Around The Block: Taking the Mystery Out Of Engine Hot Spots and Head Gasket Failures

By Don Fedak

Internal combustion engines produce power when a burning mixture of air and fuel expands. These engines also become more efficient as combustion temperature increases, but to develop maximum power, the energy lost as heat should be kept as low as possible.

If engine parts were made out of materials which did not expand, corrode or melt, heat losses via cooling systems could be reduced or even eliminated. But current engines have cylinder heads, guides and valves which do expand, corrode and melt. So today's engines, which generally run hotter, still need cooling systems. That’s why gasket engineers are constantly looking for new ways to keep combustion gases and liquid coolant separated.

Because heat is primarily generated within combustion chambers which are integral to cylinder heads, uneven expansion and contraction of cylinder heads is unavoidable. Cylinder heads expand the most because their heat load is greatest. Furthermore, they'll expand the most where the temperature of the casting is highest, i.e., between adjacent combustion chambers. But this is also where the width of the head gasket is at a minimum. So it shouldn't be surprising to find that head gaskets usually fail between cylinders. The challenge is to produce gaskets to seal those spots in engines where space is severely restricted and the temperature is highest.

Since all head gaskets are required to perform and endure while exposed to significant temperature gradients, the best gaskets available should always be installed. Good gasket designs and materials will minimize irreversible compression of head gaskets due to normal localized expansion of the head or the block. Poor designs or materials won't.

Any efficient, well-designed cooling system should be capable of handling some extra heat and most usually do. So when quality head gaskets fail, it's usually because of poor maintenance. When head gaskets fail in well-maintained vehicles, it's almost always due to either sub-standard gasket material or poor design – not hot spots.

Head gasket failure from too much extra heat can sometimes result from poor casting or gasket design, ignition timing errors in one or more cylinders, lean air-to-fuel mixtures due to a faulty carburettor, injectors or intake leak, and cooling system problems.

With time, cooling systems can and do lose efficiency, especially when they're neglected. Examples of cooling system problems which increase operating temperatures and promote head gasket failure are corroded, plugged or undersized radiators, broken fans and fan controls, defective thermostats, inefficient water pumps and collapsed hoses.

Many head gasket failures in today's engines are also caused by air trapped in the cooling system. When a cooling system is open and is being filled, it may erupt suddenly when the thermostat opens. This is one reason that many thermostats now have air-bleed valves.

Once they're filled, all pressurized, closed cooling systems may still contain a small amount of air which will be compressed as the temperature rises and the liquid coolant expands. Small air pockets will seek the highest point in the system, well removed from the head gasket or combustion chamber, and will not cause any problems.

In extreme cases, when too much air becomes trapped in a closed system, coolant will be prevented from entering the cylinder head. If this happens, the head will overheat, try to expand in all directions and compress the two-dimensional head gasket beyond its design limits. Geometry dictates that the head gasket will be compressed the most where it's narrow, between adjacent cylinders. After the engine is overheated and shut down, both the head and the gasket will cool and contract, the head will warp and pull away from the head gasket, and the combustion chamber seal will be destroyed.

Alternatively, if cold liquid coolant is allowed to flood the cylinder head of an engine that has been started and warmed up before it has been completely filled, the hot head casting will be rapidly quenched and forced to contract suddenly and unevenly. Hot thin sections, (such as areas between cylinders or valves, or next to exhaust crossovers) will distort or even crack. This can happen when cold coolant is added to a partially filled hot engine, or when a thermostat opens suddenly and allows cold coolant to flood a bone-dry, air-locked cylinder head.

The above discussion has attempted to explain the mystery, if any, associated with hot spots and head gasket failures. It should be clear that head gasket failures usually have little to do with mysterious hot spots and everything to do with improper service procedures, lack of proper maintenance, and/or poor engine and gasket design.

Reference: www.enginebuildermag.com