Norton Back With a Rotary Engine

The famous Norton motorcycle returns with a Wankel rotary engine - how they overcame some of the engine's limitations.

By Peter Hartley

After almost 18 years of careful development, the rotary-engined Norton motorcycle is all set for sale to the public by the end of this year. Its successful launch will mark a watershed in motorcycle design and possibly a significant upturn in the fortunes of the resurgent, but at present small, British motorcycle industry.

The end of 1987 should see a civilian version of Norton Motors' 588 cm^3 rotary-engined machine in full-scale production at its plant at Shenstone in the English midlands. Furthermore, the company intends to field a full works' team on specially developed, high performance versions of this model in road racing events, starting in 1988.

Philippe Le Roux, the company's managing director, said: "we plan to race next season, probably in the World Endurance Championship, and certainly in the British Grand Prix. We will enter whatever class the racing authorities permit."

Overcoming Wear Problem

The work that was to lead eventually to the development of the twin rotor engine used in the new Norton machine, was initiated by the former BSA company as far back in 1969 and the present engineering director of Norton Motors, David Garside, was involved in that project.

The Wankel type engines produced by NSU, Mazda and Curtiss Wright have oil-cooled rotors. Of necessity, therefore, each had an oil sump, pressure pump and filter, and the rotor had to have oil seals. All these components are similar to those used in a conventional four-stroke reciprocating engine.

The oil sealing system for the orbiting rotor has always presented both wear and sealing problems at high speeds. This is the reason why the crankshaft speeds of these engines have always been limited to only 20% higher than those of the equivalent reciprocating power units.

A different and more effective approach was adopted in the design of the Fichtel & Sachs 13.5kW (crankshaft) industrial engine, which BSA bought at the commencement of its development programme in 1969. Its arrangement entailed the use of induction air for cooling the rotor. The outcome was a simpler engine that cost less to produce and did not suffer the limitation of oil scraper rings becoming progressively less effective as speeds rose.

Twin Rotors

Lubrication in the Fichtel & Sachs engine was on the total loss principle, using a petroil mixture as with traditional two-stroke motors. This mixture was drawn through the passages within the rotor, lubricating all the wear surfaces and rolling elements of the bearings before being burned in the combustion chamber.
An outstanding advantage of this arrangement was remarkably low friction loss and therefore high mechanical efficiency, despite the relatively low brake mean effective pressure (BMEP) produced.
Since the power produced by the F & S engine was inadequate for competing in the motorcycle market, BSA carried out a succession of modifications designed to bring it up to 30kW (crankshaft).

Initial tests with forced air-cooling and charge-cooling of the rotor, showed that the front wheel slowed the passage of cooling air to an unacceptable extent. To correct this, the engine was doubled up to a twin rotor configuration so that a rotor chamber stuck out on either side of the wheel into an uninterrupted flow of cooling air.

This led to the adoption of the air-cooled unit's characteristic circumferential cooling fins which support the chambers and provide heat paths away from the sparking plug areas, as well as providing an attractive styling feature.

Economical On Fuel

Other changes introduced by the BSA research and development team, with the object of improving the power output, included an arrangement whereby the rotor was cooled by induction air only, the fuel being introduced just before the air entered the tuned inlet pipes to the combustion chambers. A pressure wave damping chamber, or plenum chamber, was also introduced to improve engine breathing.

By adopting the twin rotor, air-cooled layout BSA was able to achieve a power output of 60kW (crankshaft) as early as 1971. One version of the BSA engine which weighed considerably less than 45.4kg was soon developing up to 74.5kW (crankshaft). Its specific fuel consumption was about 0.3kg/kWh at maximum torque. This high degree of fuel economy was achieved with the novel arrangement of twin side-by-side sparking plugs and an intercooler in the induction system.
Manganese Bronze Holdings, the former owner of Norton Motors prior to the latter's acquisition by the Norton Villiers Triumph (NWT) Group, has invested some (pound sign)3 million in developing the rotary over the last five years. This has culminated in the evolution of the power unit used in the Norton Interpol 2 police machine and that used by the Royal Automobile Club highway patrolmen throughout Britain. The engine follows the lines adopted in the final BSA design.

