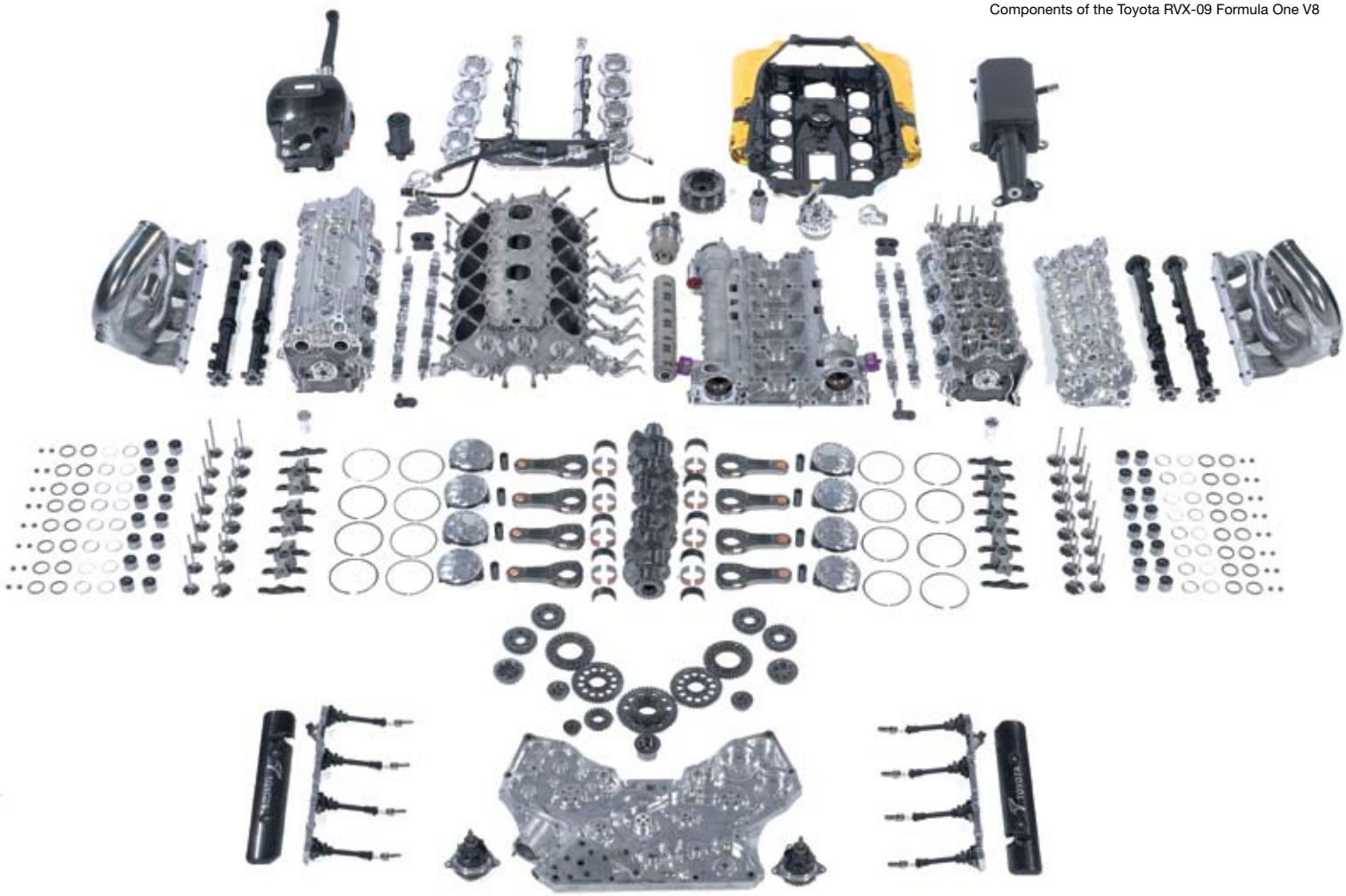
Components of the Toyota RVX-09 Formula One V8

