LUBE-TECH

NO.21

THE FUTURE FOR AUTOMOTIVE TWO-STROKE ENGINES (Part 2)

CURRENT DEVELOPMENTS

In the previous issue of Lube, the origins and initial development of the 2T engine were described. The earlier engines, characterised by smoky exhausts and poor specific fuel economy, will be remembered by many of the older fraternity, as they provided motive power for many commuter lightweight motorcycles, mopeds and scooters in the prewar and postwar years. Many vehicle manufacturers in the UK used proprietary power units manufactured by specialist engine manufacturers such as Villiers, who dominated the market, although smaller engine suppliers included companies such as British Anzani. A number of other companies, including Scott, Associated Motorcycles, Excelsior and latterly Ariel also designed their own engines, use of which was restricted in the main to vehicles of their own manufacture. However, with the demise of the UK motorcycle industry, 2T engine developments, which have progressed steadily during subsequent years, have been largely attributable to overseas manufacturers with assistance from some UK specialist consultancy organizations such as Ricardos at Shoreham. These have included the Japanese 'big four' motorcycle manufacturers, Honda, Kawasaki, Suzuki and Yamaha, and closer to home, European car manufacturers such as Wartburg, Saab and DKW. This situation of steady if unspectacular development changed dramatically with the introduction of an entirely new approach to 2T engine design, namely the Orbital 2T engine. This power unit was enthusiastically seized upon by a number of vehicle manufacturers, notably Ford, who invested heavily in further developing what was confidently predicted to be the power unit of the future.

Dramatic predictions were made for the rapid uptake of the use of such engines, which, if realised, would have had major implications, both qualitatively and quantitatively, for the lubricants industry.

However, it was emphasised at this point that there were several possible variants of the Orbital principle, and the Ford engine was only one example. It would have been possible, for example, to use a more conventional wet-sump system, although some form of charge compression would be required as opposed to the use of the crankcase compression used in the conventional dry-sump 2T engines. 'Wet-sump' engines would possibly have required a rather different type of lubricant compared with the type of oil required in the "dry-sump" system envisaged for the Ford engine, although in many ways the lubricant requirements would have been similar for the two types of engine, e.g. in the reduction in the need for antiwear type additives due to the absence of valves and their associated operating systems.

DRY SUMP SYSTEM

The oil pump delivers oil to reed valves of each cylinder.

Any oil draining into the crankcase is scavenged and returned to the oil reservoir.

Oil circulation through engine is high, nominally 70-80%.

The lubrication system dictated the use of rolling bearings rather than the more conventional plain bearings.

The lubrication system was essentially a "total loss" system, where all of the lubricant was eventually discharged into the environment.

WET SUMP SYSTEM

Similar to a conventional four-stroke engine.

The oil is collected and retained in the sump.

The oil is pumped to connecting rods and bearings.

Bearings are of the conventional pressure-lubricated shell type of plain bearing.

The requirements of the lubricants by these two types of Orbital engine were summarised as follows:

DRY SUMP

No valve train therefore no requirement for e.g. ZDDP anti-wear agents.

Diluent undesirable.

Low viscosity with high viscosity index. (SAE 5W/20?)

Synthetic-based formulation likely to be the preferred option.

Tendency for combustion chamber deposit formation would have required a low ash or ashless lubricant.

High temperatures require strong anti-oxidancy.

WET SUMP

Again, no valve train therefore no requirement for e.g. ZDDP anti-wear agent.

Diluent unnecessary/undesirable.

Conventional base oil plus viscosity index-improver is possible (SAE 10/30?).

Polymer deposits may favour synthetic approach.

Tendency for combustion chamber deposits requires a low ash approach.

The conclusion was that, in spite of the substantial differences between the types of the Orbital engines described above, it may well have been possible to meet the requirements of both types of engine with a single lubricant, although the requirements of this lubricant would have been significantly different to those used in conventional four-stroke engines.

In spite of the total-loss lubrication system of the dry-sump engine, it was anticipated that there would have been a significant reduction in lubricant usage compared with the usage rates in conventional 4T engines of that period, which would have adversely affected lubricant volumes had this system been adopted.

