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USE OF CERAMIC FILTERS IN BULK FUEL FILTRATION

1. **The importance of diesel fuel quality in modern engine performance.** The following is an extract from an article in Fleetwatch magazine (May 2009) by Patrick Swan of Aswan consulting.

DIESEL AND TRUCKING is synonymous and diesel is any trucker's biggest expense. It is also the energy source that makes his trucks move. Without it, his trucks simply go nowhere. Modern trucks are significantly more efficient in every way than previous truck generations. They are more powerful, faster, quieter, more fuel efficient, generally last longer and exhaust emissions are greatly reduced in line with international legislation. At the same time, very little in the basic engine has changed. What has changed is the combustion chamber. This is where the fuel burns and transfers its energy through the piston to the crankshaft. To make an engine more efficient, combustion must be more efficient. This also reduces some exhaust emissions.

Advances in fuel injection:
Exhaust emissions and fuel economy are the major design goals of modern engine manufacturers. In a diesel engine, raw fuel is injected into the combustion chamber where it must mix thoroughly with the waiting air, vaporise, auto ignite and burn. To start this process, the fuel is atomised so the overall air and fuel mixture is reasonably uniform throughout the combustion chamber. To improve combustion efficiency, there must be only one combustion chamber thus eliminating pre-combustion chambers, and the fuel must be injected at significantly higher pressures and through more holes in the injector tip to achieve a more uniform air fuel mixture.

Injection pressures have increased at least 10 fold in the past 10 to 15 years - from about 200 bar to a minimum of 2 000 bar, and the number of holes in the injector tip have increased to nine in some instances. These holes now have a much smaller diameter - less than 200 micron - and are laser drilled. Between 10 and 30% of the fuel entering an injector passes through into the combustion chamber. The remaining 70 to 90% is used to cool the injector tip and passes back to the tank which doubles as a radiator to cool the fuel. Modern injectors therefore see higher transient temperatures and greatly higher internal pressures. To control fuel flow within the injector, the internal tolerances have been reduced from around 10 micron to about 1 micron.

Advances in diesel fuel:
In line with international requirements, diesel fuel sulphur in South Africa has been reduced in steps to the current maximum of 0.05%, or 500 parts per million. Some fuel suppliers also offer a boutique diesel with a sulphur content of less than 50 parts per million. This boutique diesel is required for engines fitted with diesel particulate filters (DPF) and may also benefit some engines with exhaust gas recirculation (EGR).

Engine failures:
Modern engines are perceived to be more prone to failure than older engines. Given the fuel system changes in modern engines, the question is: What comes first, maintaining new technology engines or failure of new technology engines?

Dirty fuel:
The quality of diesel fuel in South Africa is controlled by SANS 342:2006. This specification loosely conforms to the European EN 590 specification and for South African conditions, gives equal performance. The major differences between these specifications are fuel sulphur and boiling range, both to assist the European industry to more easily reach their significantly more severe emissions targets than those applicable in South Africa. Because sulphur is such a good lubricant and also acts to control fuel oxidation at higher temperatures, it can be argued that South African diesel fuel is superior to European fuel - but is not as environmentally friendly.

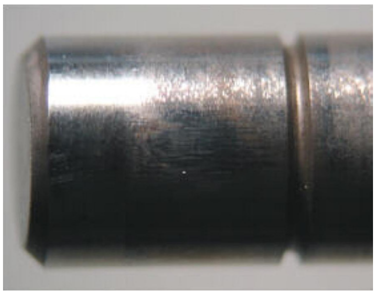

Figure 1

Figure 2

Figure 3

It's not the fuel therefore, but the solid contaminants in the fuel that matter. Solid particles in the fuel should be removed by the engine's fuel filters. When this doesn't happen, the injector nozzle needle sticks, resulting in uncontrolled fuel flow into the combustion chamber. Past engine technologies could operate with solid particles in the fuel that had a diameter of up to 5 or even 8 micron, and those particles would pass through the injector nozzle.

With a clearance of close to 1 micron, modern injectors will stick if 1 micron particles are in the fuel. Airborne dust is a major problem in South Africa due to our dry atmosphere and typical soil types and it is easy for these minute dust particles to enter any bulk fuel storage system unless breathers are also filtered to about 1 micron. The results of a sticking injector needle are disastrous. Figure 1 shows typical abrasive wear of solid particles on an injector needle and Figures 2 and 3 show typical resultant piston crown damage to a steel crown and an aluminium piston as the excess fuel burns on the crown.