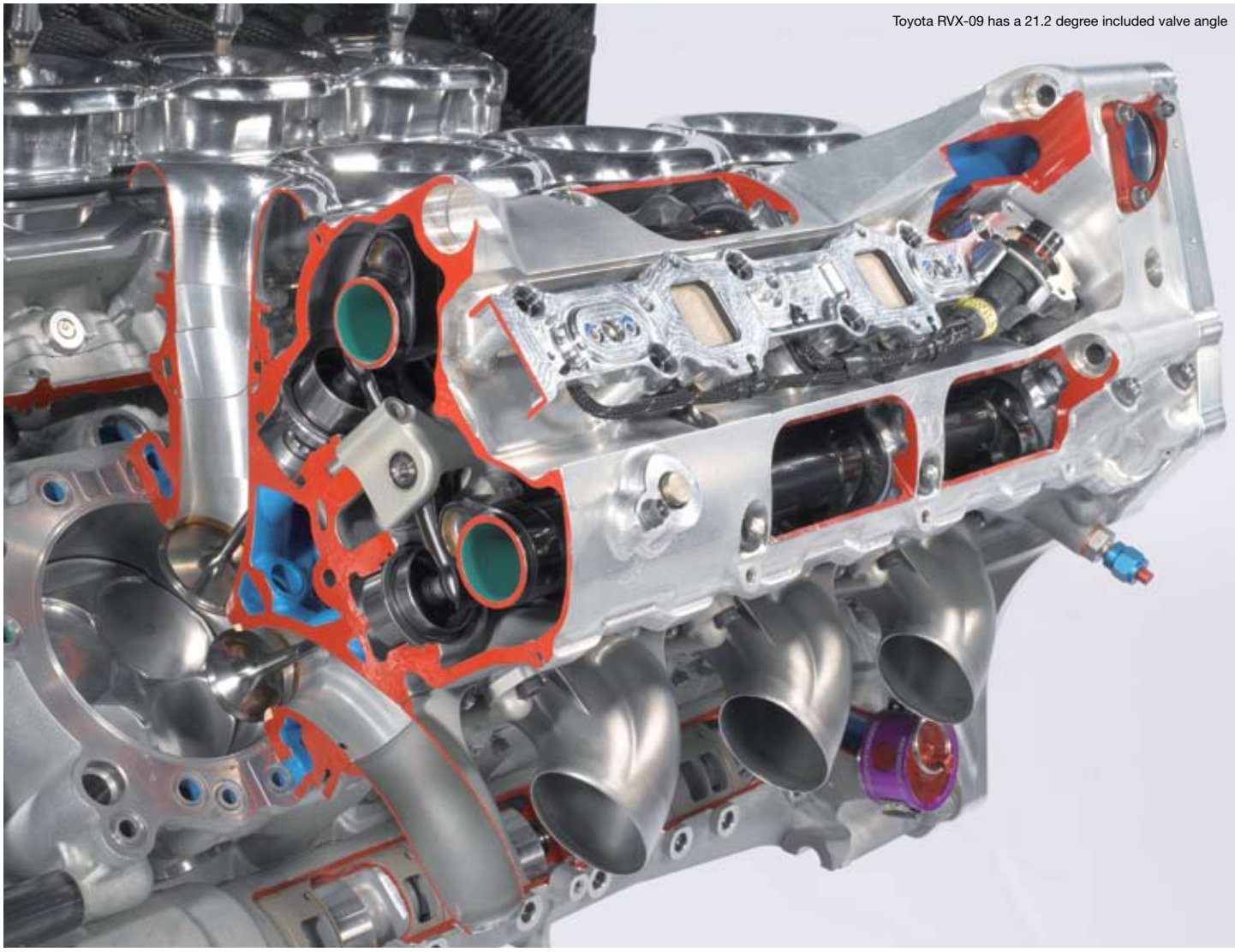


F1 from the inside

What lies inside a contemporary Formula One engine? **Ian Bamsey** visits TMG's hi-tech raceshop to find out

Although Toyota pulled out of Grand Prix racing soon after the end of the 2009 season its naturally aspirated, 2.4 litre V8 remains one of the engines homologated for Formula One under the ongoing engine specification freeze. Produced by wholly-owned subsidiary Toyota Motorsport (TMG) in Cologne, Germany, it is a state-of-the-art Grand Prix engine, which was highly competitive last year as witnessed by its pole at Bahrain and second-place finishes in Singapore and Japan.

The 2009 Formula One engines produced in the region of 735 bhp (see sidebar: Formula One 2.4 litre V8 performance). In fact, under the 18,000 rpm rev limit imposed for that season, the Toyota RVX-09 V8 is an ideal engine, having a well-tailored bore size (no alteration of


Toyota RVX-09 has a 21.2 degree included valve angle

bore has been possible since the first stage of the current freeze was implemented for 2007).

The 2009 RVX-09 V8 is derived from TMG's 2005 3.0 litre V10 engine, which had a 96.8 mm bore and ran to 19,200 rpm. With the enforced switch for 2006 to 2.4 litre V8 engines maintaining the same 300 cc per cylinder, TMG did the same as its rivals and strove for higher engine speed. The new rules for 2006 were confirmed so late, however, that for logistical reasons TMG kept the existing bore size, together with the established valve sizes, angles and so on.