Unfortunately for those who had invested heavily in the development of the Orbital engine, the rapid pace of engine development could not keep up with the even more rapid progress of the environmental legislators, who introduced a programme of mandatory emission control levels which even the more fuel efficient 4T gasoline and diesel engines were hard-pressed to meet, let alone the 2T, even in its Orbital guise. As a result, all of the earlier predictions of rapid uptake for this type of power unit were proved to be wildly optimistic.

However, in spite of this setback, the Perth-based Australian Orbital group continued to broaden its sphere of interests and currently provides a range of engine technologies for a broad range of applications including marine, recreation, motorcycle and automotive applications. The new technologies are known collectively as the Orbital Combustion Process (OCP) and use air-assisted, spray-guided direct fuel injection, lean burn combustion and electronic control systems to improve the performance of the combustion process. The main future of OCP technologies is considered to be associated with developments for the automotive 4T market. Last May, Orbital Engine Corporation gained the Chairman's Award in the Australian Technology Awards for its development of OCP for both 2T and 4T engine applications.

The Orbital 2T engine has now taken on a new lease of life with the technology developed both by themselves and by Synerject, the 50:50 tie-up between Orbital and Siemens Automotive, this new technology having now been adopted by four motorcycle producers.

Aprilia has already adopted the Orbital 2T engine in its latest SR50 DITECH sports scooter, which is claimed to offer fuel consumption benefits of some 40%, and reduction in oil usage by 60%. Since then they have introduced their Orbital-engined Scarabeo 50, claimed to be the first 2T scooter in the world to achieve the EURO 2 emissions standards without the benefit of a catalyst, which is remarkable indeed for a 'humble' 2T engine. See photographs of engine and graphic detailing lower emissions, fuel and oil consumption overleaf; engine and details refer to the DITECH 50 engine.

Peugeot Motorcycles, Europe's third largest motorcycle manufacturer, launched its innovative Looxor 50 TSDI model at the Paris Motor Show. On sale from early 2002, this model incorporates both Orbital's direct injection technology and Synerject's engine management system.

Sanyang, the Taiwanese automotive and motorcycle manufacturer and distributor, have released details of their SYM RS21 150 c.c. scooter, which claims 10% power increase, with 30% and 20% reductions in exhaust emissions and fuel consumption respectively compared with a conventional 4T carburetted engine. Sanyang now have an emission control system, which

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can meet EURO II 2T emission requirements by utilising a four-aspect system including a Catalytic Converter, an Air Injection System (bleeding fresh air into the exhaust pipe), a Lean Setting Carburettor and Speed Limitation controls. Two-stroke's EURO I emissions levels can be met with only two of these controls, the Catalytic Converter and the Speed Limiter.

Kymco, a second Taiwanese manufacturer, previewed future engines at the Milan show.

Meanwhile, Honda have developed their own system known as Active Radical Combustion 2T technology, where a complete combustion of all the

