Vance & Hines' Harley-Davidson V2, as seen from the left-hand side of the engine (all photos: Anne Proffit)

Twin peaks

Ian Bamsey investigates one of the most significant Harley-Davidson vee-twins ever developed for racing

In 2002, Harley-Davidson commissioned the Vance & Hines organisation to run a factory NHRA Pro Stock Motorcycle (PSM) campaign. Following two development years, in 2004 Andrew, son of co-founder Byron Hines, claimed Harley-Davidson's first ever PSM Championship. Since then he has added another three titles (in 2005, 2006 and 2014), while Screamin' Eagle/Vance & Hines teammate (from 2007) Eddie Krawiec has won another three (in 2008, 2011 and 2012).

It was not surprising therefore that at the end of the 2014 season the NHRA's all-time PSM records were held by the Screamin' Eagle/Vance & Hines duo – Andrew Hines with the quickest ever quarter-mile ET at 6.728 s (Mohnton Pennsylvania, October 9, 2012) and Krawiec with the fastest ever terminal speed at 199.26 mph (Gainesville Florida, March 13, 2011).

Over the past decade the Harley-Davidson PSM developed by Vance & Hines has regularly been the benchmark for NHRA racing. Here we investigate the third and current iteration of the thumping vee-twin at the heart of it. The first iteration was a two-valve-per-cylinder engine, the second a four-valve unit. Regulation changes forced a reversion to two valves for the current engine, which was introduced in 2013.

The 2013-14 Vance & Hines Harley-Davidson V2

The current Screamin' Eagle/Vance & Hines Harley-Davidson V-Rod engine is purpose-designed for NHRA Pro Stock Motorcycle drag racing. Although like most bespoke naturally aspirated engines for quarter-mile competition it uses no coolant, it reflects the longitudinal 60° V2 configuration of the street engine of the same name (and unlike some

other 60° V2 motorcycle engines, both cylinders are at 30° from vertical).

By regulation currently having only two valves per cylinder using pushrod operation, this engine nevertheless uses electronically controlled port injection of gasoline fuel within a full engine management system. The fuel in question is high-octane leaded, as mandated by the NHRA for PSM racing. Its use paves the way for a compression ratio of up to 15:1.

Permitted by the NHRA to run at 2.62 litres, this V2 has a considerably larger displacement than any Harley-Davidson road engine. Look at it this way: if it was a V8 it would have a displacement of more than 10 litres. Yet it nevertheless runs to 10,500 rpm.

The bore is 5.125 in (130.17 mm) which still leaves a stroke of 3.875 in (98.43 mm), giving a stroke-to-bore ratio of 0.76:1. At its 10,500 rpm redline, that stroke implies a mean piston speed of 34.31 m/s. By comparison, in 2006 a representative Formula One V8 – of smaller total displacement than this V2 – ran to 20,000 rpm for a mean piston speed of 26.5 m/s.

In *RET* 29 (March/April 2008) we also saw that at the same time a representative contemporary 5.86 litre NASCAR Cup V8 ran to 10,000 rpm for a mean piston speed of 27.5 m/s. The same Formula One/Cup comparison article revealed our representative American V8 experiencing maximum piston acceleration (MPA) at 10,000 rpm of 5821 *g*. At 10,500 rpm Vance & Hines' V2 experiences an MPA of 7561 *g*.

At least that isn't as high as the representative Formula One V8, which at 20,000 rpm experienced 10,622 *g*, but consider also the loading on the big end, which is a function of MPA and the weight of the reciprocating components. The Formula One engine had a piston of 98 mm diameter versus the V2's 130.7 mm. Clearly, the forces inside the Vance & Hines Harley-Davidson V2 are immense.

Development of the current iteration was prompted by the NHRA's announcement in September 2012 that two valves per cylinder would be the maximum permitted for Harley-Davidson runners the following year. Vance & Hines looked at reviving its earlier two-valves-per-cylinder PSM engine but another new rule, this one imposed two days after the last race of 2012 (as ever at Pomona, California, in November), required that the pushrods each had to be at least 8 in long. That rendered the original two-valve engine illegal as well.

