Valve Train Trouble Shooting - Valve Head Cracking / Breakage

1. Valve Headchordal Failure

In the classic case the valve head breaks through a chord line, e.g. the chord of a circle, usually producing considerable secondary damage to the piston, cylinder head and sometimes the cylinder bore. This is a fatigue type failure caused by the valve head's inability to stand up to the stresses from the gas loading, coupled with the valve head temperature effect on the ultimate tensile strength of the valve material. The initiation point is usually about halfway up the underhead radius but this varies to some extent according to the section design of the valve head. This is a problem mainly confined to the engine manufacturer during the development of a new or uprated product but it can occur in service. Although the term chordal is applied, there can be many variations on the shape of the developing crack, which sometimes travels a considerable way round the underhead radius before propagating out to the valve seat. Fundamentally, such valve head failure are caused as a result of the skin of the underhead radius at some point being too highly stressed – in service the reasons for this could be:

a) Excessive load on the engine coupled with over-fuelling or other maladjustment, resulting in excessive valve temperature and gas pressures.
b) Poor finish on the underhead radius on highly stressed valves. Note some valves are shot peened or spiral-polished to increase resistance to skin fatigue.
c) Damage marks on the underhead radius.

2. Valve Head Tuliping

In this instance, the head of the valve is cupped downwards resulting in poor sealing and loss of power. This is related to chordal failure but where the environmental conditions, valve head design and, type of material, produce initially a plastic flow, valve tuliping is spotted before final chordal failure occurs due to the resultant poor sealing and power loss. With this type of condition, it is believed that overspeed dynamic effects do help the plastic flow.
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3. Radial Rim Cracking of Inlet and Exhaust Valve Heads

The term "Radial Rim Cracking of Inlet and Exhaust Valve Heads" has been chosen in favour of the more traditional expression "thermal fatigue". Research over the last few years has clearly indicated that, in the past, many failures attributed to classic thermal fatigue have had other factors influencing the result. A radial crack is one that starts in the rim of the valve and travels inwards to the centre of the valve. As with the case of chordal failures, there are variations on this theme and, sometimes the propagation line will turn through 90°, travel across the valve head in the form of a half chord and, then back to the valve seating face, the piece breaking away being roughly triangular in form. In other cases the initial crack line will branch into a turn at 90° to both left and right, thus producing two triangular breakaway pieces. Very often these are lost and, at first glance, it would appear that the valve has suffered from a chordal failure. Sometimes this is fairly obvious but, in other cases, it can require expert identification. The causes of true thermal fatigue are:

a) Extreme cyclic temperature variations throughout the valve head, brought about by excessive temperature and pressures in the combustion chamber.
b) Continually overloading of the engine followed by abrupt unloading or frequent engine shutdown after high loading.
c) Poor temperature distribution across the valve, resulting in high tensile rim stresses, often coupled with abnormal deflection of the valve head due to excessive combustion pressures.
d) Damage marks on the rim producing stress raisers.
e) The rim or peripheral land of the valve head too thin and, with sharp edges, usually due to too frequent reclaiming or regrinding.
f) Can also be brought about by pre-ignition conditions.
g) Use of wrong material specification.

4. Back of Valve Face Burn Through

On occasions an exhaust valve will burn a hole through the valve head just at the back of the seating face, leaving the seating face virtually unmarked. Close examination, however, will show that the start of the failure is a rim crack. The combustion gases escape through the crack with rapid erosion of the valve head material. This is yet another example of radial rim cracking or, thermal fatigue.