TRIALS ENGINE DESIGN
By Jon Stoodley

With the recent introduction of the new prototype GasGas four-stroke Trials engine at the Milan motorcycle show, two questions come to mind: “What is it?” and “Why?” The answer to the first question is easy, it’s a “valve-in-block” (“VIB”) design, also known as a “sidevalve” or, as some enthusiasts call it, a “flathead” engine. The answer to the second question is much more technologically complex, and as I love “all-things-technologically-complex”, the answer(s) will also be the subject of this article. Although, at this time, I only have a simple, computer generated picture to drool over I’m assured I’ll get to totally slobber over the first GasGas four-stroke Trials model to make it to these shores and will do an in-depth article on what I find. So, now we’ll take a basic look at some of the advantages and disadvantages of the sidevalve engine in comparison to the more common over-head-cam engines now in use.

First, I’ll supply a little background. Every competition engine is a series of compromises and decisions undertaken to achieve specific goals while operating under specific conditions. The more you know about the sidevalve engine, the more the GasGas Design Engineer’s choice will start to make sense when considering the specific demands Trials competition makes on it’s engines, in relation to all other forms of motorcycle sport. When I first heard the comment, “Aw, it’s just a lawnmower engine” in response to the GasGas engine, I thought to myself, wow, these people really don’t have an understanding of what this type of engine is capable of. I started my involvement in car and motorcycle racing with the sidevalve engine and have a long history of experience and understanding of their abilities, and limitations. I’ll try not to get too “geeky” in my observations and keep it as simple as possible, but most of you know how difficult that is for me to do when discussing things as cool as cams, valves and combustion chambers…

In the common, modern four-stroke engine, there are several of ways to arrange, as well as open and close the valves. The VIB (valve in block) engine has two valves arranged next to the cylinder and the cam housed in the crankcase area. The OHV (over head valve) engine also has the cam in the crankcase area, but the valves are above the piston and usually acted upon by pushrods to open and close them. The SOHC (single overhead cam) has a single cam above the piston and usually three or four valves that are moved by means of short rocker arms and, in certain circumstances, some of the valves are directly acted upon by the cam. They can have the valve clearances set by “shims” (small metal discs of a specified thickness) and some rocker arms have a screw and jam nut arrangement. The DOHC (dual overhead cam) has two cams above the piston, usually four or five valves, and the cam acts, essentially, directly on the valves. Valve clearance in the DOHC engines is usually set by shims that are attached to the valve tip (sometimes over or under a cap known by the slang term, “bucket”). A gross generalization could be made that the higher the RPM the engine is designed to produce power at, the more complex it’s valve system. The prototype GasGas sidevalve engine, designed specifically for Trials, is rated at 10,500 RPM. Compare that to, say, the legendary Honda RC166 250cc DOHC factory six-cylinder roadrace engine singing at a reported 18,000-RPM, or maybe even their little DOHC RC116 50cc factory roadrace engine designed to shriek to a rumored 21,500 RPM. We have different engine designs to do different jobs and you would probably not want an RC engine in your Trials bike.

Let’s look at some of the disadvantages of the VIB engine to start with. First, as referred to above, the VIB engine is limited as to the effective RPM range it can operate at, in part, due to the “shrouding effect” of the gas flow under the valves at the combustion chamber area opposite the cylinder. This, coupled with the circuitous path the air/fuel mixture must travel in order to fill the cylinder would make the VIB a poor choice for ultra high RPM work.

Possibly due to the lack of mass, the VIB engine can be a little noisier than, say, an OHC type engine that has more bulk to help “absorb” the various clashes of metal that normally go on in a four-stroke.

The cylinder assembly will also tend to be a little wider due to the valve placement on the side of the cylinder, rather than above it, although not much more than the OHC, which also needs space by the cylinder to run a chain for the cam up above the head.

There are some limitations on combustion chamber design in the VIB due to the necessary above-the-valve clearance pockets and sparkplug placement is usually somewhere in between the piston center and valve centers. The VIB usually has two valves per cylinder, as opposed to the Yamaha DOHC, for example, with five valves per cylinder. Due to the necessity of having the area over the valves, as well as the piston, as part of the combustion chamber, getting effective flame front propagation during fuel burn with a chamber that large takes some serious design work. This is important, especially in light of the fact that the volume/area above the valves will always be a constant, whose height will be dictated by maximum valve lift. So, although some will see the GasGas sidevalve as a simple lawn mower engine, the design parameters of this engine have obviously been very carefully worked out.