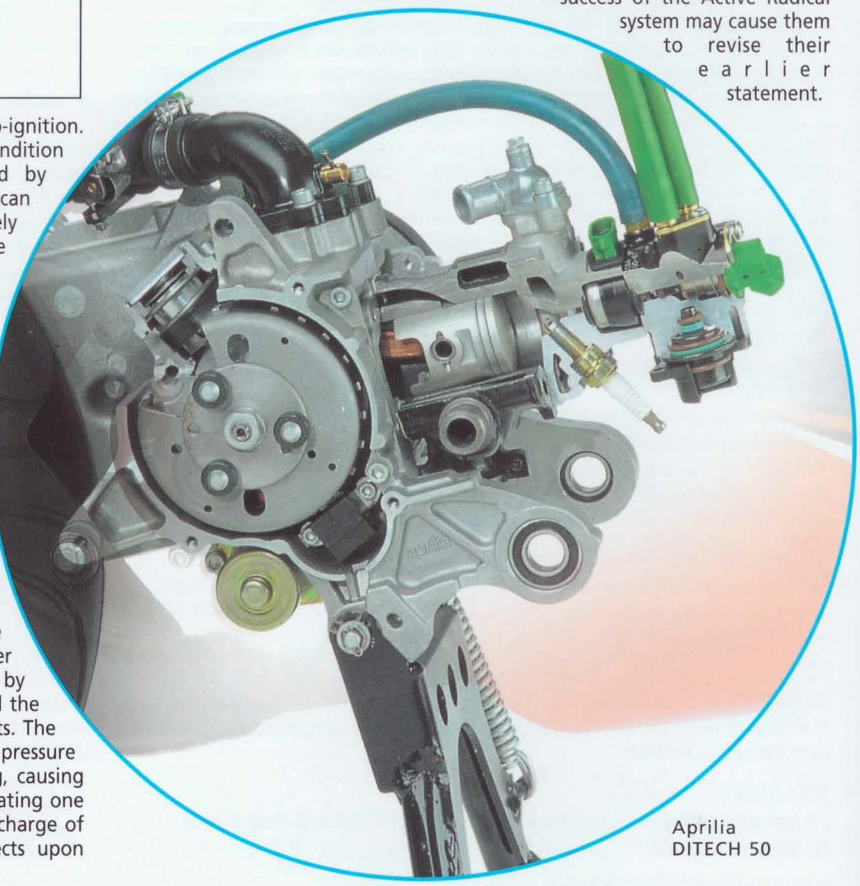
fuel in the cylinder at any one time is achieved by using auto-ignition. The term auto-ignition immediately conjures up to many the condition known as engine 'knocking' or 'pinking', which is caused by uncontrolled ignition and is normally extremely undesirable as it can lead to engine damage. In this situation, the fuel ignites prematurely before the sparking plug fires, and whilst the piston is till on the up-stroke. The hammer-like explosive pressure surge on the rising piston will not only reduce the power output and lead to excessive fuel consumption, but more seriously can cause premature and sometimes catastrophic failure of the piston. However, the Honda system actually makes use of this phenomenon in a positive way. At the right pressure and temperature, fuel molecules break down into short-lived active radical molecules, which are highly unstable chemical compounds, being an intermediate step in the actual combustion process. If some of the hot exhaust gasesremain in the combustion chamber after the power stroke has taken place, the presence of the small quantity of active radical molecules can cause the incoming fuel charge to auto-ignite at a lower temperature than would be the case in the absence of such active radical molecules. In the Honda system, highly unstable active radical molecules are deliberately combined with the incoming fuel charge enabling the mixture to auto-ignite at a lower temperature than a pure gasoline mixture. This is accomplished by using a variable exhaust port valve, which increased or decreased the fuel mixture pressure in the cylinder to meet varying requirements. The valve position is sensitive to r.p.m. and throttle opening, so that the pressure required for auto-ignition is achieved at exactly the right timing, causing complete combustion of all of the fuel in the cylinder, and eliminating one of the main problems associated with 2T engines, namely the discharge of unburnt fuel through the exhaust port with the adverse effects upon emissions and fuel economy. A further benefit is the increased power at low rpm and improved throttle response.

The system also overcomes problems known as 'four-stroking' or even 'eight-stroking' common in conventional 2T engines. This problem occurs at small throttle openings, when the amount of fresh charge of fuel entering the cylinder is small compared with the amount of exhaust gases remaining, and the fresh charge is diluted by the exhaust gas to such an extent that it cannot be ignited. Unburnt fuel (and possibly lubricant) is therefore discharged thorough the exhaust port resulting in adverse effects upon emissions and upon fuel economy. This process of non-ignition will continue until sufficient of the residual exhaust gases have been flushed out of the combustion chamber by fresh incoming charge to render the mixture combustible whereupon ignition will occur. At this point, the combustion chamber is re-filled with exhaust gases and the process is repeated. The engine therefore can misfire on alternate power strokes and therefore behave like a four-stroke engine.

