Boring Finishes!

Getting the right crosshatch for the best results.

*By Nigel Tait**

When to Hone a Cylinder

Should a bore always be honed when re-ringing, or is it good practice to re-ring a worn bore without honing?

The situation is this: with any engine and with any ring set (regardless of manufacturer), best results will always be achieved if the bores are brought back into their original condition. However, there are still situations when a good result can be obtained without honing, for example:

1. If the bores are not excessively worn and do not have any deep scratches or scuff marks.

2. If the bores are not badly distorted.

3. If the bores are not glazed.

4. If the rings to be fitted are designed to be used in unhoned bores.

Some ring sets are designed to bed-in and seal on new or worn bores. Their compression rings will have profiles which deliberately achieve bottom edge contact. This means they are downward scraping rings. Likewise, the oil rings have higher wall pressure than most original equipment rings and this also assists rapid bed-in.

NOTE: Some ring manufacturers mainly make for original equipment and their ring sets are designed with this in mind. Often these sets have barrel lapped chromium plated top rings and such rings are really not suitable for aftermarket use and certainly not on used bores - they will not bed-in and they will not control oil.

There once was a time when the practice of honing for re-ringing was actively discouraged by various ring manufacturers. The main reason for this was because of the fear (often justified) that the highly abrasive carborundum honing grit (and cast iron) would not be properly cleaned out prior to reassembly. This was especially so when the bores were re-honed with the engine in the chassis.

Also there was the fear (also justified) that an incorrect honed finish would be achieved, which could be worse than no honing at all.

Cleaning of Bores after Honing

In the honing process, abrasive from the hone stones and debris from the cylinder may be retained in the hone pattern. If this debris is allowed to remain, the early wearing out of the piston rings will result. Wiping the bores out with an oily rag or washing with kerosene or similar solvents will not remove this debris. To ensure bore cleanliness, the bores should be scrubbed thoroughly using hot soapy water and a firm brush until a white cloth wiped over the cylinder walls remains clean. Following this, the bores should be wiped over with a lightly oiled rag to prevent corrosion. If the block is to be put into storage before assembly, a preserving oil should be applied. It may be necessary to remove any storage preservative before using the components - the manufacturer's instructions should be obtained and followed.

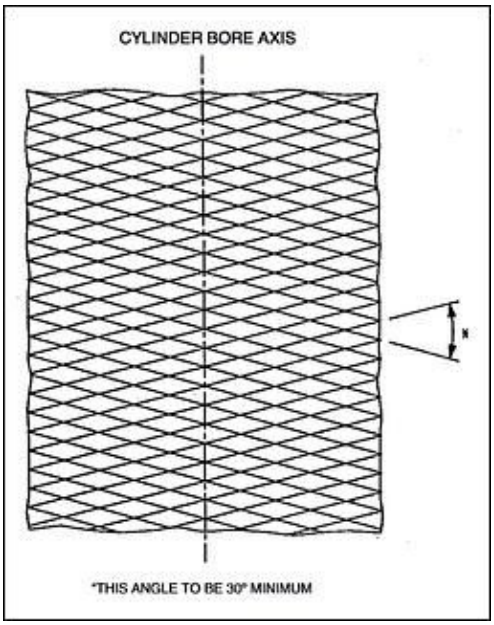
Aluminium Bores

Aluminium blocks are traditionally fitted with cast-in or pressed-in dry liners, or sometimes wet liners. In the interests of reducing costs, weight and manufacturing complexity, some engine manufacturers have developed aluminium alloys for the engine blocks which enable the piston and rings to run directly on the aluminium surface. In one technology an aluminium - known as Reynolds A 390 - with a high silicon (17%) is used and the honed bores are etched by a special chemical which attacks the aluminium leaving the silicon particles standing proud - and it is these particles that the rings and pistons work against. This technology requires the use of an aluminium alloy piston, iron plated on its skirt and chromium plating must be specified on all rings. Some late model Honda engines, eg Prelude, have an aluminium bore impregnated with ceramic fibres. These bores must be honed in accordance with manufacturer's instructions, which call for a 600 grit stone.

Reconditioning of aluminium alloy cylinders is highly specialised and requires the honing equipment to be fitted with special stones with the honing techniques specified by the relevant engine manufacturer. One aspect that is worthy of mention is that the power honing machine to be used must be absolutely free of cast iron debris and grit - in fact it is best to devote a honing machine specially to the task of honing aluminium bores, a practice which inevitably leads to these engines being reconditioned by very few specialist reconditioners.

Finishing the Bore

The final finish of a cylinder bore is the result of both honing and boring. Successful boring is unlikely to be achieved with a single cut. The final cut should be approximately 0.125mm (0.005") with nose radius on the cutting tool of not less than 0.5mm (0.020").



