EXPLORING LOW EMISSION DIESEL ENGINE OILS WORKSHOP - A SUMMARY REPORT

K. Shaine Tyson, and Margaret V. Whalen
National Renewable Energy Laboratory
and
Joseph M. Perez
Consultant

INTRODUCTION

This paper discusses and summarizes some of the results of the title workshop. The workshop was held January 31-February 2, 2000 in Phoenix, Arizona. The purpose of the workshop was *"To craft a shared vision for Industry-Government (DOE) research and development collaboration in Diesel Engine Oils to minimize emissions while maintaining or enhancing engine performance".* The final report of the workshop (NREL/SR-570-28521) was issued in June2000 by the National Renewable Energy Laboratory, 1617 Cole Boulevard, Golden, Colorado 80401-3393.

There were some 95 participants at the workshop representing industry, government and academia, Figure 1. The format for the workshop is described in Figure 2. This format allowed for considerable discussion of the various issues prior to deliberations in breakout groups. This process resulted in recommendations to solve the issues related to the next generation of diesel engine oils.

Keynote addresses by SAE President Rodica Baranescu (International Truck and Engine Corporation), James Eberhardt of DOE and Paul Machiele of EPA focused on diesel progress, workshop issues and regulatory fuel issues. A panel of experts further defined the issues of interest, presenting snapshots of the current status in their areas of expertise. A Q&A session was followed by a series of technical presentations discussing the various areas. Some two dozen presentations covered the technical issues, Figure 3. An open forum was held to allow any participant to present related studies or comment on any of the tech-nical issues. The participants broke into work groups addressing the various areas found on Figure 2. A group leader was appointed and reported on their findings, recommendations, suggested participants for projects and on related items.

Meeting Issues

The Technical Issues of the meeting included the Effect of Low Sulfur Fuels, Post Combustion Devices, Low Sulfur Basestocks, Lubricants and Additive Technology, Particulates, EGR, Alternate Fuels and Lubricants, Tribology and related issues. The needs in each area, the technical targets, current barriers were thoroughly discussed. Based on these discussions recommendations were made. The following sections summarize the workshop results on each issue and also estimates of the chances of success of solving the issues. Additional details and copies of the technical presentations are found in the final report [NREL/SR-570-28521].

NEEDS AND STATUS

The needs, status and the chances of success for the various issues from the discussions include:

1. More Tolerant Catalysts. Several current aftertreatment or post-combustion devices were reported on. To make the systems on diesel engines effective enough to meet 2006 emission regulations requires removal of sulfur from diesel fuel. The technical target is to

develop sulfur tolerant catalysts. However, the current barrier is the lack of knowledge of the mechanism of how the sulfur masks and poisons the catalyst. The chance of success was rated as low because a revolutionary approach to new catalysts is required. Time and costs involved do not make this a viable solution.

2. Role of the Lubricant. The role of the lubricant is not clear. The technical target defined was to determine the role of the lubricant on the catalysts life and durability. Current effect-tive lubricant additives contain sulfur, phos-phorus and metals. The barrier is there is no definitive knowledge of additive contribution to the problem. The chance of success of solv-ing the issue is high because research is in progress as part of the DECSE program.

3. Additive Issues. In item 2, the additive is involved. In addition to determining the mechanism of additive involvement, current estimates of additive involvement assume all of the additive is involved. This does not take into ac-count volatility factors and depletion of additive as it performs its function in the lubricant. Chance of success was ranked high due to the potential to obtain critical information rapidly using bench and engine dynamometer tests.

4. Additive-EGR Interaction. The technical target is determine the types and additives required to perform effectively in a lubricant containing high levels of soot as the result of EGR. The current barrier is that it is assumed additive effectiveness is reduced as a result of adsorption on the large soot surface area. The actual mechanism is the current barrier. Again, the success of this additive issue is rated high because bench and engine dynamometer tests can be used to resolve the questions.

5. EGR Filter. The increase in the amount of contaminants, acids/soot/particulate, in the oil resulting from the use of EGR indicated a need for an effective way to remove the contaminants, possibly by use of an EGR filter or trap. Current technology on post-combustion treatment could be considered but would have some problems similar to the post-treatment systems. Success was rated as high to medium depending on solving some of the mechanical and chemical factors.

6. New Additives. The technical target is the development of new, non-detrimental additives. There is extensive knowledge on additives and additive synthesis. However, the development of new additives would require a revolutionary approach to additive development. Normally, additive changes are evolutionary to insure reliability and performance in the engines. An evolutionary change involves risks. Medium chances of success are due to a trade-off between bench and engine test development and the cost and time required to succeed.

7. Fuels. The need is for low or non-sulfur fuels. The technology is available to produce the fuels. The current barrier is that these are only available in limited quantities. To solve the issue will require new infrastructure and an infusion of resources to produce adequate quantities for the transportation fleet. That this could be accomplished by 2004 was rated medium at best due to the cost and time to construct new refinery capability. There may also be a parallel need for non-sulfur lubricant to obtain maximum effectiveness from the fuel change.

8. Alternative Fuels. Alternative fuels would be one way to fill the need for low sulfur fuels. The three main alternative fuel candidates are Fisher-Tropsch, Alcohol and Biodiesel fuels. It has been demonstrated that reduction of emissions occur with some of these fuels. The primary concern is that these fuels are currently available in only limited quantities. Other issues to be resolved include the mixed emission results for some of the fuels, low temperature properties, stability, lubricant compatibility, lubricity, long-term storage stability and cost reduction. The need for infrastructure and consistent production quality were also factors that resulted in a medium success rating. Engine and fleet tests and studies on material compatibility were other factors in the success rating.