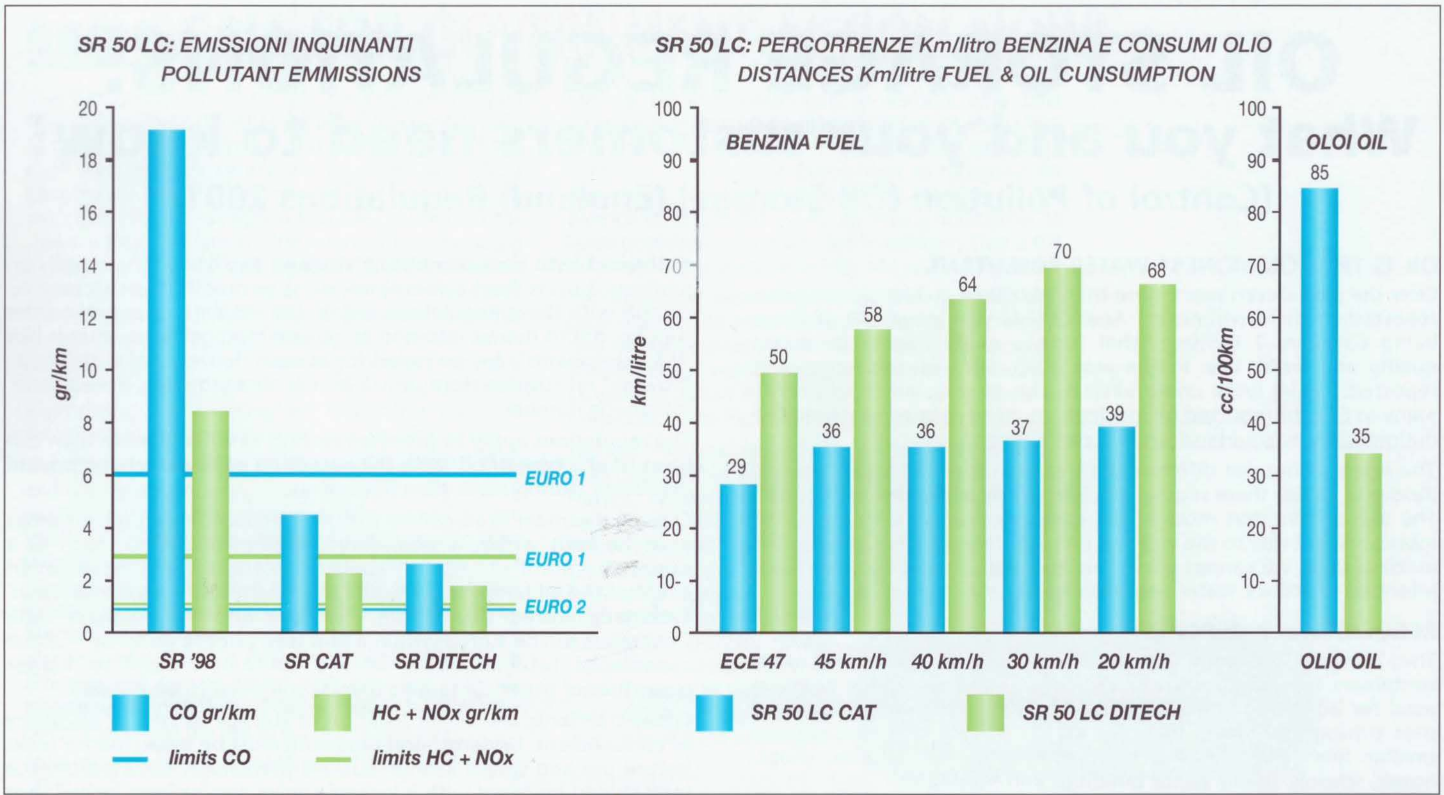
However, by igniting the entire mixture without the use of a spark, the Honda system burns off all of the fuel and lubricant in the cylinder on every power stroke, hence eliminating misfiring.

The Honda system was initially trialled in one of their 400 c.c. off-road motorcycle using fuel injection although the system would work equally well with carburettors. Competitive successes were achieved, including placings in the prestigious Granda-Dakar event, although this was not the primary object of the exercise. The 400 c.c. engine was chosen since the large combustion chamber and high piston speed gave the most unfavourable burning characteristics, on the basis that if the system worked in the large engine according to theory, it would be even more likely to work satisfactorily in smaller engines. This was subsequently proved when the system was used in the 125 c.c. Pantheon scooter.

However, Honda, who have been regarded in the past as a manufacturer of mainly 4T engines, announced some time ago that they would be discontinuing manufacture of 2T engines from 2003, although the current success of the Active Radical system may cause them to revise their earlier statement.



