Increasing Engine Efficiency with Friction Reducing-Oil Additives

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ABSTRACT

Typical enigne oils used in internal combustion gas and diesel engines are not high in thermal conductivity and are limited in friction performance, which together limit engine efficiency and longevity. Carbon nanotubes and hexagonal boron nitride nanosheets allow for extreme friction reduction, even when compared to high performance synthetic motor oils. The nanotubes and nanosheets also improve thermal conductivity, in turn increasing engine efficiency.

Coupon testing was initially performed to refine the specific nanomaterials employed as well as the concentrations of constituents. Tests were performed by Falex corporation using an ASTM G77 Block on Ring test aparatus and revealed up to a 47% wear reduction and a 12% friction reduction compared to Mobil 1 full synthetic.

A wide variety of engine tests were performed to understand the influence of the oil on a more complicated system. Engine testing showed significant improvements in fuel efficiency. Fuel efficiency improvements up to 30% in testing of engines ranging from small lightly loaded to heavily loaded diesel engines. An average fuel efficiency improvement of 18% was achieved in diesel engine equipped trucks. Based on this work, the typical application is expected to gain upwards of 10% in fuel efficiency. This is of coarse dependent on the engine type and loading, but the evidence suggests that the highest loaded engines show the largest gain in performance. In addition, horsepower gains up to 11% and torque increases up to 12% were observed during testing.

The unique method employed facilitated the optimization of engine oils for thermal conductivity and lubricity, resulting in a substantial increase in engine efficiency and performance. It is anticipated that this reduced friction and heating of engine hardware will also increase engine longevity. The result will be fuel savings and lower life cycle cost for internal combustion engines.

There are currently 32 vehicles that have operated for a significant amount of time with the oil additive. These include gasoline, turbocharged gasoline, and turbodiesel engines. All have shown significant improvement in efficiency and performance.

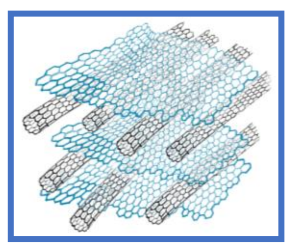
Keywords: engine oil, fuel efficiency, green oil, carbon nanotube, boron nitride

1 INTRODUCTION

Internal combustion engines use significant amounts of diesel and gasoline at great cost to the owner/operator and the commercial sector, and their emissions contribute significantly to global greenhouse gas emissions. The DoD is the world's largest user of diesel fuel. Reducing friction and increasing thermal heat transfer increases internal combustion engine efficiency.

Both carbon nanotubes[1,2] and hexagonal boron[3,4,5] nitride have been known to reduce friction and increase thermal conductivity in many applications. The combination of these two materials in the correct concentrations and proportions, were studied in detail to achieve improved performance over conventional oils or other oil additives studied to date.

Figure 1 shows how carbon nanotubes and hexagonal boron nitride may interact to further reduce friction when compared to high performing engine oils or individual nano components.



A similar structure has been suggested for carbon nanotubes and graphene.[6]

Fig 1: Visualization of nanotube rollers distributed between boron nitride sheets

Fig 2. [left] cutaway of diesel engine, [right] example engine subject to wear

2 VISCOSITY MEASUREMENT

Viscosity measurements were made using a UNHEWUHUA NDJ-9S device capable of viscosity measurements across a range of temperatures. Considering the experimental standard deviation noted in the baseline oil, no oils recipes with additive included fell outside of the scatter in the baseline data. Samples were tested not only at room temperature, but also at an elevated temperature of 100°C showing the same similarity to the baseline data. These results are consistent with the nature of nano-materials which have high surface to volume ratios. This allows a very dilute addition of material to the oil to have a significant impact on engine performance.

