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Ignorance of fuel quality leads to poor performance and engine debilitation

Some firms sacrifice plant health and performance by ignoring fuel quality. Brid Walker of Fuel Technology Pty Ltd says treating fuel problems early can mean large short-term and long-term savings. He says some remedies are really just "good housekeeping".

In Australia we are fortunate to have fuel companies supplying what is normally a good quality product. Despite this, machinery problems caused by poor fuel are more common today than many fuel users realise.

Think of it as a health matter. The old saying "we are what we eat" is as true now as it ever was (even if people sometimes choose to ignore it). The same principle applies to engines: poor fuel results in poor performance and, inevitably, engine health and longevity suffer.

But where does low quality fuel come from? First, the manufacturers' product is not perfect: most experts agree the quality is decreasing as more overseas oil is imported. Second, once the fuel leaves the manufacturers' doorstep, some dreadful things can happen to it. Yet to a casual observer it still "looks" good.

Poor fuel generates further expense for mining companies, and unless the operation is very efficiently run, management may never know the real cause of machinery ills. Just in the last year, our company has received an increasing number of pleas for help from users of automotive diesel fuel (ADF, diesel or distillate).

Problems being experienced include reduced storage life of the fuel, fuel filter plugging, greatly increased engine deposits and increased smoking.

Most of the problems Fuel Technology has advised on are easily solved. And in view of the very low costs involved in doing something constructive, it is simply terrible economics to ignore the problems till the bitter end.

Because of the breadth of the topic, this article will be divided into three parts:

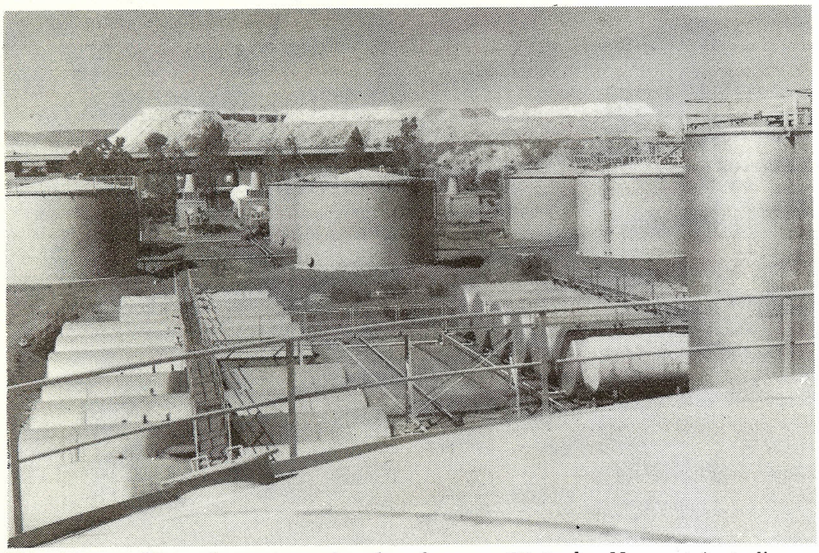
1. Fuel contamination, degradation and management practices;
2. Altered production methods for diesel fuel. What does this mean for the diesel operator, now and in the future?
3. Just what is Ferrous Picrate Combustion Technology and how does it reduce engine deposits?

Parts two and three will appear in later issues.

Fuel contamination, degradation and management practices:

Contaminants of fuels and lubricants are silent killers of machinery. Since contaminants of engine lubricants can originate in fuel, special attention to fuel quality is certainly warranted.

Some fuel contaminants are natural, originating in the particular stock of crude oil used to make the fuel and not removed in the process. Others come in from the outside environment. Still other contaminants are produced when fuel deteriorates.



With 6.9 megalitres storage capacity shared across 24 tanks, Newmont Australia Ltd's Telfer mine has to pay special attention to "tank farm management" to minimise fuel degradation.

Natural contaminants

Waxes are naturally occurring paraffins in crude oil. In diesel fuel, problems occur when low temperatures cause dissolved waxes to precipitate. The fuel then begins to look cloudy. The temperature at which this process starts is the "cloud point" of the particular fuel.

Caterpillar recommends a cloud point of at least six degrees below the minimum ambient temperature to avoid plugging of fuel filters. Fuel companies vary the cloud point to suit summer and winter conditions, so it is important not to carry over summer fuel, which has a higher cloud point, into winter.

Combustion of fuel produces oxides of sulphur which, with water vapour, form sulphuric acid. The greater the sulphur content, the more acid produced. Valve guides, liners, bearings and so on are all at risk.

