Review of European Master's of Automotive Engineering thesis
„Optimization of the calibrations of the start
for a mass production Flex-fuel direct injection engine"
by Valentin Raute

The thesis addresses the control of a direct injection spark ignition engine during the start phase when the engine is powered by neat ethanol. Various combinations of calibrations and settings of injection and ignition timing, quantity of fuel injected and its distribution among multiple injection, throttle position, and air-fuel ratio are investigated experimentally with the goal to arrive at an optimal calibration.

The topic fits well in the area of Master's studies in Automotive Engineering, and is not an easy one. Cold start is probably the most challenging condition of any engine operated on fuel with high alcohol content, and especially on neat ethanol: the „E85" fuel contains 15-30% of other, primarily volatile, compounds, primarily for the reason of ensuring engine startability.

The experimental setup includes a rather extensive set of engine calibration tools, including special control unit and software, diagnostic tools, and external sensors. Cold start on an automobile engine can be, at the best, performed 2-3 times a day, severely limiting the number of conditions that can be evaluated. In order to compare the options, test cell temperature must be consistent throughout the series of the tests.

This setup is documented extensively – introduction and experimental setup extend up to page 45 of the thesis. Still, not all issues are addressed, for example, on p. 46, „the vehicle pressure environment was approximately 1 bar" suggests that barometric pressure, without a statement suggesting it is not an important parameter, was not taken into the account.

The results section examines the effects of throttle position, ignition angle, injection angle, and injection pattern on two key parameters, engine start time and engine speed overshoot. The engine speed overshoot is then compared to „validation zone", which seems to define the target or acceptable range. The omission of units on X and Y axes is purposeful, so that confidential data can be presented in the thesis. This is not, and should be, expressly stated in the thesis. Evaluation of experimental uncertainty, for example by repeating the tests at the same conditions multiple times, would be useful.

The results presented on p.47-54 are discussed and a qualified judgement is made as to the settings to be used in subsequent optimization of start injection factor (metering of additional fuel to ensure the engine wil start), which was carried successfully, and of lambda set point (target air-fuel ratio), not completed due to unstable engine roughness signal.

Conclusions are realistic, are supported by observations and argumentation, and suggest that both additional work and follow-up work (i.e., effects on emissions) is needed.

It is my opinion that Mr. Raute has demonstrated engineering knowledge and judgment and gained considerable experience while carrying on the work. The outcome, despite seeming incomplete, is commensurable to the time available and other circumstances. The writing is generally technically correct and average, however, credit should be given for writing in a foreign language.

I recommend the thesis for defense and, with respect to the complexity of the topic addressed and the overall quality of the work, I classify it as B – very good.

This classification is given with an assumption that questions raised below will be satisfactorily addressed during the defense.

Prague, September 7, 2017

Michal Vojtisek

Thesis advisor
Associate Professor of Mechanical Engineering
Institute for Automobiles, Combustion Engines and Rail Vehicles
Faculty of Mechanical Engineering
Czech Technical University in Prague
Technicka 4, 166 00 Prague 6, Czech Republic
Tel. +420 – 774 262 854
michal.vojtisek@fs.cvut.cz

Questions:

- Please explain Fig. 1. Are you comparing BMEP (brake mean effective pressure) as indicated in the legend, or BTE (brake thermal efficiency) as indicated on the Y axis? Why there are such large differences between gasoline and ethanol?
- Table 2: How much more water is in the exhaust of an engine powered by neat ethanol relative to petrol? What is the reason for higher amount of water in the exhaust being a problem?
- What is the source of Fig. 6?
- What is a „baric center“ mentioned on p. 25?
- On p. 26, is the best start with lambda undershoot being lower or higher?
- In Fig. 14, you mentioned misfires. How would you identify a misfire from the figure?
- Please explain changes in the ignition angle apparent in Fig. 19
- What is a high pressure start mentioned on p. 35?
- How would the user verify the calibration, as suggested on p. 35?
- What would be „poor fuel“ mentioned on p. 44?
- On page 50, Fig. 39, what do the five points on the bottom of the Y axis (seemingly zero values) represent?