3 FRICTION AND WEAR TESTING

Eleven samples were prepared and sent to Falex Corporation for friction and wear testing per ASTM G77 (see table 1). These samples consisted of varying ratios of carbon nanotubes (MWNT-OH) to hexagonal boron nitride (hBN) as well as varying concentration of additive to oil. Pure Mobil 1 Full synthetic ESP 5W-40 was also tested as a baseline. In addition two samples, Samples C and D, were produced with identical ratio and conentration to verify the reliability of the data. These two samples came back with the same coefficient of friction but with a small difference in wear scar providing an indication of possible scatter in wear scar results. Mobil 1 had an average block scar that was similar to our ratio #5 nano oil additives. All other samples revealed a much lower block scar than Mobil 1.

Table 1: Summary of Independent lab testing of a variety of nano oil additives compared to sample A which is a pure Mobil 1 full synthetic motor oil.

Sample	MWNT-OH:hBN	Dilution Ratio Oil:Additive	Coefficient of Friction (CoF)
A	0:0	N/A	0.126
B	#5	44:1	0.128
C	#5	22:1	0.131
D	#5	22:1	0.131
E	#1	44:1	0.116
F	#2	44:1	0.127
G	#3	44:1	0.112
H	#4	44:1	0.139
I	#6	44:1	0.124
J	#7	44:1	0.142
K	#8	44:1	0.131

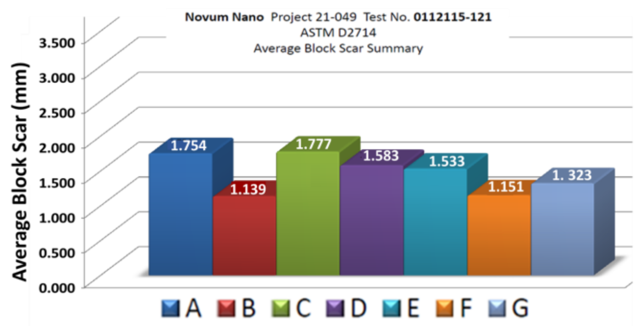


Figure 3 Average block scar data from Falex Corporation of samples A – G.

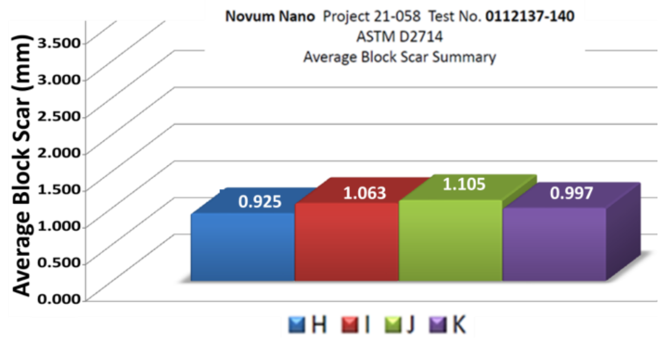


Figure 4 Average block scar data from Falex Corporation of samples H – K.

4 MOTORCYCLE DYNAMOMETER TESTING

Six Harley-Davidson motorcycles ranging in model years from 1998 to 2017 were tested with the oil additive at a Harley-Davidson dealership near Rapid City South Dakota. In total 34 Dyno sets with 3 runs with a total of 102 runs.

Harley-Davidson dynamometer testing of 6 bikes in range from 3 years to 22 years in age with mileage range of 6,925 to 56,985 miles showed increases in torque of up to 11.92% and horsepower increases up to 10.99%.

These dyno tests allowed us to further narrow down the amount of oil additive that is required to achieve maximum benefit.

Dynamometer testing of motorcycles proved to be very successful in demonstrating the performance gains that can be obtained by the addition of the oil additive. Testing demonstrated that the most significant improvements were produced from dilution ratios of oil additive:engine oil of 44:1 to 22:1. Oil additive proprietary MWNT-OH:hBN ratio #5 was selected for all motorcycle testing.

