GRINDING WHEEL SCREENING BY THE GRINDO SONIC METHOD

Dr. Chi-Hung Shen
Machining Department
GMMD

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SUMMARY

A series of experiments were performed to evaluate the Grindo Sonic Method which purported to measure the elastic modulus of a wheel non-destructively. The modulus measurements showed that identically labelled wheels might have very different modulus readings. Grinding tests using these wheels indicated that the grinding performance in terms of wheel wear could be correlated successfully with the elastic modulus.

I INTRODUCTION

Various aspects of the grinding operation have been investigated in details in recent years. Most of these studies were directed towards either analyzing the process or delineating specific mechanisms, e.g. the spark out process, the grain wear phenomena, and the effects of coolant additives. The main actual physical components in the grinding operation, i.e. the machine, the wheel, and the dresser have received little research attention. Thus, there have been very few advances in developing methods to quantitatively evaluate the grades of grinding wheels. The wheel users have to trust the wheel manufacturers to deliver the same types of wheels consistently over long periods of times. However, up till now, the manufacturers themselves do not have reliable methods of inspecting and screening their own wheel non-destructively. The correct grade or quality of a wheel is recognized only when the wheel is actually grinding and producing parts. By then, a considerable number of scrap parts may have been produced and a significant portion of machine down time and de-bugging efforts may have incurred. There is thus an urgent and pertinent need to devise an accurate and reliable technique of non-destructively inspecting a grinding wheel to identify its true grade.

II PRINCIPLES OF THE GRINDO SONIC METHOD

Currently wheel manufacturers can check out their products roughly by several kinds of tests. These include density check, chisel penetration test, sandblast test, and elastic modulus check. The methods are slow, unreliable, and destructive and they cannot be applied to inspect all the wheels (100%) manufactured.

One of the methods, the measurement of the elastic modulus of the wheel, has been singled out and is the preferred test by many European suppliers. Several sponsored research studies have been undertaken to correlate the elastic modulus with wheel grades and compositions. So far, the results have been encouraging. As a matter of fact, the Grindo Sonic Method and unit is developed from one of the research attempts to simplify and speed up the elastic modulus measurement procedures.

The Grindo Sonic instrument in essence measures the period of vibration in milli-seconds of a vibrationally excited object. The elastic modulus of the regularly shaped object can then be computed from well established equations if its mass and geometrical dimensions are also known. During the testing, the grinding wheel is rested horizontally on the four ridges of a rubber cone (Figure 1). A light tap is given to the rim of the wheel to set up its fundamental vibration mode. The vibrations are picked up by a microphone and fed into the Grindo Sonic instrument. The unit measures the period of the vibrating wheel and displays it digitally in the front panel. The elastic modulus is computed from a pre-programmed HP-97 calculator which comes together as a package with the Grindo Sonic unit.

III OBJECTIVES AND TESTS

The purpose of the present study is to evaluate the Grindo Sonic unit as a simple and reliable non-destructive wheel screening device. During the vibration period measurements it became evident that the procedures were very simple to follow and the tests were fast and repeatable. The emphasis and the objectives of the evaluation were therefore centered around the reliability of the method and the following goals were established.

1. To determine whether those grinding wheels labelled the same and packed into one box by the wheel supplier will have the same elastic modulus. This can be viewed as a quality control check on the supposedly identical wheels. The wheels may have the same dimensions as well as the same mass and yet they may still have different elastic moduli or stiffnesses.

2. To ascertain any correlation the elastic modulus may have with grinding performance. The elastic modulus as well as the grinding performance are both affected by the hardness or grade of the wheel. The letter used in grading the hardness of a wheel is only qualitative and relative. It would be a tremendous gain in wheel grade characterization if the elastic modulus which is quantitative and absolute can be correlated successfully with the wheel performance.

III OBJECTIVES AND TESTS (CONTINUED)

With these aims in mind, over 400 wheels were measured by the Grindo Sonic unit for their elastic modulus values. These wheels were supplied by Norton Wheel Company and Bay State Grinding Wheel Company and included a wide variety of wheel grades, grit sizes, and grit types. For each specific batch, a minimum of eight wheels were tested. It was found that the wheels in certain batches were very consistent and had practically the same elastic modulus while in some other batches identically labelled wheels had very different elastic moduli. Wheels were then selected for evaluation of their grinding performance. The grinding tests were done on the GMMD small bench grinder. Each test wheel was first trued and dressed by a rotary diamond dresser. The wheel was then used to plunge grind one piece of 4150 hardened steel disc. The resultant wheel wear determined by the shim stock method was used as a criteria to evaluate the wheel performance. The specific grinding conditions are as follows:

