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# The Use of Ultrasound For The Investigation of Rough Surface Interface

**Ramesh S.[1], K. Srinivasa[2], Subramanya K. P.[3]**

[1,3]Department of Mechanical Engineering, Rashtreeya Vidhyalaya college of Engineering, Bangalore, Karnataka, India

[2]Head of the Department, Department of Mechanical Engineering, ATME College of Engineering Mysore, Karnataka, India

[1]ramesh@rvce.edu.in, [2]Sri4suni@yahool.co.in, [3]subbu.mech2@gmail.com

**Abstract—*Perthometer is an instrument used for the measurement of surface roughness, externally and some intricate internal parts. The stationary part of this instrument gives the details of the surface roughness by using the grit numbers and graph which is helpful at a certain extent. This paper makes the use of disadvantage of Perthometer that, the readings give the details of the surface roughness in the form of grit numbers and only the external flat surfaces can be inspected by this instrument. To overcome this disadvantage, we are using ultrasonic investigation of surface roughness. The sensitivity of the ultrasonic technique has been quantified using a simple model, from which the stiffness of individual gaps and contacts are calculated and their effects on the ultrasonically measured stiffness predicted. The reflection of ultrasound at a static interface between rough surfaces can be investigated. The effect of surface roughness on the resultant contact can also be investigated. However, it is clear that the model is a powerful non-destructive tool to evaluate surface roughness in an easier way.***

**Keywords**—Perthometer,Ultrasonicinspections, transducer, surface roughness, NDT, Oscilloscope

## I. INTRODUCTION

Non-destructive testing (NDT) has been defined as comprising those test methods used to examine an object, material or system without impairing its future usefulness. A number of other technologies - for instance, radio astronomy, voltage and amperage measurement and rheometry (flow measurement) - are non-destructive but are not used to evaluate material properties specifically. Non-destructive testing is concerned in a practical way with the performance of the test piece. Modern non-destructive tests are used by manufacturers are (a) to ensure product integrity, and in turn, reliability; (b) to avoid failures, prevent accidents and save human life; (c) to make a profit for the user; (d) to ensure customer satisfaction and maintain the manufacturer's reputation; (e) to aid in better product design; (f) to control manufacturing processes; (g) to lower manufacturing costs; (h) to maintain uniform quality level; and (i) to ensure operational readiness.

Non-destructive testing (also called NDT, non-destructive evaluation, NDE, and non-destructive inspection, NDI) is testing that does not destroy the test object. Destructive testing is also inappropriate in many circumstances, such as forensic investigation. That there is a trade-off between the cost of the test and its reliability favours a strategy in which most test objects are inspected non-destructively; destructive testing is performed on a sampling of test objects that is drawn randomly for the purpose ofcharacterizing the testing reliability of the non-destructive test. Therefore choosing the right method and technique is an important part of the performance of NDT.

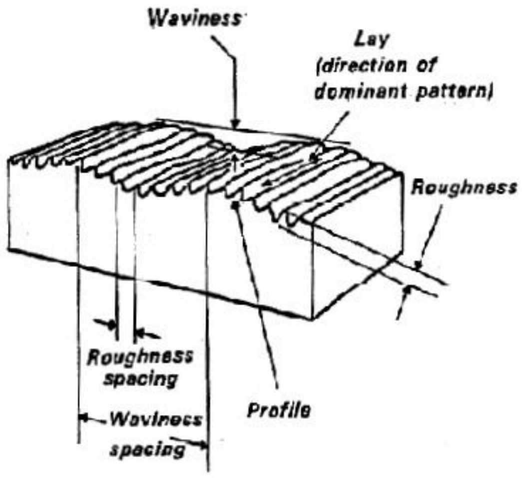
## II. ELEMENTS OF NDT

Regardless of application or method, all non-destructive testing shares the same basic elements:

A. *Source- provides a medium for testing.*
B. *Modification - The probing material must get modified due to variation in the source.*
C. *Detection- A detector which will determine the changes on the probing medium.*
D. *Indication- Some means of indicating/recording signals received from indicator.*

## III. SURFACE ROUGHNESS

It is the variation in the straightness of the surface. The term surface roughness represents all the spatial structure of peaks and valleys that exist on a surface (Ref fig.1) [5]. Waviness consists of more widely spaced irregularities which might be formed by the vibrations or chatter in the machine. Flaws are discrete and infrequent irregularities which may include cracks, pits and scratches. Roughness consists of closely spaced irregularities, and these may be the cutting tool marks or may be produced by the grit of a grinding wheel.The commonlyused instrument for the measurement of surface roughnessis thePerthometer.