5 DIESEL GENERATOR TESTING

A light tower generator powered by a Kubota diesel engine was selected for further oil additive testing. This engine is very typical of diesel engines and runs at a lower rpm than most gasoline engines. All testing was performed outside and as such test variables such as air temperature had the potential of influencing outcome. To minimize this variability, extensive baseline testing was performed before any additive was added to the engine. Baseline testing was performed for over 20 hours over a period of four days. A single dose of nano oil additive was added to the engine and testing was performed over several more days to get a reliable average value. Over the 4 days of baseline testing , 19 runs were made to obtain an average fuel usage of 1387 grams per hour. A single dose of nano oil additive was added, and 21 tests were run to obtain an average of 1319 grams per hour. This yielded a 4.9% improvement in fuel consumption for the diesel-powered light tower equipped generator. With the addition of a second dose of nano oil additive, a 0.5% incremental improvement was recorded over 6 total tests. This yielded a total improvement of over 5% compared to the use of standard engine oil (see figure 5). All tests were run with MWNT-OH:hBN ratio #4, and the single and double dose corresponded to 44:1 and 22:1 dilution ratios respectivly.

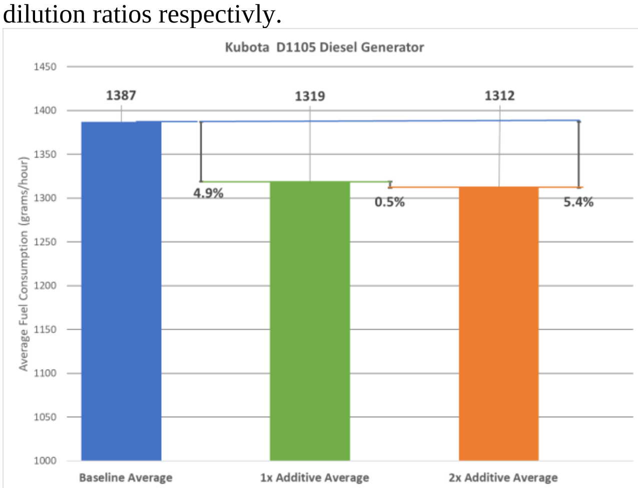


Figure 5: Comparison of fuel efficiency of the light tower equipped generator with standard engine oil and with the nano oil additive at single and double doses.

6 DYNO TESTING OF SEMI TRUCK

A 2010 Peterbilt straight truck equipped with a Paccar PX8 engine was tested at Western Dakota Technical College. While under load, the turbo temp dropped from 740 degrees Farenheit down to 720 degrees Farenheit after the addition of Nano Oil Additive at the dilution ratio of 44:1 and the MWNT-OH:hBN ratio #5. This is significant as the primary limitation in truck speeds for vehicles of this type is the temperature of the turbocharger. Sustained high temperatures can cause premature failure drastically increasing life cycle costs of the vehicle. It is likely that the primary source of the temperture reduction is the frictional losses in the engine such that the trubocharger does not have to work as hard to maintain the vehicle speed.

Figure 6: 2010 Peterbilt straight truck equipped with a Paccar PX8 engine

7 FUEL EFFICIENCY OF PICKUP TRUCKS

A 2019 Chevrolet Duramax was tested comparing baseline oil performance with the performance of oil with the nano oil at several additive dilution ratios and MWNT-OH:hBN ratios. This truck was driven at freeway speeds along the same route, then at slower speeds along a separate route which better simulates the use of a typical Aerospace Ground Equipment (AGE) equipment conditions. In both low and high speed testing the nano oil additive was able to produce a significant fuel savings. The MWNT-OH:hBN ratio that yielded the best fuel economy improvements correlated with the lowest friction and wear testing according to coupon testing done at FALEX Corporation.

A baseline was established for each route with fresh oil and filter. Three different additives were used for the testing. Each additive of varying MWNT-OH:hBN ratios were tested in three different concentrations. This allowed us to explore what ratio of MWNT-OH:hBN showed the best performance in fuel efficiency. This also confirmed the proper dilution of the additive required for maximum efficiency.