Workpiece material	4150	H.S. R_C 50-52
Workpiece diameters	3"	initial
	2.875"	final
Workpiece R.P.M.	175	
Workpiece speed	137	SFM
Wheel diameter	3"	
Wheel R.P.M.	7,000	
Wheel speed	5,500	SFM
Wheel radial infeed rate	0.033"/Min	
Coolant type	Trim Sol	
Coolant dilution	1:10	

IV RESULTS AND DISCUSSIONS

Figures 2 to 7 depict the scatter or consistency in the modulus data for various batches of wheels. The wheels made by Norton Company usually are more uniform and have about the same modulus values for each specific batch. In Figure 2 when the wheel is harder its elastic modulus also increases correspondingly. The grit size does not influence the modulus appreciably (Figure 3) while the grit type (quality) certainly affects the wheel stiffness (Figure 4). The Bay State wheels exhibit similar trends as illustrated in Figures 5 - 7. However, it is noted that on the whole the Norton wheels have less scatter and are more consistent than the Bay State wheels.

The wear test data from selected wheels have been plotted against the elastic modulus in Figure 8. It is observed that wheels with low elastic modulus (softer wheels) wear faster than wheels with high modulus (harder wheels). All the data points seem to lie close to a straight line suggesting a linear relationship between wheel wear and elastic modulus. It is also demonstrated in Figure 8 that although some wheels are identically labelled and come in as one batch their wear and grinding performance are vey much different. However, their elastic moduli as measured by the Grindo Sonic unit can expose the differences and identify their correct grades and performance potentials.

The Grindo Sonic Unit also computes the density of a wheel. Figure 9 is a plot of wheel wear versus the density of the wheels. The data seem to depict a non-linear correlation. In comparison with the wear-modulus plot in Figure 8, it is seen that the density correlation has a much wider scatter.

IV RESULTS AND DISCUSSIONS (CONTINUED)

From the results presented in Figures 8 and 9 it is apparent that the elastic modulus is a more accurate and relevant parameter than the wheel density in screening and grading wheels. The Grindo Sonic Unit enables the measurement of the modulus to be simple and reliable. Hence, a 100% non-destructive checking on the wheels is both feasible and practicable. Hopefully, the Grindo Sonic Unit will enhance a wider acceptance of the elastic modulus concept thus ensuing more consistencies in grinding wheel production.

V REFERENCES

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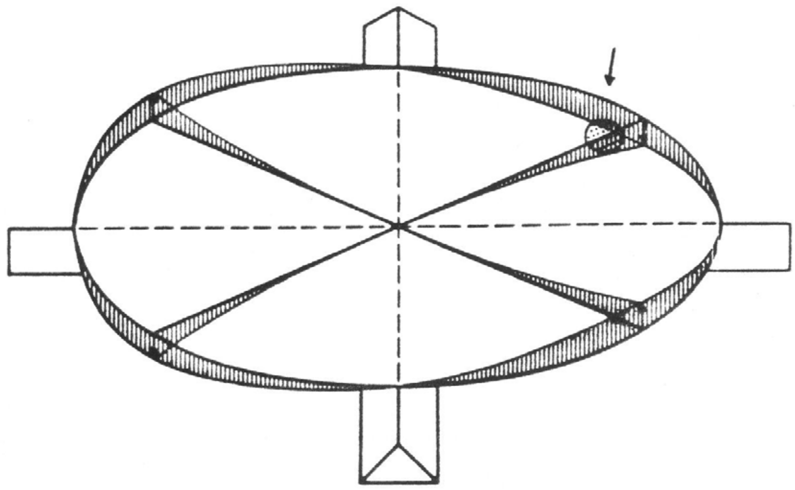
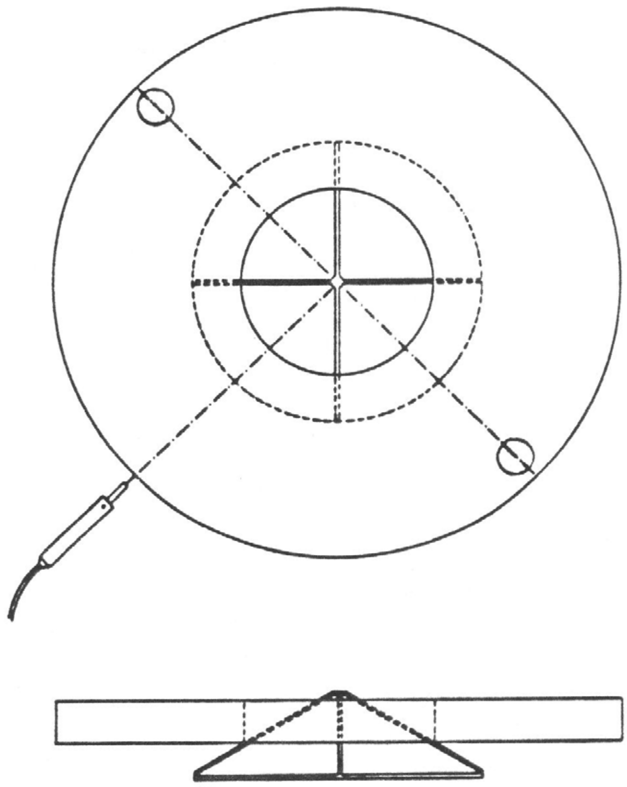
3. L. V. Colwell, R. O. Lane, and K. N. Soderlund, "On Determining the Hardness of Grinding Wheels - I", J. Eng. Ind., February 1962, p. 113-128.