Australia produces light crudes with a low sulphur content. Heavier crudes — those imported from Singapore are just one example — have a much higher sulphur content. Unfortunately, Australia's level of self-sufficiency in oil peaked in 1986-87.

Since then, the use of heavier high-sulphur crudes as a source for our diesel has been increasing. Once sulphur levels of 0.5% and over are reached in fuel, revised maintenance procedures are necessary.

Engine life can be dramatically reduced if oils of higher alkalinity reserve (TBN or Total Base Number) are not used. More frequent oil changes may also be recommended. The cooling system temperature should not fall below 80°C, and the crankcase breather system should be operating properly to limit condensation.

Aromatics are large cyclic molecules which are difficult to burn. They occur naturally in crude oil, but are also a product of catalytically cracking heavier crudes. They tend to lower the cetane number of fuel, that is they increase the ignition delay, and when in sufficient quantity they cause deposit formation, poor starting and reduced performance.

The importance of aromatic inclusions will increase with our dependence on overseas crude imports in years to come, however some firms are already taking measures to deal with these problems.

Carbon-rich fuels are also difficult to burn. They are high in unsaturated hydrocarbons (HCs) and therefore have a higher ratio of carbon to hydrogen than saturated HCs. The fuel has a greater tendency to form carbon during combustion, giving greater soot production (both in lube oil and exhaust) and deposit formation. Residual carbon content is more critical with high-speed diesel engines typical of mobile mining equipment, since the time for combustion is shorter.

Carbon promotes hot-spots on liners which then result in a burned oil film and subsequent piston scuffing, liner wear, sticking rings and deposits in turbochargers and engines. Ferrous picrate combustion technology greatly reduces these adverse effects and will be fully discussed in part three.

External contaminants

Water causes flow problems through filters and plays havoc with fuel injection equipment. Inclusion of water can occur at any stage after the fuel leaves the refinery. In most cases we have investigated, moisture either enters the fuel during transport, or more commonly through condensation during storage.

Sea water is an even more serious problem and leads to fouling deposits and corrosion in high temperature areas. Storage tanks should be fitted with suitably positioned drain cocks to aid removal of water and sediments.

Sodium chloride is highly reactive chemically and is introduced into fuel tanks through incorrect transport and handling procedures, usually as sea water, or through salt air condensation. As you can imagine, sodium contributes greatly to exhaust valve corrosion and deposits on injector nozzles and turbocharger turbines.

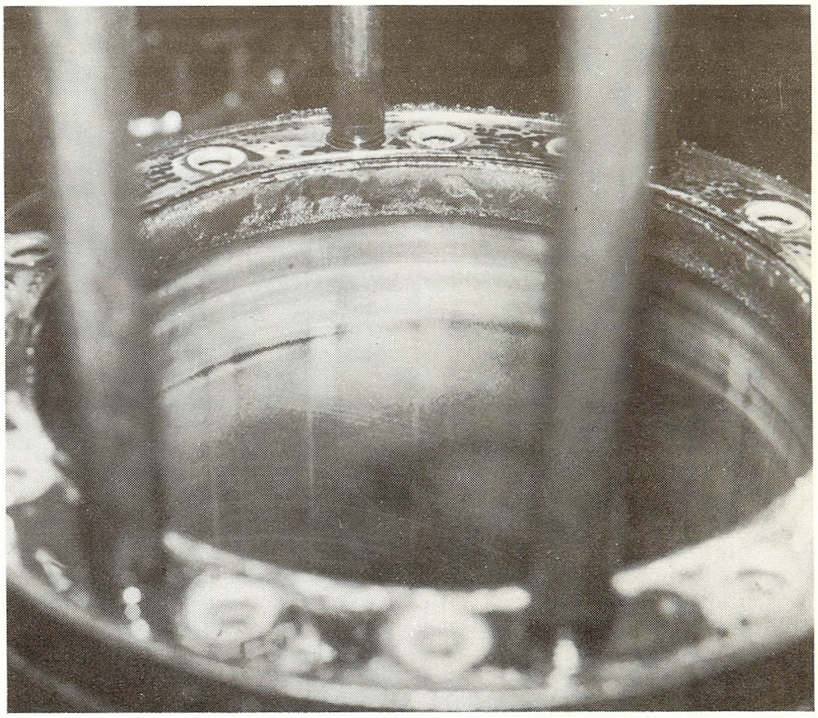
Such debris as rust, scale, dirt and weld slag readily find their way into fuel tanks and can have very serious effects. Most sediment can be removed by settling and normal filtration. However very small sediment particles will pass through filters to cause wear in fuel injection equipment, corrosion and deposits.

