, with similar slope of the investigated parameters curve, but starting at lower temperature.

All the normal gasolines behave very similarly among them, with slight differences. For all tested gasolines, the spray near field width start to increase when the fuel temperature exceeds its boiling point or initial distillation curve, and shows very similar trends. The spray far field angle shows some slight differentiation also among gasolines, for example Fuel04, which has more light components, shows some more angle narrowing.

The gasolines behave quite differently from pure components: gasolines show a smother slope of their parameters variation, whose curves lays between the curves from the N-hexane and the heavier pure component couple.

The very light C5 Fuel have a stepper parameter variation more similar to the pure components' slope.

The result can be summarized as follows: the pure components and the light fuel, due to their univoque saturation curve or a very short distillation curve, show a stepper change with the temperature increase, while all the gasolines have show smother variation, between those of N-hexane and iso-octane.

A general consideration that can be drawn is that, although pure components are appreciated to test injectors and production quality with high accuracy thanks to the reproducibility of the results, these results can be quite far from the real ones obtained with any real gasoline in real engine conditions, even thought of different composition.