Surface characteristics and terminology [5]

Fig1. Showing surface characteristics

## IV. PERTHOMETER

It is an instrument used for the measurement of surface roughness. The tests using a MahrPerthometer(Ref fig.2)[6].Concept type stylus instrument according to the measurement arrangement shown in Figure.

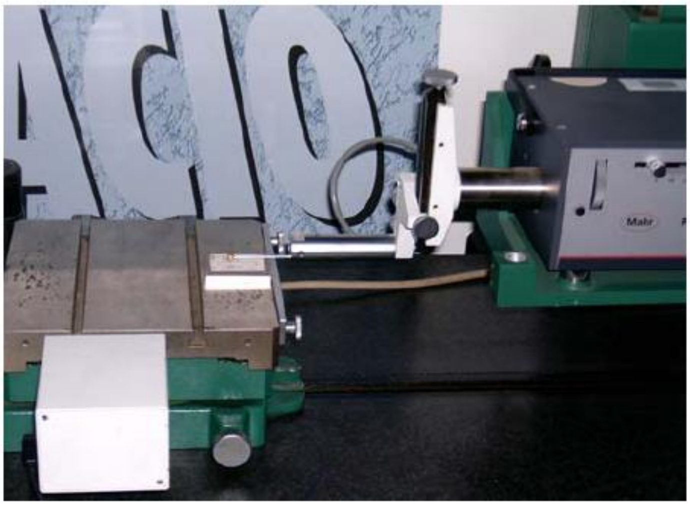


Fig 2: Measurement arrangement

The unit on the left side of the picture is the object table, on which various fitting and fixing devices can be fastened. On the right side of the picture, the unit holding and moving the stylus instrument is shown, whose main function is to drag the stylus instrument at the appropriate speed, to position it vertically and to hold it fixed. The signals detected by the stylus instrument are transmitted to a PC through the control unit; thereby data can be recorded and evaluated promptly after the measurement. Passive vibration proofing is provided by the granite table constituting the machinery unit base.

Fig 3: Perthometer

The above figure (Ref fig.3)[6] shows the stationary part of the Perthometer which gives the details of the surface roughness by using the grit numbers and graph as shown in the figure.

### A. Major drawbacks of Perthometer.

The main disadvantage of this instrument is that it gives the details of the surface roughness in the form of grit numbers and only the external flat surfaces can be inspected by this instrument.
To overcome this disadvantage, we are using ultrasonic investigation of surface roughness.

## V. ULTRASOUND: WHY WE USE FOR NON-DESTRUCTIVE MATERIAL TESTING?

At the beginning of fifties the technician only knew radiography (X-ray or radioactive isotope) as a method for detection of internal flaws in addition to the methods of NDT of material surface, example the dye penetrant and magnetic particle method. After Second World War the ultrasonic method, as described by Sokolovin 1935 and applied by firestone in 1940 was further developed so that very soon instruments are available for ultrasonic testing of materials. The ultrasonic principle is based on the fact that solid materials are good conductor of sound waves. Whereby the waves are not only reflected at the interfaces but also by internal flaws (material separations, inclusions etc.) the interaction effect of sound waves with the material is stronger the smaller the wavelength, this means the higher the frequency of the wave.

## VI. ULTRASONIC TESTING IN NDT

Sound with a frequency above the limit of audibility is called 'ultrasonic'. It ranges with a frequency of 0.2 MHz to 800 MHz Ultrasonic inspections provides a sensitive method of non-destructive testing in most materials, metallic, non-metallic,

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magnetic or nonmagnetic. It permits the detection of small flaws with only single surface accessibility and is capable of estimating location & size of the defect providing both surfaces are parallel. Ultrasonic techniques may be used for thickness measurement, where only one surface is accessible. The effective result of an ultrasonic test is heavily dependent on subject surface condition, grain size & direction and acoustic impedance. Ultrasonic techniques are very widely used for the detection of internal defects in materials.

Ultrasonic inspection operates on the principle of 'transmitted' & 'reflected' sound wave. Sound has a constant velocity in a given substance; therefore, a change in the acoustical impedance of the material causes a change in the sound velocity at that point producing an echo. The distance of the acoustical impedance (flaw) can be determined if the velocity of the sound in the test material, and the time taken for the sound to reach & return from the flaw is known.