The reason that a large nose radius tool is required for the final boring cut is that this leaves the least depth of peak to valley height on the surface for honing. If a tool of 0.15mm nose radius is used, the surface finish of the final bored surface will probably be approximately 5 micrometres (200 microinches) Ra and will have a peak to valley height of 0.3-0.5 micrometres. This takes a lot of honing to remove, especially if a hand hone is used, or if fine stones are used in a power hones. If a larger nose radius tool is used for boring, the surface finish achieved will be much smoother, around 1.8 micrometres (70 microinches) Ra and the peak to valley height will be 0.1-0.2 micrometres. This makes it easier to ensure that all boring marks are removed, minimises honing time, and importantly, reduces the sub surface disturbance during the final honing operation.

Coarse cutting or tearing of the bored surface will result in disturbance of the sub-surface which cannot be satisfactorily corrected during the honing process. A honing allowance sufficient to completely remove all boring marks must be left. The amount of this allowance will, of course, depend on the depth of cut of the boring process but in general should be 0.05mm-0.07mm (0.002 in-0.0025 in).

Honing is best carried out using a honing machine which enables a consistent hone pattern to be achieved. Hand honing, although still practiced, suffers from the problems of inconsistency of pattern and a natural reluctance of the operator to remove comparatively large amounts of metal by this process. The chances of leaving boring marks after hand honing are high and high oil consumption will be the inevitable result.

Multi stage honing has been found in practice to give the most satisfactory and consistent results, giving not only a finer finish but a significantly smaller variation between cylinders.

Several heavy diesel engine manufacturers stipulate three honing stages. For general reconditioning, however, two stages give consistent and satisfactory results. The first stage of honing removes stock and establishes a hone foundation. This stage must remove all boring marks. The stone grit may vary from 80 to 220 grit, the most common used being 180 grit. Too coarse a base will call for excessive use of the finishing hone. The second stage should be the use of a hone of 280 to 400 grit. Depending on the number of stages of honing used and the characteristics of the engine, 280 to 320 grit stones have, in general, given satisfactory results with 320 grit being preferred. For those engines which, by reason of their operating characteristics or hardness of block material, require a finer finish, 400 grit may be necessary as a third stage of honing.

The first stage of honing should be carried out using a hone in order to maintain a true and parallel bore. A few low pressure or "dwell" strokes should be given at the end of each honing stage. The final stage may be carried out economically by the use of a flexible hone.

A correctly remanufactured engine after 150,000-200,000km of use may be expected to have a bore finish of 0.13 to 0.15 micrometres (5 to 6 microinches) Ra. Engines produced for original equipment may be expected to have bore finishes in the range of 0.38 to 0.76 micrometres (15 to 30 microinches) Ra with the majority being in the range 0.25 to 0.51 micrometres (10 to 20 microinches) Ra.

In summary, to achieve consistent good oil and blowby control -

1. The final boring cut should be 0.125mm (0.005")

2. The tool should have a nose radius of at least 0.5mm (0.020")

3. A honing allowance of 0.05mm-0.07mm (0.002"-0.0025") should be left

4. Honing should be carried out in at least two stages with a final hone grit size of 300 or finer

5. The third stage may be carried out using a flexible hone

6. More honing stages will give a finer surface finish and a smaller spread of values

7. The factor having most influence on the final finish is the grit size of the hone stone although the lubricant has some effect.

8. Bedding-in is more rapid and less debris is deposited in the oil with finer finishes.

9. Harder block materials require finer finishes.

Cylinder Bore Honing For Race Engines - Plateau Honing

This method of honing is quickly gaining a wide acceptance as it offers an easy and cost effective way to achieve excellent sealing with low friction and good oil control. While discussed here is plateau honing of race engines, the practice can and should be employed for every type of engine. Note that in order that the bores are as round and straight as possible, all serious race and performance engines should be honed with a deck plate in place. This will consist of a 40-50 mm steel plate with holes drilled for the studs and bores, bolted to the top of the block with the same bolt torque as the head is intended to have.

Step 1. Bore out to within 0.004" (0.1 mm) from finished size using a large radius tool. The surface must be evenly cut and free of gouges or cracks caused by excessive pressure/feed rate or blunt tool. Resultant maximum finish Rz 500 Microinches (12.5 micrometers, Ra 125 Microinches (3.2 micrometers).

Step 2. Rough hone virtually to size (the last honing operation will remove no more than 0.0001-0.0002" (0.0025-0.0050mm) of stock) using 220 grit stones. The cross-hatch pattern should be uniform in both directions with sharply cut lines. The included angle should be 30 to 60 degrees. Resultant maximum finish Rz 175 Microinches (4.5 micrometers), Ra 35 Microinches (0.95 micrometers).

Note: Engines for endurance events or street use should be rough honed with coarser grit stones, ie 100 to 180 grit.

Step 3. Finish Honing.

a) Rigid Honing:

Finish hone with 600 grit rigid hone reducing pressure for the last 5-10 strokes. Alternatively, if 600 grit is not available or proves to be too difficult to use, substitute with 400 grit stones and then finish off with 600 grit rigid or 400-600 grit flexible hone.

b) Flexible Honing:

Hone with a 400-600 grit flexible hone for at least 1 minute. Use oil with a flexhone to develop an abrasive slurry, the rule being: the thicker the slurry, the more consistent the finish. An adequate result can also be achieved with a coarser grit flexhone by using high viscosity oil or grease and longer cycle times.

