2022-01-0620 Published 29 Mar 2022

Correlation Between Vibration Level, Lubricating Oil Viscosity and Total Number Base of an Internal Combustion Engine Operated with Gasoline and Ethanol

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Citation: Santana, C.M., "Correlation Between Vibration Level, Lubricating Oil Viscosity and Total Number Base of an Internal Combustion Engine Operated with Gasoline and Ethanol," SAE Technical Paper 2022-01-0620, 2022, doi:10.4271/2022-01-0620.

Received: 24 Jan 2022 Revised: 24 Jan 2022 Accepted: 11 Jan 2022

Abstract

Lubricating oils for automotive engines have been incorporating important improvements in chemical properties to increase engine performance, reduce fuel consumption and vehicular emissions indices, in addition to increasing the time interval for changing the lubricant itself. The objective of this study is to investigate the vibrational behavior of the block and crankshaft an Otto cycle internal combustion engine operated with ethanol and gasoline fuel as a function of the viscosity and total base number (TBN) of the lubricant. The study consisted of instrumenting the block and the 1st and 5th fixed bearings of the crankshaft with accelerometers to measure the engine vibration intensity and operating the engine on a bench dynamometer in a specific test cycle. Each experiment lasted 600 hours and every 50 hours a block and crankshaft engine vibration level were measured and 100ml sample of lubricating oil was collected to check viscosity and TBN chemical lubricant's properties. The results show that the block and crankshaft engine vibration level increases with the time of use of the lubricating oil and that this increase is very significant when the oil viscosity an TBN chemical properties reaches the minimum value stipulated by the manufacturer lubricating oil. Semi-synthetic and synthetic lubricating oils have similar engine protection characteristics, but synthetic oil protects the engine for a longer period of time due to less degradation of viscosity an TBN chemical properties compared to semi-synthetic. Mineral lubricating oil presented protection for a very short test period, due to the rapid degradation of chemical properties and measurements showed an average increase of 20% of vibration engine running with mineral lubricating oil in relation synthetic and semi-synthetic oils.

This research is important because it correlates the degradation of the lubricating oil with the engine vibration level and vibration problems in internal combustion engines produce premature wear on the internal components of the engine, which contributes to reduce the lifespan of the engine. This study also shows how is important to observe the correct application of automotive oils.

Introduction

Khuong et al. [1] investigated the oil degradation, and lubricating efficiency of fully-synthetic oil diluted with various bioethanol-gasoline blends. A fully synthetic oil was homogenously mixed with five formulated fuels such as pure gasoline, gasoline with 10% ethanol, gasoline with 20% ethanol, gasoline with 30% ethanol and gasoline with 85% ethanol. This experimental study shows that the assess the impact of bioethanol-gasoline blends, on the tribological performance of engine oil under selected conditions using four-ball wear tester. The 6% addition of all bioethanol-gasoline blends to fully-synthetic oil significantly decreased the viscosity of the fresh oil to about 30%, compared to fresh synthetic oil. The decrease in viscosity from ethanol dilution may result in the thinner boundary film and higher wear because viscosity reduction causes more contact between asperities of the surface. Bioethanol-gasoline diluted oils show slightly higher the acid number, compared to fresh synthetic oil. The engine oil needs to be more alkaline to prevent the metal surface from corrosion. However, bioethanol is more chemically reactive compared to gasoline, which enhances the degradation of the fuel-oil mixture. Therefore, the fuel diluted lubricants contain more acidity making the surface more susceptible to corrosion, thus increasing wear losses. The addition of ethanol-gasoline fuels to synthetic oil shows that there is no clear trend or conclusive indication of each fuel-oil mixture is worse for friction at both loads, but during the test, it was shown that the ethanol rapidly and fully evaporated from the lubricant at the temperature of 75°C. This minimal effect on the friction behavior is also due to the fact that the tests were conducted under boundary lubrication regime. Although bioethanol fuels have slight impact on the frictional characteristic of the oil, it has significant differences in the amount of wear. At both 40 and 80 kg loads, fuel-oil mixtures beginning test to approximately 10.80 mgKOH/g at the end test. The results of tests with SAE 20W50 lubricant oil and ethanol fuel show that vibration in the engine increased with the engines test hours and after 50 hours of testing the increase in vibration level in the engine was more intense. The viscosity of the oil 20W50 with ethanol fuel decreased with the engines test hours and the minimum reference value was reached with approximately 75 hours of testing. The oil TBN also decreased with the engines test hours and the minimum reference value was reached with approximately 200 hours of testing. Analyses of results show that, after approximately 50 hours of test, the vibration intensity is more significant because the oil was degraded with viscosity and TBN.

The comparison of the tests performed with the SAE 5W30 synthetic oil, SAE 15W40 semi-synthetic oil and SAE 20W50 mineral oil lubricant with gasoline and ethanol shows an average increase of vibration of the engine run on ethanol in comparison to gasoline. Such increase in vibration intensity in the tests performed with ethanol is related greater degradation of lubricating oil properties in engines fueled with ethanol than with gasoline. This degradation of the oil is characterized by the reduction of viscosity and TBN which is related to workload, temperature and dilution of fuel. The 5W30 synthetic oil and 15W40 semi-synthetic oil lubricants has the same degradation characteristics, but 15W40 protects better the engine against 5W30 since the vibration level is smaller. The 20W50 mineral oil lubricant which is a mineral oil degrades faster working in same conditions as 5W30 and 15W40 lubricants which are synthetic and semi-synthetic oil respectively, which rapidly increases the engine's vibration level.

Chiavola et al. [11] also demonstrated that the combustion pressure in an engine influences the vibration level in the engine block. This study confirms that the vibration level of an internal combustion engine depends on the type of fuel used in the engine. Keskin [12] investigated vibration effect of ethanol and gasoline blends on two stokes spark ignition engine. The experiments were at 1500, 2000 and 2500 rpm engine rotational speed. The results demonstrate that vibration characteristics of engine changed significantly at 1500 and 2000 rpm with gasoline blend with ethanol fuels and the vibration amplitude of the engine with ethanol showed a trend of increasing. Chowdhury and Rama [13], Chowdhury et al. [14], Ravi et al. [15] and Nieuwstadt et al. [16] also investigated vibration in internal combustion engine.

Conclusions

This study confirms that the vibration level of an internal combustion engine depends on the type of fuel used in the engine. In the present work, the vibration level of the engine running with ethanol was more intense than the engine running with gasoline in all operating conditions. The intensity of vibration in an internal combustion engine increase as the oil degrades. The degradation of the oil is characterized by the reduction of viscosity which is related to workload, temperature and dilution of fuel. In all operating conditions, the ethanol-run engine has higher vibration intensities than the gasoline-run engine. For the same type of fuel, an oil of higher viscosity attenuates the level of vibration of the engine. The 5W30 and 15W40 lubricants has the same degradation characteristics, but 15W40 protects better the engine against 5W30 since the vibration level is smaller. The 20W50 lubricant which is a mineral oil degrades faster working in same conditions as 5W30 and 15W40 lubricants which are synthetic and semi-synthetic oil respectively.

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ISSN 0148-7191