EUROMOT

Reduction of Hydrocarbon Emissions from Stationary Gas Engines

A Euromot Non-Paper

As of 23 November 2010

EUROMOT

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of Internal Combustion
Engine Manufacturers

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ENGINES IN SOCIETY

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EUROMOT is the European Association of Internal Combustion Engine Manufacturers. It is committed to promoting the central role of the IC engine in modern society, reflects the importance of advanced technologies to sustain economic growth without endangering the global environment and communicates the assets of ICE power to regulators worldwide. For almost 20 years it has supported its members, consisting of national associations and companies from all over Europe and abroad, by providing expertise and up-to-date information and by campaigning on their behalf for internationally aligned legislation.

For further information about the Association, please visit our website:
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Status: 2010-11-12

1 INTRODUCTION

In May 2010 EUROMOT invited stakeholders from industry (engine and catalyst manufacturers), University and German/Dutch authorities to a workshop to discuss the challenges of reducing the Emissions of THC (Total Hydrocarbons). This was a follow-up to the meeting on May 30, 2008 between EUROMOT and Dutch Environmental Ministry (VROM).

During the workshop, experts explained that large stationary gas engines have to operate with lean combustion due to:

- Thermal durability of turbochargers and exhaust system
- Higher efficiency and low NOx emissions of the engine

There is a balance between NOx and unburned emissions (e.g. CO, THC). Higher NOx emission lead to lower THC but the operation window is very narrow due to the knocking risk. During recent years engine manufacturers have reduced the hydrocarbon (HC) emissions substantially (since beginning of 1990´s by up to 50 %) e.g. by reducing the crevice volume in the cylinder and improving the combustion control systems (ignition stability, etc.) while maintaining low NOx emissions.

According to the EU's goals for 2020 the emission of greenhouse gases need to be further reduced, including non-CO_2 greenhouse gases. The Workshop showed that engine and catalyst manufacturers are focusing their Research and Development efforts on this goal and some promising progress has been made. However, currently no solution is available for all applications and further extensive R&D work is needed in order to achieve the envisioned future emission targets (e.g. the Dutch emission THC-limit value of 1200 mg/Nm^3 @ 3% O_2 discussed in the past).

Furthermore, the recent European gas quality harmonization project shows that the future gas quality (due to increased import of LNG) in Europe could deteriorate and would thus impose new big challenges for the gas engine industry. Varying gas qualities will have big impacts on the power output, efficiency and emissions of the engine. E.g. the wide Wobbe range proposed will require most of the engine to adjust the gas admission timing system of the fuel supply. A wider control range will have negative consequences on amongst all emissions, i.e. fuel gas composition is setting boundaries on achievable emission levels from the engine.

EUROMOT believes that coordinated research programmes jointly funded by public grants and industry investments could facilitate and speed up the development of economically feasible solutions. This research should be based on a broad cooperation between universities, research foundations and private companies including engine and catalyst manufacturers. In such programmes the achieved results can be shared between stakeholders in a more cost-effective way.

The intention of this paper is to present current and possible future research initiatives of EUROMOT members and briefly discuss items which need further R&D actions. Also a possible framework for establishing a research, development, demonstration and commercial application programme to promote and speed up the research of needed appropriate technologies for total hydrocarbons (THC) is proposed.

2 RESEARCH PROPOSAL FOR THC

In a previous Non-Paper (2008)[1] EUROMOT proposed setting up two programmes; one for engine internal measures and one to develop and evaluate catalyst systems and estimated the overall associated costs:

1) *A **five year** intensified programme on engine internal measures, aimed at further stabilisation of the combustion process and the reduction of crevice volumes. This can include spark ignition, laser-induced ignition as well as prechamber and diesel pilot systems. The associated costs are estimated at **25 million €.***

2) *A **five year programme** to develop and evaluate catalyst systems (plasma assisted, heat recuperation catalysts, syngas swing regeneration, etc.). TNO, the NL universities and other European Research foundations can play an active role in this. The associated costs are estimated **at 30 million €.***

EUROMOT still views this proposal to be essentially valid and the best way forward.

3 EXAMPLES OF RESEARCH IN RECENT YEARS

Unfortunately, EUROMOT got very limited response on its proposals for research programmes in the above mentioned Non-Paper from 2008. Nevertheless, the engine manufacturing industry has in the mean time been very active in developing initiatives and R&D programmes aimed at reducing THC emissions.

