Radiology Techniques Department, College of Medical Technology, The Islamic University, Najaf, Iraq

Theoretical Radiation Physics

Third stage- Radiology Techniques Department

Lecture 10

By

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(Refraction of ultrasound waves)

When the ultrasound wave travels from a medium in which its velocity is (v_1) to a medium in which its velocity is (v_2) through the acoustic boundary so that ($v_1 \neq v_2$) the ultrasound wave will change its direction , and This is called refraction.

If the ultrasound waves travel from The medium (1) to the medium (2) and the velocity (v_2) was greater than the velocity (v_1) , then the waves will be refracted in the second medium, moving away from the line perpendicular to the acoustic boundary, Thus the angle of refraction is greater than the angle of incidence($\Theta_{refr} > \Theta_i$).

If ultrasound waves travels from the medium (1) to the medium (2) and the velocity (v_1) is greater than the velocity (v_2), then the waves will be refracted in the second medium, approaching the line perpendicular to the acoustic boundary, Thus the angle of refraction is smaller than the angle of incidence($\Theta_{refr} < \Theta_i$).

If the ultrasound waves travel from The medium (1) to the medium (2) and the velocity (v_2) was greater than the velocity (v_1) ,and the refractive angle equal (90^{o}),then the incidence angle is called the critical angle and denoted by the symbol (Θ_c),this can be expressed as follows

If $v_2 > v_1$

And $\Theta_{refr} = 90^{o}$

Then $\Theta_i = \Theta_c$

In all of these cases

$(\sin \Theta_i / \sin \Theta_{refr}) = v_1 / v_2$

This relation called Snell's law.

Absorption of ultrasound waves:

Absorption is the process of converting **sound energy** into **thermal energy** in the medium in which ultrasound waves propagates , Whereas the medium in which the sound energy is transformed into heat energy is considered an **absorbent medium** for the sound energy.

the absorption depends on the following factors.

1- Frictional forces between molecules of the medium:

The frictional forces between the molecules of the medium appear when these molecules are moved by ultrasound waves, and as a result, part of the sound energy is converted into thermal energy, and this means that the absorption process takes place, when the **frictional forces increased** , the **amount of the generated thermal energy increased**, and this means that **the amount of sound energy converted into thermal energy increases**, that is, **the absorption process increases.**

2-the relaxation time of the medium:

It is the time required for the molecules of the medium to return to their **original position** after

the occurrence of disturbance due to the ultrasound wave.

If the relaxation time is **short**, the molecules of the medium return to their **original position before arrival the new disturbance**.

If the relaxation time is long, then the new disturbance due to the new ultrasonic wave will meet the particles during their return to their original position, and thus the movement of the new ultrasound wave will be opposite to the movement of the particles returning to their original position, and this means that the wave will face the movement of the returning particles as well as the forces of friction, and this means The loss of a greater amount of sound energy and its conversion into thermal energy, so the **long relaxation time** leads to **a greater absorption of sound energy.**

3-The ultrasound waves frequency:

The increase in the frequency of the ultrasound waves leads to an increase in the vibration of the molecules of the medium and this increases the rate of friction between the molecules, and thus the amount of heat generated due to friction increases, Also, the increase in the frequency of the waves reduces from the probability of the molecules returning to their original position due to the increase in the interception of the successive waves to the vibrating molcules, and this increases the amount of sound energy that converted into

thermal energy because the movement of the molecules in a direction opposite to the movement of the waves, and thus the absorption occurs due to friction and because of the movement of the molecules in the opposite direction to the movement of waves, and therefore the absorption increases with increasing frequency of ultrasound waves.

Acoustic shadow:

It is the region behind the medium that **completely absorbs** ultrasound waves