Improved Power Output

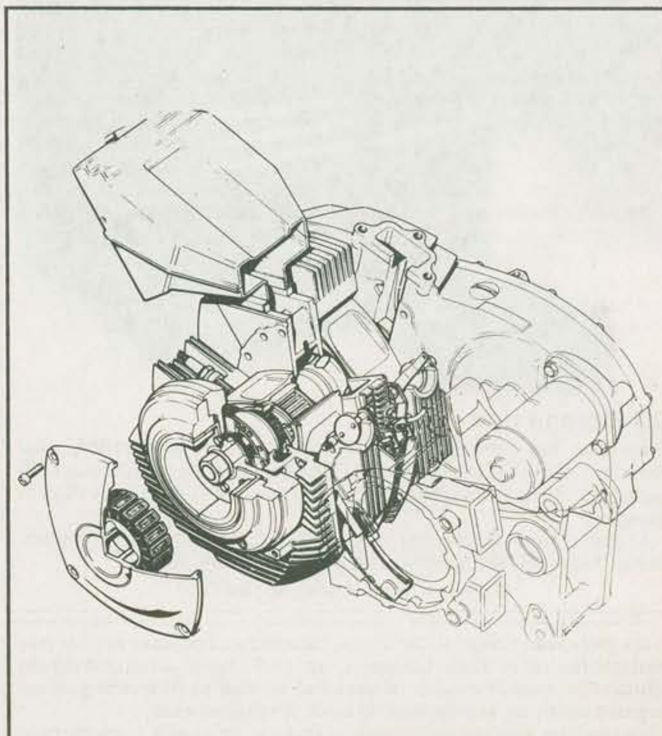
In the new civilian model's engine, air enters the power unit through a filter and passes into a chamber between the two rotors. It is then drawn through the rotors and over the crankshaft, to emerge via ducts on each side of the top of the crankcase.

The hot air then enters a plenum chamber built into the box- section spine frame of the machine where its temperature is said to fall by some 30°C. However, when it leaves the plenum chamber and enters the constant-velocity SU carburetors, the air is still at a much higher temperature than the optimum. This leads to a disappointing BMEP of about 760kPa. The butterfly valves that control mixture flow are sited as close as possible to the inlet ports to provide optimal throttle response.

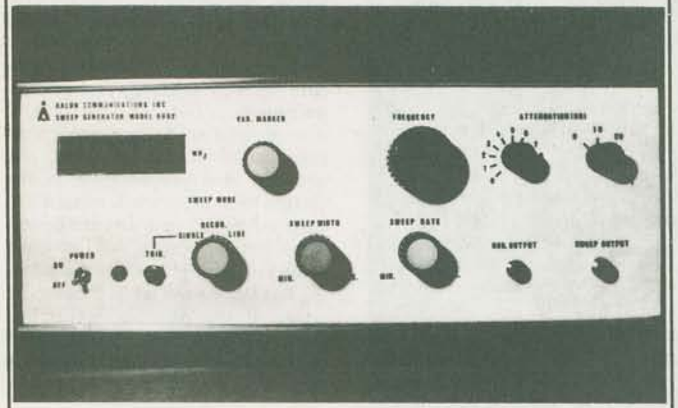
The water-cooled version of the engine to be adopted on the civilian model uses exactly the same layout but gives a BMEP of between 900 and 970kPa which compares with the latest Japanese multi-cylinder motor cycle engines. The Norton factory claims a power output for the water-cooled version of 60kW (crankshaft) at 7000 rev/min and a torque output of 68.5Nm at the same crankshaft speed.

Little Maintenance Needed

The twin-rotor engine, of course, has no valve gear or other highly stressed parts. Moreover it has only three major rotating components, a crankshaft and two three-lobe rotors each orbiting around inside a two-chamber housing. As a result, its reliability is exceptionally high and very little maintenance is needed.
The perennial rotary problems of



A part-sectional view of the Norton rotary motorcycle engine. The problem of seal wear was overcome by the use of air cooling.



Wide Band Sweep Generator

The Kalun Model 6082 Wide Band Sweep Generator is designed with RF and digital electronics to provide accurate and effective sweep frequency measurements. The sweep signal covers the 600MHz frequency range in one sweep with 0.5dB flatness. The marker frequency is displayed as an intensified spot on the frequency response trace, while also being indicated by a digital frequency counter.

Spectral purity is -30dBc including all harmonics and non- harmonics; sweep width is continuously variable from 200kHz to full bandwidth. Output is 75 ohms, 50dBmV; an output attenuator is continuously variable from 0-10dB and also has steps of 10 and 20dB.

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rotor-tip seal wear and heavy fuel consumption were solved relatively early on in the Norton power unit's development. The trochoidal surface of the casings against which the rotor tip seals bear, are plated with Elnisil, a nickel containing 4% by volume of silicon carbide particles, to form a very hard and durable bearing material. The combination of the plates surface and the seals has been shown to last for over 160 000km of road operation in a motorcycle engine.

As is well known, the flanks of the rotors of the Wankel type engine at all times run just clear of the walls of the chamber with only the seals in the rotor tips and end-faces bearing upon them. Furthermore, the rotor and crankshaft rotate on roller or needle-roller bearings of substantial dimensions, enabling them to last the whole life of the engine without attention. The tip seals are honed from a specialized steel that is heat treated.

Smooth At Low Speed

Even the spark plugs specially developed for the engine by Champion, are the long-life surface discharge type with a platinum central electrode, and the higher power capacitor discharge (CD) electronic triggering and distributor ignition system again have no moving parts.