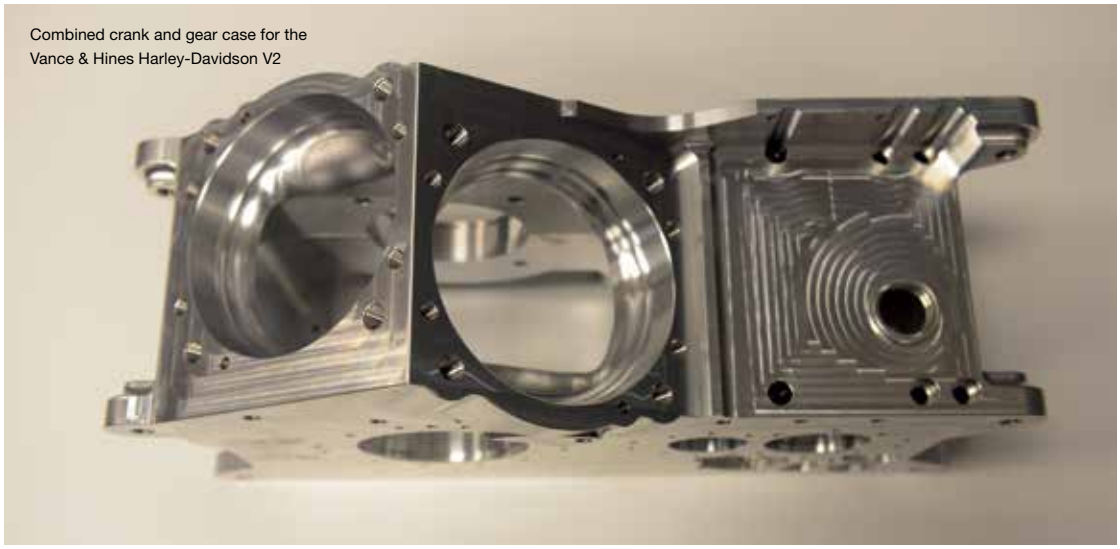
> "Look at it this way: if it was a V8 it would have a displacement of more than 10 litres. Yet it runs to 10,500 rpm"

Thus it was that three days after the 2012 season finale, on November 14, work began at the Brownsburg, Indiana, base of Vance & Hines on a new, factory-supported Harley-Davidson PSM V2 engine.

The team designing the current-iteration V2 was headed by Byron Hines and sons Matt and Andrew. Byron co-founded the company and its racing team with Terry Vance in 1979 (the pair had been racing together since 1972). Elder son Matt won his first PSM title in 1997 and went on to win three in a row. He, like his father, is now retired from riding. At the end of 2012, Krawiec was the reigning NHRA PSM champion, and he assisted the design team.

The lower portion of the existing four-valve engine – the combined crank and gearbox case, and many of its internals – was carried forward (with just a small modification to the case for rear-cylinder cam box clearance) while the barrels and heads were clean-sheet-of-paper designs. This was partly a pragmatic approach: the lead time for a new crankshaft didn't fit the time available before testing began for the 2013 season, which as usual kicked off at Gainesville in mid-March.

The reciprocating components had to be redesigned, not least owing to a longer rod requirement as a consequence of the 8 in pushrod rule pushing up deck height, while the opportunity was taken to change the type of timing drive, since that in any case had to be redesigned. The earlier two-valve and four-valve engines were both belt-driven, but issues with this approach had been observed in testing using Comp Cam's Spintron facility.



Combined crank and gear case for the Vance & Hines Harley-Davidson V2

In particular, the engine's uneven firing (at long intervals) had caused the belt to whip. Given the 60° bank angle and both con rods sharing the same crankpin, the leading cylinder is fired, then the trailing cylinder 300° later and then there is another 420° of crankshaft revolutions before the leading cylinder is fired once more. As the belt ▶

Andrew Hines racing Suzuki runner Jim Underdahl at Bandimere during Colorado's 2014 Mile High Nationals