Sediment levels should not exceed 0.05% at the engine (after settling and filtration). Special filtration may be required to handle high sediment levels.

Many species of fungi, yeasts and bacteria can live quite happily in diesel fuel. As long as moisture is present, all their requirements for a good life are provided by the fuel. A recent visit to Consolidated Rutile's mineral sand operation on North Stradbroke Island clearly showed that high humidity regions are especially susceptible to microbial contamination of fuel.

The organisms usually enter with dust or water. They live in the water phase, while feeding off the hydrocarbons in the fuel and when large populations are present the fuel typically has a black, brown or green slimy sediment.

They can cause problems long before they have had time to breed to large numbers. Indeed, the problem may exist long before the typical symptoms of fuel filter plugging and damage to injection equipment appear.



The resultant deposit formation from diesel fuels high in aromatics, or carbon residue.

Besides damaging engines, organic acids produced by these microbes accelerate corrosion to fuel tanks. The spores produced by fungi are very hardy and resist even the most thorough tank cleaning programme so that they can once again infest the system.

The only sure-fire method of dealing with the problem is by using the proper biocidal agents designed for the job. Biocides such as FTC (an Australian product the equal of anything produced overseas) will quickly, safely and economically put paid to all the bugs.

Ash consists of metallic and other fuel contaminants that cannot be burnt during combustion. It acts like fine grit on the innards of engines. Ash causes abrasive wear to fuel injection systems, rings, liners, valve seats and turbochargers, as well as creating fouling deposits. Special filtration and settling procedures are the best means of reducing the ash content in fuel.

Contaminants from fuel degradation

The people from the Australian Institute of Petroleum are the experts on fuel deterioration and they are quick to point out that like all petroleum fuels, diesel has a limited storage life. Fuel of good quality and free of contaminants will give maximum storage life if recognised management practices are enforced.

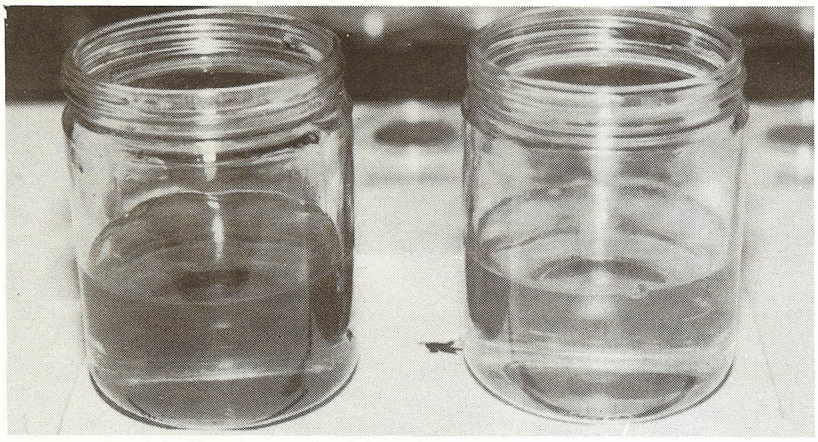
Fuel that has been allowed to become contaminated with water, sludges, microbial growths or even products from its own degradation, will undergo accelerated degradation. Fuel typically takes on a darker appearance and the amount of suspended particulate matter will increase as degradation proceeds.

Oxidation of the fuel produces gums and resins that do not evaporate readily nor burn cleanly. They cause fouling deposits on fuel injection equipment and filter plugging. Another degradation process is polymerisation of fuel components in which high molecular weight compounds are formed and these precipitate to tank bottoms and also plug filters.

The method of production of diesel is another factor affecting its storage stability. Diesel which is sourced by catalytically-cracking heavier crudes will exhibit greatly reduced storage stability unless an expensive hydrotreating process is used, but this is normally considered cost-prohibitive.

Storage tanks (both vertical and horizontal) should be fitted with drain cocks that will allow tank sediment which has accumulated at the lowest point to be run off. With vertical tanks, a conical base should be installed with a small pit positioned at the centre of the cone for sediment collection. From this pit, a pipe should run to the drain cock fitted at a convenient position on the outside of the tank.

Horizontal tanks should have the drain cock positioned towards one end, and on the underside, of the tank. The other end of the tank should be elevated so that the fuel outlet is about 10 cm higher than the drain cock.



