Wear in Engines using Alternative Fuels

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Policy Relevance

Alternative motor fuels will be an important element in future transportation, since we are moving away from diesel and gasoline. The relatively sparse experience we have had so far has revealed that these fuels often need special attention in relation to wear in combustion engines. This task seeks to give an overview of experiences so far with the most relevant fuels for decision makers to take these aspects into consideration when evaluating the role of these fuels in future transportation.

Major Conclusion

A review of wear associated with application of the most relevant alternative fuels in combustion engines has been carried out.

Important players on the international scene have contributed with their experiences of application of fuels. China has been an important participant with respect to methanol applications, Brazil has been important with their extensive knowledge of ethanol application, and research institutions from Denmark, Finland and Germany have covered a broader area of biofuels suitable for diesel combustion and fuels with high content of hydrogen (ammonia alcohols, DME and pure hydrogen). The wear problems seen can be divided into 3 major categories: mechanical issues, chemical issues and interaction with the lubricant. Major bullet points summarizing the findings in these categories for each fuel are listed in the main report ("Task 62: Wear in Engines Using Alternative Fuels - Main report") in Table 4 (biofuels suitable for diesel combustion), Table 5 (ethanol), Table 6 (methanol) and Table 7 (ammonia, DME and hydrogen).

With precautions engine wear problems associated with the application of alternative fuels can be avoided. This means that careful choice of engine materials and lubricants must be taken.

Background

Electric Vehicles (EV's) are gaining more volume in road transportation in these years, mainly due to Green House Gas (GHG) emission concerns. The plan, in many countries, is to phase out the use of gasoline and diesel fuels in road transportation. However, the traditional fuels cannot be replaced by electricity in all practical cases, and the solution here could be application of alternative carbon neutral fuels, like biofuels and e-fuels.

These fuels have already been introduced in many applications, but today the application volume is limited compared to gasoline and diesel. This is, however, foreseen to change much in the future few decades. Therefore, the wear issues that have occurred during application of other (alternative) fuels in traditional engines must be addressed now, before the introduction of these fuels accelerate fast.

So far, we have quite much experience with application of biodiesel, methanol and ethanol in combustion engines. This is also reflected in this report, where the reported sections of these fuels are well covered compared to other relevant alternative fuels like DME, hydrogen and ammonia. The experiences concerning engine wear with these fuels will be expanding in the coming years as the application is seen to a wider extend. However, a common feature of these fuels is the increased hydrogen to carbon ratio, H/C, which in this investigation has been found to be of major importance in relation to engine wear.

Research Protocol

- General literature review

A general literature review for alternative fuels has been carried out, focusing on those relevant to ongoing studies related to engine applications in the countries involved in the task: methanol, ammonia, and biofuels suitable for diesel combustion among others.

In the literature review, compilation of the available information was reported in a structured way that supports future application of alternative fuels.

- On-line seminars

Activities related to engine wear are ongoing in the involved AMF countries. These studies were communicated through presentations from the responsible “activity” persons (or other designated people) at frequent seminars. The results from the seminars also provided a background for the literature review report.

Key Findings

For biofuels suitable for diesel combustion the major problems are associated with dilution of lubricant with fuel, the fuel tends to biodegrade, and corrosive nature is seen towards some materials.

For ethanol, wear conditions are worsened due to lowering lubricant viscosity and due to water content in the lubricant. Ethanol, furthermore, reacts with the lubricant. This increases the acidity of the lubricant and the breakdown of some lubricant additives. On top of this, increased water content of ethanol, which is often seen, increases engine corrosion.

For methanol, the same issues as for ethanol with water is seen. Chinese experiences conclude on more specific material issues which are summarized in Table 6. Furthermore, formation of formic acid has a negative impact on anti-wear performance. Methanol, lubricant and water forms an emulsion at low temperatures which can cause lubricant to fail. Lubricants needs improved alkali values and antioxidant properties for the engines to work properly. Finally, spark plugs undergoing pitting and ablation is seen.

Hydrogen is reported to cause surface embrittlement, fuel injector failure (due to bad lubricity) and prevention of formation of surface protective oxides. Furthermore, hydrogen is seen to decrease lubricant additive content in many different ways, and it can cause emulsification of the lubricant. Finally, excessive wear is caused by water condensation on the cylinder liner.

Ammonia is a relatively new fuel for combustion engine applications. Therefore, much more experience is needed to describe the fuel impact on wear completely. However, corrosion effects on copper alloys are reported, and it is expected that this is also the case for other materials. Increase in lubricant viscosity has been reported, caused by amines, and high water content in the exhaust is expected to cause excessive wear due to water condensation on the cylinder liner.

DME was seen as a highly relevant potential fuel to substitute diesel in the early 2000´s. The problems with DME is that it is an excellent solvent which can cause damage to most materials. However, materials resistant to DME have been identified due to huge interest in applying DME in the early 2000´s. DME’s low lubricity has caused surface wear in the fuel injection system. Additives have been developed to mitigate this problem.