ENGINE COOLING SYSTEMS

AIR-COOLING

Motorcycles use either liquid or air-cooling to create an optimal temperature for combustion while preventing overheating. Without proper cooling engines will wear out and/or break quickly. All engines utilize the cooling provided by the engine oil.

Air-cooling works well for small displacement, single cylinder and older parallel twin-engine designs. Bikes using these engines are usually scooters and off-road dual sport bikes.

Air-cooled engines use aluminum alloy heads, pistons and cylinders to dissipate heat. Aluminum dissipates heat much better than iron, and aluminum has long since replaced iron in motorcycle engines.

Note that all air-cooled engines – and liquid-cooled engines – also rely on the circulation of engine oil throughout the engine for some cooling.

The following engines still use air-cooling. As of 2013 for example, Honda builds a 644cc dual sport, single cylinder trail bike that is air-cooled. Suzuki builds a 124cc air cooled off-road trail bike. Yamaha still builds 249cc, 124cc and 49cc off-road dual purpose bikes that are air-cooled.

As of 2013, Ducati still builds a 696cc and 796cc displacement air-cooled engine for their Monster line of street bikes.

Air-cooling also works well for large displacement V-twin and flat-twin engines. These engines are used in the big baggers, touring bikes, and cruisers built by Harley Davidson, BMW, Star Motorcycles and Victory Motorcycles.

Large displacement air-cooled V-twin engines have displacements that range from 883 cc (54 cu inch), to1,854cc (113 cu inch).

For example, Star motorcycles uses a 1,854cc (113cu in) air-cooled V-twin engine in their biggest bikes. Victory motorcycles uses a 1,731cc (106 cu in) engine in all of their air-cooled V-twin cruisers and touring bikes.

All Harley engines, except for the V-Rod model, use an air-cooled V-twin engine design.

Harley uses an 883cc (54cu in), and 1200cc (73cu in) engine, in their Sportster models. The Dyna, Softail, Fat Boy and Road King models use a 1,688cc (103 cu in) air-cooled V-twin engine.

Harleys' biggest engine is the CVO Road King which uses a 1,802cc (110cu in) air-cooled V-twin engine.

Up until 2013, BMW has used air-cooling exclusively in their flat twin engines for about 90 years. In 2013 BMW adopted partial water-cooling for their very popular flat twin touring bike – the R1200GS. However, to maintain the classic look of the BMW flat twin, about 65% of the engine cooling is still from air with cooling fins in the cylinder and head.

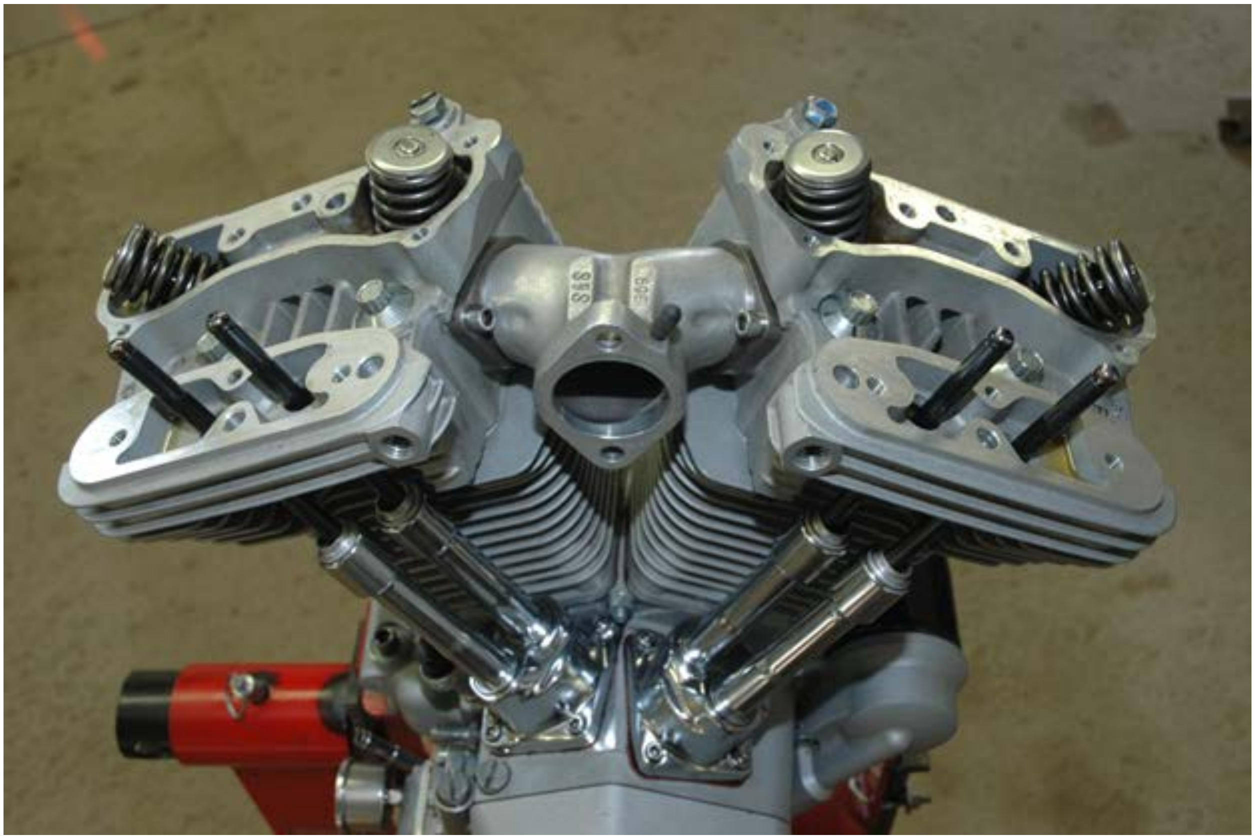
To summarize, air-cooled engines are still popular in scooters and a few single cylinder dual sport off road bikes. Air-cooled engines are still very popular in big cruiser and touring bikes that use the V-twin or flat twin engine design.