Both samples of distillate have suffered degradation in storage. The sample at left is suffering from severe microbial infestation, even though it has a high turnover rate.

Tanks should be installed on concrete pads, preferably in an area protected from wind-blown dust. Vents, incorporating screens (or even filters in very dusty environments) should be fitted and their design should ensure no dust enters through fall-out.

Where high ambient temperatures are experienced, try to keep fuel as cool as possible. Tanks should be painted in light colours. Horizontal tanks aligned east-west will absorb the least heat. A tropical roof over these tanks can make a huge difference to in-tank temperatures in extreme situations.

The larger the fuel volume held in a vessel, the less the diurnal temperature fluctuations. For example, horizontal tanks may have diurnal variations of 10°C, whereas large vertical tanks in the same situation may vary only two degrees Celsius or less.

A 10°C increase in fuel temperature will approximately double its rate of degradation. With the trend now towards secondary production methods for diesel fuel, these considerations should not be overlooked.

Additional hints

To get the best out of the fuel, a wise user will attend to the following points.

1. The fuel storage area should be kept clean.
2. Fuel hoses should be capped and hung up with their ends pointing down.
3. Tank sediments should be drained
a) when tank is almost empty and prior to refilling, and/or
b) on a weekly basis (depending on the time between refilling the tanks).
4. Fuel tanks should be almost empty prior to refilling, so as to minimise dilution of fresh fuel with aged. This is particularly important where the fuel turnover rate is low.
5. Routine visual inspection of fuel when opening drain cocks is essential.
6. Fuel, as delivered, should be regularly analysed.

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Distressing gap between fuel standard required and that produced for modern engines

Brid Walker, of Fuel Technology Pty Ltd presents the second part of a series of three articles on identifying, understanding and correcting problems caused by diesel fuel.

Automotive diesel fuel can be contaminated when we buy it. What we formerly regarded as high-performance distillate may now incorporate various unwanted components. Further contamination occurs with handling and storage — mainly from slack housekeeping. Dirt, moisture, scale and microbes are not uncommon.

With time, fuel breaks down to release further contaminants, the rate of its decay increasing with the level of contamination. Sounds grim, and it is, especially if we're trying to make a profit using machines running on the stuff.

Fortunately, the remedies are mostly cheap and simple. They include better housekeeping practices, improving storage facilities and use of an **effective** fuel additive. If we do nothing the costs can be very high indeed, though the real cause of poor machine life and efficiency can remain well hidden from managers and accountants.

Consumption up

It's just as well the remedies are cheap: problems resulting from low quality fuel are increasing as production of Australian crude declines. To cope with our increased use of fuel, particularly diesel, more crude is being imported. The imported crude is not nearly as good for making quality diesel as the local crude.

Australia is using more diesel fuel than ever before. In 1960, diesel engines were much less common than they are now. There were still plenty of trucks and tractors running on petrol. In 1960 the ratio of petrol:diesel consumption was 5.5:1. By 1985 it was down to 1.9:1.

Today, the ratio is estimated at less than 1.7:1 and still falling. The ratio will continue to fall because of increased diesel consumption by transport, mining and other industrial activities, coupled with a strong trend to diesel-powered cars and light commercials.

Figures just released by the Australian Institute of Petroleum show diesel consumption is increasing by 4% annually; an alarming statistic, twice the figure predicted only 12 months ago.

Australia's level of crude oil self-sufficiency peaked at around 80% in the mid-1980s and is now declining. The Australian Minerals and Energy Council estimates that by 1990/1991 we will only be 55% self-sufficient. Australian refining and marketing companies expect a 45% increase in diesel fuel sales over the next 10 years.

But unless **major** new fields are found — and this is acknowledged as unlikely — domestic production in 1998 will be sufficient to supply only the Sydney and Melbourne metropolitan areas.

Some Australian-produced crude is exported. Since January 1, 1988 when the Federal Government deregulated the crude oil market, producers may also sell offshore. (Australian refiners may also sell their products overseas, but competition is fierce.)

Although the increased export is balanced by increased import, the net result is Australian machines must burn even more diesel derived from imported crude.

It's a sad situation, because our crude is one of the best for producing diesel without having to resort to secondary treatments. Our crude has an average 30% yield. Compare this to the 21% typical of imported stocks, which Ampol's research manager, Dr A J Clark, says are generally heavier, higher in sulphur and less suited to production of diesel. (The corrosive effects of burning high sulphur fuel were discussed in part one.)

How is Australia's increased demand for diesel fuel to be met? Refiners are today in an increasingly difficult position. They have two options if they are to meet today's demand for diesel: refine more crude; or attempt to squeeze more diesel from each barrel processed.