Norton claims fuel consumption figures of 15 to 18km/litre, based on data from police vehicles. The rotor temperature is in fact much the same as on the original F & S motor. The cooling system is also self-regulating in that the air flow increases with engine speed and hence heat production. Over-cooling of the rotors, however, can lead to heavy fuel consumption and high hydrocarbon emissions from the exhaust. Indeed, it took until 1979 for Norton engineers to get the unburned hydrocarbon levels in the exhaust below the statutory emission requirements of the United States, one of its potential export markets.

A major problem in developing the rotary for motorcycles was the idling system. On its first customer machines, Norton Motors used a dead-chamber system. In this the sparks to one combustion chamber were cut so that it pumped cold air via a bypass directly into the plenum chamber. This also put enough drag on the crank to ensure that the working chamber was filled efficiently. Unfortunately, the early users — the police and armed forces — used their machines for a lot of slow speed escort work. The idling system, cutting in and out, made for an unacceptably jerky low-speed ride. This led to the carburation and ignition systems being refined to cope with both cambers firing at idle speeds.

No Vibration

The transverse 180-degree crankshaft of the new rotary-engined Norton is machined from a single casting supplied by Laystall of Wolverhampton, in the English midlands. Just about every other engine component is machined from either stock metal or castings in Norton's own factory.

The primary drive is taken from the offside of the crankshaft via a duplex chain to the clutch drum, which also engages the starter motor. The other end of the crankshaft carries the alternator. This all adds up to an engine that displaces a nominal $588cm^3$ but produces over 60kW (crankshaft). It is also extremely compact and is said to be free from vibration. The design of the engine has been discussed at length here because of its unusual configuration and the somewhat chequered history of previous attempts at applying Wankel type power units to motorcycles. However, a motorcycle is not just an engine and some mention should be made of the gearbox and cycle parts of the new Norton.

The transmission uses a five-speed gearbox and the final drive is by chain. The box section spine frame has an integral oil tank and features swinging-fork rear suspension fitted with twin gas/oil damped Marzocchi suspension units having a five- position preload capability. The front and rear wheels are both cast in light alloy.

Racing Model.

The front wheel is mounted in a pair of 38mm diameter tubing, Marzocchi damped telescopic forks, while the braking is taken care of by twin 280mm diameter discs at the front and a single 280mm disc at the rear. The civilian version of the Norton rotary motorcycle is scheduled to go on sale direct from the factory on 20 December, at a price that should be competitive with BMW's K100 four-cylinder machine and with a 225km/h top gear performance. According to Mr Le Roux the NVT Group, which owns Norton Motors, is looking to produce up to 5000 of the $588cm^3$ rotary engines a year, of which 2000 or so will go into the Interpol 2 machine and the new water-cooled civilian model. The remaining engines will be sold to the aerospace and defence industries for applications where their high power-to-weight coefficient is required, such as in portable generating sets and for powering remotely piloted aircraft.

Already in the United States the Teledyne company, which makes Continental aircraft engines, is licensed to manufacture Norton rotary power units, and the Mercury marine company is assessing the rotaries as replacements for two-stroke outboard motors. In Britain, Thorn EMI is buying engines for it Cymbeline radar programme.

Meanwhile, on the motorcycle front, the Norton rotary racer is still in its infancy, but the company claims to have already achieved a power output of 97kW (crankshaft) with another 15kW confidently expected after further tuning. Such tuning, incidentally, is similar in approach to that adopted with two-stroke engines. The rotary has been found to respond to alterations in the length of its induction systems, port timings and exhaust dimensions.

Peter Hartley is the deputy editor of Engineering, a publication from London, England.

Bromine and the Ozone Layer

The seasonal depletion of the earth's protective ozone layer above Antarctica has both intrigued and concerned scientists for several years. Chlorofluorocarbons have generally received the blame, buut some researchers belive catalytic bromine reactions may also play a role. To study the theory, researchers at the Georgia Institute of Technology are using laser photolysis to create the suspect chemicals in an atmosphere simulating the frigid cold of the Antarctic winter.

A possible explanation is a catalytic reaction involving bromine monoxide and chlorine monoxide. The two highly reactive chemicals are commonly found the atmosphere as a result of photochemical degradation of halocarbons used in refrigeration, foam insulation and fire extinguishing. Through a series of reactions, the bromine and chlorine monoxides could catalytically break the ozone into diatomic oxygen. Because they act as catalysts, the chemicals are not broken down, but remain to continue their destructive work.

Under normal conditions, atmospheric nitrogen dioxide reacts with the chemicals to tie up the more damaging forms. However, another set of reactions causes nitrogen dioxide levels to drop during the cold winter months.

The Georgia Tech group will create the bromine monoxide and chlorine monoxide with laser photolysis and follow the reactions with spectroscopic techniques.