Ultrasonic inspection is usually performed with two techniques

1. Reflection (Pulse echo) technique. [4]
2. Through transmission technique.

'Pulse echo' technique is most widely used in aircraft maintenance inspection. [1]

### A. SURFACE ROUGHNESS MEASUREMENT USING ULTRASOUND

The measurement of ultrasonic reflection can be used to study the contact between rough surfaces (Ref fig 6&7). An incomplete interface will reflect some proportion of an incident wave. This proportion is known as the reflection coefficient, if the wavelength is large compared with the width of the gaps in the plane of the interface. Then the reflection mechanism can be modelled by considering the interface as a spring [3]. The proportion of the incident wave reflected (reflection coefficient) is then a function of the stiffness of the interface and the frequency of the ultrasonic wave. The sensitivity of the ultrasonic technique has been quantified using a simple model, from which the stiffness of individual gaps and contacts are calculated and their effects on the ultrasonically measured stiffness predicted. The reflection of ultrasound at a static interface between rough surfaces can be investigated. The effect of surface roughness on the resultant contact can also be investigated. A simple plastic contact model can be described which allows prediction of the average size of the asperity contacts and their number. This model shows the average size of the contacts remain constant over most of the loading. Whereas, the number of contacts increases almost linearly. The contact stiffnesses can also be modelled with two well-known elastic rough surface contact models. These models predict lower interface stiffness which can then be observed in the experiments. However, they provide a useful way of interpreting the ultrasonically measured interface stiffness data.

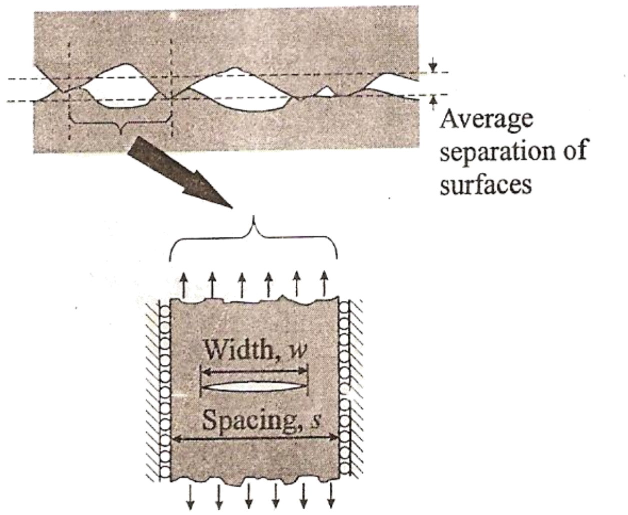



Fig. 4. Schematic diagram of the modeling of a contacting interface as an array of penny shaped cracks

When two rough surfaces are pressed together, contact occurs at the asperity peaks (Ref fig.4). Ultrasound will pass through the contacting regions but will be reflected at the gaps(Ref fig5).