The bore surface produced by this method will have around 90% of its area as plateaux with very smooth finish to allow for quick run-in, excellent sealing and low ring to bore friction. The remainder of the surface will have an evenly distributed network of narrow valleys for oil retention. The depth of the valleys should be in the order of Rz 100-125 microinches (2.5-3.2 micrometers), while the bearing surface will be Rz 25-40 Microinches (0.6-1.0 micrometers).

Cleaning After Honing

To reiterate, it is absolutely critical that the bores are properly cleaned after any honing operation. DO NOT USE PETROL OR KEROSENE! Neither is suitable for bore cleaning. A hot tank with suitable fluid is suitable but best results are achieved with a nylon scrubbing brush and soap and hot water. Then swab the bore with a clean oily cloth.

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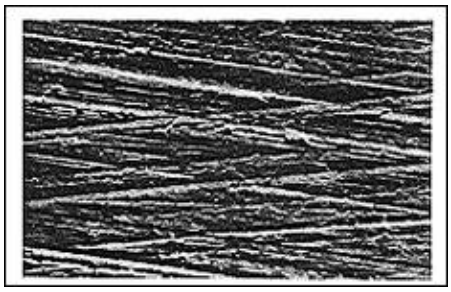
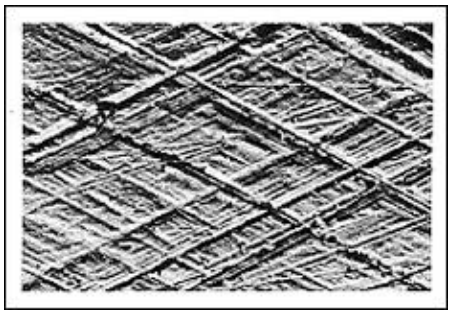
Crosshatch Angles

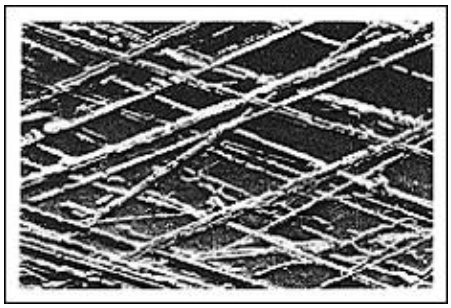
Cross hatch angle too low. This can lead to scuffing and premature ring wear.



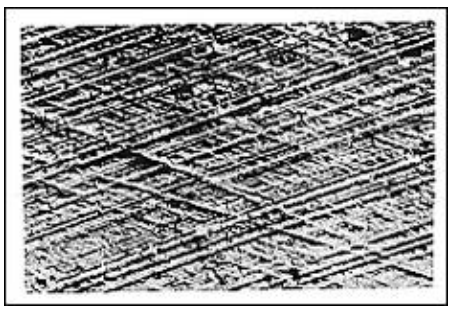
This shows a typical bore finish before the engine has run.



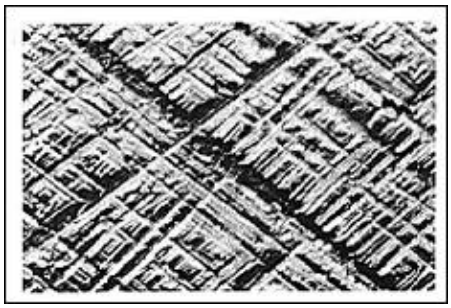
The same finish after the engine has been run for some while.



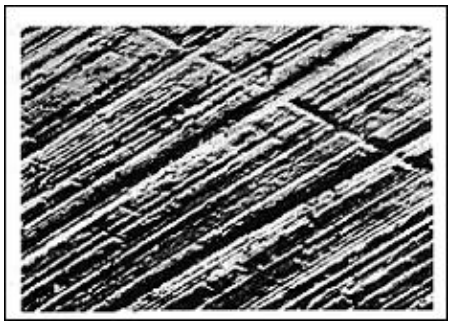
Plateau is too low. Not enough "oil void volume" for adequate lubrication.



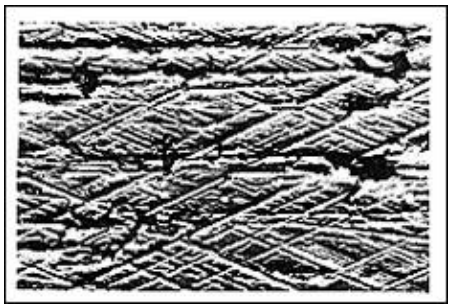
A good finish showing good angle of crosshatch and a mixture of shallow and deeper scratches. Remember these photos are all at very high magnification!



Unidirectional honed angle as a result of worn honing equipment. Can cause ring spinning and rapid ring and groove wear.



Boring marks remaining after honing. There was insufficient allowance made for the honing. Oil consumption will be excessive.



Note: The trend is towards finer finishes, these photos depict finishes that were prevalent in Australian-made 6 and 8 cylinder engines through the '60s to '80s. But the principles remain unaltered.

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