JAM, LTD

Company Background

JAM Consulting LLC (dba JAM, Ltd.) was formed in 1996 to continue development, patent and commercialize its internal combustion engine technology.

JAM Consulting LLC was initially developed for V-Twin motorcycle engines to solve poor fuel efficiency and low power problems. The success of the implemented technology in the V-Twin gasoline engines gave the company impetus to continue development and implement the same technology for diesel and gaseous fueled internal combustion engines.

To continue development of JAM, Ltd, a dynamometer/emissions test cell was set up in Reno, Nevada giving Speed of Air the ability to validate and develop the technology in a controlled environment.

The first JAM, Ltd. engine test utilized a Cummins B Series 5.9 12 valve diesel engine. This engine was selected due to results from early testing on farm equipment utilizing this engine and also because of the 5.9 engine's multiple stationary, off-road and on-road uses. During the development and testing of the Cummins 5.9 engine a considerable reduction of emissions were realized (significantly the reduction of NOx simultaneously with reductions in other criteria emissions) in conjunction with increased power and lower fuel consumption.

The data from the diesel engine, both internal and independently verified by a EPA/CARB certified lab, was presented to companies within the oil & gas industry using natural gas fueled engines for pipeline gas compression. Based on this test data, JAM, Ltd. was given an opportunity to test and validate our technology in a CAT G3516 TALE engine. This engine incorporated JAM, Ltd. and was independently tested on site resulting in lower emissions than the lowest emission CAT G3516 ULB (Ultra Lean Burn) engine. This engine has continued to run at this site with consistent results for approximately 35,000 plus hours.

Current development projects in process include:

- High altitude/low emission transit bus applications for diesel and natural gas engines (25,580 hours of run time).
- Landfill methane gas fueled low emission/reduced maintenance electric generation engines (12 ,500 hours of operation.)
- Mining haul truck high efficiency/low emission engines (17,570 hours of run time)

Owner:

Joe Malfa – Owner / Inventor – 40 years in the automotive industry. Inventor and innovator on development of intellectual property related to internal combustion engines. Experience includes technical training development and customer relations for Porsche Cars North America and director of corporate programs for development of business and technical programs for college curriculum. Expertise in internal Combustion engines, engine flow dynamics, automotive suspension, electrical systems, and vehicle emission testing.

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JAM, Ltd.

JAM, Ltd. Claim

Our patented, specially modified pistons and heads enabled a Cat G3516 TALE 2.0 NOx gr/BHP-hr lean burn engine to run in a stable manner at 81% lower NOx, long after the unmodified engine would have formed combustion deposits and started to knock, all while reducing other emissions and without worsening fuel economy.

Introduction to the Technology

The internal combustion engine technology developed by JAM, Ltd. focuses on optimization of efficiency within the combustion chamber by promoting better fuel mixing. The goal is to produce the lowest possible emissions and also low fuel consumption while maintaining or increasing power. JAM, Ltd. unconventional approach to this optimization has resulted in a dramatic improvement in spark-ignition (SI) performance as demonstrated in controlled tests.

To maximize the energy produced in spark-ignition (SI) engines requires combustion of an optimally mixed air/fuel charge with a uniform and complete flame front. To maximize thermal efficiency, the combustion process must be completed in a short time. In SI engines a properly timed and complete uniform combustion process can raise engine efficiency by extending the range of stable engine operation, allowing very dilute air/fuel mixtures to be used. Also, faster burning permits use of higher compression ratios without knock, again leading to an increase in efficiency[1].

The introduction of different mechanisms to control the turbulent air/fuel mixture flows, such as swirl, longer stroke/bore ratios and higher squish have had a large effect on the performance of state-of-the-art engines. One way to improve micro-turbulence that has not been researched a great deal is to "tune" the fluid boundary layer between the combustion flame front and the cooled metal that encloses the combustion chamber. This is an extremely important region of the combustion chamber as it influences the degree to which the flame front can approach the cooled metal surface before being extinguished or slowed excessively by that cooler surface.

