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Diesel particulate trap regeneration on a turbodiesel engine powered by heated rapeseed oil

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Background

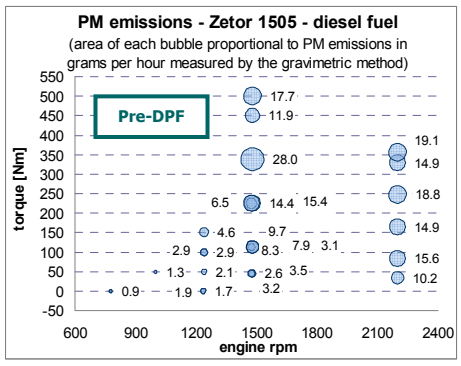
• Vegetable oils are emerging as a popular fuel for diesel engines worldwide.
• Relatively high viscosity of vegetable oils, along with relatively high boiling points, often lead to deteriorated combustion and increased emissions of particulate matter at idle and low rpm and loads.
• Along with low exhaust gas temperatures at low rpm and loads, such characteristics may pose a challenge for diesel particulate filters (DPF). On the other hand, operation on biodiesel has resulted in lower balance point temperature (at which the pressure drop across the filter remains constant, from which it is inferred that the particle loading of the DPF is constant) [Williams, SAE 2006-01-3280].

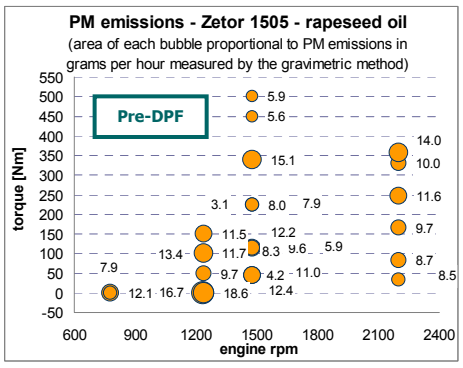
Goal

To evaluate the diesel particulate trap regeneration (ability to regenerate, balance point temperature, regeneration rate) on a turbodiesel engine fueled by heated fuel-grade rapeseed oil.

Experimental

• A Zetor 1505 turbodiesel tractor engine (525 Nm @ 1480 rpm, 90 kW @ 2200 rpm) was tested in the departmental laboratory on a Schenck Dynabar D-630 water brake dynamometer.
• The engine was powered alternately by diesel fuel and by heated fuel-grade rapeseed oil (FabioProduct, Holín, Czech Republic).
• The engine was fitted with a non-catalyzed DPF (HUSS Umwelttechnik). A fuel-borne catalyst (Satacene, Innospec) was added to the fuel at 0.1% by mass.
• The filter was loaded at high rpm and low load and regenerated by stepping up the torque in discrete steps [SAE 2006-01-3280].
• The goal was to determine the "balance point" DPF inlet temperature at which there is no change in the pressure drop across the DPF.
• The DPF was also loaded at idle interleaved with moderate load, and at low rpm/load point. The rpm were then raised for the regeneration sequence which was same as described above.
• Long term accumulation of mass determined by weighing the DPF after each test series.





Discussion

• When DPF was loaded at 2000 rpm and 50 Nm, BPT was around or slightly above 400°C at the DPF inlet for both diesel fuel and rapeseed oil.
• When DPF was loaded at 1240 rpm and 50 Nm or at idle (where combustion of rapeseed oil leads to high PM emissions), BPT appeared to be at 260-290°C. After sustained operation in these regimes, however, the pressure drop has reached its minimum and continued to increase. Further increases in the load demonstrated accumulation stage, until regeneration was observed around 400°C.
• It appears that the decrease in DPF pressure drop at 260-290°C is due to the organics being driven off (it is not clear to what extent they are combusted or just evaporated) – most of the constituents of vegetable oil boil or decompose at 280-320°C [Demirbas, Fuel, 77, 1998, 1117-1120].
• The filter appears to regenerate fully during operation on vegetable oil, operation on diesel fuel after regeneration on vegetable oil does not lead to further decrease in the DPF pressure drop.
• Long-term accumulation of mass in the filter corresponds to the iron in the fuel-borne catalyst.

Conclusions

• The balance point temperature on a non-catalysed DPF with fuel-borne iron catalyst was observed to be around or slightly above 400°C for both diesel fuel and heated rapeseed oil.
• Some particulate matter accumulated during operation on vegetable oil at low rpm and loads is driven off the DPF at 260-290°C, but other particulate matter still accumulates at temperatures up to 400°C.
• No signs of DPF not being able to fully regenerate on vegetable oil were observed.