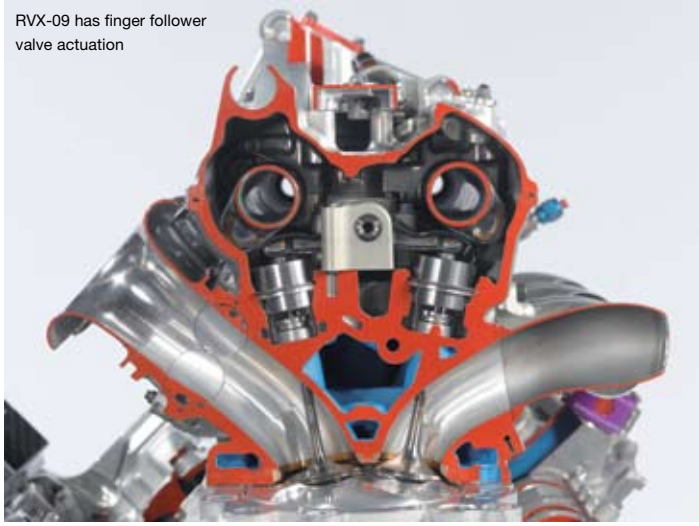
Essentially, rather than a complete rethink, TMG's G/H-spec V8 of 2006-9 is an evolution of its 2005 F-spec V10 but with two fewer cylinders. Not only did the bore size remain the same but – aside from the loss of two cylinders – the block, heads and sump were of the established pattern, the timing drive was identical, and so on. Mind you, the new rules imposed many parameters (see sidebar: Formula One 2.4 litre V8 regulations) while a 90º bank angle, flat-plane crankshaft V8 is fundamentally different in operation from a V10 with the same bank angle.

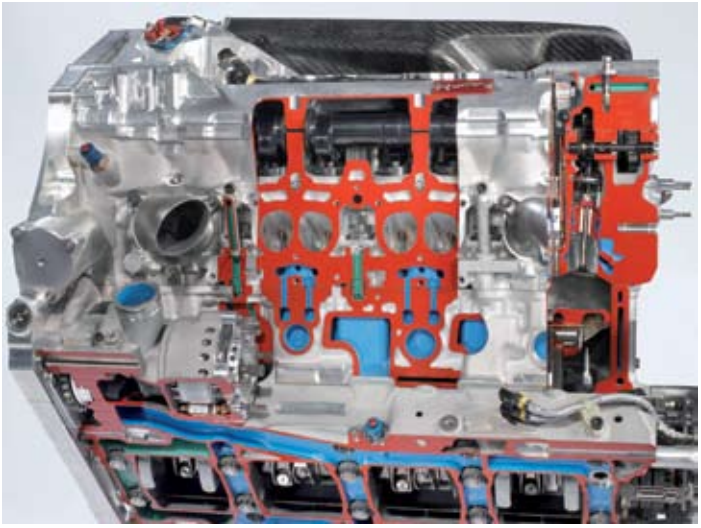
Nevertheless, from the outset, the basic concept had been to produce an engine to the 2006 rules that didn't stray too far from established practice and then to design a more optimised V8 based on lessons learnt from that exercise. Indeed, initial investigation for the V8 project consisted almost literally of chopping two cylinders from an existing V10, fitting a new crankshaft and running the resultant experimental engine on the dyno.

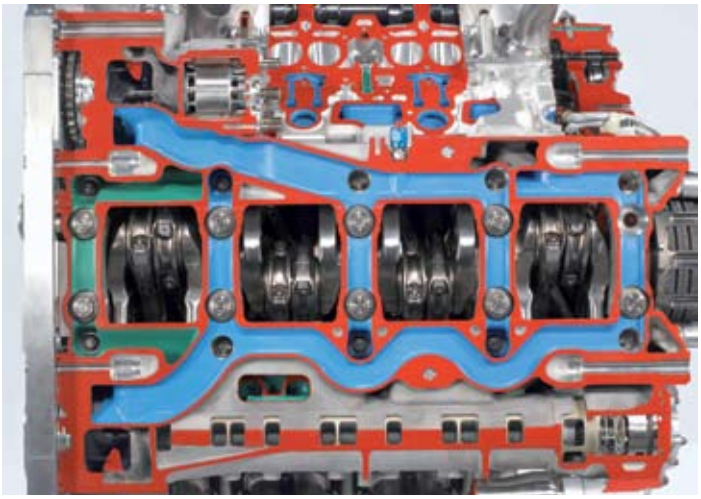
TMG's 90º bank angle V10s of 2001-5 (see sidebar: Toyota V10 Formula One engines) had been inherently well balanced in terms of torsionals. Given the second-order vibration inherent in the use of the flat-plane (180º phased) crankshaft necessary to optimise exhaust pulse tuning, however, finding the optimum balance for the V8 proved a significant challenge. As such, the design of the V8 crankshaft took far longer to optimise than anticipated. It was partly for this reason that there wasn't time to redesign the engine for the start of the 2006 season as completely as might have been hoped, in the quest for ever higher engine speed.