The solution JAM, Ltd. developed influence the thermos-physical boundary layers within the combustion chamber of the engine to optimize the flame front and combustion efficiency. JAM, Ltd. use of a dimpling process (similar to a golf ball), directional grooves and thermal coatings is designed to achieve a micro turbulence creating a thermo physical boundary layer across the combustion surfaces (piston, cylinder head, cylinder liner and valves). The micro turbulent boundary layer created by this process has more drag initially but also has better adhesion to combustion wall surfaces and is less prone to separation. This micro turbulent boundary layer within the combustion chamber creates a stirring action at the surface which postpones detonation due to hot spots. It also scrubs carbon deposits off the surface which are one cause of hot spots.

The characteristic of the combustion with this technology is a uniform and complete flame front, releasing the heat faster and more completely, creating greater useful force on the piston top. This complete early burn of the air/fuel reduces emissions of Total Hydrocarbons (THC), Carbon Monoxide (CO), VOC (Volatile Organic Compounds), Formaldehyde (HCHO), and Nitrogen Oxides (NOx). NOx typically increases with lower THC and CO, but is decreased with SOA's technology owing to optimized air/fuel mixing and a faster combustion process[2] .

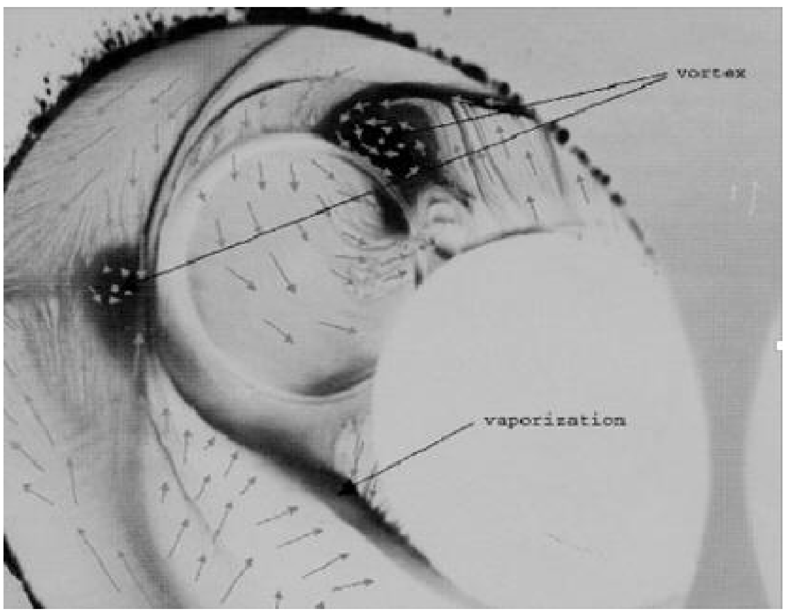


Image of vortices within a combustion chamber

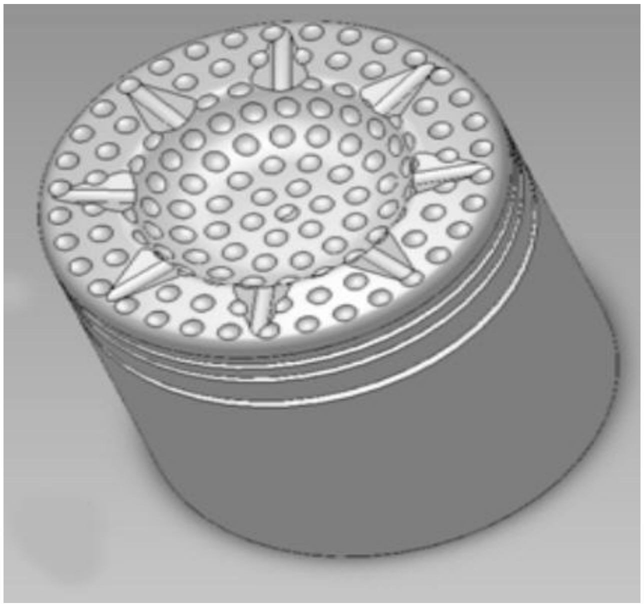


Image of JAM, Ltd. piston design for natural gas engine. The top surface of the piston is also coated with a ceramic thermal barrier.

Why JAM, Ltd Technology Works

Through our endeavor to improve the efficiency of the internal combustion engine in our development and testing, we have discovered the benefits of changes to surface physics within the combustion chamber as well as the intake and exhaust systems. We found dimpled surface physics, similar to a golf ball, created improved airflow in the intake and exhaust system as well as creating a dramatic improvement within the combustion chamber. As shown below the dimples create a micro turbulent boundary layer allowing the majority of the air flow to move with low restriction.

