FIERCE FUEL SYSTEMS™
Diesel Reinvented

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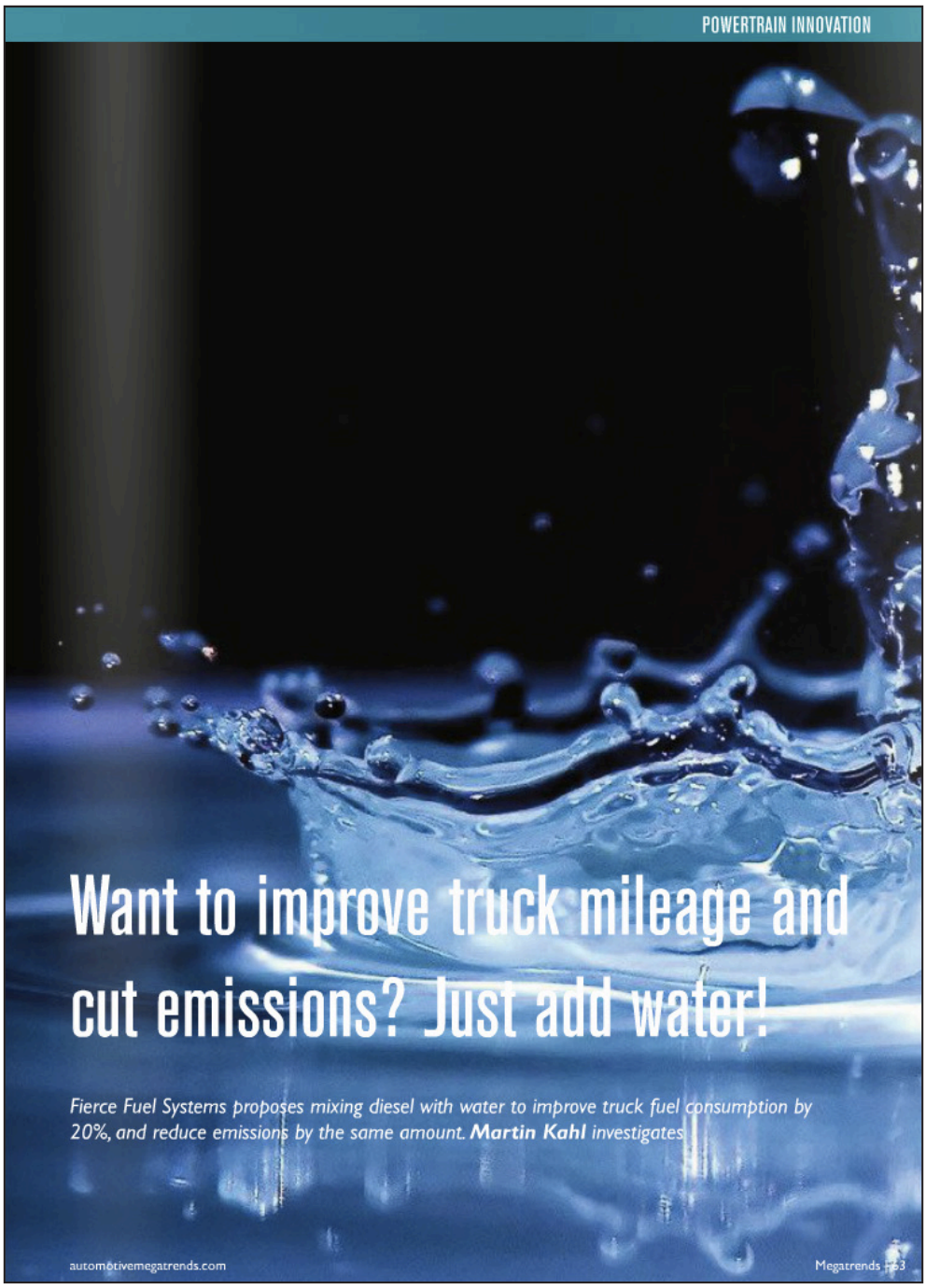
Want to improve truck mileage and cut emissions? Just add water!

Fierce Fuel Systems proposes mixing diesel with water to improve truck consumption by 20%, and reduce emissions by the same amount.

~ Martin Kahl investigates



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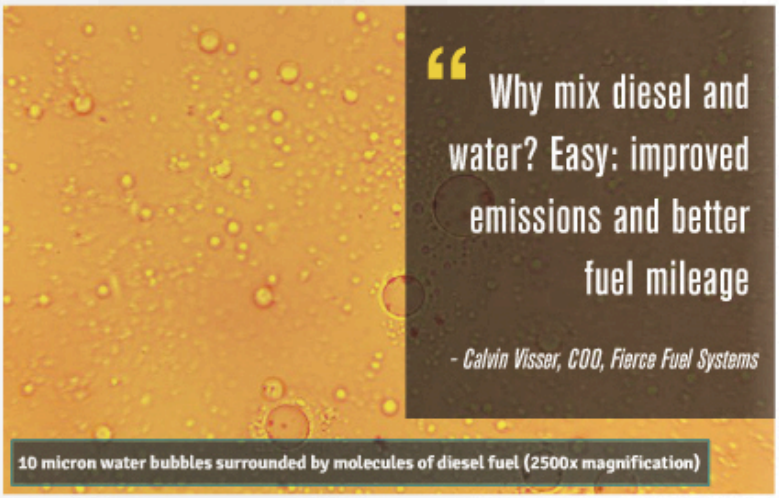
Thanks to advances in diesel engine technology, new medium and heavy duty trucks have never been as clean as they are today. These developments, however, count for nothing for the millions of older trucks on the world's roads. Over time, the older vehicles will come out of circulation, but that could take decades; in the meantime, those vehicles' emissions and fuel consumption continue to take their toll on the environment - and on fleet operators' bottom lines.

