

The Performance of the KCFP for the year 2011 – 2012: a report to the KCFP Board

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Preamble

This is the second time that the KCFP Board receive an annual report on progress from the IAB, but this is the first time that I have provided a report on the KCFP (although I have done so in a different context on 2009). For my benefit, if not that of the KCFP, I include:

- The “brief” that I have been given as Appendix 1, so that the context of my report is unambiguous;
- The direction of the KCFP as Appendix 2 (which I have extracted and modified from the introduction to the “2011 Annual Report”, in the document entitled “Vision, Mission and Strategy” and in the KCFP work plan entitled “Towards High Efficiency Engine , THE Engine”);
- My summary of the HD Roadmap as Appendix 3;
- My summary of the LD Roadmap as Appendix 4.

My understanding is that the KCFP board receives a report annually from the IAB, that the KCFP produces an annual report and that the KCFP holds reference group meetings twice a year. My report is based primarily on my single attendance, at the most recent reference group meeting, held in Lund in September 2012, and secondarily on my knowledge of the output of the KCFP as part of my own research work.

Report

My report responds to the numbered questions in the brief (Appendix 1).

1. *“Check the direction of the work within KCFP “*

The reference group meeting had competent and interesting presentations under the headings of

- PPC - HD
- PPC - LD
- PPC - Model
- PPC - Fuel
- PPC - Control
- GenDies (including application of laser instruments to ICE, LES simulation)
- Gas Engine
- WHR

All these headings appear in the roadmaps. Thus the direction of the research in the KCFP is, on the evidence available to me, completely aligned with the roadmap from industry.

2. *“[Is the KCFP] working reasonably according to schedule?”*

As to whether the KCFP is “working reasonably according to schedule”, I shall base my assessment on the brief paragraphs, where available under the separate topic headings, in the “Annul Report 2011”, describing future work.

2.1 PPC

- PPC - HD.

The campaign with gasoline, promised for 2012, has indeed been pursued very comprehensively, investigating the effects of Oxygen and EGR dilution quite exhaustively; the modification with the 'two new combustion chambers' will start in October 2012. Progress seems quite satisfactory.

- PPC - LD.

The intention to finalise the experiments with NVO have been completed as has the effect of fuel injection strategy and the use of a glow plug, once again very comprehensively. It is not clear as to what has happened to the intention to rebuild of the engine in 'optical dress'.

- PPC - Modelling.

The modelling of PPC covers a wide range of topics, namely (a) Sandia Spray A; (b) Large Eddy Simulation of Partially Premixed Combustion in an Internal Combustion Engine; & (c) Large Eddy Simulation of Partially Premixed Combustion in a Light Duty Optical Engine. This topic had no outline of 'future work' in the 2011 Annual report, but it is possible for me to see that substantive progress has indeed been made relative to the results presented there.

- PPC - fuel.

The 'future work' in 2011 was to find a reference fuel based on toluene and ethanol using a DoE model to study effect on the LTR phase and emissions. This has been thoroughly investigated.

- PPC - Control.

This topic outlined future work in the 2011 report as being the optimal control of injection timing and valve strategies to achieve desirable heat release profiles. This topic has indeed been very comprehensively studied. It is in fact possible that this topic has been completed, although this is not altogether clear from the documentation available to me.

2.2 GenDies.

Progress under this heading is indirectly ascertained, because I have not been able to find any explicit references to 'future work' under the '2011 Annual report' (I recommend that future annual reports have a short paragraph at the end of each project with this title). However, the

- "Development of a laser extinction setup for soot"

is a topic which is effectively new for 2012, as is the

- "Large Eddy Simulation of Diesel Combustion".

Both projects have made substantial progress: the latter reporting on (a) Jet-Jet Interaction in Diesel Engine Combustion; (b) Lift-off and stabilization of n-heptane combustion in a diesel engine with a multiple-nozzle injection; and (c) LES Study of Jet-Wall Interaction in an Optical Heavy Duty Diesel Engine. The former is essentially an *ab initio* project and a good start has been made. The

- "SLIPI"

work to establish the air entrainment in wall jets in an HD engine has made progress. Finally the effect of

- “Jet-Jet”

has progressed to starting the investigation of the liquid fuel penetration in an HD engine, having completed the investigation of lift-off length in 2011, but was inevitably disturbed by the lab control system upgrade.

2.3 Gas Engine

My understanding, from the “2011 Annual report”, is that the current student started just over a year ago. There has been a remarkable amount of work performed in the Pre-Chamber Spark Plug as an alternative ignition technique in terms of (a) Further post-processing of Experimental data, (b) Study of Cycle-to-Cycle and Cylinder-to-Cylinder variations and in the (c) Study of Ionization Current Sensing Technique Signal Characteristics with Pre-chamber spark plug.

2.4 WHR

My guess is that this is a new project since the “Annual Report 2011”. There has been a thorough and fruitful investigation into the use of a Rankine cycle.

3. *“Are we doing the right things? Should we put higher or lower priorities on some parts?”*

It is hard to make ‘strategic’ comments under this heading, because I would be surprised if it were not the case that the ‘die has been cast’ in terms of both commitment to programmes of PhD research and in terms of purchased equipment or ‘sunk time’ in the development of computer programs. I am also loathe to provide ‘tactical’ comments on the basis of limited my exposure to the current KCFP programme: my colleagues - who have had a longer period of reporting to the IAB - are better positioned to make such suggestions.