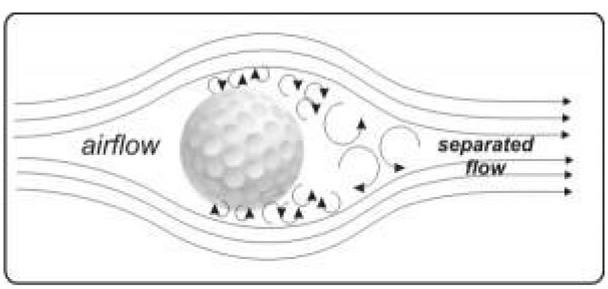
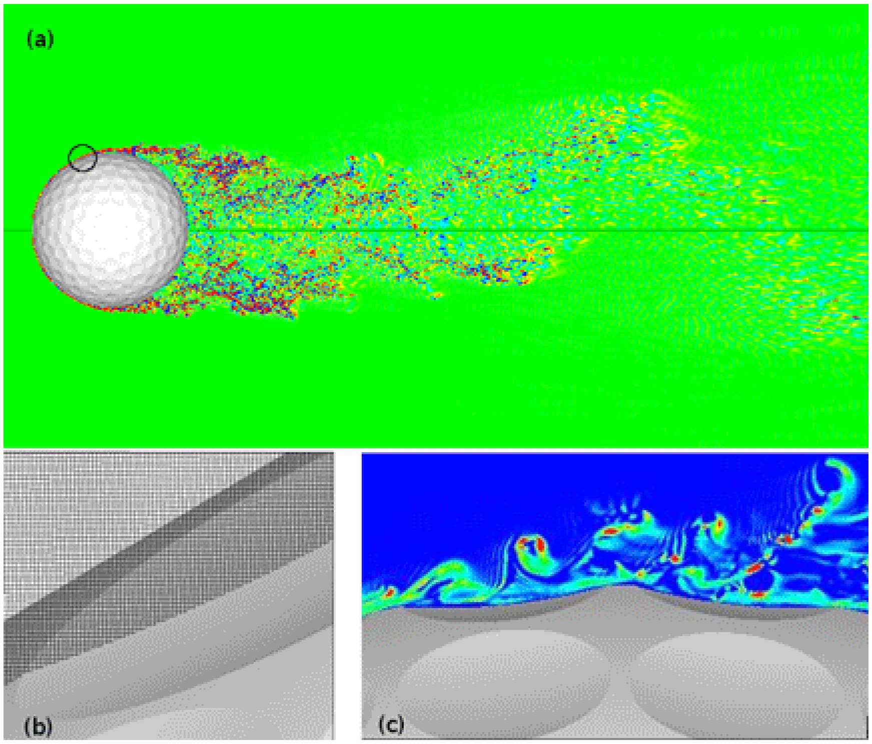


Illustration of the micro turbulence boundary layer created by dimples on a golf ball