<u>Primary measures:</u>

The methane emissions have been further reduced from some engine types by introduction of cylinder pressure sensors enabling more reliable knock, misfiring detections, etc. Also other primary reduction means such as further combustion optimization, external exhaust gas recirculation, air by-pass, etc. have been tested and are still under test to decrease the engine emissions while maintaining performance at different loadings.

<u>Secondary measures:</u>

The plasma generator project for simultaneous CH_4 and NOx reduction project undertaken at a research institution in Holland (2009) can be named as an example for a secondary R&D programme. The project was co-financed by 2 industrial companies (without any state grants) and the research institute. The aim was to achieve a moderate NOx (80 %)-CH_4 (50 %) emission purification in the first phase at a low fuel penalty (1 - 1.5 %). Due to different reasons the project was delayed more than one year and the tests showed that the concept worked unsatisfactorily with a very low CH_4 reduction at a high electrical efficiency penalty. In fact the tests showed that more CO_2eq emissions were generated than reduced by the CH_4 destruction (*about 50 % "extra" CO_2 needed to remove 10 % CO2eq CH_4*)!

In the year 2009, a Dutch research foundation made tests with an afterburner to oxidize the CH4 component of the flue gases. The CH_4 destruction was almost complete but the electrical efficiency penalty of the plant was in the order of **10 % (!)** and calculations showed that more CO2eq

[1] Euromot Non-Paper (prepared on the request by VROM in the 2008 meeting): "Technical and Financial Guidance for Emission Limit Values of Stationary Engines BEES-B Netherlands" as of 31 July 2008

emissions (due to the extra fuel needed to heat up the flue gas) were produced than reduced by the CH4 destruction.

The development of a new regenerative (oxidation) catalyst by one gas engine manufacturer has also continued (formula selection and production of new catalytic material). The first test results of the pilot unit were unsatisfactorily low and evaluation of the measurement results are currently under investigation in order to find out needed improvements in order to increase the CH4 reduction capacity of the catalyst.

Furthermore, FVV[2] is currently running a research project for investigating emissions in two existing biogas engine plants. The main focus lies on formaldehyde (HCOH) (regulated in the TA LUFT 2002 ruling) but also NOx and CH4 emissions are being measured. Two different technology options are being looked into:

- Oxi-cats in combination with gas cleaning and
- RTO (Regenerative Thermal Oxidizer)

This project is currently in the final stage with the last meeting of the research group being scheduled for the 3 December 2010. The final written report is expected to be made publicly available by the end of January 2011. A presentation of the results will be made at a workshop in February 2011.

As part of the R&D more field measurements are also recommended in order to learn more about the reasons to the wide emission spreads (at time of commission and later during life cycle) seen in the field (e.g. in the Dutch KEMA measurements in 2007 and 2009).

As the research results described above show, despite numerous R&D efforts, still no efficient, cost-effective and durable CH4 emission reduction methods exist today. Above examples underline that a R&D programme financially supported by the government (as proposed in the 2008 EUROMOT Non-Paper) could help to speed up the process and minimize the risks for individual companies. A **publicly** supported R&D program is needed which provides a path to a global solution for a global problem (to decrease the GHG emissions). In the May 2010 meeting with the Ministry VROM, the engine industry showed a positive example of a publicly funded programme in the US called ARES. EUROMOT believes a similar programme set up within the EU countries in cooperation with industry would be very beneficial in promoting environmentally friendly technology in Europe.

4 RESEARCH PROGRAMME ON ENGINE INTERNAL MEASURES

The engine manufacturing industry is currently in advanced stages of setting up a research programme under the auspices of FVV[3], an experienced research organisation in the field internal combustion engines, which works closely together with manufacturers and with researchers from various distinguished universities. The internal decision making bodies of FVV have accepted the proposals and the application for funding is currently being considered by the German Ministry of Economics and Technology.

The proposed programme aims at:

- Improving the understanding of the cause of formation of THC emissions in gas engines and influencing parameters (e.g. differences in gas composition; differences in process conditions; the state of wear of an engine within a specified maintenance interval)

[2] Further information on FVV is available on the FVV website: http://www.fvv-net.eu/about-us/profile
[3] Further details of this FVV project will be made available once the project has been finalised.