9. Alternative Lubricants. The world-wide interest in biodegradable, environmentally friendly lubricants is the current driving force in this area. However, the potential to produce sulfur free biodegradable lubricants with effecttive new additive chemistries is a viable technical target. Biodegradable lubricants have been shown to ability to reduce diesel engine emissions. The

need is to develop new additive packages and to improve oxidation stability and low temperature properties. The chance of success is high but was rated medium for the 2004 time frame due to fluid costs, lack of current engine and field tests and the insufficient volume of some base stock components.

10. Tribology. The next need is to resolve some of the issues related to Tribology. As new low sulfur fuels are developed there are significant concerns regarding the friction and wear of the fuels. Engine component durability and life are of concern. In the lubricant area, the effect of soot on the friction and wear capabilities of the oil are of concern. Data available indicate increased friction and wear occurs as sulfur is removed from the fuel or soot increases in the lubricant. Another issue is the possibility of increased water solubility in the low sulfur fluids and its effect on corrosive wear and filterability. The ability to solve these issues using additives, bench tests and engine dynamometer tests is high.

11. Health Effect Issues. The distribution of diesel particulate size has changed with current improvements in engine technology. Concerns over nano-size particles raised the question of the origin and type of particles in the lower particle size range. Recent studies have shown that many of these particles may be of organic origin, i.e., liquid droplets containing sulfur condensates. The reduction of sulfur may reduce the number of smaller sized particles. The need is to establish in fact the origin and role of these nano-sized particles and to determine the effect of low and non-sulfur fuels. The technology to resolve this issue is available and the chance of success is high.

CONCLUSIONS

- Studies of current Post Combustion Systems (PCS) indicate fuel sulfur is a negative factor in durability and system life and lower sulfur fuels are required to meet 2004 (2006) EPA emission requirements.
- At present, there is no clear-cut winner among the current PCS systems.
- Particulate characterization studies indicate the increase in smaller particulates may be due to nucleation of organic materials rather than smaller soot particles. Non- or low sulfur fuels could resolve this issue.
- EGR will increase particulate loading in the lubricant and lubricant performance and engine durability and life may be affected.
- Alternative fuels and lubricants contribute to a reduction in diesel engine emissions.
- It is known that sulfur in the fuel is a problem for PCS. The significance of the sulfur, phosphorous and metals in the lubricant is not known.
- If required, the development of new lubricants cannot be evolutionary as in the past. A revolutionary quantum leap will be required , if needed by 2006.
- A joint industry-government program, the Diesel Emissions Control Sulfur Effects (DECSE) program, is addressing key issues related to the current fuel - sulfur problems but needs to increase the effort on the lubricant role. [The program is now the Advanced Petroleum-Based Fuels Diesel Control Program or APBF-DEC].

RECOMMENDATIONS

The key recommendations of the group were:

- Increase the DECSE (APBF-DEC) funding to obtain needed basic information on lubricant effects on PCS.
- Initiate a Tribology effort to determine the role of increased particulate levels in the lubricant on their performance and system life.
- Initiate a program to develop alternative lubricants. Laboratory, engine and a field tests and a demonstration project are needed to push these lubricants beyond niche markets.
- There is a need to develop meaningful bench tests to reduce the costs of expensive certification of lubricants in engine sequence tests. Increased use of technical societies to develop screening tools and standardize test methods for low sulfur, alternative fuels and lubricants is recommended.
- Characterization of particulates is an important health effects issue. Continue research to determine the mass, number and origin of nanoparticles.

ACKNOWLEDGMENTS

- Attendees at the workshop - Their participation and technical input resulted in a very productive workshop
- Dr. James J. Eberhardt, Director , Office of Heavy Vehicle Technologies, and the USDOE for the vision and support in exploring this area of needed research.
- The National Renewable Energy Laboratory (NREL) for guidance and support in conducting the workshop.

.

Figure 1.

PARTICIPANTS

- **Petroleum Industry - Basestocks Manufacturers**
- **Additive Manufacturers**
- **Catalyst Manufacturers**
- **Lubricant Manufacturers**
- **Automotive and Diesel OEMs**
- **Industry Organizations**
- **Government**
- **Academia**
- **Others**

Figure 2

MEETING FORMAT

1. **Keynote Speakers**
2. **Technical Panel Discussion of Issues**
3. **Technical Presentations**
4. **Open Forum**
5. **Breakout Sessions**

BREAKOUT GROUPS

ADDITIVES
C. Passut*

BASESTOCKS
W. Runkle*

CATALYSTS(PCS)
M. Khair*

ALTERNATIVE FUELS
A. BIRKE*

ALTERNATIVE LUBES
S. Erhan*

*** group leader**

Figure 3.

TECHNICAL ISSUES

1. **POST COMBUSTION DEVICES - Which Current System is Best?**

2. **FUELS - Role of Sulfur, Availability of Low Sulfur & Alternative Fuels?**

3. **BASESTOCKS - Key Properties, Characterization, Availability?**

4. **ADDITIVES - Extent of Problem, Levels Needed, New/More Effective?**

5. **LUBRICANTS - EGR Effect, Long Drains, Performance & Durability?**

6. **ALT. LUBES - Biodegradability, Emission Reduction, Performance?**

7. **PARTICULATES - Health Issues, Morphology, Source of Nanoparticles?**

8. **TRIBOLOBY -EGR Effects, Low S Frict.&Wear, Component Durability?**

9. **OTHER - How to Reduce Certification Costs (PC-9 ~ $350-450K), Improve Screening Test Methods, New Tests, Utilization of Technical Societies.**