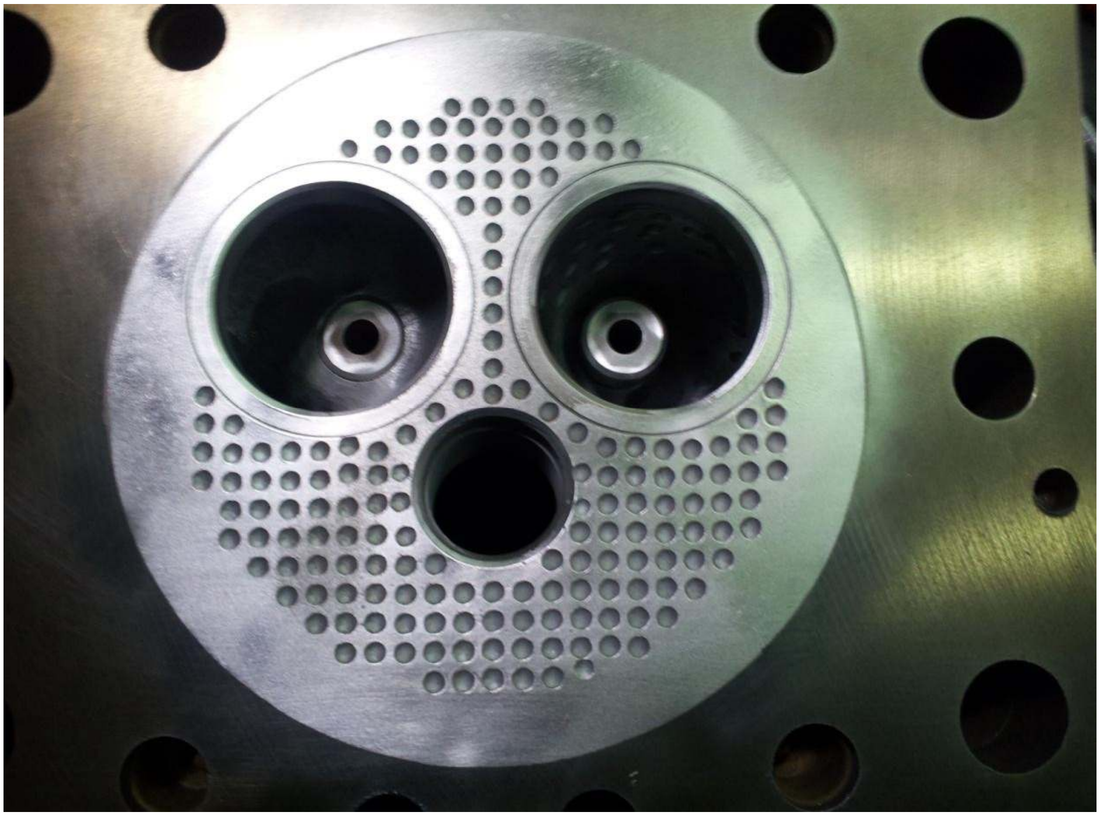


Above is the results of a "direct numerical simulation of the flow around a dimpled sphere at Re=110000. Figure (**a**) Side view of the wake visualized by spanwise vorticity isolines.; Figure (**b**) Detail of the mesh in a dimple; Figure (**c**) Visualization of the shear layers in a single dimple.[3]

While it is fairly easy to show the change in flow characteristics in the intake and exhaust system, changes to the combustion characteristics are not as easily determined or measured.

Many studies have examined the benefit of the turbulence field and charge flow velocities in the combustion chamber. These studies were designed to validate different approaches with the same goal of improved combustion efficiency using computational fluid dynamics (CFD)[4], high speed laser tomography analysis[5], high-speed cycle-resolved chemiluminescence imaging[6] and fiber laser Doppler velocimetry (LDV)[7]. All of these studies have shown a correlation of combustion chamber turbulence, mixed air/fuel charge, and charge flow velocity to improved engine efficiency.

The benefit of JAM, Ltd. technology creating a micro turbulent boundary layer on the combustion surfaces to postpone the onset of knocking, along with improved flow characteristics within the intake and exhaust systems, has been shown by our test results to create a significant improvement of combustion efficiency. Our test results, both internal and independent, have been limited to the comparisons of power output, exhaust emissions and fuel consumption (when available) to engines with our technology applied.



Natural gas cylinder head with dimples and ceramic thermal barrier

Application of JAM, Ltd. Technology to Gaseous Fueled Engines

JAM, Ltd. technology was initially developed for SI gasoline and CI diesel fuel engines. The results of our development led us to the potential for the JAM, Ltd. combustion technology to increase the efficiency of lean-burn SI gaseous fueled engines.

The challenge for operators of gaseous fueled engines within the current regulatory environment is low emissions (primarily NOx), stable power, and reduced maintenance cost while maintaining the power requirements necessary for the application.

A majority of high horsepower natural gas and landfill gas fueled engines are based upon a modified diesel engine design. The adaptation of the diesel engine combustion chamber typically exposes an area of the cylinder wall at top dead center of the piston stroke, and along with the shape of the piston and cylinder head does not create an optimal combustion chamber for gaseous fuel combustion. The best results by engine manufacturers for engines within the high horsepower, low emission (NOx) requirements have been limited to low altitude applications and are very sensitive to fuel (BTU) changes.

The JAM, Ltd. technology has been applied to both natural gas and landfill gas engines to test the benefit of improved combustion efficiency achieved by the micro turbulent boundary layer created by changes to the surface physics and thermal control of the combustion chamber design.

