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AN APPRAISAL OF THE GRINDO-SONIC MATERIAL TESTER

By: P.J. Emerson

SYNOPSIS A limited number of tests have been carried out on iron test bars and castings with the Grindo-Sonic material tester. This instrument measures the resonant frequency of the component being tested. It has been found that the Grindo-Sonic readings correspond very well with the resonant frequency measurements taken with the BCIRA sonic test equipment, and hence this instrument could have use in iron foundries. For foundry use, however, the instrument would need to be more robust, and the hand operation used in laboratory tests might not be satisfactory.

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OBJECT The Grindo-Sonic is a new non-destructive test instrument for measuring material quality by measurement of resonant frequency. The object of this work was to establish if it could be applied satisfactorily to iron castings.

CONCLUSIONS The Grindo-Sonic test instrument produced satisfactory results on iron castings which correspond well with the resonant frequency measurements made with conventional sonic test equipment. The Grindo-Sonic instrument could, therefore be used in any instance where sonic testing is applicable, mainly in the assessment of graphite form and indirect assessment of mechanical properties of nodular graphite castings. The instrument could be used in automatic inspection systems.

INTRODUCTION The Grindo-Sonic material tester has recently been introduced to the British market from its country of origin, Belgium. This instrument was originally designed for checking the quality of grinding wheels by measurements of the resonant frequency. Since it is known that resonant frequency measurements are a satisfactory indication of the form and amount of the graphite in iron castings and this provides an indirect assessment of mechanical properties from the work carried out at BCIRA on sonic testing, it could be anticipated that this instrument could be employed for the inspection of iron castings. The instrument has been developed both as a production test system and a research instrument and it was the research instrument that was used in tests at BCIRA.

The Grindo-Sonic carries out its measurements on the short transient vibration resulting from the mechanical disturbance in the test object caused by striking the test object with a small hammer. In this respect, a Grindo-Sonic differs from the sonic test equipment which uses a forced continuous vibration for the measurement of resonant frequency. Because of this difference in method of measurement, the Grindo-Sonic requires no manual tuning and readings related to the resonant frequency are taken automatically.

In operation a piezo-electric detector or a microphone is placed near the casting to pick up signals. The operator taps the casting thus setting up the required transient vibration and the signal produced by the detector is amplified and conditioned by the electronic circuits of the instrument. The initial signals include many transient frequencies that rapidly die out and as the energy of the initial complex vibrations are dissipated, there is a natural filtering action leaving the main resonant frequency as the only detected signal. At this stage, the Grindo-Sonic measures the duration of a number of cycles and indicates this figure as the Grindo-Sonic reading. This reading is directly proportional to the reciprocal of the resonant frequency. For simple shapes the modulus of the test component can be calculated and the laboratory version of the Grindo-Sonic includes a programmable calculator for determining the modulus. Programmes are provided for various shapes of test components but for investigation on iron castings these calculations were not necessary, since comparisons between different castings of the same shape were all that were required.

In operation the positioning of the supports for the test object, the positioning of the detector and the point at which the casting is struck are all factors which affect the ease of operation and the reliability of the reading. For example, if the test piece is to be resonated in a bending mode then supports at the nodes are necessary and the test piece should be struck sideways. Alternatively, if a longitudinal mode of vibration is to be excited, a test bar should be supported at its centre and the bar struck on the end. By suitable choice of support and striking location, various modes can be excited.

Tests were carried out at BCIRA on a number of machined test bars using both the Grindo-Sonic instrument and the conventional sonic test equipment. The test bars included those with varying degrees of nodularity and varying amounts of pearlite in the matrix structure.

Tests were also carried out on a small number of crankshaft castings using both techniques to establish if the two methods gave comparable results.

In general the preferred method of vibration for the Grindo-Sonic instrument was a bending mode because of the ease with which the bar could be balanced on two supports whereas for the sonic test equipment the preferred method is a longitudinal vibration mode. The longitudinal mode requires that the bar is balanced as a single support at its centre, but with the forced vibration system used in sonic testing the method of support is of less importance than in the transient vibration system of the Grindo-Sonic test. However, both modes of vibration are controlled by the modulus and therefore good correlation should be anticipated.

RESULTS The Grindo-Sonic readings on the test bars measured in a bending mode and the sonic test readings measured in a longitudinal mode are given in Table 1 together with a brief description of the test bar structure. The relationship between the results for the two test methods is given in Fig. 2.

DISCUSSION The results shown on the test bars a very good correlation between Grindo-Sonic readings and the sonic test reading, and on the crankshaft castings, it was shown that by suitable choice of excitation method the same frequency readings could be obtained on the Grindo-Sonic and sonic test methods.

