HDT-RMCS DIESEL MILITARY MOTORCYCLE

Introduction

The programme by the Royal Military College of Science [RMCS] and Hayes Diversified Technologies [HDT] to design and develop a diesel motorcycle was undertaken to provide a machine to meet the requirement for all NATO armed forces to operate their entire inventory of powered equipment on either diesel fuel or aviation kerosene. This capability has major logistic advantages in obviating the need to carry other fuels to battle. The lower flammability of these fuels, in comparison to petrol, also greatly reduces fire hazards.

The diesel motorcycle programme is being carried out by RMCS and HDT under contracts sponsored by the United States Marine Corps [USMC] and the UK Ministry of Defence.

Military motor cycles are used both on the battlefield and for road work, such as convoy escort, policing and courier duties. An 'all-round' on/off-road performance capability is therefore required.

Design and Development

The diesel power unit for the bike was designed by Dr Stuart McGuigan and John Crocker of RMCS, with development and production being spearheaded by Fred Hayes of HDT. Full collaboration between HDT and RMCS is being maintained throughout the entire programme, leading up to full commercial production.

Objectives

The aim was to produce an engine having realistic power output and performance characteristics for the duties outlined above. This is achieved by utilising state-of-the-art high-speed automotive diesel engine technology in the design of a single cylinder engine. (Other attempts at producing diesel-powered motor cycles based on industrial diesel engines (e.g. Ref.1) have not achieved viable power output and performance).

To achieve the required performance, the objective was to produce the best possible torque without resorting to turbocharging, which is impracticable for this application at present, and to run at the highest practicable engine speed to maximise the power output. To this end, the engine uses four valves and an indirect-injection combustion chamber. Indirect injection also gives lower peak cylinder pressures – enabling lighter engine construction, less 'diesel knock' and reduced particulate emissions.

The engine design is founded on a technical feasibility and 'technology demonstrator' programme instigated by RMCS in 1992 (Ref. 2). This programme established that current automotive diesel engine technology could, with some development, be employed at low technical risk to provide a viable power output from a naturally aspirated engine unit suitable for packaging in a motorcycle. Figures 1 – 3 show the demonstrator engine and bike which were built to confirm the viability of the design philosophy used.

The demonstrator programme lead to the current collaborative project by HDT and RMCS to provide a production military diesel motorcycle. The production bike is based on the running gear of a Kawasaki KLR650 petrol-engined trail bike, a military variant of which is already supplied by HDT for service with the USMC. The petrol KLR650 has established an excellent reliability record with the marines; the diesel machine utilises the same basic 'rolling chassis'.

The HDT-RMCS engine (Figure 4) is a liquid cooled, single cylinder four stroke, which displaces 584 cm^3, and currently produces some 18 kw (24 bhp). It is a double overhead camshaft design, with a four-valve cylinder head. A multi-cylinder engine was rejected as unnecessary, on grounds of increased weight and because diesel engines work less efficiently in small cylinder sizes.

Though the engine unit has been designed specifically for this application, some standard Kawasaki components have been incorporated, to keep overall production cost to a minimum and thus facilitate a realistic selling price. The clutch and gearbox are basically Kawasaki assemblies, with modified gear ratios to account for the power delivery characteristics of the diesel engine. All other major engine components have been designed expressly for the diesel power plant. An extremely robust built-up crankshaft with a plain big-end bearing is employed. A special fuel injection pump, developed by Unique Injection, enables the desired power and throttle response characteristics to be achieved. Instant throttle response is an essential feature for a cross-country motorcycle. Starting is by conventional motorcycle electric starter and 'unspillable' battery, with the aid of a decompressor during cranking. A glow plug is provided to facilitate cold starting. A push-start is possible as a reversionary mode.

Achievement

As currently configured, the bike has a top road speed of around 80 mile/hour, and general levels of performance and acceleration are comparable to a conventional 250 cm^3 petrol-engined bike. However, the low speed torque of the diesel engine is outstanding. The need and desire for gearchanging are thus much reduced, which aids cross-country riding over difficult terrain and also greatly facilitates the training of military riders who are new to motorcycling. Even experienced riders use the gearbox much less than with petrol-engined bikes. When the diesel bike and a more powerful petrol-engined machine are ridden cross-country at speed by the most competent riders, the petrol machine struggles to maintain the pace of the diesel. In the most arduous conditions, the torque characteristics of the diesel engine enable speed to be maintained where the petrol machine is slowed considerably.

Another important benefit of the diesel bike is improved fuel consumption. The extent of the advantage, compared to a petrol bike, depends greatly on conditions. However, typical overall consumption will be some 30% superior to a typical petrol-engined machine. This enables a reduced fuel tank capacity for a given range, so that although the dry weight of the bike is a little greater than a petrol-engined equivalent, the all-up weight, including fuel, will be similar.

Pre-production motorcycles are now under evaluation by the USMC, and have been very favourably received (Figure 5). Reliability to date has been excellent. Further trials will take place as the specification is refined to full production standard. Delivery of production motorcycles to the USMC for service, and conversion of current in-service

petrol-engined bikes, will commence following full user evaluation trials. Machines will shortly be supplied for evaluation to the UK Ministry of Defence and interest has also been expressed by the defence procurement authorities of several other NATO countries.

Commercial Potential

HDT and RMCS see great potential for similar diesel engines beyond the military motorcycle application. Possible commercial development and marketing opportunities include:-

Motorcycles for the Third World

In countries where motorcycles are still widely used for every-day transport, rather than as leisure vehicles, the improved fuel economy of a diesel bike, perhaps of somewhat lower performance than the current military unit, would bring major economic advantages and conserve scarce fuel resources. The engine could also be run on kerosene or bio-diesel, if required.