My impression is that the programme adequately reflects the funding, namely that half the budget is on PPC, one third is on CI and one sixth on SI. For what it’s worth, I was initially slightly surprised that SI has such a small proportion, given the importance of downsizing trends in this sector. However, I take into consideration that the KCFP is but one centre amongst two others and also that the KCFP is - correctly - taking the opportunistic approach [with no derogatory implication in the use of the word ‘opportunistic’] to be the world leader into the investigation of ‘gasoline as a diesel fuel’.

4, *“Are we missing something? “*

Knock?

5. *“If we need to reduce the budget with one or two students, what projects must go?”*

I am least familiar with the topic of WHR: my knowledge is limited to superficial

knowledge of the BMW project on the use of the Rankine Cycle and on the current interest in the competing “Turbo-compounding”. On the basis of undergraduate Thermodynamics, my initial feeling is that Turbo-compounding is not limited by the 2nd law, while the Rankine cycle is: and prejudice, and no more than that, that condensers are ‘trouble’ and hence less likely to be a good candidate for WHR. Thus, on this flimsy evidence, I would look closely at this project as a candidate for removal. That statement having been made, however, I found the student to be one of the more impressive and he ‘made’ a great deal of the project which, in other hands, might well have been an unremarkable presentation.

Other than that, it is hard to find any topic which is ‘weak’ and a candidate for removal. On this basis, I would then examine matters by budget size. PPC has the Lion’s share, by far, and hence would be least damaged were it to take the brunt of any cuts that were to be made.

Coda

In addition to my comments above, I will provide a brief, wider perspective.

- A The litmus test of a group is whether one directs students to read the publications produced. The KCFP is my ‘first stop’ for students in this field of research. In this sense, the “pre competitive documented knowledge”, one of the requirements from the industrial partners, is admirably delivered.
- B The KCFP is also a leader in the “Development of analytical and experimental tools within ICE R & D”, a further requirement of the industrial partners
- C As to whether the students constitute a “High Competence Recruitment base” and “PhD and MSc to industry”, this is something for the industrial partners to judge. On the basis of a limited contact with the students, my impression is highly favourable in this regard.
- D On the basis of my being relatively close to the “Lund Group” for about a decade, I certainly judge it to be a “Long term centre of expertise”;
- E The KCFP is active in terms of “International Collaboration” at many levels, including European Union initiatives such as the Marie Curie scheme and in hosting visitors, notably Paul Miles from Sandia National Labs for an extremely productive stay.

Appendix 1: Brief for the report in 2012 (this is a repetition of the 2011 brief)

Dear IAB of KCFP,

We are approaching the KCFP reference group meetings and thus also you visit to Lund. Bianca and Choongsik was in Lund a year ago for the very first IAB of KCFP and this year will be the first with all three of you.

There are a few things I would like to ask you to consider in your report of KCFP this year:

- 1. KCFP is one of three centers in Sweden focusing on internal combustion engines. The four Swedish engine companies that have representatives in all three center boards have asked you to check the direction of the work within KCFP with the roadmaps of the industry. To enable you to comment on this you need the roadmaps (attached for light duty and heavy duty) and the vision, mission and strategy document for KCFP (also attached). You can also use the KCFP work plan for the current phase named "Towards High Efficiency Engine , THE Engine" which you find under "Documents" on the KCFP webpage (and attached).*
- 2. The annual report for 2010 is now available on the webpage (under documents). Please take a look and compare it to the work plan. Are we working reasonably according to schedule?*
- 3. The presentations from the reference group meetings February 2011 are available on the webpage and soon will also those for September 6-7 be uploaded. Are we doing the right things? Should we put higher or lower priorities on some parts? Considering the budget constraints we cannot increase one part without reducing another.*
- 4. Are we missing something? Please give you open opinion on the "hot" topic of combustion in engines and if something significant is lacking in Lund and KCFP.*
- 5. As Saab most likely will not be part of the KCFP in the future and administration cost has increased we must start thinking of budget cuts. IF we need to reduce the budget with one or two students, what projects must go? Permanent staff is much harder to cut.*

Appendix 2: The Vision, Mission and Strategy of the KCFP

In brief, these may be summarised as the need for efficiency in the context of available and acceptable fuels and low, legislated emissions. More specifically,

The aim is to improve our knowledge of and ability to control the combustion process in internal combustion engines

The objectives come under the following five disciplines:

- i Thermodynamic engine studies
- ii Optical diagnostics
- iii Combustion modelling
- iv Combustion control
- v Fuel effects

Appendix 3: The HD roadmap

This includes the following R & D “drivers”:

- Energy efficiency (implying thermo cycle analysis, spray combustion including PPC, Gas exchange, WHR and Advanced combustion control);
- GHG reduction (implying biofuels);
- Regulated emissions.

with “outputs” to include:

- Pre competitive documented knowledge;
- Development of analytical and experimental tools within ICE R & D;
- High Competence Recruitment base.

Appendix 4: The LD roadmap

The LD roadmap includes the following R & D “drivers”:

- Emission regulations;
- efficiency/fewer GHG/improved fuel consumption;
- Drivability without penalties for emissions or fuel consumption;
- Alternative fuels and energy storage;
- Short turn-around cycles.

and highlights the following “modifiers”:

- LD and HD have different operational conditions which affects their optimisation - even though the physics is “the same”;
- There is need to consider details (combustion, surge etc) and the complete system (system simulations such as WHR, *etc.*).

and proposes the proposed research headings:

- Gas exchange;
- combustion;
- system assessment;
- NVH;
- Improved numerical models;
- Advanced measurement technologies related to ICE.

with output in the form of

- PhD and MSc to industry;
- International Contacts;
- Speaking Partner;
- Long term centre of expertise;
- Meeting point for industry;
- International Collaboration.