4. L. V. Colwell, "On Determining the Hardness of Grinding Wheels - II", J. Eng. Ind., February 1963, p. 27-32.

5. J. Peklenik , R. Lane, and M. C. Shaw, "Comparison of Static and Dynamic Hardness of Grinding Wheels", J. Eng. Ind., August 1964, p. 294-298.



Fundamental flexural mode of vibration of a grinding wheel.



Grinding wheel on plastic support cone. Note that the detector is held half way between two ribs. The possible points of impact are at 90° either way.

Figure 1 Principles of the Grindo Sonic Method

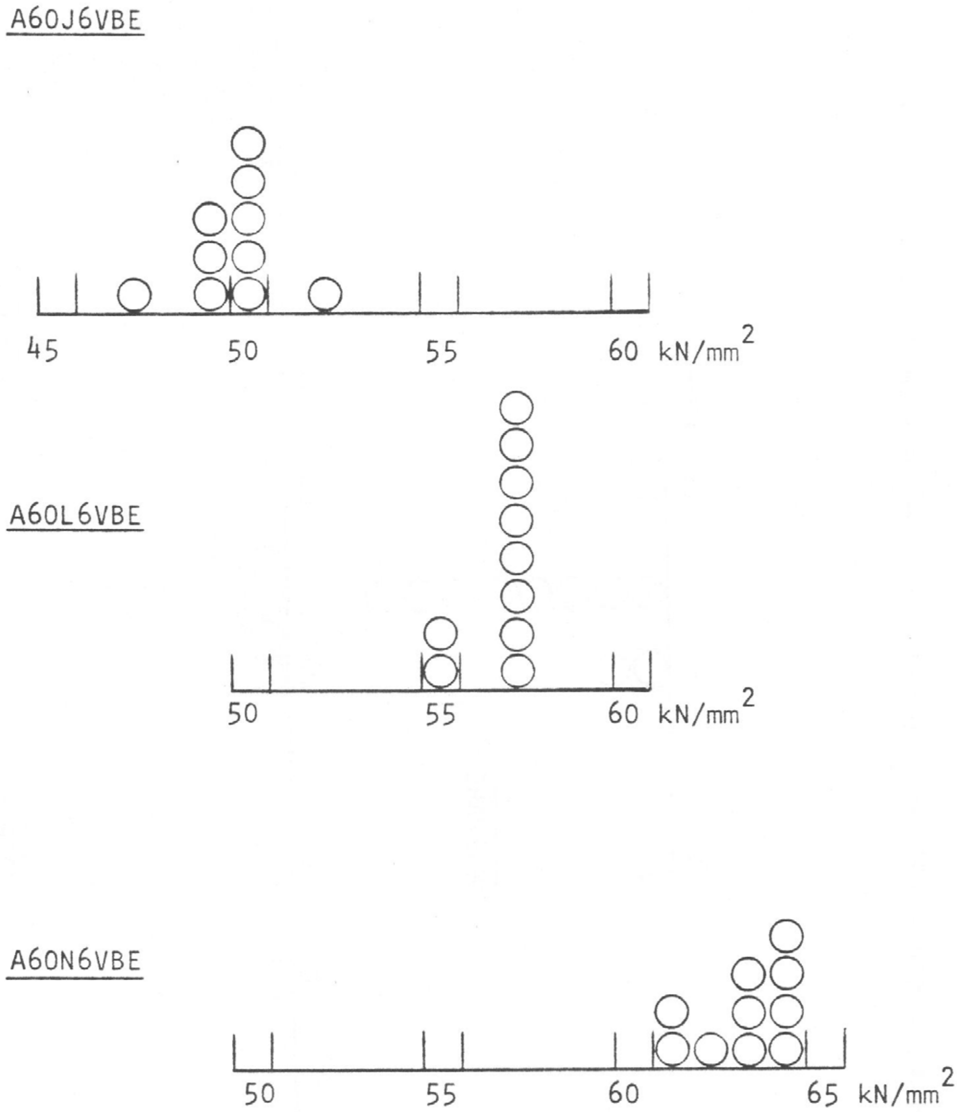


Figure 2 Elastic Modulus distribution with hardness for NORTON wheels