Refining more and more crude does nothing to improve production efficiency. It also ignores another of the refiners' problems. Having separated off the easily marketable products, refiners have to do something with the remainder.

Unfortunately for them, the market for residual products has decreased since 1984 (eg demand for fuel oil has dropped 30%), and this trend is expected to continue, leaving refiners with an excess at the heavier end.

Refiners can increase the yield from each barrel of crude by including in the fuel extra products obtained (a) by relaxing the fuel specifications, for example by extending the distillation temperature range, or (b) from secondary processing methods which convert some heavily residual components into forms suitable for including with distillate.

Extending distillation range

The traditional way to produce diesel fuel was by distilling the desirable fractions from crude oil. Thus the name distillate. Increasing the distillation temperature range increases the yield by including in the distillate some less desirable, heavier fractions.

Although a less homogeneous fuel is produced, some degree of balance is achieved through inclusion of LCOs (see below). At a recent conference of the Australian Institute of Petroleum, BP researchers AED Gunn in Australia and CJS Bartlett in the UK said extending the final boiling point just 30°C will increase diesel yield substantially.

Greater yield has a price. The heavier fractions include waxes which can raise the cold filter plugging point (CFPP) — the filter is clogged prematurely, at a higher minimum temperature than before. Also, substantial increases in density and viscosity may occur.

At the same conference, a service engineer at Caterpillar Australia, Marshall McKelson, said viscosity and density of diesel fuel can have important effects on engine operation. Since fuel is metered through injection systems on a volume basis, and density reflects the heat value, such variations alter the power output. Injection timing depends on fuel viscosity, which can affect the advance and hydraulic governor mechanisms.

Low viscosity causes leakage and excess wear, while high viscosity causes filter damage and pump wear (because of increased resistance). The higher the viscosity the worse the injector spray pattern, leading to reduced power and economy. Poor spray patterns also tend to wash cylinder walls, removing the oil film and causing excessive wear and dilution of the lube oil with fuel.

The Standards Association of Australia says that fuel of high distillation temperatures promotes increased deposit formations, wear and exhaust smoke. Full load tests on heavy duty direct injection engines have shown significant increases in black smoke for fuels with 90% distillations above 338°C. It is worth noting that current (1988) Australian Standards exceed this temperature (a 357°C maximum is allowed).

Secondary processing

Light cycle oils (LCOs) are made by splitting some of the heavier residual products by a process known as "catalytic cracking". LCOs have a few problems. They are carbon-rich compounds, highly aromatic with many single, double and multi-ring structures. They are also relatively unstable and do not burn well, so refiners limit the amount they include.

The cetane number of LCOs is of the order of 20–30, that is they have a long ignition delay. We've been fortunate to enjoy fuel of cetane numbers 50–55 in recent times and the new Australian Standard for diesel announced last year allows for a minimum of 45.

All Australian refineries now have facilities for mild hydrotreatment of LCOs, which is a process of adding hydrogen atoms to break most of the double and multi-ring molecules to give single-ring molecules. This process helps stabilise the mixture and removes a deal of sulphur, replaced in the molecule with hydrogen.

Unfortunately, mild hydrotreating has little effect on the cetane rating. It is possible, through a process of severe hydrotreating, to fully saturate these compounds and raise the cetane number to that of specification diesel. At this stage the cost is prohibitive, although this clearly remains an option for the future.

Even when hydrotreated, LCOs are still quite carbon-rich. Carbon-rich fuels are strongly associated with deposit formations and their degradation can lead to filter blockage, injector fouling and further loss of combustion performance.

The higher aromaticity due to LCO inclusion is associated with increased black smoking. Also, LCOs are one of the main contributors to production of gums and insoluble particles, through a variety of reactions (eg oxidation, polymerisation and esterification).

Modern engines

Modern diesel engines need high-quality fuel. Engine manufacturers aim for high fuel efficiency, high reliability and extended maintenance intervals. They also have to meet new levels of exhaust emissions. Most engines built today for the mining and transport industries are turbocharged and intercooled, with a trend to electronically controlled fuel injection, much higher injection pressures and faster delivery of fuel.

Injector orifice sizes will probably become even smaller to aid misting. Turbocompounding and the use of ceramics are also likely to be considered by engine manufacturers seeking improvements in engine design.

All very impressive, but why pay for the last word in engine technology unless you can take advantage of it with good fuel.

The very best diesel engines today are about 44% efficient. Theoretically, 50% efficiency is obtainable but this needs a high performance fuel.

