Ring Gaps vs Knowledge Gaps

During school summer holidays there occurs a period known as the "silly season" when breaking news is slack and newspapers, radio and TV issue forth all sorts of drivel to justify their existence.

In our industry I sometimes think that we use ring gaps to fulfil a similar purpose – and we do it all year round. There are more old wives tales about ring gaps than any other facet of our job, so lets spend a while and bin a few of them.

Frequently I hear in court that when an engine is dismantled it is discovered that the ring gaps were not staggered when they were installed. Frequently I read workshop manuals that go into great detail on the necessity to stagger ring gaps. Frequently these manuals specify ring gap limits – which is yet another myth we can bin before we are finished.

In days gone by, some compression rings used to have a 'threepenny bit' expander behind them. These braced against the base of the ring groove and forced the ring onto the cylinder bore but these are very much the technology of yesteryear and, as such, an exception to what I am about to say.

Piston rings are free agents and can rotate or not rotate as they see fit. They are not in touch with the base of the groove and neither are they trapped between the upper and lower faces of the groove. The rings are entirely free to rotate – except where a stop peg is fitted – so what's the point in staggering the gaps on installation?

We used to work on a minimum of 0.020" back clearance on radius or, to put it another way, the inside diameter of the ring when installed in the cylinder must be at least 0.040" bigger than the groove root diameter. Minimum side clearance was generally held to be 0.0015" and if you could fit a 0.006" feeler gauge in the groove along with the new ring then the groove was "goosed" so the piston was replaced.

The piston ring was manufactured with a tangential load – the force with which the ring presses against the cylinder wall – but apart from that it is completely uncontrolled. There is no way, under these circumstances, that you could prevent the ring from turning so, to repeat the question, why stagger the ring gaps on installation?

Staggering ring gaps when installing pistons is every bit as daft as having four tyres fitted and placing all the valves at "twelve o'clock". One trip to Tesco and they end up all over the place.

Equally daft are those who expect ring gaps to stay staggered when the engine is in operation. When there is clearly nothing to prevent the ring from rotating, why should the gaps stay staggered?

More than one county court judge has fallen for the hocus pocus that because the gaps were in line when the engine was dismantled, they must have been in line when installed. Absolute poppycock! Yet the inclusion of such rubbish in workshop manuals does admittedly give it an air of authority.

When you think about it, you don't need me to tell you – but I will anyhow – that rings do rotate in operation. Every now and again the gaps do line up – and once lined up there is a tendency for them to stay lined up at least until the vehicle hits the next pothole in the road when one or other will

rotate and break the line. Staggering ring gaps when installing rings is a myth that we can bin forthwith.

Even worse is the preoccupation with the size of the ring gap. Yes, there is a minimum but this varies considerably depending on the material used. Normally 0.003"/0.004" per inch of bore size is given but where, for example, low expansion SG (spheroidal graphite) iron is used, it can be considerably less.

It's no problem if the gap is too small because it can, in the final analysis, be filed bigger but what do you do if it's too big? You cannot stick a bit extra in there!

Well, the answer to that was that you melted them down and started afresh – until AE research asked the question, "What is too big?" and set out to quantify that. The results were interesting – very interesting – and what you are about to read was kept quiet because it bestowed an enormous commercial advantage on AE. This is probably the first time the information has been published although the research was undertaken in the late 1970's – almost 25 years ago.

A Ford Kent engine was stripped and fitted with compression rings which had end gaps of 0.015" when fitted in the bores. The engine was wired up with the usual telemetry to measure blow-by and oil consumption and then run in one of the test cells. After making due note of the blow-by and oil consumption, the engine was stripped and fitted with new compression rings with gaps of 0.025" and the test cycle repeated.

These rings were subsequently replaced by ones having end gaps of 0.035" and the test cycle repeated again. It had been planned to stop at 0.035" gaps ----------> but the results were so interesting that it was agreed to proceed to 0.045" and then not to 0.0055" but to 0.0625" – 1/16"!

Whoever heard of rings with 1/16" gaps – a ridiculous figure – but the interesting thing was that the increase in blow-by and oil consumption at 0.0625" was only marginally above the figures obtained with 0.015" gaps.