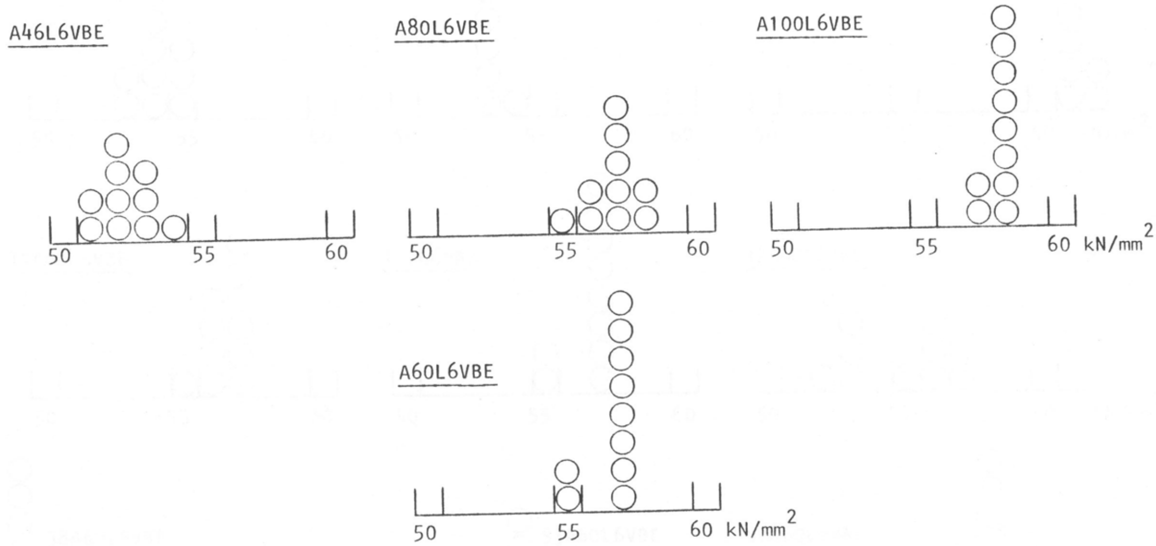


Figure 3 Elastic Modulus distribution with grit size for NORTON wheels

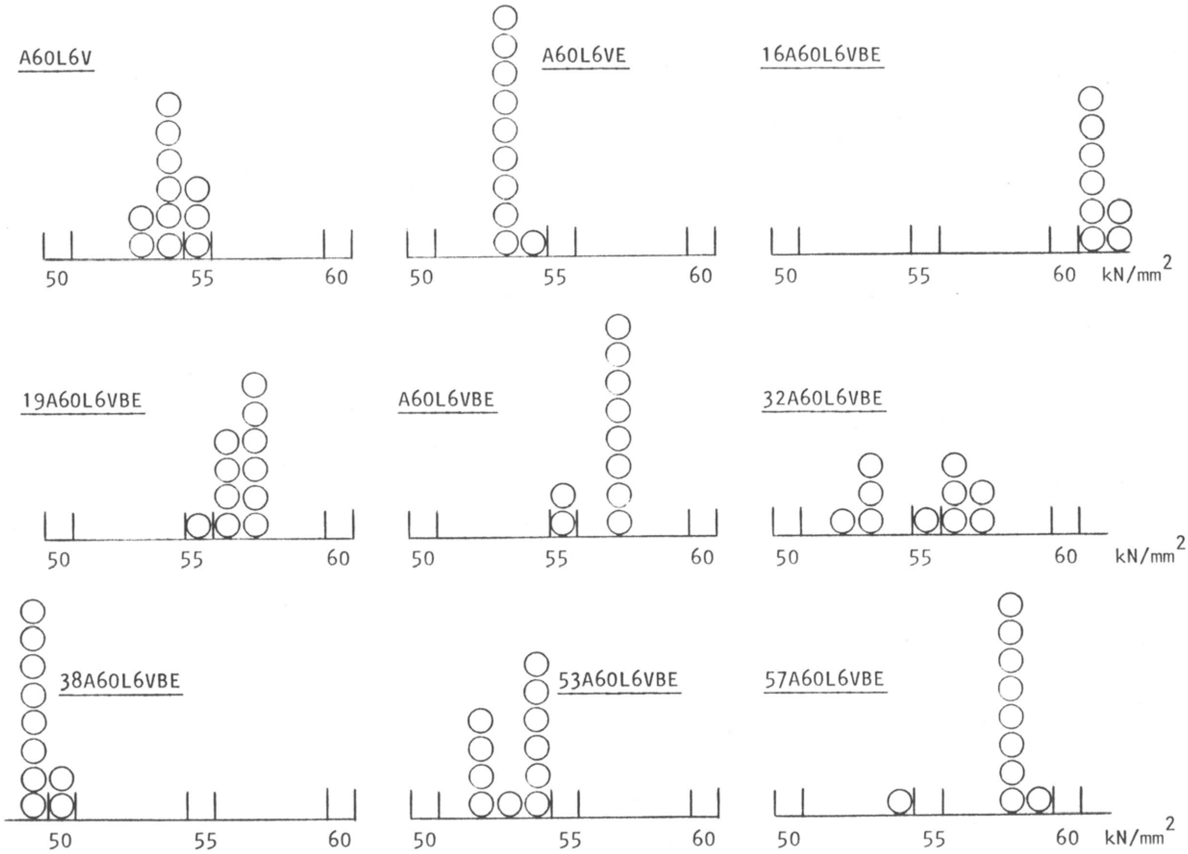


Figure 4 Elastic Modulus distribution with grit type for NORTON wheels

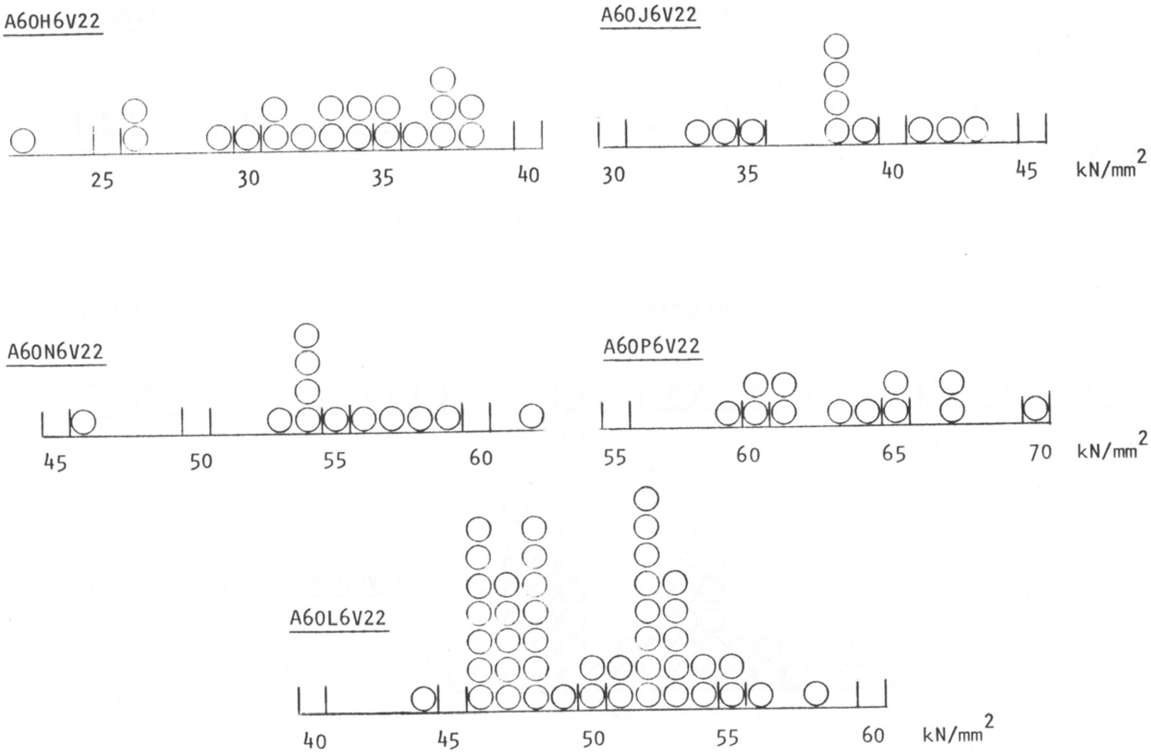