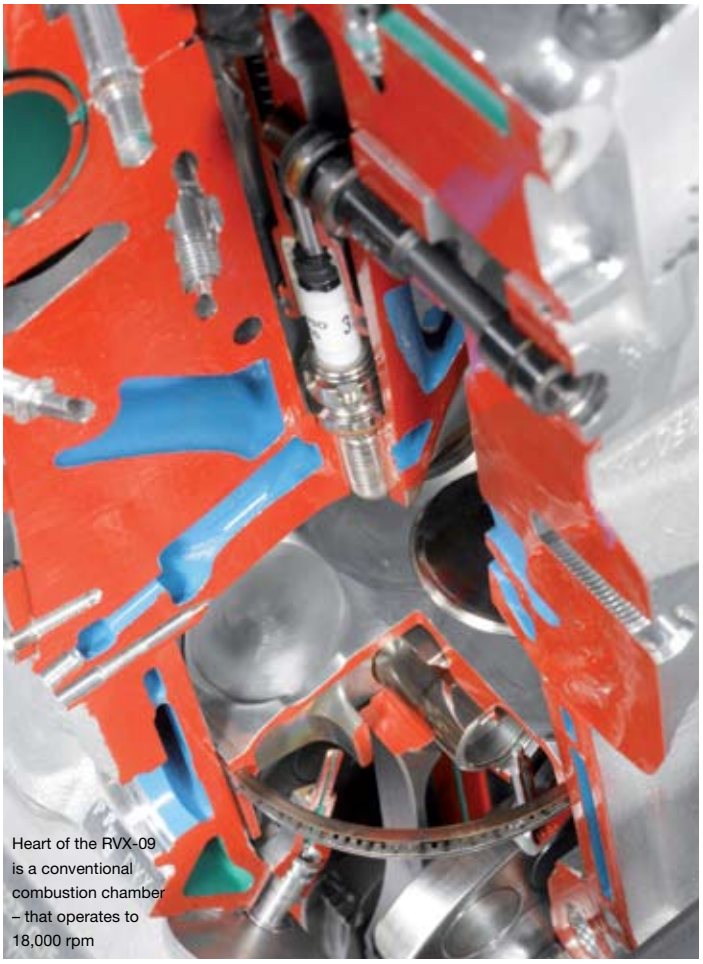
It is worth noting that the final two years of the V10 era were characterised by an increasing engine mileage requirement, the challenge of which had temporarily pegged the usual ongoing increase of Formula One engine speed. Lessons learned in 2005, however, left TMG and its fellow engine manufacturers confident of progressing from the 19,000 rpm region towards 20,000 rpm. At the same time, the new rules for 2006 made 98 mm the maximum permitted bore size and thus the logical choice in view of the quest for 20,000 rpm.

Capable of attaining well over 19,000 rpm with its initial V8 ▶


RVX-09 has finger follower valve actuation




RVX-09 features water passages through the main bearing cap bulkheads (as also seen in the picture immediately above)


Heart of the RVX-09 is a conventional combustion chamber – that operates to 18,000 rpm

engine, TMG planned to move to a 98 mm bore for the second iteration, which was targeted at 20,000-plus rpm. But before that could be introduced the FIA had moved the goalposts once more by announcing the impending specification freeze. TMG consequently had to switch its focus for 2007 to homologating the G-spec.

Happily for TMG, this initial specification freeze was accompanied by a 19,000 rpm rev limit, which was reduced to 18,000 rpm for 2009. This new limit favoured an engine having a smaller bore over that which had been designed to the maximum permitted 98 mm.

As in 2005, in 2006 engines had to run two complete race meetings, which implied a mileage requirement of anything up to 1300 km. For 2009, the requirement was even tougher, the FIA now permitting only eight engines to be used for the entire 17-race season. This implied attaining a 2000-plus km engine mileage. At the same time, any changes to the homologated specification had to be approved by the FIA. TMG's Norio Aoki discussed the ramifications of the 2009 rules in RET 40 (August 2009).

In essence, through the V10 and V8 years, TMG had increased engine mileage fourfold, in particular by paying careful attention to exhaust valve and piston and bearing life. There weren't any major issues otherwise, thanks partly to the benefits of ongoing materials and coatings development. But the difficulty of multiplying valve, piston and bearing life should not be underestimated.

The piston challenge was addressed partly through modification of the underside oil spray-jet provision. Where earlier engines had a pair of jets spraying each piston, the move was made to four – three on the intake side and one on the exhaust. Toyota's R&D division in Japan helped with identifying the optimum size and angle of the jets.

Detail development of specification including materials, coatings and operating environment likewise allowed the required exhaust valve and bearing component mileage to be obtained. The bearings had to be made more robust while lubricant development by supplier Exxon Mobil was another key factor. ▶