Further testing was performed by a Utah based company and collaboration partner with detailed detailed data collection practices for their fleet of trucks and vans. They evaluated the nano oil in both a Mercedes diesel Sprinter van and two Ram heavy duty trucks equipped with the high output Cummins diesel engines. These vehicles were tested with the MWNT-OH:hBN ratio #5, and the dilution ratio of 44:1

The novel nano oil additive was added at an odometer reading of 14,515 miles to the Sprinter van. The van was a 2016 with a 3.0 liter v6 diesel, and had a 1 ton suspension with 4x4. Before the addition of the oil additive, the average fuel milage was 17.2 miles per gallon (mpg) with the lowest recorded reading of 14.6 mpg. This vehicle was often worked hard as it was required to travel on steep mountain roads. Within about 1000 miles before this test, engine improvements in the air filtration increased the average fuel economy to 18.2 mpg. The addition of the nano oil additive increased the average again to 19.27 mpg.

It was noted that much of this testing was under adverse high head wind conditions, so additional testing was performed under more typical weather conditions resulting in a fuel economy of 21.1 mpg.

Table 2 Summary of 2019 Chevy Duramax Fuel economy driving from Rapid City, South Dakota to Wall, South Dakota. Novum Oil is listed in ratios of MWNT-OH:hBN.

	Trips at Freeway Speed			
Oil Type	# of Trips	Total Miles	Average MPG	Average Improvement
Mobil Delvac 15W-40	1	111.0	14.4	N/A
Novum Oil Ratio #5	3	326.6	14.9	3.50%
Novum Oil Ratio #4	3	325.3	15.5	7.99%
Novum Oil Ratio #6	3	326.6	15.9	10.31%

Table 3: Summary of 2019 Chevy Duramax Fuel economy driving from Rapid City, South Dakota to Sturgis, South Dakota. Novum Oil is listed in ratios of MWNT-OH:hBN.

	Trips at Slower Speed			
Oil Type	# of Trips	Total Miles	Average MPG	Average Improvement
Mobil Delvac 15W-40	1	88.0	15.5	N/A
Novum Oil Ratio #5	3	270.5	16.9	8.73%
Novum Oil Ratio #4	3	261.7	18.1	16.45%
Novum Oil Ratio #6	3	261.9	18.1	16.84%

Additional testing was performed under load by using the van to pull a trailer through a 70 mile round trip. The company had documented this same route with trailer in previous tests and noted a fuel economy average of 12.1 mpg. After adding the nano oil to the engine in the same vehicle, the average fuel economy was noted at 16.2 mpg for the same trip under the same loading conditions. A qualitative note was made that the largest increases in milage were noted whe the vehilce was under the highest load (pulling the trailer along hilly terrain). It should be noted that up to 5% of the 33% performance improvement noted may be contributable to the air filtration system modifications made prior to the testing.

At the same Utah based company, the nano oil additive was added to a 2017 RAM pickup with a high output diesel engine and a Aisin transmission at an odometer reading of 11,283 miles. This truck averaged 11.6 mpg pulling a trailer loaded at roughly 8000 lbs. Once the nano oil was added to the engine, the fuel economy increased to 14.7 mpg average.

In a separate test a 2014 RAM pickup with a high output diesel and an Aisin transmission with an odometer reading of 36,019 miles was tested. This vehicle had a historic average 14.6 mpg when pulling trailers weighing 4500 lbs. Once the nano oil was added to this vehicle and after several days and 526 miles of operation, the average fuel economy was noted at 17.3 mpg. After another 210 miles of hauling the fuel economy increased to 18.6 mpg.

8 CONCLUSION

A novel nano oil additive has been developed that provides increased fuel economy that saves money and aids in the reduction of greenhouse gas emissions. Tests further demonstrated that power and torque improvement could be realized with this additive putting less stress on the engine and auxilary components. Coupon testing further suggests that engine wear will be reduced and is expected to result in increased engine life. Testing multiple recipe ratios of carbon nanotubes and boron nitride nanosheets, with varying quality management system requirements related to raw material requirements, including types and quality of carbon nanotubes, resulted in an effective recipe for best performance of the novel nano oil additive.

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