The magnitude of the amplitude of the reflected signal from the rough surface has been studied in many literatures. One possibility for the mathematical representation of the magnitude of the amplitude of the reflected pulse from bottom unevenness is a method of small disturbances, and in particular the method of Rayleigh.

The purpose of this work is to investigate and develop the model of Rayleigh reflection of an uneven surface and verify the development of model by experimental testing.

Application of the conventional Rayleigh method for presented reflection of longitudinal ultrasonic wave from uneven bottom surface

Formulation of the problem for calculation with the method of Rayleigh is shown in Figure 1. Method in this work is applied for medium steel with velocity of disseminated longitudinal ultrasonic wave CL = 5920m/s. The calculations are performed for the area of uneven surface greater than the area of the ultrasonic beam on the bottom surface of the test.

On fig.1 with arrow is shown ways of ultrasonic waves 1, 2, and 2/ emitted by the probe in the medium and received by him, after reflection from different parts of the uneven profile of the bottom surface. Rayleigh method considers only the difference in the waves between ultrasonic waves 1 and 2. Other ultrasonic wave 2' will be the object of investigation at a later stage in this work.

The limits of validity the method

The restriction of validity is its use for surface with sufficiently smooth unevenness profile with a normal distribution, to border values of Ra. To clarify the restriction for surface with sufficiently smooth unevenness profile it is necessary to quantify. In the literature this term is defined as unevenness for which Ra ≈ Λ. Numerical representation of the definition of surface with sufficiently or insufficient smooth unevenness profile can be expressed with the characteristic degree of unevenness q, depending on the angle of inclination of unevenness γ. The degree of unevenness is determined by the ratio q=AA/Ra. Characteristic q(γ)= 2γ/Λ, written with the following relationship:

\[ q(\gamma) = \frac{q_a}{\Lambda} = 2\gamma/\Lambda \]

Calculated values in dimensionless units are represented on the ordinate of the graph in figure 2. On X-axis is given angle of inclination γ in degrees.

For the case of surface with sufficiently smooth unevenness profile, degree of unevenness q=1 (Ra=AA) and angel of inclination γ=25°. For angel of inclination of unevenness γ=0° and γ=90° have a practical smooth surface, for which Ra=AA are zero.

Fig.2. Degree of unevenness q depending on the angle of inclination of unevenness γ

A second limitation of validity for the model is for unevenness profile having a normal distribution. Method is applied to reflecting uneven surface with a regular triangular profile with a normal distribution. The results for this profile are transferred to Rt with depending Rt=Ra=4.4. Ra.

The third limitation determines upper border for value of phase shift q for which the method is valid. In many literature defined physical boundary of the validity of method to values characteristic phase shift q=1. According mathematical relationship for the method of Rayleigh, the reflected from uneven signal weakens monotone and exponentially. Method should be valid until the phase shift of ultrasonic waves 1 and 2 equal to q, as the difference in their paths is given by the geometric characteristics Rt. Because the Rayleigh method is for characteristic of the profile Ra, the phase shift should occur minimum in n/4. When a phase shift greater than n/4 it is possible to reflected signal begin to increase. For these reasons, the limit of validity of the method should be to phase shift q=2/4-0.8. The reasoning and conclusions allow defining precisely the limit of validity of the model. This assumption about the limit of the method will be verified experimentally.

CONCLUSION

- Conducted a thorough analysis of the conventional method of Rayleigh and set precise limits of the applicability of the method.
- In the work is made proposed for modification of the method of Rayleigh which included pitch of uneven profile for regular triangular unevenness. The limitations for the modified method have been investigated and set precise.
- In the work have been performed ultrasonic experimental investigations to confirm the proposed modification of the method. There are quality matches of the results from ultrasonic experiment and the results from modified theoretical model.

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