Acknowledgments

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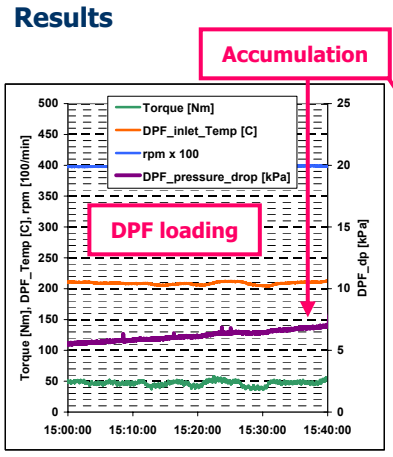
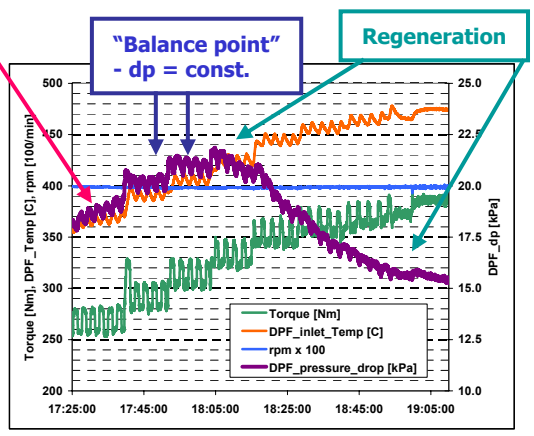
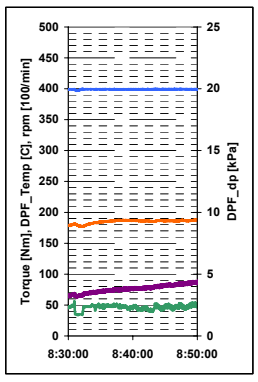
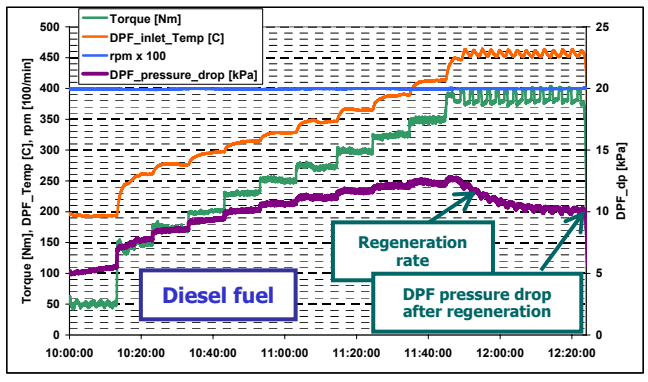
Results

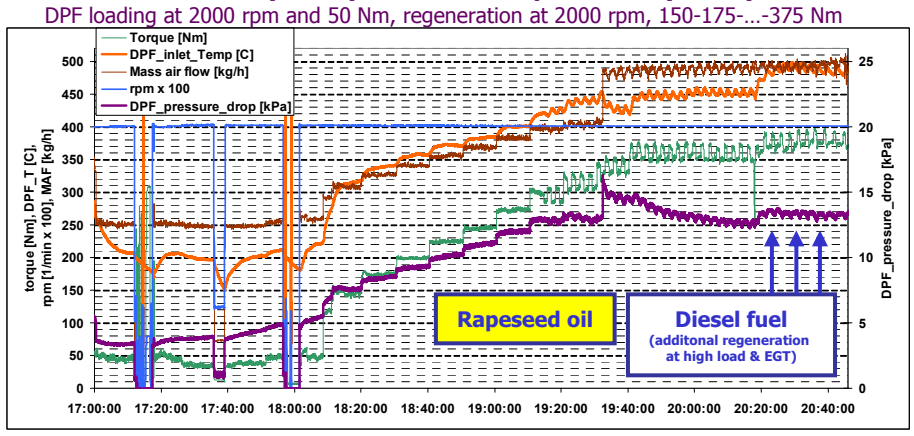








Diesel fuel (above) and heated rapeseed oil (below)
DPF loading at 2000 rpm and 50 Nm, regeneration at 2000 rpm, 150-175-...-375 Nm



Heated rapeseed oil – loading of the filter at low rpm and loads
DPF loading at 1240 rpm, 50 Nm, regeneration at 2000 rpm, 150-175-...-375 Nm