Figure 5 Elastic Modulus distribution with hardness for BAY STATE wheels

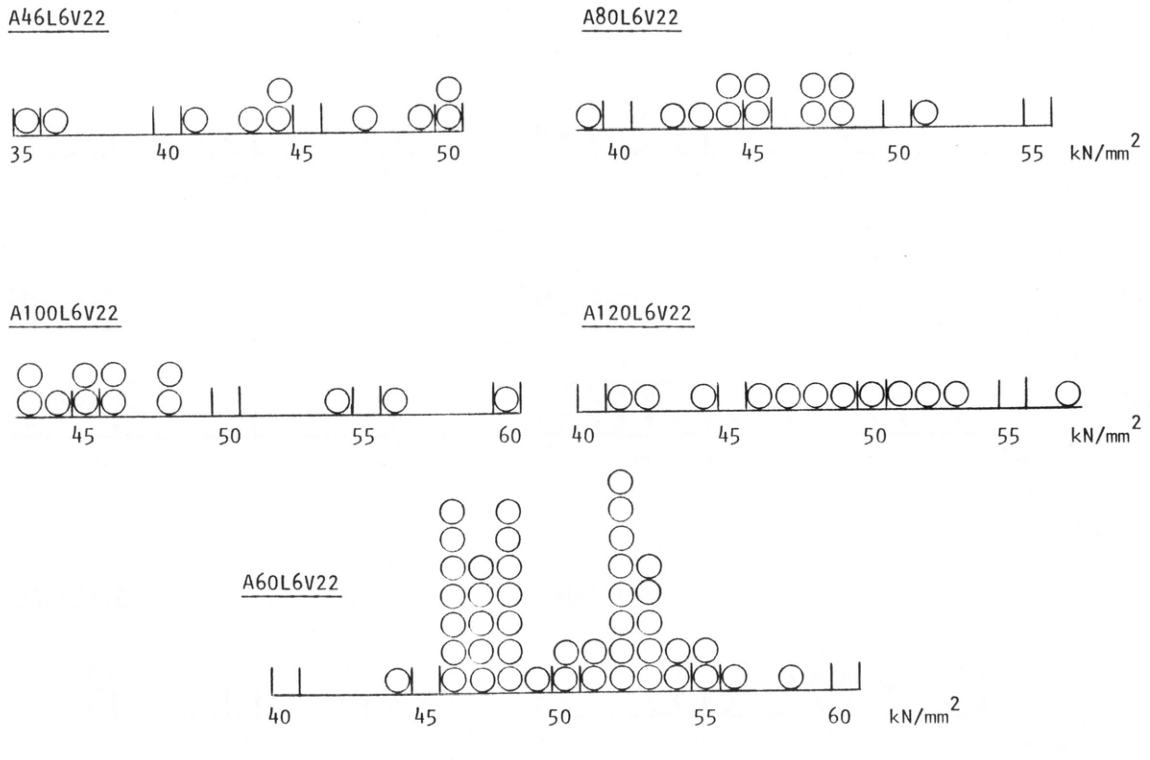


Figure 6   Elastic Modulus distribution with grit size for BAY STATE wheels

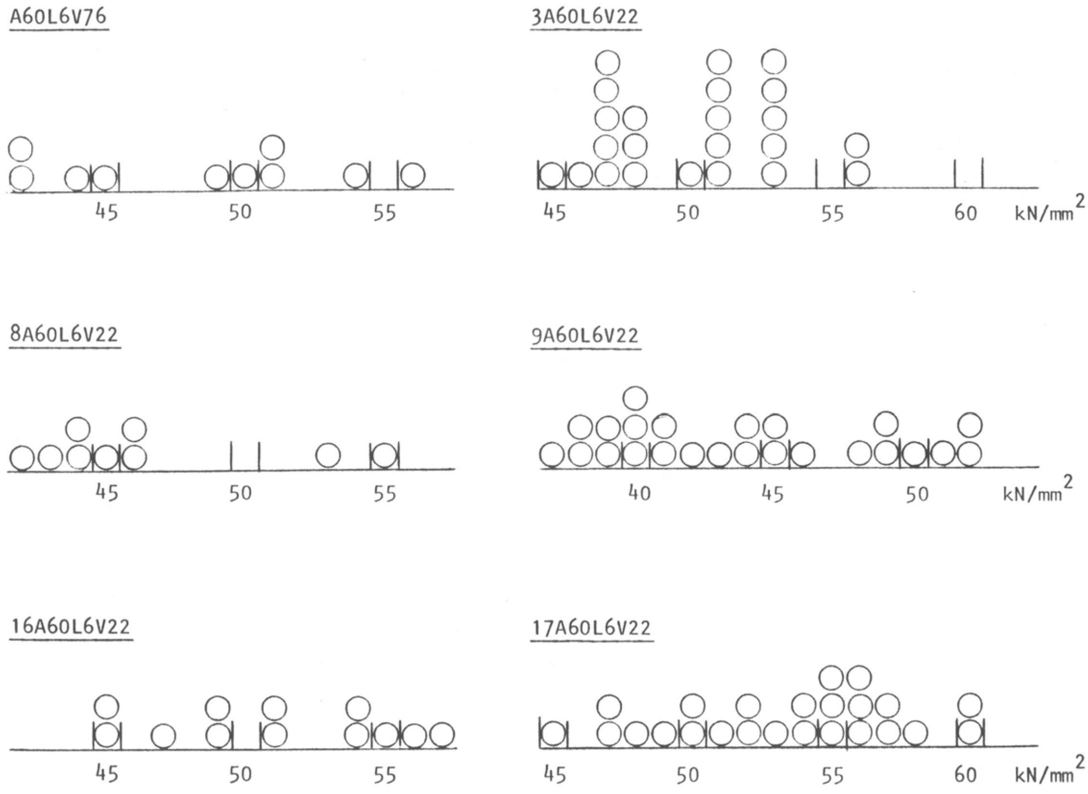


Figure 7 Elastic Modulus distribution with grit type for BAY STATE wheels