Now, let's look at some of the possible advantages of the sidevalve engine, specifically in the area of Trials application, for which the GasGas engine appears to be purposely designed for:

The lack of ultra-high RPM capability is not a limiting factor in Trials, where on/off throttle application and a wide range of power is needed. Low and upper-mid range torque, rather than high-end horsepower is what gets the job done and the VIB engine has no problems there. The VIB engine's valves are perfectly capable of filling it's cylinder just fine in the operating ranges Trials engines are subject to. Upon looking closely at the computer generated "blow-up" (a term few race tuners ever enjoy using) picture of the GasGas Trials four-stroke, I noticed what appears to be a shallow channel from the valve area over to the top of the cylinder bore (I could be mistaken). If true, this is known as a "relief" in racing VIB circles, and one of the changes I would do when modifying the ports and block for performance. A sidevalve engine that was extensively modified for racing with high-speed grinding tools (and a lot of experience) was said to be "ported, polished and relieved". That "relief" was designed to improve gas flow at higher engine speeds. Although the VIB engine is generally not known to be capable of ultra-high RPM, the GasGas Trials four-stroke engine is rated at 10,500 RPM, a lofty area where few riders will ever spend much time.

Simplicity, compact size and lighter weight, as compared to the OHC engines, are three of the things that are obvious at first observation. The GasGas four-stroke is about the same height as the two-stroke and probably only a few centimeters wider. The comparative lower engine weight means that the bike is much lighter overall, but also that the engine mass is carried lower and more centered in the frame. Centering mass within the frame structure has a very big effect on handling in a motorcycle, especially quick directional changes, which Trials is all about. Two motorcycles can weigh exactly the same, but can have quite different handling characteristics due to where that weight is placed on each motorcycle. It has to do, in part, with "moment of inertia", which is similar to inertia, except that it relates to rotating movement rather than linear movement. More important to our discussion, there's "polar moment of inertia". When the mass of an object is distributed far from its axis of rotation, the object is said to have a high polar moment of inertia. When the mass distribution is close to the axis of rotation, it has a low polar moment of inertia. …Oops; sorry, sorry…was just having another little "geek fit" there…

The exhaust and intake tracts are low on the VIB cylinder; much like a two-stroke, and the fuel injection system essentially lies over the top of the engine case, rather than being mounted up high, back behind the combustion chamber area on the OHC. This further contributes to keeping the weight lower within the frame and helps promote a low polar moment of inertia.

The simplicity of this type of engine is in more than just the fewer number of parts. Getting adequate lubrication oil to all the extra parts above the piston in an OHC engine is a complex job and requires a series of precision oil passages and a pressure pump (sometimes two pumps, one pressure and one scavenge) to get oil to all the bearings, bushings and

cam chain and then back down to the engine sump. The VIB engine does not require as sophisticated an oiling system as it has fewer valve gear parts and they are located down in the engine case. The cam appears to be supported by ball bearings, rather than the usual machined recesses in the head commonly found in some OHC engines. Another by-product of simplicity is that manufacturing costs will be kept low due to fewer parts and complex machining operations needed. And, of course, there is the obvious advantage for the owner of having fewer parts to break or wear out

Engine maintenance and checking valve clearances should be easy. The GasGas engine appears to use replaceable valve tips to adjust clearances and the valves are apparently easily accessible for checking clearances from the side of the engine through small covers. Anyone who has ever adjusted the valve clearances on a multi-valve, shim-under-bucket four-stroke (like I have many, many times), will appreciate this feature. Adjusting the valves on a DOHC engine, for instance, usually involves taking the tank off, taking the top cover off, checking/recording the valve clearances, backing off the cam chain tension, removing the cam supports, removing the cams, carefully removing each cap ("bucket") to not lose the shim down in the engine, measuring/recording each shim and doing the calculations to determine the appropriate shim to replace it with, then replace all the components while making sure the cams are correctly timed to crank top-dead-center, check all the clearances again and if the valve clearances are not then within specifications (it happens), do it all over again. Luckily, the SOHC engines are usually a little easier to work with and the valves can often be set without disassembling the valve train. However, not to make this a complete horror story, in my experience, the shim-under-bucket DOHC would be quite understressed, considering it's intended design parameters relative to Trials use, and they tend to go a long time between valve re-setting need than, say, the screw and jam nut adjusters on some of the OHC engines.

Although the VIB engine usually only has two valves, they can be of fairly large size, as their placement/diameter is generally not limited by the size of the bore. They can be as large as necessary for adequate flow area rather than having to resort to multiple valves. Although, having those necessary recesses above the valves for lift clearance makes combustion chamber design a little more difficult, it also has the advantage of allowing valve timing to be whatever the engine designer wants it to be. As there are no piston/valve clearance problems, you can open and close the valves whenever you want, as fast as you want and for as long as you want (and generally not have to worry about "valve float" type problems).

Another couple of positive features for the VIB design is, due to the fewer parts to get spinning, kickstarting should be easier, probably without the need for the extra complexity of a de-compression mechanism and the battery-less fuel injection system should also contribute to easier light-off, hot or cold. When running, less mass to accelerate and decelerate generally equals better throttle response, all other things being equal.

So, there you have a few of the basic pluses and minuses of the various Trials engine designs. Some riders will love the VIB design and others will not, but for those who can see beyond pre-conceived notions of what is the "correct" type of engine for a Trials motorcycle, there is some innovative technology in the new GasGas four-stroke that seems to result in some clear advantages in meeting the specific demands of Trials riding. Now, if I can just talk GasGas into putting this new engine in that new, lightweight frame Adam Raga is testing…