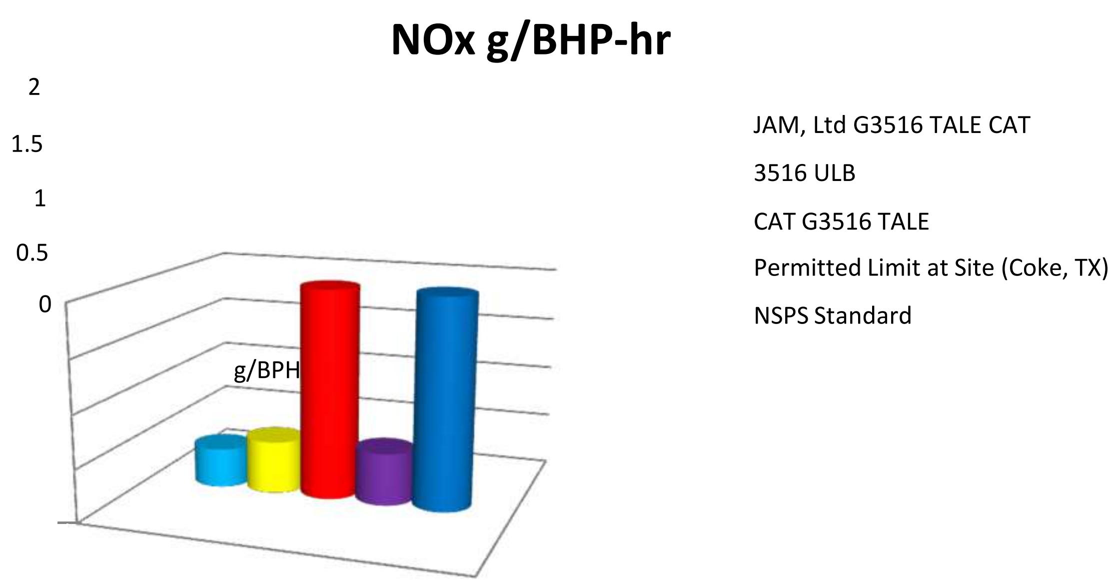
For the natural gas engine, we applied JAM, Ltd. technology to a Caterpillar® G3516 TALE lean burn engine rated at 2.0 g/BHP-hr.

After the application of the SOA technology the engine was able to run in a stable condition at the horsepower requirement of 1085 HP at a level as low as a NOx level .16 g/BHP-hr. The engine was tested at .375 g/BPH. This NOx level appeared to be the optimal level of NOx reduction while maintaining lower HC, CO, VOCs and HCHO emissions. The operators of this test site were not able to run the untreated Caterpillar® G3516 TALE lean burn engine at this NOx level in a stable condition maintaining the required horsepower.

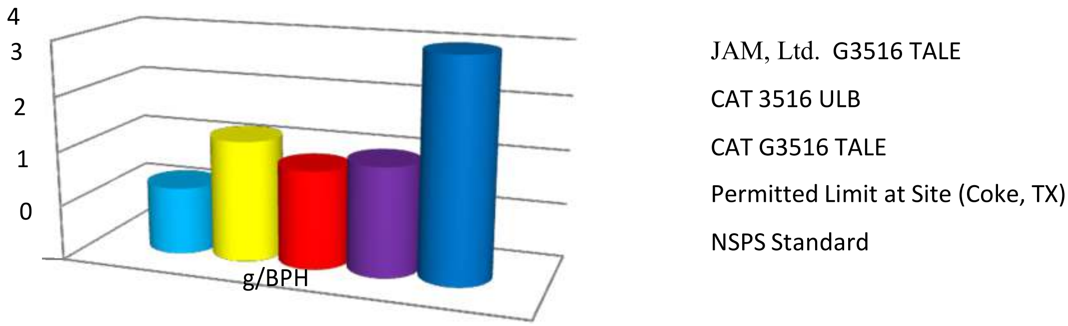
What is notable is the ability for the JAM, Ltd. engine to maintain a stable operating condition at the rated horsepower in an ultra-lean burn condition with reductions of HC, CO, VOCs and HCHO simultaneously at an elevation of 2000 ft. The results of this test are displayed below[8].