A small company headquartered in the shadow of the Chrysler Technical Centre in Auburn Hills, Michigan, may just have the answer to this problem – and it's an unexpected one.

Fierce Fuel Systems proposes mixing diesel with water for increased fuel mileage of up to 20%, and a significant reduction in emissions.

"Diesel-water emulsion is not a secret - it's been around since the 1930s," explains Fierce Fuel's President and Chief Executive, Louis Conti, "but it's been plagued with a number of operational issues. The main challenge is keeping the fuel emulsified for an extended period of time, which has always required a relatively high volume of surfactant to keep the emulsion in suspension. Specifically, the varying size of the fuel encapsulated water bubbles has provided cause for concern." The technology may have been around since the 1930s, but to date diesel-water emulsified fuel has been produced in large quantities using land-based processing systems with three-phase motors that burn energy quickly. Furthermore, adds Conti, the cost of creating emulsified fuel was more expensive than straight run fuel.

Several factors enable Fierce to overcome these challenges. Firstly, Fierce uses a patented vacuum-based production process that reduces the fuel to vapour and reconstitutes it along with the entrained water and chemicals added by the refinery. Secondly, in order to reduce energy and transportation costs, Fierce's systems - the X1and X2O - use 12 volts DC, drawing power from the battery bank. "We're able to use that energy from the alternator, which is already being driven," says Conti. Thirdly, Fierce produces its diesel-water emulsified fuel in micro batches. Historically, emulsified fuel has been produced in very large bulk batches, and stored in underground tanks. Doing so causes numerous problems, including separation of the diesel and water; the natural occurrence of atmospheric water entering the mix inside in the tank; and of course, transporting the fuel from the tank to point of distribution.



> "Why mix diesel and water? Easy: improved emissions and better fuel mileage
>
> - Calvin Visser, COO, Fierce Fuel Systems

10 micron water bubbles surrounded by molecules of diesel fuel (2500x magnification)

"We've developed an on-board system, and we meter the water and fuel in. We blend it in micro batches, using our technology, and include an emulsifier," says Conti. "We sequester the return fuel to prevent it getting back into the truck's tanks."

Adding water to fuel seems counter-intuitive. Does this not dilute the fuel, effectively eliminating a similar percentage of the diesel's potential?

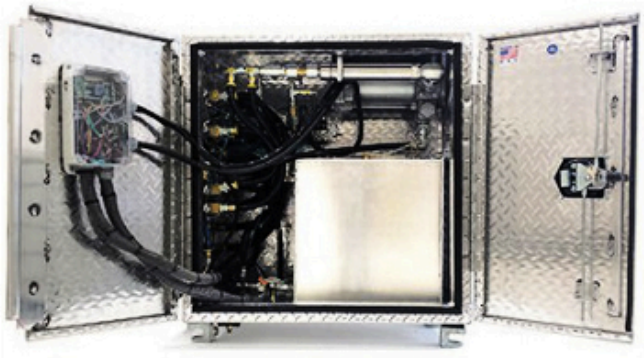
Conti accepts the reasoning behind the question, and responds with confidence: "There is of course a loss of potential energy with higher water ratios. However, units never use 100% of the power available. Losses are negligible. We've had customers with brand new trucks driving six miles straight up the side of a 6% grade mountain, on 30% water, without noticing much of a difference in performance while using less fuel and cutting 20% in EGR temperatures."

At this point, Fierce Fuel's Chief Operating Officer, Calvin Visser, interjects: "Why mix diesel and water? Easy: improved emissions due to lower combustion temperatures and better fuel mileage. And we can do that very consistently. Independent third party testing shows an almost linear impact: if we add 30% water, we're saving about 27% of fuel, and that's on a chassis dynamometer." The Fierce system uses precise ratios of water and fuel, along with a very small dose of emulsifier while processing.

Chassis dynamometers measure constant load, rather than real world performance. "We see that, when you begin to extrapolate the data, actual fuel savings will be greater because of the times when drivers coast as opposed to driving on constant throttle, as would be tested on a chassis dynamometer." In Conti's view, testing on a chassis dynamometer is a worst case and non-biased controlled scenario.

The process of emulsification takes place on-board the truck, requiring the fitment of specific equipment. The X1 and the imminent X2O, the two systems currently being promoted by Fierce, are intended for trucks already on the road. The X1 can be used on all trucks, while the X2O is designed for non-high pressure common rail (HPCR) vehicles.