The preference for using the Grindo-Sonic instrument in a bending mode on test bars is only satisfactory when fully machined cylindrical test bars are available. The frequency of vibration in a bending mode is a function of the cross sectional dimensions of the test bar and its length. The frequency of longitudinal mode vibration as measured in a sonic test instrument is a function only of the casting length as long as the length to diameter ratio is more than about 8. Since in practice many test bars would be measured in an unmachined condition with variations in the cross sectional dimensions, the longitudinal method of vibration has considerable advantages. Hence, the bending mode used in these measurements for the Grindo-Sonic reading is not the best one. Measurement in the longitudinal mode with the Grindo-Sonic instrument requires more care since the test bars must be supported at the centre. In the Grindo-Sonic technique it is necessary to minimise external damping to obtain a satisfactory reading. This is not the case with the forced vibrations of the sonic test system in which external damping has little effect. Changes in damping can interfere with the Grindo-Sonic reading. The internal damping of ferritic material is greater than that of pearlitic material. However, the change in internal damping in the test bars was not sufficient to interfere with the readings.

When used on castings it is necessary to determine the optimum test method. This is simply carried out by holding the detector and striking hammer in different positions to determine which configuration gives the most reproducible results. Since the piezo-electric transducer is only sensitive to vibrations in one direction, it is possible to detect preferentially a particular mode of vibration. The microphone detector whilst being adequate in a laboratory would not be satisfactory in a noisy industrial environment.

The speed of testing is remarkably high. A single test takes only a few seconds and testing rates would be limited by handling the castings rather than the test itself. The speed of testing with the BCIRA Automatic Sonic Test Equipment is of the same order, and again is limited by the mechanical handling of the casting. Either method slowly achieves testing rates of 500 castings per hour.

It would be possible to use electro magnetic transducers with the Grindo-Sonic equipment although this has not been fully developed since the instrument has, to date, been mainly used in the abbraisive and ceramic industries. An electro magnetic transducer might be advantageous since there would be no contact required as is necessary with the piezo-electric transducer and it would not be sensitive to noisy surroundings as is the microphone transducer. The striking system could also be easily automated. In this case the optimum striking energy and striking material could be used.

The Grindo-Sonic instrument could easily be used in a foundry for the measurement of the resonant frequency of iron castings. It could be simply automated and the instrument is already equipped with the high and low level limits to enable automatic sorting to be achieved. Some further development to use electro magnetic transducers and automatic initiation of the transient would be desirable although this would seem not to be a considerable problem.

The prices of the instrument as would be required by a foundry is of the order of £4,500 which makes it comparable with automatic sonic test equipment or with ultrasonic velocity test systems which are also used to check graphite form by indirectly measuring modulus. The instrument is made in Belgium but the British agents are:-

J.W. Lemmens-Elektronika, 6 Westbourne Park, Mackworth, Derby

whose help in carrying out the tests must be acknowledged.

Figure References

Fig. 1 Photograph 33/1/183
Fig. 2 Drawing No. 16752

Lab Book 362 p 211-2

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TABLE 1 GRINDO-SONIC AND SONIC TEST RESULTS

Bar	Approximate Structures % Nodularity	% Pearlite	Sonic Test Frequency	Grindo-Sonic Figure
1)	45	60	12734 Hz	904
2)			12667	911
3)	100	65	12043	882
4)			13041	886
5)	55	30	12816	898
6)			12737	906
7)	75	65	12911	896
8)			12966	894
9)	100	75	12875	898
10)			12890	893
11)	55	80	12795	900
12)			12832	897
13)	98	20	12998	888
14)			13000	886
15)	100	85	13060	883
16)			12058	883
17)	97	35	12951	892
18)			12919	891
19)	65	35	12860	895
20)			12895	899
21)	80	80	13010	890
22)			12978	892