Lightweight All-Terrain Vehicles [ATVs]

The use of light four-wheeled ATVs ('quad bikes') in agriculture, horticulture, forestry and prospecting is expanding rapidly in many countries. The HDT-RMCS motorcycle engine would be ideally suited to ATV applications and would enable users to employ a common fuel with tractors, other vehicles and implements, achieve much improved fuel economy and take advantage of tax-free agri-diesel fuel.

Lightweight, High Output Industrial Engines

The motorcycle power unit would also form an ideal basis for a light industrial diesel engine for powering pumps, generators and similar portable industrial equipment. Such a unit would offer a power-to-weight ratio around twice as good as current small industrial diesels. Development of the engine for this type of application is already under active consideration by HDT and RMCS.

References

1. See web site:- http://www.royalenfield.com

2. Design and Construction of a Diesel Powered 'Technology Demonstrator' Motorcycle, S J McGuigan, J M Crocker and A C Arnott, SAE Paper No 982051, presented at International Off-Highway and Powerplant Conference, Milwaukee, Sept 14-16 1998.

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Fig. 1 **'TECHNOLOGY DEMONSTRATOR' MOTORCYCLE**

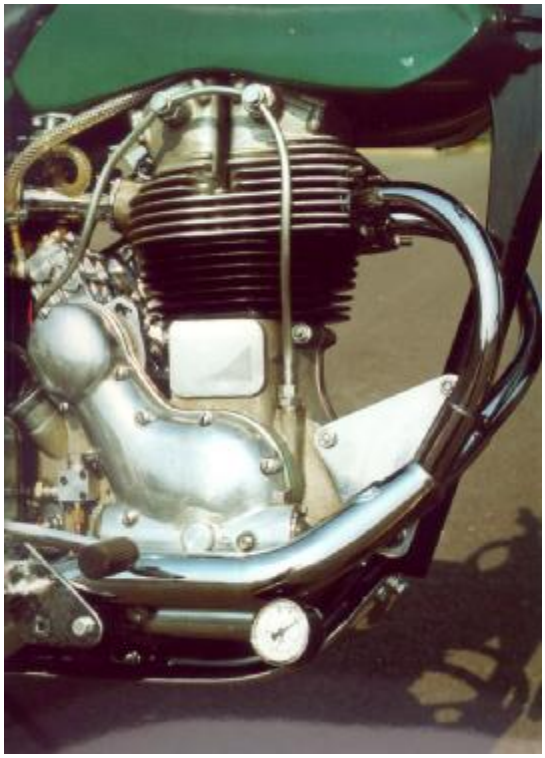

Fig. 2 **DEMONSTRATOR ENGINE**

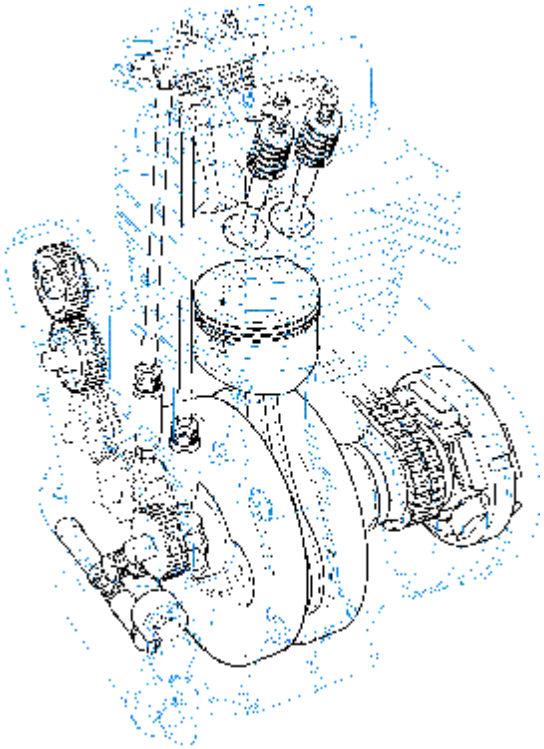

Fig. 3 **DEMONSTRATOR ENGINE DRAWING**

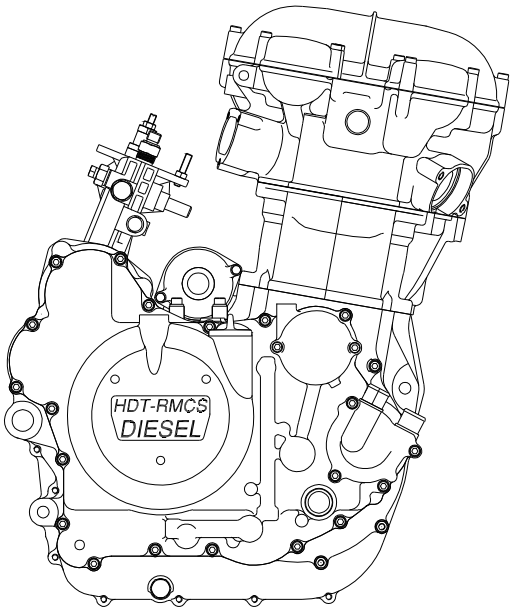

Fig. 4 **HDT-RMCS DIESEL ENGINE**

Fig. 5 **PRE-PRODUCTION MOTORCYCLE UNDER TEST BY USMC**