Air-cooling is not used with current production engines using the following engine designs: inline six cylinder, inline four cylinder, inline 3-cylinder and V-4 cylinder. There is too much heat buildup with the multiple cylinders and it is impossible to get cooling to the cylinders which lie between other cylinders.

Note that all competition motocross bikes are now manufactured with a single cylinder water-cooled engine.

PROBLEMS WITH AIR-COOLING

For the engine designs found in scooters, small displacement off-road bikes, V-twin or flat twin cruisers, engine cooling with air alone works fine. However, the rear cylinder of the V-twin engine does run hotter than the front cylinder. This is because the rear cylinder sits behind the front cylinder which blocks direct airflow to the rear cylinder.



Cylinder and cylinder head cooling fins on this Harley engine provide the only cooling for the engine in addition to the engine oil.

For higher displacement, higher horsepower, higher revving, and higher compression ratio engines such as in sport bikes or competition motocross bikes, air-cooling simply cannot cool the engine fast enough. But even more importantly, the middle cylinders are hemmed in on both sides in the inline 6, inline 4 and inline 3 engine design – these cylinders simply cannot get enough exposure to air cooling.

Although the large V-twin cruisers do have huge displacement, they are not typically revved to 13,000 rpm and above, as is the typical sport bike. In addition, there are only 2 cylinders in the V-twin configuration and both cylinders are able to get direct air-cooling. Therefore, air-cooling is a viable option for the big cruisers. Some models also have an oil cooler which assists the air-cooling.

That said, the old Honda CB750cc inline 4 air-cooled engines in the 1970's did work with lots of cooling fins on all the cylinders and heads. However, when displacement climbs to 1,000cc and above in high horsepower, high revving, and higher compression sport bikes for example, air-cooling is out of the question. An air-cooled engine with these design features would quickly overheat.

Although air-cooling is successful with large displacement V-twin engines, the fact remains that the exhaust valves of air-cooled engines still do not get direct air-cooling. This is in contrast to liquid-cooled engines that use water jackets to circulate liquid coolant through the cylinder head in close proximity to the exhaust valves, as well as around all the cylinders.

Heat is destructive to any engine. Without enough cooling, the pistons will seize against the cylinder walls and lock up the engine causing plenty of engine damage.

Unfortunately, only a small percentage of the heat of combustion creates mechanical power – about 25 to 30%. The remainder of combustion heat is removed from the engine through the exhaust or through the cylinder and cylinder head. Modern gasoline engines are simply not very efficient.

Cooling fins are built into the outside of the cylinder and the cylinder head in an air-cooled engine. These fins transfer heat from the cylinder and head to the outside air when the outside air flows over the fins.

Heat is also transferred from the engine to the outside air through the engine case, which may also use cooling fins built into the oil sump part of the case. Oil circulating throughout the engine also helps to cool the air-cooled engine, as well as a liquid-cooled engine.

Air does not conduct heat nearly as well as liquid which is far denser than air. Therefore, air-cooling requires a huge amount of air to flow over a large surface area with cooling fins. The problem is that there is only so much engine surface area available where cooling fins can be cast or machined into place. To make matters worse, combustion heat travels slowly through the cylinder and cylinder head. Then, when the heat finally does reach the cooling fins, the heat is transferred slowly from the cooling fins to the outside air.

This classic air-cooled Honda motor from the 1970's is in demand for some custom builders.

Heat must also be transferred out of the exhaust valve, which experiences constant waves of extreme heat. Cool air from the outside cannot reach the exhaust valve. The exhaust valve must transfer its heat from the valve face into the valve seat, and from the valve stem into the valve guide.

The bridge between the intake and exhaust valve is also a location of great thermal stress. The incoming fuel and air charge through the intake valve is cool, but the exhaust gasses blowing past the exhaust valve are extremely hot. This thermal stress in the bridge area is often where cylinder head cracks typically show up.