JAM, Ltd G3516TALE Emissions Comparison

Engine	NOx g/BPH	Reduction	Reduction %	CO g/BPH	Reduction	Reduction %
JAM, Ltd G3516 TALE CAT	0.375			1.238		
3516 ULB	0.500	(0.13)	25%	2.220	(0.98)	44%
CAT G3516 TALE	2.000	(1.63)	81%	1.800	(0.56)	31%
Permitted Limit at Site (Coke, TX)	0.500	(0.13)	25%	2.000	(0.76)	38%
NSPS Standard	2.000	(1.63)	81%	4.000	(2.76)	69%



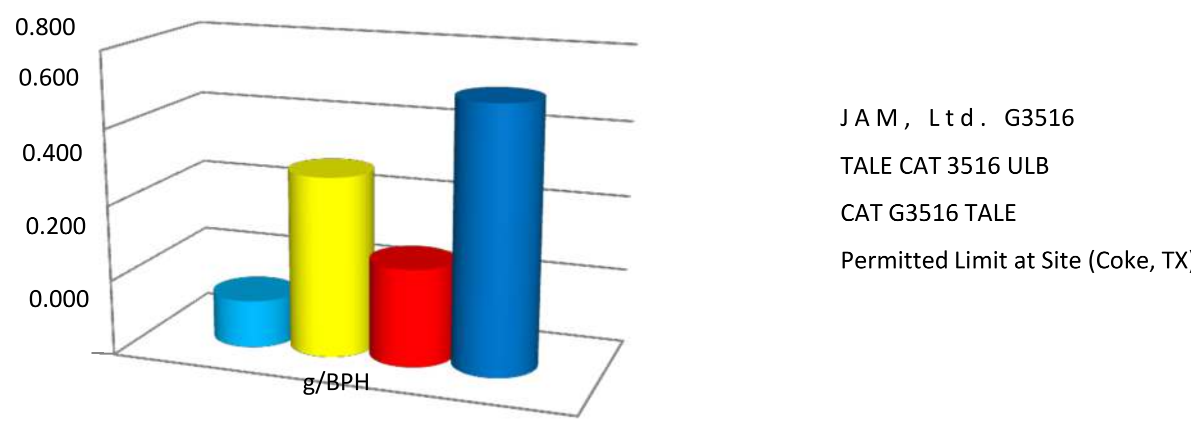
Carbon Monoxide g/BHP-hr



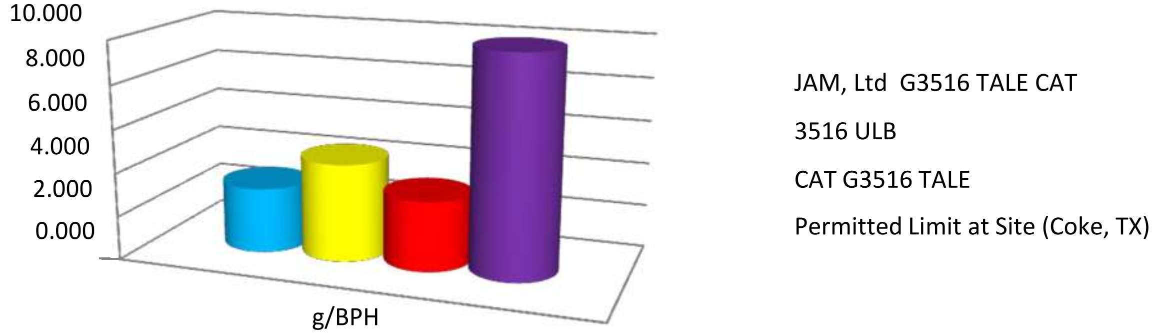
JAM, Ltd G3516TALE Emissions Comparison

Engine	VOCs g/BPH	Reduction	Reduction %	THC g/BPH	Reduction	Reduction %
JAM< Ltd. G3516 TALE CAT	0.127			3.000		
3516 ULB	0.480	(0.353)	74%	4.500	(1.50)	33%
CAT G3516 TALE	0.260	(0.133)	51%	3.210	(0.21)	7%
Permitted Limit at Site (Coke, TX)	0.700	(0.573)	82%	10.000	(7.00)	70%
NSPS Standard	1.000	(0.873)	87%	N/A	N/A	N/A