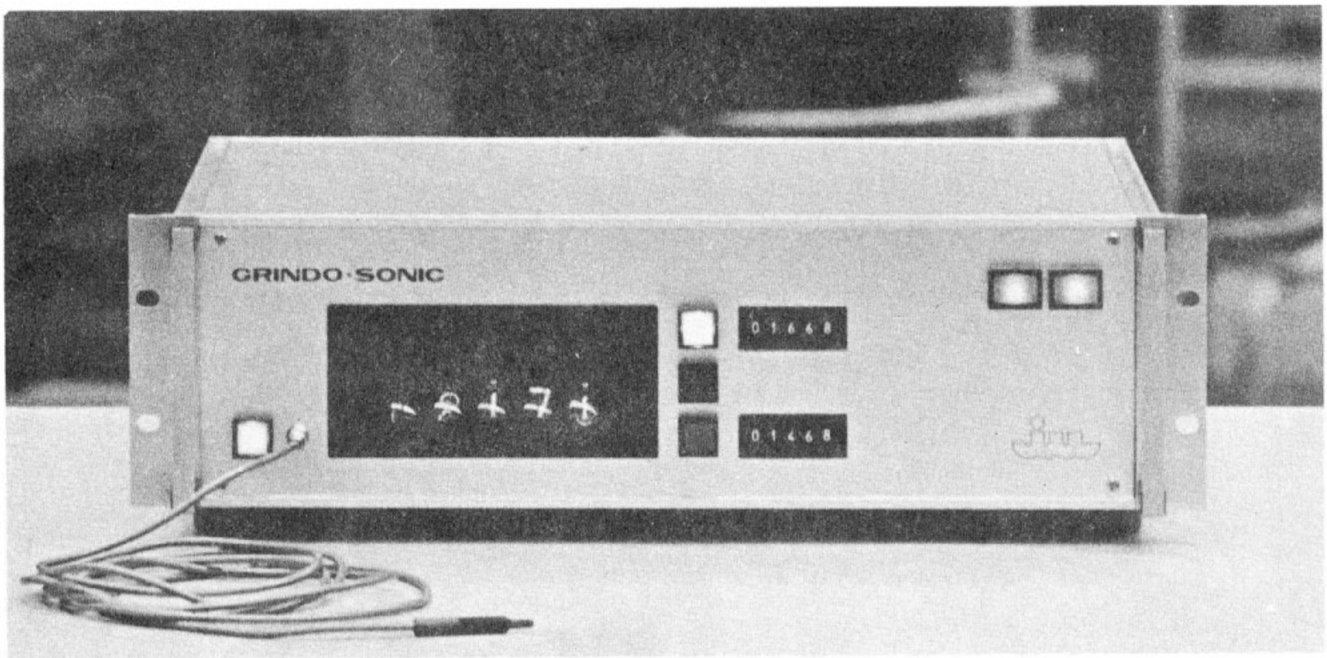

Fig. 1 The Grindo-Sonic Test Equipment

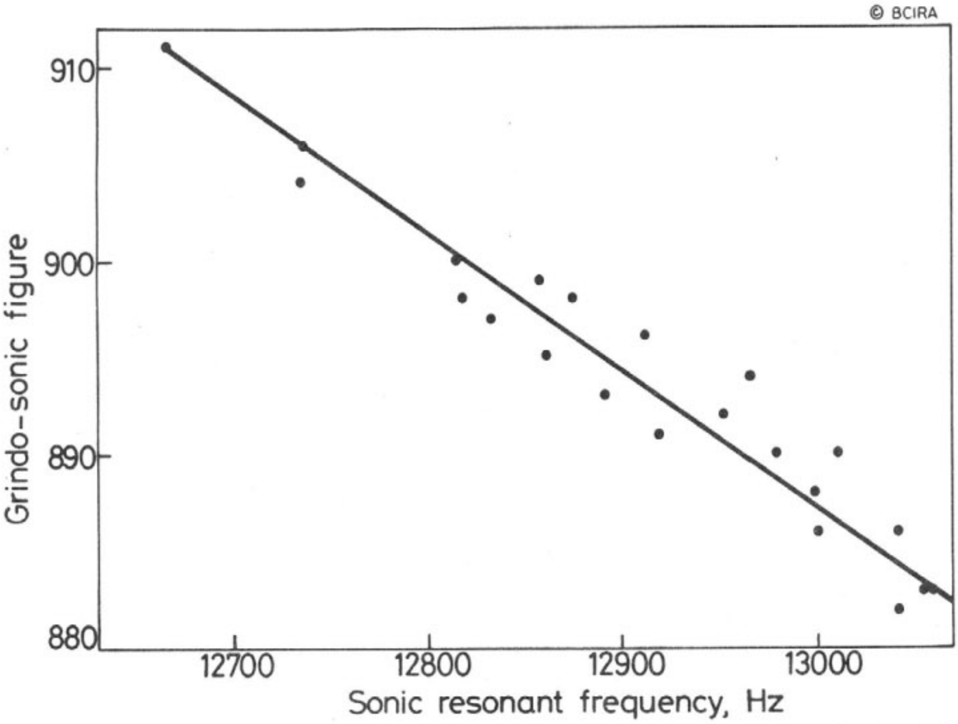

Fig.2 Relation between Grindo-sonic reading and sonic test frequency