Aprilia
DITECH 50



In addition to Honda, a number of other variants of the basic 2T system have been explored, one of the more revolutionary being the Cybertooth 153 Parallel Combustion Two-Stroke Engine (PC2S), for which the American inventor is currently seeking a qualified partner interested in further development, testing and marketing. Briefly, the system comprises a linear-moving connecting rod, two independent chambers within the operating cylinder and an external combustion chamber mounted parallel to the operating cylinder. Although working on a two-cycle principle, in that there is one power stroke for each revolution of the output shaft, each stroke is separate and distinct without overlap. This eliminates the major sources of combustion inefficiency and excessive emissions associated with more conventional 2T engines. Other advantages with are claimed for this system include better balancing and reduction in frictional losses due to the use of a hypocycloid gear system to convert linear piston movement into rotary motion, also reduced cooling losses and improved thermodynamic efficiency since the isolated combustion chamber with high temperature valves approaches adiabatic operating conditions and eliminates the need for a cooling system. The linear gear drive mechanism and the associated lubricants are not exposed to products of combustion thereby ensuring that the lubricant has an easier time with consequent extended operating life. Since piston sealing is achieved with Teflon-coated rings, and side loads are removed due to the linear motion, there is no need for lubrication. The system is ideally suited to multi-fuel operation, including hydrogen, since the combustion process is more highly controlled. Bore/stroke ratios can be optimised for combustion conditions rather than for mechanical considerations. Although intended for power generation initially, the inventor sees no reason why the system cannot be developed for automotive use, either in hybrid systems or as a direct replacement for conventional automotive 4T applications.

SUMMARY

The original basic 2T engines, manufactured in the UK by organisations such as Villiers, British Anzani, Excelsior, AMC and which were used to power a variety of simple scooters and lower capacity motorcycles often used for commuting purposes, have long since disappeared in most developed countries. In many third-world countries where much of the economy is based upon the use of rudimentary 2T engines with all of their attendant problems, major efforts are currently being made to convert existing 2T engine users to use cleaner-burning fuels such as compressed natural gas; a longer term objective being to replace them with 4T engines.

Although recent established developments have enabled the 2T engine to, at least in part, overcome the inherent disadvantages of poor fuel economy and high emission levels, it does seem that in these aspects, the 4T engine will always be a step ahead. Also, the increasing technological complexity of the most recent high-performance 2T engines is offsetting one of the basic advantages of the original 2T concept, namely its simplicity. Even in that most competitive of development environments, the racetrack, the future opening-up of the regulations to allow 4T engines to compete on an equivalent power basis reflects a realisation that the 4T represents the most environmentally attractive option for power sources for the immediate future. In next seasons 500c.c. Motorcycle World Championship, the Formula 1 of the motorcycle world, and now named 'MotoGP', we will see 500 cc 2T engines competing against 990cc 4T engines. Manufacturers involved in such competition will in future no doubt opt to concentrate their respective research and developmental efforts to 4T activities, which will in turn undoubtedly yield more benefits to road-going vehicles, as has so often happened in the past.

To summarise, with increasing attention on environmental issues such as atmospheric pollution from exhaust emissions, coupled with the need to conserve resources, becoming paramount, it would seem that the 2T engine will continue to always be a step behind the 4T engine and will therefore be of limited application, except for a few specialised situations where its high power density provides a particular advantage. Even so, when it is more generally realised that some 25-50% of the fuel used in small, simple 2T engines used to power lawnmowers, chainsaws, snowmobiles etc. is wasted through the exhaust ports without being ignited, it may well be that such power units used for non-automotive applications will also have a limited life.

David Margaroni

LUBE-TECH

OIL STORAGE REGULATIONS:

What you and your customers need to know!

(Control of Pollution (Oil Storage) (England) Regulations 2001)

OIL IS THE COMMONEST WATER POLLUTANT.

Over the past eleven years more than 64,000 oil incidents have been reported to the Environment Agency (EA) with over 500 of these being Category 1 incidents that have a major impact on water quality and water use. In the year 2000, 6215 oil incidents were reported. Earlier work undertaken by the Agency indicated that as many as 60% of reported oil incidents could have been prevented or mitigated by adequate secondary containment.

The Agency does not differentiate between fuel and lubricating oil incidents. Under these regulations **lubricants are classified as 'oil'**. The BLF believe that most of the spills were to do with fuels, not lubricants, but due to the way the EA's reporting scheme handles the incident data, we cannot prove this assertion. These regulations are intended to reduce water pollution by oil.