- Quantifying the THC composition according to the cause of THC formation
- Improving the understanding of how engine parameters influence THC formation
- Quantifying the existing potential for further reduction of THC emissions from gas engines.

Most importantly, the proposed programme seeks to reduce emissions of Greenhouse Gases, especially Methane and CO2, and increase the efficiency of gas engines.

If accepted, the proposed programme could begin in 2011 and would run for three years.

5 RESEARCH PROGRAMME ON SECONDARY ABATEMENT

As the EUROMOT Workshop in May 2010 showed, catalyst manufacturers have made some promising progress on secondary abatement technologies in the past years. However, a number of challenges still exist before secondary abatement technology can be broadly applied.

Currently, secondary abatement technology for many applications is still not available and possible existing technology for certain applications are very expensive.

Today, following challenges still exist for secondary abatement technologies, for example:

- High activation temperature of catalysts (the exhaust temperature of gas engines is too low)
- Oxi-cats do not have the required long-term stability/durability
- RTOs (Regenerative Thermal Oxidizers) have high investment costs and non negligible running costs as well as a bigger size then typical Oxidation Catalyst Systems. The heat up time is higher due the higher thermal capacity. Therefore these systems are not state of the art in interrupted operation mode applications such as peaking plants, etc.
- For a technology to find a broad application the cost has to be acceptable for the operator.

Needed research items in order to overcome above listed obstacles are:

1. A. Novel catalyst substrates and new wash coat chemicals (formulas) to improve the CH4 light off temperature, which enhance noble metals role in the catalyst.
   B. Optimum noble metal compounds and loading strategy into the substrate need also to be studied.
   C. Study the wall thickness of the substrate (catalyst element), with ultra thin walls in order to achieve a lower thermal inertia.
   D. Study the deactivation (poisoning) of the improved chemistry and develop different regeneration mechanisms.

2. New wash coat chemicals to improve the CH4 light off temperature which enable noble metals role in the catalyst in a lower amount (big cost saving potential!). See also b, c, and d as above.

3. Non-noble metal catalyst development for CH4 reduction and items a, c, d as above. Non-noble metals have higher light off temperatures compared to noble metals but big cost savings could be achieved when replacing or in combination with noble metals.

4. Location of the catalyst with respect to the turbocharger. Pre- and post turbocharger placement have their own distinct challenges.

5. Study of parameters: catalyst performance at different speeds, engine modes, and air fuel ratios, etc.

6. Overall consideration of the energy balance (possible extra fuel additions) and emissions, including GHG.

Above R&D items require long field durability tests after the laboratory testing phase before any commercial release can take place. As can be seen from above, substantial catalyst & material expertise is required and thus a possible R&D project needs to be done in close co-operation with catalyst manufacturer companies, research foundations, as well as universities in order to reach the targets.

A possible proposal for a research programme will also have to go through all the decision making processes of the company participants, research organisation and funding organisations which can take a year or more. To achieve relevant results at least 3-4 years are needed. Overall 5 years from today are a reasonable indicative timeline.

6 CONCLUSION

EUROMOT believes that decentral energy, especially co-generation based on the highly efficient clean gas engines of today, can and will play an increasingly important role in achieving the European Union’s climate and air quality targets in a cost effective and reliable way.

However, there is still potential for further improvement with regards to the reduction of THC. R&D is costly and big resources are tied up for each individual company with the corresponding risks. By introducing a joint programme involving engine (and for secondary abatement catalyst, etc.) manufacturers and university researchers/research foundations the knowledge could be pooled, resources shared, costs and other burdens reduced while at the same time improving the likelihood of succeeding. The R&D work should be done in partnerships between the different entities.

A further challenge lies in varying future gas qualities in Europe which are expected due to import. This will also have an impact on amongst all emissions.

It should also be mentioned that harmonized European emissions legislation are essential to drive new technology development to a success. Industry is willing to invest in R&D and technology validation, but due to limited resources a clear focus of the activities and also the potential of a reliable market to bring in the efforts is a must. Furthermore, emission limit values must be set at a technically and economically feasible level.

By partly funding R&D projects, the state of Netherlands could cost-effectively promote innovative products which help to reduce greenhouse gas emissions. EUROMOT remains open minded with regards to finding the best format and structure for possible research projects to foster environmentally friendly technologies to reduce THC emissions. This also applies to the inclusion of further potential research partners.