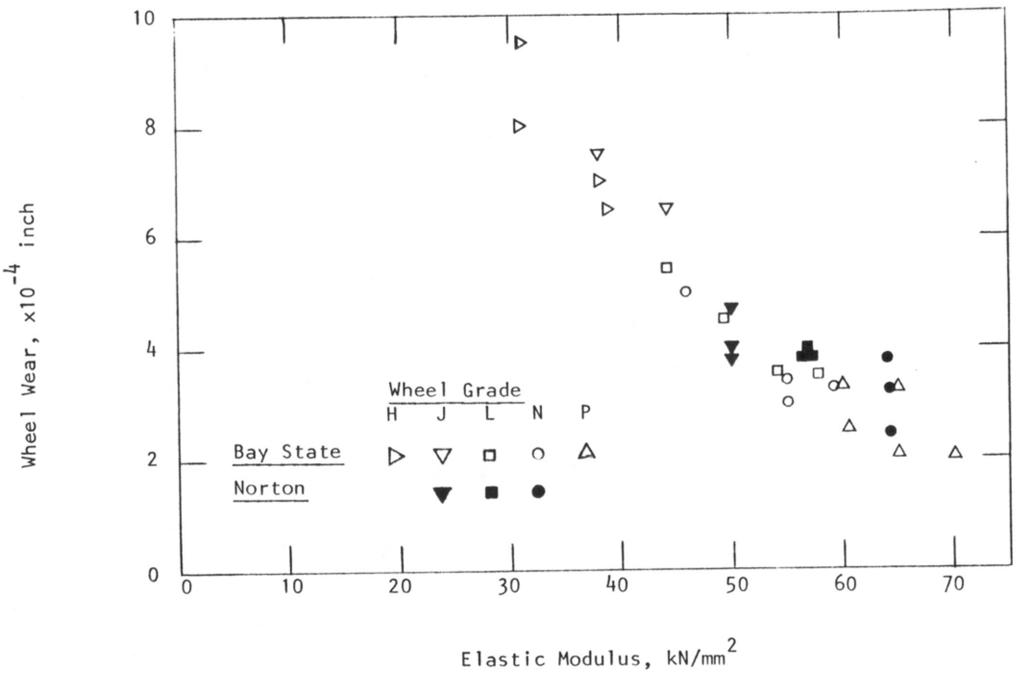


Figure 8 Correlation between wheel wear and elastic modulus

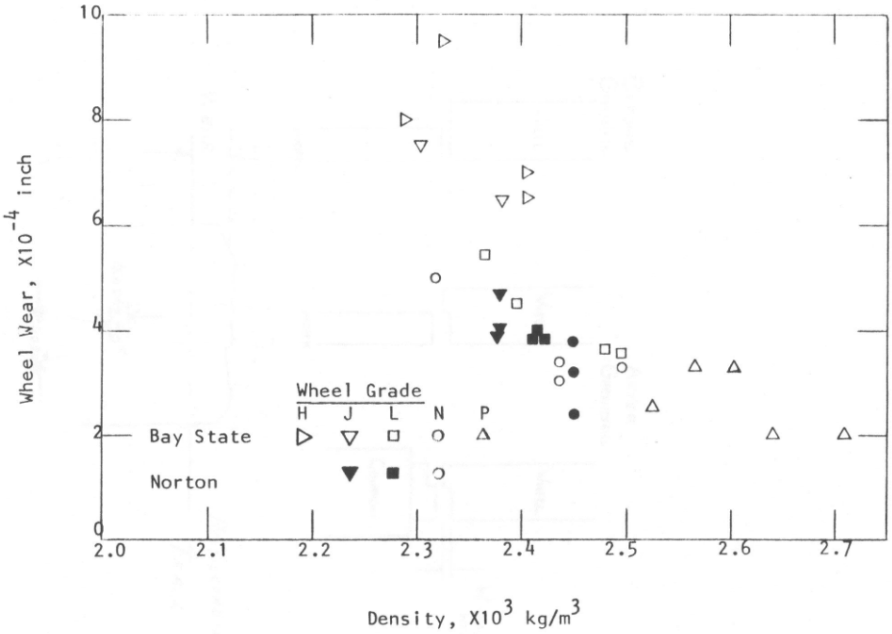


Figure 9 Correlation between wheel wear and density

APPENDIX--SHIM STOCK METHOD FOR MEASURING WHEEL WEAR

When a used wheel plunge grinds into a piece of thin shim stock (about 