Volatile Organic Compounds g/BHP-hr



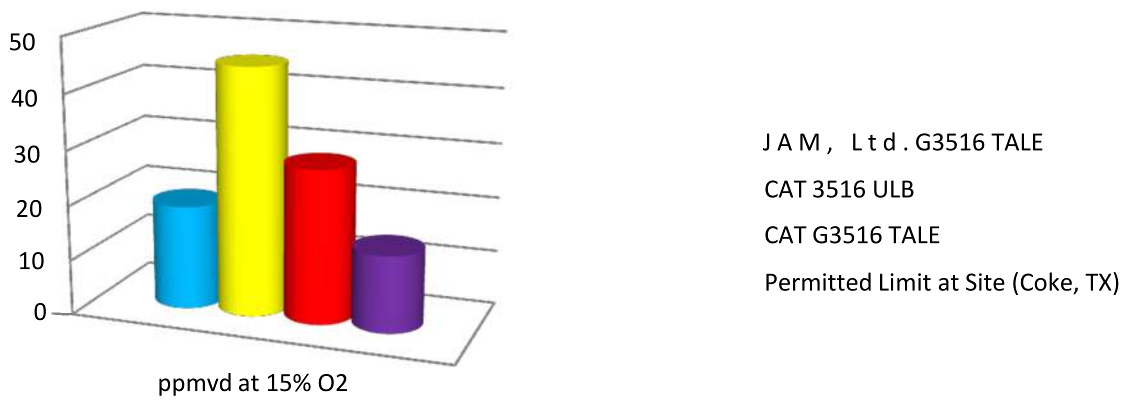
Total Hydrocarbons g/BHP-hr



JAM, Ltd G3516TALE Emissions Comparison

Engine	HCHO (Formaldehyde) ppmvd at 15% O2	Reduction	Reduction %
JAM, Ltd G3516 TALE CAT	19		
3516 ULB	45	(26.00)	58%
CAT G3516 TALE	28	(9.00)	20%
Permitted Limit at Site (Coke, TX)	14	5	-11%
NSPS Standard	N/A	N/A	N/A

HCHO (Formaldehyde) ppmvd at 15% O_2



<u>Additional Benefits of SOA Combustion Technology</u>

An additional benefit of the micro turbulent boundary layer is the reduction of carbon and other deposit build up on the combustion surfaces. These deposits can cause auto-ignition and cause uneven, less efficient burn of the air/fuel mixture. This attribute of JAM, Ltd. technology has shown significant reduction in SO_2 deposits in our testing of a landfill gas fueled engine used for power generation on landfill sites. The methane used in the landfill operations contains siloxane which creates SO_2 deposits upon combustion at a rapid rate to the combustion chamber. These deposits significantly reduce engine life and increase the frequency of de-coking to maintain the engine in operating condition.

Conclusions

When the Caterpillar G 3516 TALE was up-fitted with JAM, Ltd. “treated” parts, it could then be re-tuned to:

- Run at 81% lower NOx without knock or misfire
- Also simultaneously provide 51% lower VOC, 31% lower CO and 32% lower formaldehyde

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[1] Mattavi, J.N., "The Attributes of Fast Burning Rates in Engines," SAE Paper 800920, 1980

[2] S.L.V Prasad et al. “Experimental Study of the Effect of Air Swirl on Diesel Engine Technology” International Journal of Engineering Science and Technology, 2011

[3] Elias Balaras group, University of Maryland

[4] Wendy Hardyono Kurniawan, et al., CFD Investigation of Fluid Flow and Turbulence Field Characteristics in a Four-Stroke Automotive Direct Injection Engine, Journal - The Institution of Engineers, Malaysia (Vol. 69, No.1, March 2008)

[5] M. Mouqallid, B. Lecordier, and M. Trinite, “High Speed Laser Tomography Analysis of Flame Propagation in a Simulated Internal Combustion Engine – Applications to Nonuniform Mixture” SAE Paper 941990, 1994

[6] A. Vressner, A Hultqvist and B. Johansson, Study on Combustion Chamber Geometry Effects in an HCCI Engine using High-Speed Cycle-Resolved Chemiluminescence Imaging

[7] B. Kim et al. “ In-cylinder turbulence measurements with a spark plug-in fiber LDV” Kobe University

[8] Vaquero Analytical Services, LLC, Speed of Air Test Results, February 28, 2013