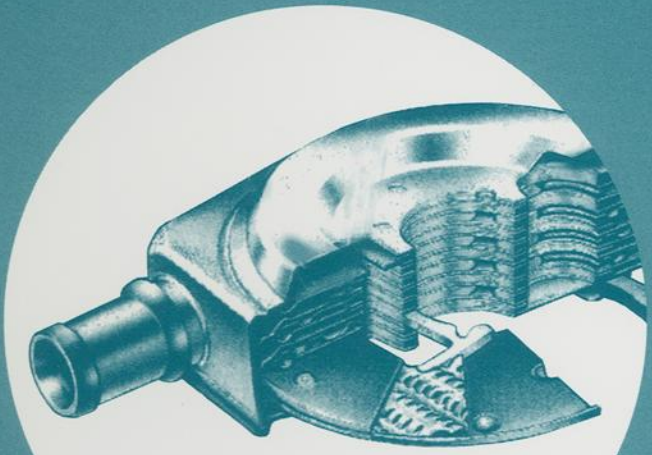
OIL FLOW STUDIES at LOW TEMPERATURES in MODERN ENGINES



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Foreword

This publication, *Oil Flow Studies at Low Temperatures in Modern Engines,* contains papers presented at the symposium of the same name held in St. Louis, Missouri, on June 21, 1999. ASTM Committee D02 on Petroleum Products and Lubricants sponsored the symposium. Harold (Hal) Shaub, Center for Innovation, Inc., Irving, Texas, presided as the symposium chairman and is the editor of this publication.

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SESSION II

Overview

A symposium titled "Oil Flow Studies at Low Temperatures in Modern Engines" was sponsored by ASTM Committee D02 on June 21, 1999, at the Adams Mark Hotel, St. Louis, Missouri, to summarize and discuss the results of industry (ASTM and others) studies on low temperature oil flow in modern engines with modern oils. The symposium was held in conjunction with the June 20–25, 1999 Committee D02 standards development meetings. Twelve papers were presented during two (AM and PM) sessions. In addition to the studies carried out under the auspices of ASTM, the symposium provided a forum for presentation and discussion of similar studies conducted outside of ASTM technical committees. Seven papers covered the ASTM work while five papers summarized results and conclusions from the independent industry studies. The overall aim of the symposium was to assist the industry in understanding the issues involved in oil flow related engine operation at low temperatures in modern engines (lubricated with modern oils) and to provide a good basis for future specification development.

An extensive industry (ASTM) program on cold start and pumpability, with modern oils in modern engines, was designed and carried out over the past six plus years. This study was in response to four specific concerns voiced by the Fuels and Lubricants (F&L) Division of the Society of Automotive Engineers (SAE) in a May 1992 letter to ASTM Subcommittee D02.07 on Flow Properties. The SAE F&L Division pointed out that five technical changes in modern engines and oils could lead to substantial lowering of the starting temperatures of these engines which could, in turn, adversely effect low temperature pumpability. The five changes included (1) low friction engine designs, (2) fuel injection systems, (3) computer control of ignition and fuel flow, (4) higher power-density starting motors and batteries, and (5) friction modified engine oils.

A Low Temperature Engine Performance (LTEP) task force was established within ASTM Subcommittee D02.07C in June 1992 to study and address the four SAE concerns, namely:

- To determine if modern engines start (on average) at lower temperatures than earlier engine designs do.
- To determine if there is a "safety margin" between limiting cranking and pumping viscosities in modern engines.
- To determine the cranking and pumping limitations of single grade (non-VI improved) engine oils.
- To assess the benefits and limitations of current methods for identifying oils that could result in pumpability failures in engines.

The work reported at the June 21, 1999 symposium went a long way in answering the four SAE F&L Division concerns about low temperatures oil flow in modern engines with modern oils. More specifically, the studies carried out within ASTM and reported in the first seven papers of the symposium, showed that modern (1993–94 model year) engines do indeed start, on average, at substantially lower temperatures than earlier engine designs. Because of this and in order to maintain at least a 5°C safety margin between limiting cranking and pumping viscosities, the SAE, in mid 1995 lowered the MRV measuring temperatures by 5°C and raised the limiting viscosities for each SAE "W" viscosity grade. As a result, the five multigrade and one monograde oil used in the LTEP study demonstrated acceptable pumpability at temperatures 5°C to 9°C lower than the minimum starting temperatures. Although CCS viscosity correlated with engine startability in the LTEP studies, the limiting starting viscosities were considerably higher than the SAE J300 April 1997 limits. Therefore, it was recommended that the industry revisit the cold cranking viscosity/temperature limits. Recently

(Dec. 1999) SAE has successfully balloted modifications to CCS "W" grade measurement temperatures and viscosity limits which are more in line with cold starting data from the LTEP program.

The ASTM LTEP work also showed (1) under appropriate cooling and operating conditions, air-binding pumpability could be generated in certain engine types and that (2) air-binding was only observed in these engines when significant structure was detected in the oils (gel index >40, MRV yield stress 70-105 Pa). This work helped address the fourth SAE concern noted earlier; namely, "to assess the benefits and limitations of current bench test methods for identifying oils that could result in pumpability failures in engines."

Work conducted outside the ASTM LTEP Program also helped address the fourth SAE concern. A paper titled, "SAE 5W-30 Pumpability Studies in Modern 4- and 8-Cylinder Engines: Gelation Index and MRV Effects," by C. J. May, et al., showed that four oils with gelation indices (GI) ranging from 6.0 to 15.7 did not produce air-binding tendencies in full scale engines (2.0L I-4 and 4.6 L V-8) tests. Several drain samples from those pumpability tests showed reduced GI values relative to those for the fresh oils. Perhaps, even short-term engine operation can "break-up" the subtle low temperature structures detected during Scanning Brookfield testing. A second paper titled, "Relation between Low-Temperature Rheology of Lubricating Mineral Oils and Gelation Index," by R. M. Webber, et al., proposes and presents evidence to support the supposition that the gelation index characterizes the onset of nucleation rather than the formation of macroscopic wax crystals that would be associated with a yield stress and gelation.

As far as the future is concerned, used oils in general and, more specifically, sooted oils and highly oxidized oils and their influence on low temperature pumpability are rapidly becoming a new challenge. New skills and perhaps new instruments may be needed to predict the effects of these factors on low temperature pumpability. In preliminary work, described in a paper by T. W. Selby titled, "Pumpability - Past Accomplishments; Present and Future Challenges," a new bench test technique [The Scanning Brookfield Technique-Extended Range (SBT-XR)] has shown promise in predicting low temperature pumpability with highly oxidized (thickened) and sooted used oils. A task force has already been formed in ASTM Subcommittee D02.07 to address these future needs and to investigate the SBT-XR and other approaches as potential viable predictors of "used oil" pumpability.

Much thanks goes to Dr. K. O. Henderson of Cannon Instrument Company, then chairman of ASTM Subcommittee D02.07, for suggesting that this symposium be held; Dr. C. J. May of Imperial Oil Ltd., chairman of the LTEP task force, organizer of the ASTM presentations at this symposium, for acting as symposium moderator, and for the symposium paper authors and ASTM personnel that have made this publication possible.

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