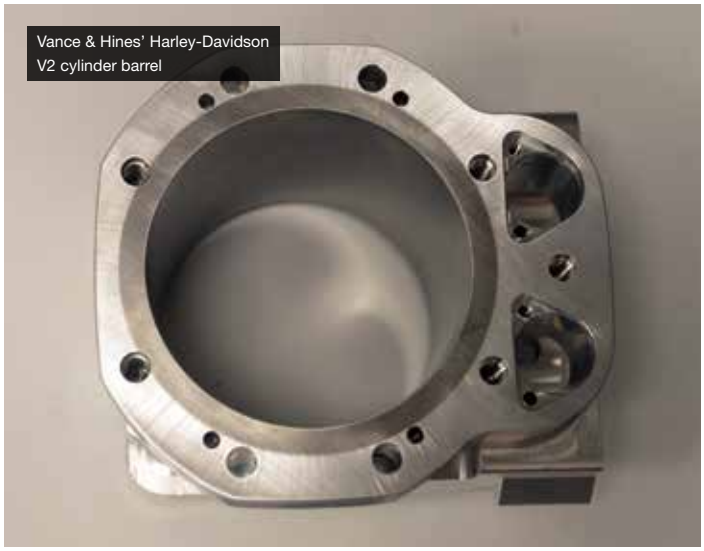
unavoidably tensioned and slackened, it promoted valve bounce.

It was clear that a gear drive could in theory provide the necessary precision of cam operation, but would such an approach work in this unusual engine?

In practice it worked just fine, despite the engine's challenging pulsing. Surprisingly, vibration dampening is not required for the crankshaft or for the gear timing drive. Matt Hines says, "You would think that a vee-twin at 10,000 rpm would have some vibration, but the motor runs pretty smooth on track. I know some of the opposition using Buell [V2]s can complain of vibration, they can find their handlebars feeling really big, but perhaps because our crank is so strong and well balanced, we don't have that problem.

"Our Harley-Davidson Pro Stock motor has been really smooth since we debuted it in 2002, using essentially the same crankshaft as today. The stroke has changed a few times and, since they have been supplying it, Marine Crankshaft has designed the crank throws differently. But for the most part it is the same as it was in 2002."

The single crankpin is sandwiched by a pair of counterbalance webs that provide a 60% balance factor. The webs, rather than being full


Vance & Hines' Harley-Davidson V2 cylinder barrel

circle, splay on the side opposite the pin and have tungsten carbide slugs embedded to add mass. The drive comes from a pair of con rods that are I-section aluminium productions machined from billet, as also used in Pro Stock cars.

In recent years supplier MGP has redesigned its con rods for Pro Stock cars to lighten them, but Vance & Hines has retained the older specification for durability – one set can last as many as 75 runs. The same is true of the three-ring pistons. These are of a contemporary boxed and bridged, slipper race style but thanks to the size of the cylinder bore, bare piston weight is more than 550 g.

Matt Hines notes that if the weight of the rod or the piston is altered then that affects the balance. While the balance factor can be adjusted, there is a danger that the net effect might be the introduction of a vibration issue. The same consideration steers Vance & Hines clear of the current Pro Stock car paddock's experimentation with steel con rods.

General engine arrangement

As with the road bike, the crankshaft is transversally mounted in the motorcycle frame. When the V2 is seen in plan, the leading cylinder is arranged such that its exhaust port faces forward, its intake rearward with the two valves located to the right-hand side of the head, exhaust ahead of intake (with respect to the longitudinal axis of the motorcycle). The two rockers are transversely arranged such that the two pushrods run up the left side of the cylinder (exhaust situated ahead of intake).

There is an approximately 10º of included valve angle; the exhaust valve is inclined slightly towards the front of the engine, the intake slightly towards the rear (this splay relative to the vertical transverse plane through the central axis, which the rocker axis corresponds to). In addition, there is an equally modest amount of cant (relative to the vertical longitudinal plane).

Twin spark plugs are used in view of the size of the bore, while the two valves are as large as can be squeezed in; their seats are siamesed. As seen in plan, with the smaller exhaust valve leading the inlet, the plugs flank the area where the two seats touch. The valve seats also touch the adjacent bore wall but there is some squish area either side of the piston's central dome.

The domed piston crown is pocketed for each valve, plus there is a slight relief under each spark plug; that is in recognition of the 15:1 compression ratio. "The piston is cut to get a compromise between compression and combustion," Matt Hines notes. "The dome even needs to be trimmed beneath each spark plug for plug clearance."

The two cylinders are identical, with the trailing cylinder rotated 180º so that its exhaust port faces rearwards, its intake forwards. Thus ▶

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