Correct fuel filtration is critical. OEMs supply appropriate filters but often these filters are more expensive than aftermarket filter elements - so after market filter elements are used. That's all well and good but do ensure that the filter performance is equal or the results will be disastrous.

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2. Bulk fuel cleaning

2.1 Background

Contamination in the fuel adversely affects the performance and reliability of the combustion components and this will affect the overall efficiencies – carbon generation, heat, oil, emissions, fuel consumption, lifecycle and failures. Fifty to seventy percent of heavy-duty diesel engine failures are related to the fuel system, and South Africa has higher levels of dirt with smaller particle sizes than they have in Europe.

According to a recent study, a positive correlation between clean diesel and injector wear and performance was established. When diesel was cleaned from 80 ppm to 1 ppm, injector wear reduced from 10% to 0% when using high efficiency filters, and from 25% to 15% when using standard filters. Injector wear due to particulate in diesel can be significantly minimised if users become aware of the problem and enforce good housekeeping practices.

Clean diesel fuel – fuel that is within specification – still has 21 mg of dirt per litre. That's 21 g for each 1 000 litres. Cleanliness levels on our large mines commonly range between 50-75 mg per litre of fuel. The normal dirt-holding capacity of a premium brand synthetic fuel filter of a 420 hp engine is 45g. Normal engine fitted fuel filters struggle with their dirt-holding capacity, which raises the possibility that the filter becomes compromised during its service life-cycle.

The key issue with traditional cellulose media and with nanofibre filter media, is that too many dirt particles will cause the filter to plug. This results in particles being forced through, a problem which gets progressively worse as the differential pressure across the filter increases. Vibration and surges also accentuate this problem, as does any ingress of water. When these media fail, they can cause problems in three different ways. Firstly, the previously trapped particles can be released to pass through the break. This is called unloading. Secondly, the media fibres them selves can break off and migrate through the filter and thirdly, consecutive breaks can form a channel to allow fuel to by-pass the filter media.

To mitigate the impact of dirty fuel on engine performance, it is therefore critical that the fuel be pre-filtered to acceptable cleanliness levels prior to vehicle fuelling.

2.2 The use of ceramic depth filters for bulk fuel cleaning

Ceramic filters, comprising wear resistant Pyrophyllite and a binder offer the following advantages over traditional media:

1. ***Sustainable cleanliness levels can be maintained.*** The structural rigidity and strength of ceramics, compared to other types of filtration media, means that ceramic filters don't form channels, don't have medium migration and there is no risk of severe unloading of contaminants due to filter medium structural failure or during flow or pressure surges.
2. ***Structural integrity.*** Due to their inherent strength and chemical resistant properties. ceramic filters can operate successfully under a wide range of operating conditions including fluid surge conditions, hammering effects, operating pressure effects (high or low), severe pressure variances, chemical attack from contaminants such as surfactants, water, acids, and biocides.
3. ***Sustainable capture efficiency.*** Ceramic filters have a very high collapse strength. This is important because on collapse, unfiltered fluid can be routed back into the system. The ceramic filters will always block and not break thus achieving constant cleanliness levels.
4. ***Low resistance to flow or differential pressures.*** The constant porosity minimises pressure drops across the filter and resistance to flow. This low resistance has a direct bearing on the filter's lifecycle.
5. ***Holding capacity and dirt retention,*** is the main "Achilles heel" of other types of non-ceramic filtration media. In ceramic filters dirt remains in the filter due to the high structural integrity of the filter medium.
6. ***Reliable filtration monitoring***. As the medium does not compromise the filtration monitoring system, system sensors reflect the actual real time status of the filtration process. This allows much more efficient management of the filtration system and taking the guess work out of estimating filter change intervals.
7. ***Cost effectiveness.*** Ceramic media, due to their large contaminant holding capacities and high structural integrity, can prove to be a cost effective alternative to traditional methods due to lower maintenance costs.
8. ***Flexibility.*** Ceramic media porosity can be customised during manufacture to suit the required flow rates, micron rating, and differential pressure requirements of the application.

Ceramic filter media. Multi-functional for air, gas, liquid filtration e.g. air rating, coalescing, purification, cooling, & insulating.

Portable unit

Current installation