The fuel must also burn fully and cleanly, and part three of this article covers a somewhat neglected area of technological development — fuel combustion and the truly exciting headway made in combustion technology.

A striking example

In the name of engine efficiency, some engine manufacturers have repositioned the top compression ring closer to the piston crown, thus reducing combustion space. The build up of carbon on the top land and ring grooves can be rapid.

Contact of these deposits with the cylinder wall causes areas of "bore polish" as the abrasive deposits wear away the cylinder cross-hatch. The problem worsens with ring sticking, increased oil consumption, blow-by, further deposits and thickening of the lube oil with soot, which rapidly exhausts the oil's cleaning effect and increases abrasive wear.

These are classic symptoms of a combustion problem. Despite this, it is a fair bet that in 95% of cases, the lube oil is the first thing to be blamed for the problems! Changing to an oil with better detergency/dispersancy qualities will help, but is a band-aid remedy.

The future

We can expect our fuel to suffer the following changes: amount of LCO inclusion, cold filter plugging point, distillating range, sulphur, viscosity, particulate matter, and density all to increase, and cetane number to decrease.

Not one of these changes is beneficial to users.

We can expect increased use of imported crudes, with more products of catalytic cracking and extended distillation temperatures included to increase the yield of diesel from each barrel.

The fuel companies will continue to do their best, but there seems to be a widening gap between the fuel standard required by modern engines, and that being produced. Fuel contamination and degradation during user handling and storage further aggravates the problem.

Our company believes it would be eminently intelligent for equipment users, engine manufacturers and fuel producers to work together, accepting compromises where necessary. Is this likely to happen?

Perhaps it doesn't matter, since developments in combustion technology have provided another solution able to satisfy the aims of all three parties. This will be discussed in part three.

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Improving diesel fuel quality, combustion and reducing exhaust emissions in engines

This is the third part of an article aimed at identifying, understanding and correcting engine problems related to diesel fuel. We now look at improving fuel combustion, and cashing in on the many benefits of ferrous picrate.

By Brid Walker, B.App.Sc.
Fuel Technology Pty Ltd

In the previous two parts of this series article, loss of engine performance and deposit problems were blamed directly on fuel contaminants, degradation of fuel in storage and the current trend to produce diesel fuel of lower performance.

For this to occur at a time when engine designers are building more sophisticated engines is of considerable concern for equipment operators.

However, recent developments in combustion technology bring some good news for fuel users. In this final part, the contribution of ferrous picrate to engine and exhaust cleanliness, reduced maintenance and fuel efficiency is discussed.

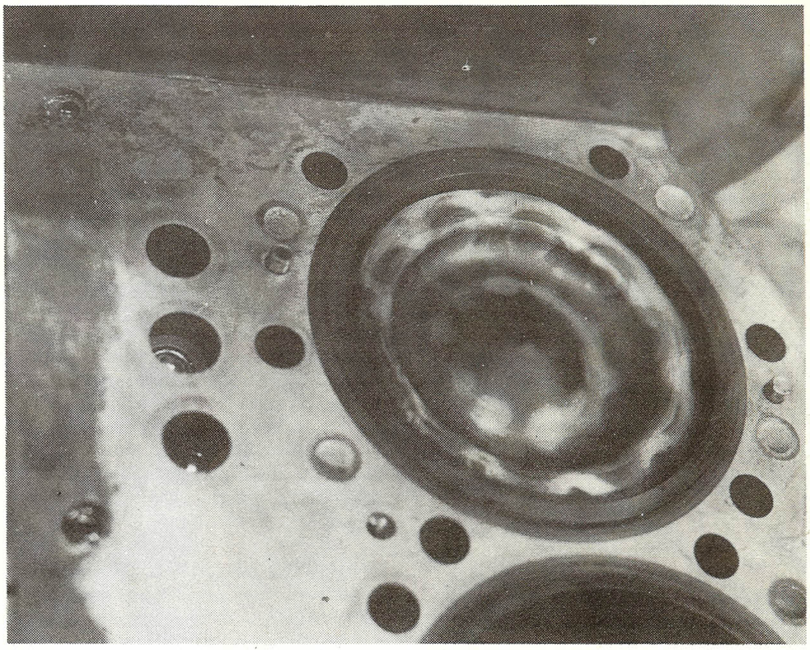
Whatever the application — mining, power generation, road transport or farming — equipment operators are demanding greater efficiency from their machines. To this end, engine manufacturers try to improve engine efficiency. There are three areas where improvements can be made.

