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Honing stone testing pays big dividends

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By using stones of similar bond hardness for each honing operation on diesel engine parts, one company has improved the component's surface finish, reduced stone consumption considerably, and cut overall manufacturing costs. Arthur Barker reveals that the savings are achieved with a device which tests and classifies the stones.

The installation of a Belgian-made device to test bond hardness of honing stones has revolutionised honing operations at the Darlington works of Cummins Engines. The new equipment has led to a marked improvement in the quality of honed bores of wet liners for diesel engines; has reduced overall manufacturing costs, and brought other benefits, too.

In achieving such gains, the most important factor was the rather unexpected discovery that stones which are supplied as being of certain grade may, in fact, vary in bond hardness – a characteristic which was costing Cummins unnecessary down-time, excessive stone consumption, and drastic reductions in stock removal rates.

With the new Grindo-Sonic unit, the stones are now accurately checked so those that are closely matched are selected for each eight-stone set for the Gehring two-spindle machines, on which the liners are rough and finish honed in separate stages.

Because the stones are now effectively utilised, since the honing load is distributed uniformly over an entire set, average working life has been extended from 400 liners/set to between 1500 and 2000 liners/set. The glazing of the work surface by a particularly hard stone in a set was often the reason for a drop in removal rates, and the only remedy was a fresh set of stones.

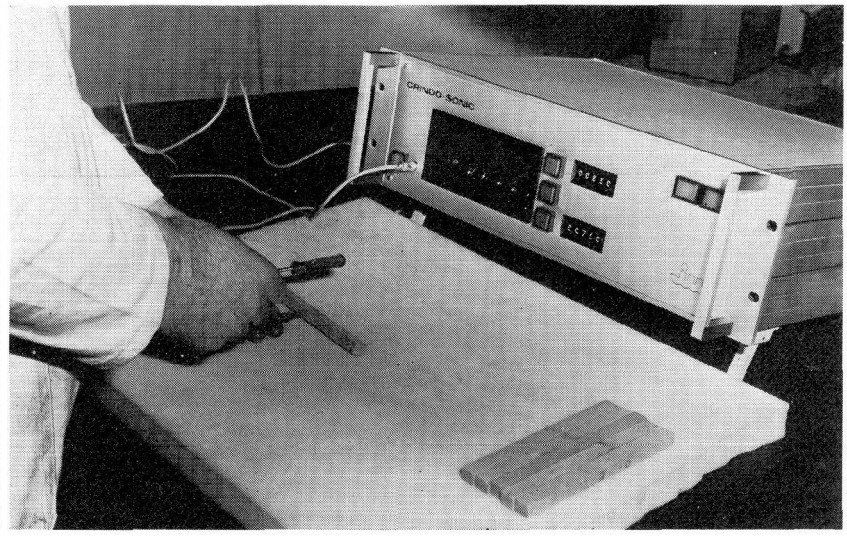
With the new technique, average consumption has fallen from 133 stones/week to 148/month.

The Cummins investigation, by engineer Ken Claybourne, into ways of improving the quality of the cylinder liners was embarked on due to glazing of cylinder bores and the idea that improved performance could be achieved. The bench-mounted Grindo-Sonic equipment is intended to check the modulus of elasticity (the criterion of hardness) of the bond of a grinding wheel or honing stones. An index number appears on a display panel, and this number is then applied to a special calculator to obtain the modulus. For Cummins' needs the instrument is used merely as a comparator, so the hardness index suffices.

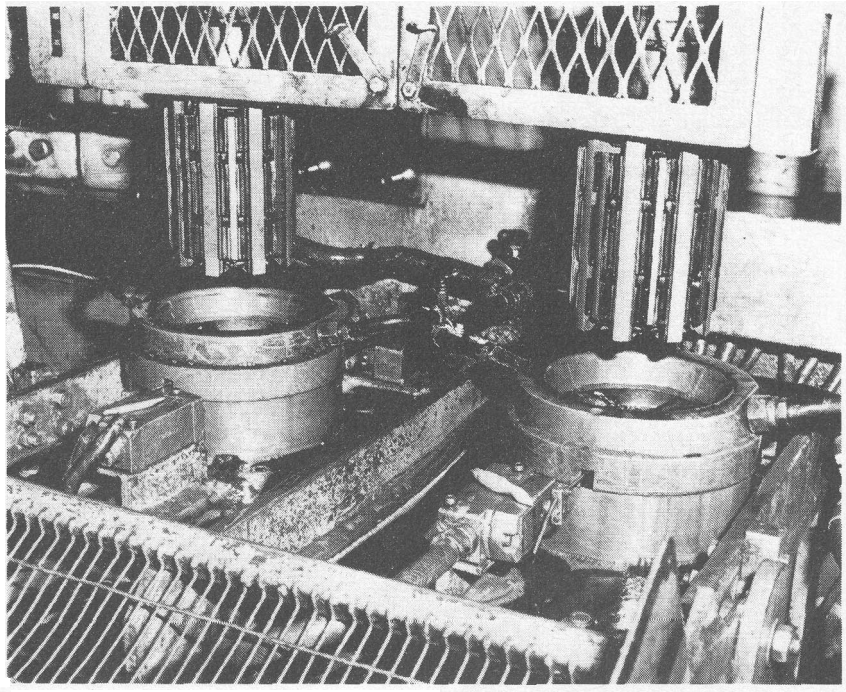
Readings varied

Cummins tested 1800 J grade honing stones, which gave hardness index readings that varied over a range of 240. Such a range of Grindo-Sonic readings covers five hardness grades. In fact, it has now been established that stones nominally of J grade can provide for Grindo-Sonic readings from 800 to 1100, covering more than six grades.