Conti explains why Fierce is targeting the aftermarket. "Newer engines use HPCR systems. The X1 emulsifier unit has a logical solution that helps keep the paraffin and entrained water from condensation, and chemicals added by the refinery in the fuel are freshly blended into a homogeneous mix so that when it goes into the high pressure common rail, there's no risk of free water." Free water in this sense means the uncontrolled quantities of water in the fuel; this is one of the causes of the complaints about fuel quality in the US and thus one of the greatest challenges to high-tech engine component manufacturers; indeed, concern is such that the senior executives from Bosch, Continental, Delphi, Denso and



Stanadyne signed the Common Position Statement of the Joint (FIE) Manufacturers in March 2012 outlining their concerns, and stating that "minimum standards of fuel quality are essential to maintain durability and emission compliance over a longer duration."

Boasting a 50,000sq-ft facility with a laboratory, assembly area and warehouse, Fierce differs from other small companies with breakthrough technologies in that it does not license its technology – it manufactures its own products.

Fitting the X2O the system takes three hours, with no modifications required to the engine, meaning that the engine can continue to operate with standard diesel fuel when desired, and is the default condition when the system is off. "The whole point is that the diesel-water emulsified fuel only enters the engine when the truck has reached the correct operating temperature," explains Visser. "300 gallons of diesel would require 50 to 60 gallons of water, and another smaller tank of emulsifier. We run it all through an integrated control system that we put behind the cab." Fuel delivery is controlled by a series of valves, and significantly, the controller or driver can switch back to 'pure' diesel automatically or with the press of a button on the touch screen display in the cab.

"Fuel accounts for the largest part of any trucking company's standard cost," says the company's COO. "Trucking companies in the US operate on fairly thin margins, so a 20% saving means anywhere between US$800 and US$1,200 a month per truck, depending on driving conditions and loads, that can go directly into that fleet's bottom line, or be reinvested to improve profitability. We see that as a compelling argument for older trucks, not to mention the fact that we're reducing emissions as well."

The savings have been highlighted; how about the cost of the system? "The unit's going to cost US$13,500 for the water emulsion system," says Visser. "The return on investment is ten to 18 months, depending on miles driven. It's a very compelling business case for a fleet owner or independent operator."

One of the concerns with any technology which requires a system to be added to a vehicle is the weight of that system. "Both units weigh about 200-240lbs (90-110kg)," explains Conti. "Then you add the weight of the water, at 8lbs a gallon, and you could be looking at 500-600lbs including the water unit." However, the weight of the water is equal to the diesel that has been saved, so essentially the added weight is around 240lbs.

"The weight makes less of an impact in performance, but it's a consideration for those hauling close to their legal limit," adds Conti, "but when you're looking at a vehicle that typically moves 80,000lbs, it's not significant." And it's for the heavy-weight long-haul applications that this diesel-water emulsion system is intended: although diesel-water fuel has been used for many years in numerous applications, including industrial and marine, Fierce Fuel is focusing on trucks. "The form factor for our design and the technology that we control lends itself to smaller engines. The system is flexible and can be used on anything under 30-litres," says Conti.

This tees up our next question: can this technology be applied to light duty vehicles? "We can do it on a half-ton pickup. We can do it to a Volkswagen Passat. We can do it to any diesel engine, even a single cylinder generator," says Visser, "but we'd rather target it at long haul, over-the-road applications at this time with other units in development for smaller commercial vehicles in the three to 10-litre range."

The fuel system must be purged of the diesel-water emulsified fuel before the engine is shut off, something that Conti suggests would quickly become part of the driver's routine, or can be handled automatically by the system controller. "It takes about three to 15 minutes in most cases and is a function of a vehicle's specific engine and driving conditions."

So, how close is Fierce to putting this into series production? "We have trucks trialling the technology. We're currently in the process of starting mass production, and we do have commitments from a few fleets," says Visser, adding that Fierce Fuel is poised to launch its X1 and X2O products in the summer of 2014.

Fleet managers are faced every day with a catalogue of fuel saving, emissions-reducing technologies; why should they invest in Fierce Fuel technology?

Conti takes this question: "Aerodynamic solutions, so far, have been the easiest plum to pick, but they offer diminishing returns. You can add aerodynamics to the truck for a small gain, and then add skirts to the trailer and maybe save a little more, but add the two together and you might still only see a small cumulative value. We're offering a production system that provides a fuel improvement straight away of between 17% and 22% while under continuous load. Imagine what you can then do when you begin to add all the other things, like technological and aerodynamic improvements."

Selling green technology is not as easy as selling technology that offers an immediate financial benefit, and Conti returns to this theme as we wrap up. "It can cost US$30,000 to upgrade an existing truck to new technology that meets today's emissions standards or go with an alternate fuel such as CNG or LNG. For US$13,500, you can get 80% of the way there and save money on fuel." Furthermore, he adds, diesel-water emulsions are well documented by a number of universities, large corporations and government agencies.

Installing an infrastructure for alternative fuels is a slow, costly undertaking, and considerably more complex than finding somebody who sells diesel fuel and water, concludes Visser. After all, he adds, "clean water is commonly available."