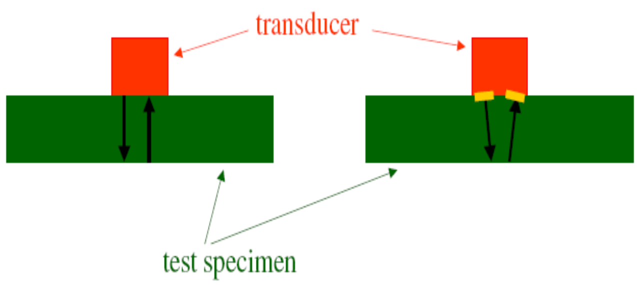



Fig 5: Reflection in the test specimen

Fig 6: Experimental setup for surface roughness measurement

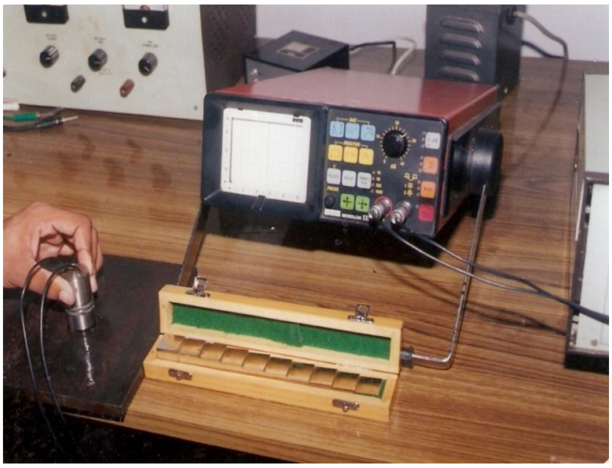
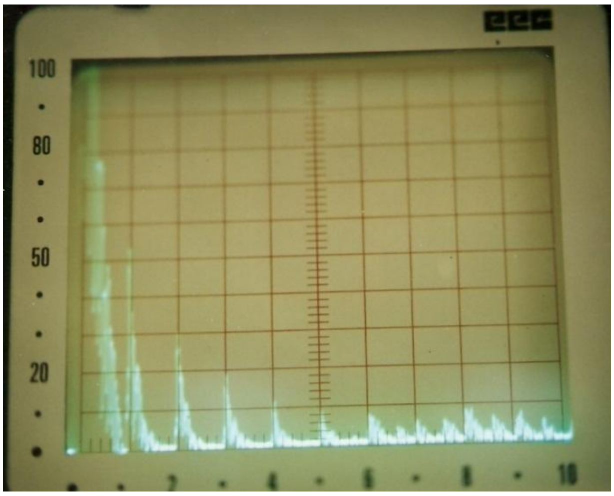
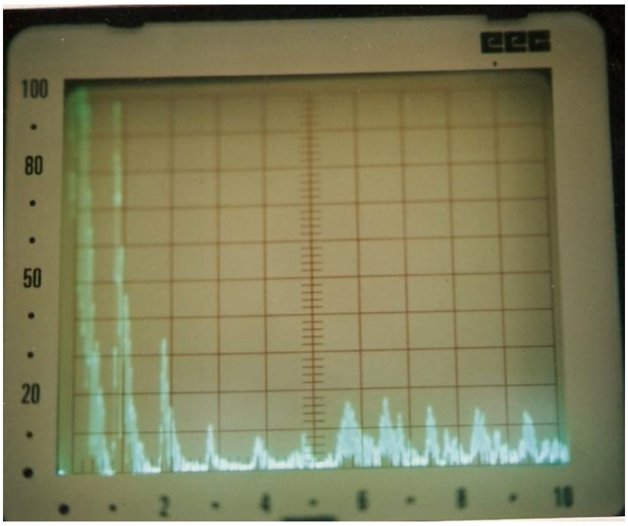


Fig 7: Experimental setup for surface roughness measurement (2)

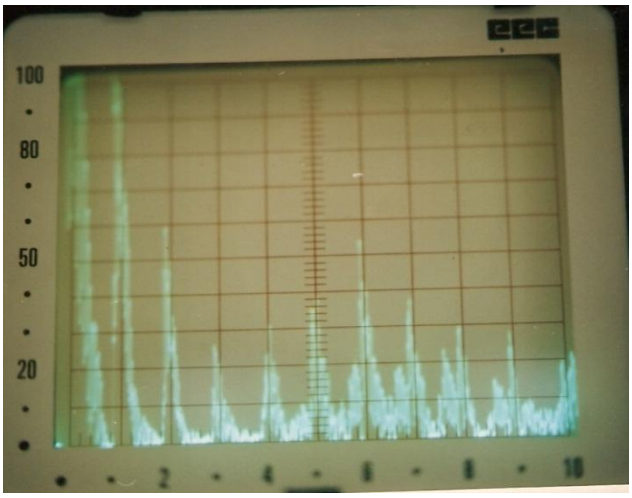
**B. Oscilloscope readings of surface roughness measurement for different materials with different grit numbers with different frequencies.**