Practical tests established that the gap was not the villain of the peace. To all practical purposes the size of the gap didn't matter. It is important to stress at this point that we were dealing with compression rings that were brand new when fitted to the test engine.

The gap was specially manufactured for the tests. So how come all oil burners and heavy breathers have ring gaps you can back a bus through? Well, the tangential load that the ring exerts onto the cylinder wall is a direct function of its radial thickness.

As the periphery wears in contact with the bore, the radial thickness obviously decreases, as does the tangential load. Peripheral wear means a smaller ring o/d and this manifests itself as an increase in the ring gap.

So, whilst all oil burners and heavy breathers have big ring gaps, it's not the gap but the reduced tangential load that is detrimental to the performance of the engine. The ring gap is a complete red herring.

Imagine four top compression rings all with 1/16" gaps. The total gap for all four would be 1/4". Now imagine the seal provided in an 80 mm diameter bore. Pi x Diameter = Circumference, so we

have 3.14” x 3.15” = 9.891”. Multiply that by four cylinders and we have 39.564” – over a yard of contact seal between piston rings and bore. Now visualise the many litres of blow-by and consider whether all the gas is squeezing through 1/4” of total gaps or passing through 39½” of reduced pressure contact seal!

But even this ignores one important facet of the argument because there is not just the one compression ring on a piston – there are usually at least two and that is because rings work as a team to form a labyrinth seal.

For gaps to be the villain of the peace, the gas would have to find the gap in the top compression ring and pass through. It would then have to circulate to find the gap in the second ring and pass through that and so on. Now this may be possible if the power stroke lasts for 10 minutes but it doesn't, does it?

At 3,000 rpm the power stroke duration is a mere 1/100second. Quite simply, the power stroke does not last long enough for the combustion gas to find its way around the maze – or labyrinth seal, so the villain of the peace has to be the reduced tangential load of the ring on the bore caused by peripheral wear or reduced radial thickness of the ring.

This was our hypothesis based on the results obtained in the engine test cell but it took a very clever American to prove it. This genius invented telemetry that measured gas pressure between the piston rings in a working engine.

Use of his brainchild revealed that some gas did get through the top ring gap sufficient to generate a hell of a pressure between the top and second rings – so it clearly was not finding the gap in the second ring. The labyrinth was working well. Caterpillar and IHC must have thought it was working too well because they increased some second ring gaps to 0.050” and 0.070” thought to be beneficial.

Come to think of it, the exception proves the rule – as usual. Two stroke engines would not need stop pegs to prevent the end gap from crossing a port if the ring didn't rotate. The people who allege that ring gaps were not staggered when installed just because they are in line when the engine is dismantled don't need stop pegs.

They could simply position the end gap away from the port and expect it to stay there – and we all know that this would get them into more hot water than a Yorkshireman’s tea bag! So why do they always blurt out their rubbish on the importance of staggering gaps?

The very presence of a stop peg also proves my point about the size of ring gaps. Where a peg is fitted, the end gap has got to be 1/8” to accommodate the peg. There would be one hell of a draught through that if the 0.015”/0.018” boys were correct.

This knowledge was commercial dynamite because, instead of the '0.015”/0.018” spec., it meant that new rings with gaps over 0.018” could be used without any detriment to the engine's performance. The gap was only detrimental when it was the result of peripheral wear. Customer acceptance was the only problem.

To re-educate the customer would let the cat out of the bag, thereby losing the distinct commercial advantage. It was decided, therefore, to accept rings with gaps of up to 0.030” in a nominal bore but even then there were arguments. 0.030" in a nominal bore is 0.045” in a bore worn by 0.005” – and its normally engines with this sort of wear that get new rings.

The gaps on the new rings were bigger than the gaps on the ones being replaced which led to several heated conversations – and how the hell do you pacify the customer and keep the cat in the bag?

It made diagnostics a lot harder too because when all rings set off in the 0.015”/0.018” area gaps of .040” meant something but now, when you don't know what they set off at, what they measure is meaningless.

Well, now you know. All rings are free agents to rotate as they like, making staggering of gaps on installation a joke and ring gaps are not a problem provided that the gap is not the manifestation of reduced ring radial thickness caused by peripheral wear.

In the light of the logic expressed in this article we are offering an expensive prize to anyone who gives us a good reason for staggering ring gaps on installation – a free burial at sea.

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