Honing tests with sets of matched stones of 320-J-V grade covering this wide range indicated the pattern of working life. Based on these results, it has been established that only stones that provide for hardness readings between 850 and



A honing stone is checked with the Grindo-Sonic equipment; note how testing is carried out with the stone slightly tilted.

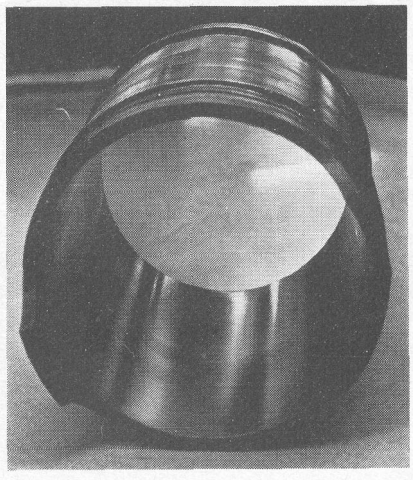


950 will be used for the liner honing operations. Acceptable stones are classified into categories each with a bandwidth of only 10 on the Grindo-Sonic scale, and all stones for a set are selected from a single category.

The Grindo-Sonic instrument analyses vibration characteristics detected at a specific stage during decay of vibration initiated by a single impact. Checking is performed with a stone resting on a foamed-plastics pad, to isolate it from external vibration. A hand-held probe serves as the vibration pick-up. It has been found that effective application conditions are obtained if the probe is pushed against a side face of the stone so the latter is tilted slightly.

Internal vibration of the stones is initiated by striking the stone lightly with, for example, the handle of a small screwdriver. The checking operation is quick (about 4 h for 1000 stones) and although Cummins' toolroom supervisor admits some skill is involved, he says it is soon acquired.

The equipment has reduced cycle time. This is now consistently below 1 min; previously, it might vary from 1 to 5 min. It is now possible to hone at least 500 liners/shift, while the previous rate was usually 270/shift. And machine downtime is reduced because a single head is retained in use for an entire shift. Previously, a set of stones often needed to be replaced after as little as 30 mins. The fact that all stones in a head are participating in the cutting action means that lower radial feed force is needed. And the rubber



Top: the set-up on a Gehring two-spindle machine where wet cylinder liners are machined.

gripper rings which hold the workpiece in a fixture now enjoy longer life – further reducing machine downtime.

There has been a massive reduction in demands on the toolroom for the preparation of fresh honing head assemblies, in which stones are secured by epoxy adhesive. Previously, one man was engaged continuously on this work; now about only four hours each month is spent doing this. And the benefits do not end there.

Consumption of lubricating oil is 1 oz/h or less, compared with 4 oz/h. As part of Claybourne's investigations, Mobil Oil Co Ltd suggested the adoption of its Vacmul O3D cutting oil. And this oil has led to a reduction in consumption by 40 per cent/component; has assisted the cutting action; and ensures clean stones and workpieces machined to consistent accuracies. The value for a character termed blow-by, which is a measure of the combustion leakage between piston rings and cylinder bore, has fallen by a factor of four. And the loss of weight by piston rings, due to wear from operation over a given period, is 0·01 to 0·03 gm instead of 0·07 gm.

One major point in these advances was the avoidance of glazed marks formed in a bore when a hone is withdrawn at the end of a working sequence. Such marks were caused by a particularly hard stone in a head which ultimately became proud of the others and, consequently was not retracted adequately when the head was collapsed.

Consistent bores

In addition, the use of sets of stones that are closely matched for hardness has resulted in improved consistency of the workpiece bores for size and roundness, and there is virtually no risk of bell-mouthing. Bell-mouthing is also caused during hone withdrawal by a hard stone. Surface finish is now consistently between 14 and 23 μm rms, well within the requirements.

The cylinder liners are cast iron, with a bore of $4\frac{5}{8}$ in diameter by $7\frac{7}{8}$ in long. The rough and finish honing stages remove 0·0015 to 0·0035 in of stock, and the honing stones used have been of the 320-J-V grade. Production trials are to be undertaken shortly with 220-G V stones, a grade chosen on account of the latest and particularly stringent design requirements for liner bore surface finish.

One outcome of the whole procedure is the potential of the Grindo-Sonic instruments for bringing a new degree of control and predictability to results of abrasive machining operations. Cummins is now looking into its use to permit classification of grinding wheels in relation to the service performance of ground items. □