Mechanical efficiency (ME) refers to how well an engine converts heat energy released by the fuel into mechanical energy. Some heat is lost into the cooling system. This is one area where the use of ceramics offers potential for reductions in heat loss. Internal friction can account for up to 25% loss of power! Approximately half of this occurring between the piston rings and cylinder walls.

Volumetric efficiency (VE) is determined by the degree to which cylinders are filled with air during the intake stroke. Naturally aspirated engines have VEs of 70-80%. Supercharging, turbo-charging and turbo-compounding are methods of increasing VE.

Thermal efficiency (TE) is the efficiency of converting the energy contained in a fuel into *useful* heat. Engine design has made significant contributions here also, with combustion chamber designs which optimise turbulence and mixing of air and fuel. Better misting and faster fuel delivery are provided by more advanced fuel injection systems.

There is one area which engine designs cannot improve. That is, the chemistry of combustion. It is this area where ferrous picrate is of direct benefit.



Same engine with ferrous picrate treated fuel. Note how the deposits have been eroded due to a cleaner burn

More work — same fuel?

The conditions inside the combustion chambers of internal combustion engines are certainly less than ideal for efficient combustion. The idea of chemically improving the combustion reaction is not new, as demonstrated by the countless number of fuel additives offered for sale. However, the market place generally views the use of additives with a great deal of scepticism, since very few have been demonstrated to assist combustion, and those that have were often too pricey to use.

For ideal combustion, fuel should be burnt completely and as quickly as possible (without exploding). Higher temperatures are reached as combustion time is reduced. Heat release occurs almost instantaneously and at minimum volume (ie piston at top dead centre). The cylinder pressure peak will be greater and occur earlier. More work will be extracted for the same energy released.

In practice, there is a delay period before ignition is initiated. During this time, fuel mist is mixed with air and vaporised, and pre-flame reactions take place to create 'localised ignition'.

The second phase is one of rapid combustion, where the fuel that has had time to vaporise and mix thoroughly is burnt. By now the bulk of the fuel has been burnt.

During the third phase, the remainder of the fuel charge is burnt as it is injected. This is a less efficient burn, and is followed by the 'tail of combustion'.

The whole process can take as long as a quarter of a crankshaft revolution. The quicker the process, the more work is done for the same fuel burnt!

Combustion problems

As fuel is burnt, energy is progressively released as molecules are continually broken down into smaller, less complex ones. During the peak of this reaction, carbon monoxide (CO) is formed at extremely rapid rates. The oxidation of CO to carbon dioxide (CO_2) is, by comparison, quite slow, so the combustion environment becomes choked with CO. This limits the progress of the fuel burn. Instead of a clean burn, less desirable products result (eg noxious emissions and deposit formations). Any trend away from a high performance diesel fuel will magnify this result.

Ferrous picrate

Strictly speaking, the action of ferrous picrate is not chemical. That is, it does not alter fuel specifications, and will not provide more energy than contained in the fuel, so there can be no detrimental effects. This is important from an engine warranty point of view. The overall reaction is modified to favour oxidation reactions. More complete combustion is achieved in a shorter time. The action is threefold.

Primary atomisation. The solvent carrier acts as a misting agent upon injection of the fuel, thus presenting a larger surface area of fuel exposed to the air.

Secondary atomisation and initiation. According to University of California, Los Angeles, studies by A. F. Bush, et al, ferrous picrate microcrystals are formed in the air fuel mixture due to solvent evaporation. These quickly absorb heat energy and ignite. Further atomisation results and a system of multiple flame fronts develops. This increases the flame speed.

Catalysis. As the ferrous picrate ignites, iron radicals are released which act as a catalytic agents between oxygen in the air and carbon in the fuel. Clearly, the catalytic action promotes oxidation. Similarly, this rapidly assists oxidation of CO to CO_2.

Thus the ignition delay is reduced and the period of rapid combustion is assisted by a faster flame speed, more intimate mixing and a more complete burn. The results: peak cylinder pressures are higher, occur earlier and last longer, providing smoother combustion and less mechanical stress. Less desirable fuel components are burnt more cleanly.

Power, fuel efficiency

Subsequent engine efficiency improvements have been well documented in large fleet use, since the late 1970s. Field trials in Australia in mining and power generation industries have consistently demonstrated fuel efficiency improvements of 3-5% for slow — medium speed diesels, 5-8% for high speed diesels.

Test methods employed were:

- Specific fuel consumption.
- Exhaust Carbon Balance.
- Statistical Computer Model.