0.030") the wear profile of the wheel is transferred onto the shim (Figure 10). The profilcorder trace of the replicated profile along the edge of the shim can then be measured to determine the amount of wheel wear.

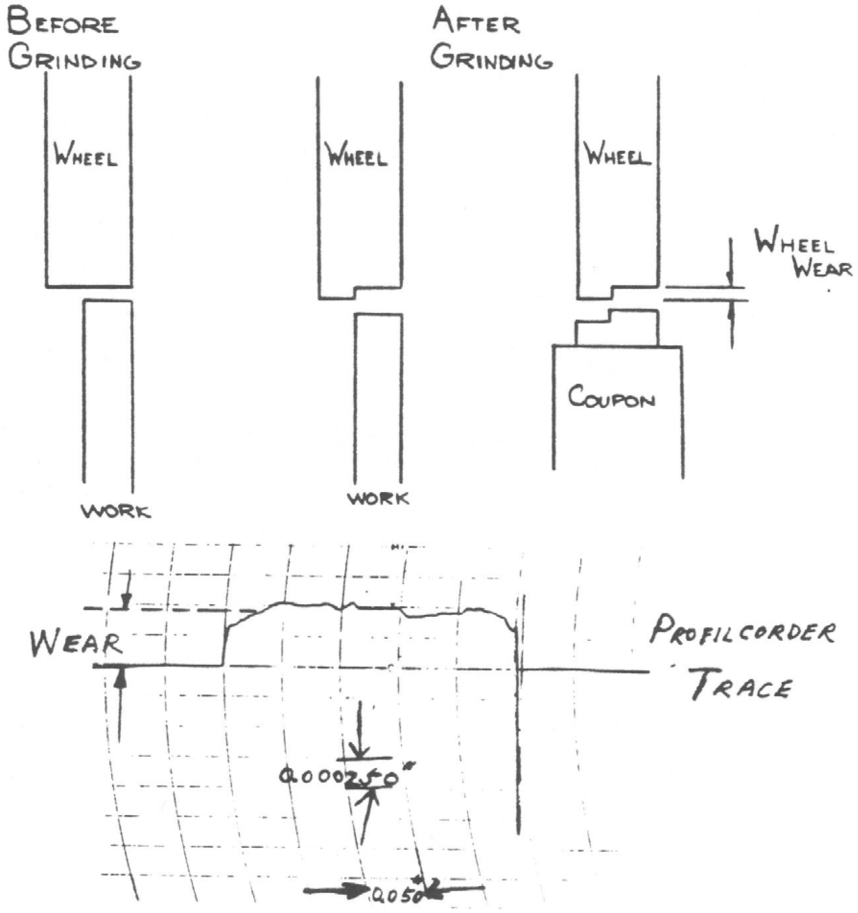


Figure 10 Shim stock method for measuring wheel wear.