REGULATIONS KEY POINTS:

They apply to **external fixed above ground tanks, drums and other containers (all called tanks in this article) and to mobile bowsers used for oil storage** on all industrial, commercial and institutional sites storing more than 200 litres of oil. Private domestic storage smaller than 3,500 litres is exempt. They cover factories, shops, hotels, schools, public sector buildings and hospitals.

- They apply to NEW tanks from 1st March 2002
- They apply to existing tanks by 1st September 2005
- Tanks should have a design life of 20 years (a legal requirement for agricultural tanks) and must be in a sound condition.
- Tanks should be positioned to minimise the risk of damage by impact.
- Tanks and ancillary equipment must be situated inside a secondary containment system, such as a BUND.
- SINGLE Tank Installations: the secondary containment system BUND must hold a minimum 110% of the tank's capacity; in certain circumstances a greater capacity bund will be required.
- MULTIPLE Tank Installations: the secondary containment system BUND must hold a minimum 110% of the biggest or 25% of the total tank capacity, whichever is the greater; in certain circumstances a greater capacity bund will be required.
- The secondary containment system must be impermeable to oil and water.
- Tanks situated within 10 metres of a watercourse must be bunded by September 2003.
- New tanks have to be manufactured and tested to meet various standards for steel and plastic designs.
- EA can invoke swifter imposition of these regulations, for environmental safety.
- Any permanent taps or valves should be fitted with a LOCK and kept locked SHUT, when not in use.

The regulations apply to lubricant storage tanks with in England. BLF members and other suppliers of lubricating oils (and greases) within England {note: similar regulations are likely to be introduced in Northern Ireland, Wales and Scotland) will have to ensure that

1) their customers know about the changes, because

2) **if they supply products into storage tanks, which breach these regulations - they could be implicated in any prosecution. Strictly, under these regulations and 'The Duty of Care' Regulations, lubricants or fuels must not be delivered into non-compliant storage facilities.** The onus is on lubricant buyers (tankowners/end-users) to modify their storage to comply with these Regulations within the set timescales and on the supplier not to deliver into non-compliant storage tanks, sounds like 'risk assessments' may be called for at each delivery point. 'Whistle-Blowing' on suspect storage will be encouraged via a 'Free Phone' telephone number.

The regulations apply to premises storing externally more than 200 litres of any type of oil, with the exception of waste oil and private dwellings storing more than 3500 litres.

One of the main requirements of the regulations is that oil tanks must be kept within a secondary containment system, such as a bund. The bund should be capable of containing a minimum of 110% of the oil tank's capacity and be impermeable to oil and water. Externally stored Drums, Oil Packages and Intermediate Bulk Containers can be stored within a drip tray, but the drip tray must be capable of retaining 25% of the containers capacity. Larger quantities of other containers (packs) will need to be bunded.

Other standards are set for location of storage as well as adequacy of containment. Underground pipework must be inspected for leaks before use and tested at intervals. All permanent outlets from the tank should be fitted with a lockable valve and be kept locked shut when not in use. Any escape of oil from the tank must be directed into the secondary containment system and a drip tray must be used during deliveries for transfer pipes outside the containment facility.

The regulations will be phased in over a four-year period, with new stores needing to comply by 1 March 2002. Sites close to controlled waters will need to comply within two years because of their "higher risk" location. By the 1 September 2005, the regulations will set new minimum standards, which all oil stores will need to comply with.

The Environment Agency will be responsible for enforcing the regulations and reporting back to DEFRA on their success. Non-compliant storage facilities could be served with a notice to bring them to the required standard.

A joint leaflet produced by the Environment Agency and DEFRA is now available from Agency offices, outlining the main requirements of the regulations and where to go for further help. DEFRA guidance to accompany the regulations was made available on their website from October.

The revised EA Pollution Prevention Guidance note on 'above ground oil' storage was also available from October (PPG2) emphasising the statutory requirements of the regulations, as well as providing practical advice to minimise pollution from oil.

The regulations will have wide reaching consequences for lots of small and medium sized businesses that store oil. **An estimated 36,000 new tanks** are bought each year as replacements to meet new requirements. **Overall, there are around 800,000 tanks** at industrial and commercial premises. Improvements to existing facilities can be phased in to achieve compliance within the two or four year time scale.

Rod Parker

LINKS

www.environment-agency.gov.uk
(search using keyword PPG02)