The Exhaust Carbon Balance method (AS2077-1982) offers the most accurate, quick and hassle-free test method. This is because it measures *instantaneous* flow rates. The above results have been confirmed in controlled trials at Curtin University's thermo-dynamics laboratory (WA). Quite simply, less fuel is required to do the same work, and more power is produced for the same throttle setting.

Exhaust emissions

There are significant benefits for underground operation. Tests at NSW Department of Mines at Londonderry Research Station determined a reduction in exhaust emissions using ferrous picrate as a catalyst. Although these tests were not long enough to properly 'condition' the test engines, the following reductions were observed:
Hydrocarbons (HC) 38%
Carbon Monoxide (CO) 12%

Reductions in HCs of 80% and CO of over 50% are regularly recorded in field trials using exhaust gas analysis equipment.

Reduced engine deposits

In an SAE Technical Paper (No. 831204), by J B Parsons and G J Germane, the maintenance benefits of ferrous picrate were closely examined in several fleets. One 69 piece fleet of Caterpillar equipment included haul trucks, D9 and D10 dozers, 992 loaders, scrapers and graders. The first engine examined was a 348 Cat from a 992C loader with four months catalyst use, and 8000 meter hours.

Examination of the engine showed carbon deposits at near 'normal' levels but with a marked softening of the normal hard carbon being noted in some areas — particularly the centre of the piston crown where bare metal could be exposed by wiping with a rag. There was also evidence of reductions in deposits in the upper liner area above the ring travel, and soot in the manifold exhaust area was "finer and drier".

A progression of this pattern was observed with engines subsequently overhauled. At the end of the two year trial, there was almost a complete absence of hard engine carbon, as the soft residue which remained was easily wiped from cylinder heads, valve ports and piston crowns.

The normal build up of hard scale on these surfaces was absent. Piston rings were exceptionally free of deposits and cylinder compression in high hour engines had been maintained. Valve and piston part numbers were clearly visible. Less exhaust smoke was evident and engine 'startability' showed a marked improvement. Of particular interest was the reduction in liner wear being experienced by the haul trucks. At 8000-9000 hours, liners could be re-used. This was not typical of previous experience. Fuel efficiency improved by seven per cent.

A thirty-two piece fleet of GM powered buses showed similar maintenance benefits. After 12 months operation on the catalyst treated fuel, the fleet began burning blended fuel with no increase in exhaust emissions, while still maintaining the same level of engine cleanliness. However, when the catalyst was removed from the fuel, smoke increased to unacceptable levels. Fuel usage reduced 8% due to ferrous picrate treatment.

Several Cat D353 engines from D9 H dozers in open cut operations were also inspected. They'd operated for some 2800 hours on catalyst treated fuel. Of particular interest was the absence of hard carbon encrustation on the upper ring land of pistons, an area of normal build up, which often results in bore polishing. Sulphur and hard carbon deposits had vanished from valve faces and exhaust valve stems were exceptionally clean.

The extension to engine life can be quite substantial. Particularly where severe combustion problems (eg bore polishing) have been encountered.

Cleaner oil

Cleaner combustion and cleaner oil go hand-in-hand. High carbon solids (soot) in lube oil is a very common complaint these days, which rapidly overloads the oil's detergency/dispersancy package. Higher quality oils and more frequent change intervals might appear to be the correct action to take, but is, in fact, a 'band aid' solution to a combustion problem. Ferrous picrate is of benefit by directly assisting combustion.

Biological growths

FTC, the Australian formulation of ferrous picrate, also has strong biocidal activity to effectively control fungal, yeast and bacterial infestations in fuel.

Reducing maintenance, downtime and fuel costs are prime objectives of any efficient operation. Achieving this goal is made increasingly difficult as fuel quality is reduced. Maintenance people need to know more about their fuel specifications so that they can tailor their maintenance to suit.

In conclusion, ferrous picrate may be unique. It is one product that has been proven beyond doubt to live up to its claims as a combustion improver.

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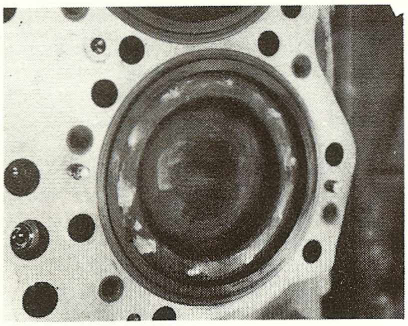

Cummins KT19 engine. Note deposit formed after running on low grade fuel.