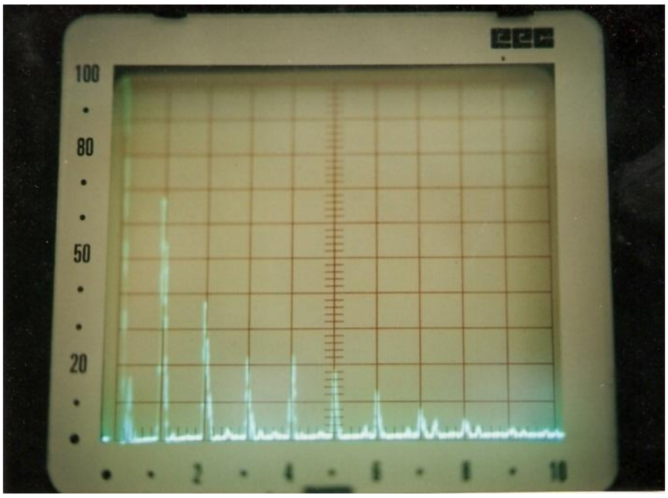
ALUMINIUM 220, 2 MHz, 14 DB



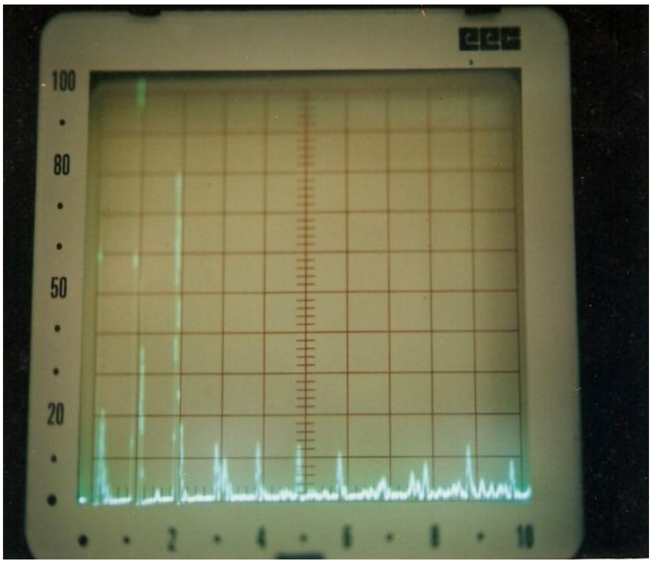
ALUMINIUM 320, 2 MHz, 14 DBS



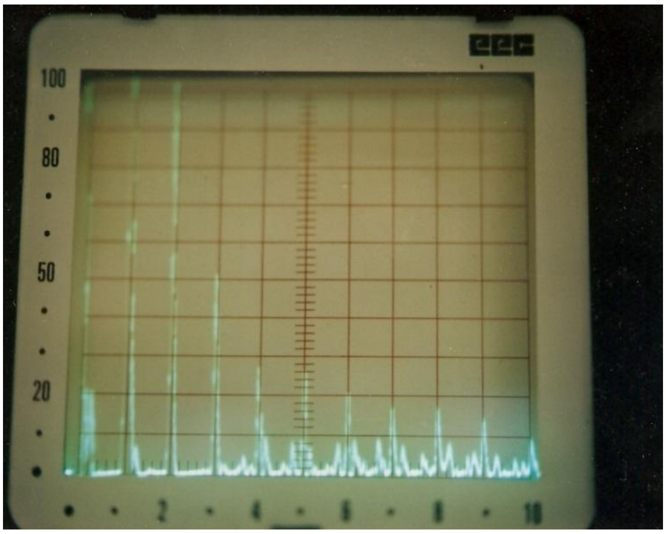
ALUMINIUM 400, 2 MHZ, 14 DB



STEEL 220, 4 MHz, 14 DB



STEEL 320, 4 MHz, 14 DB




STEEL 400, 4 MHz, 14 DB

### C. ADVANTAGES AND LIMITATIONS

Advantages:

i. The main advantage of using ultrasonic testing is because of its low cost.
ii. It can measure the surface roughness more accurately.
iii. These waves can pass through any medium to find the surface roughness.
iv. Internal surface roughness can also be measured by this technique.

Limitations:

The main disadvantage is that this technique is not suitable for large surface roughnesses like stone like surfaces. Materials those are too rough, very irregular in shape, very small, exceptionally thin or non-homogeneous are difficult to inspect. Surface must be accessible to transmit ultrasound.

### D. CONCLUSION

Roughness is the feature of a surface that defines how it looks, feels and behaves in contact with another surface. In order to precisely quantify and control the roughness of the slider and media during manufacturing, it is necessary to measure and describe the roughness.

The measurement of ultrasonic reflection provides a flexible method for interrogating interfaces. In the low frequency regime, the reflection of ultrasound is related to the stiffness of the interface by a spring model. By the oscilloscope readings we can conclude that, the softer material aluminium has thicker crests and troughs due to the larger roughness present on the material, than the other steel, which has small peaks and thinner crest and troughs shown in the readings.

## VII. REFERENCES

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