VELOCITY OF SOUND IN METALS

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Recently developed methods of determining sound velocities in the sonic and ultrasonic regions have resulted in interesting observations being made in respect of certain substances. For instance, Druyvesteyn (1941) found that the velocity of sound shows a considerable variation in β brass according to the mechanical and heat treatment received by the specimen. Bordoni (1947) found that the sound velocity when plotted against the percentage impurity in aluminium in the range 100–99% aluminium shows a marked minimum at the 99·65% composition. Such investigations, when pursued in detail, are likely to be of interest from the point of view of both the technical and the academic aspects of metallurgy. Somewhat similar results were reported by Bez-Bardili (1935) with regard to the velocity of ultrasonic waves in aluminium. The following values are taken from his work:

Frequency	Mc/sec.	5·23	8·52	18·00
Ultrasonic velocity ..	m/sec.	5880	6150	6330

A marked dispersion of ultrasonic velocity (7·6%) in aluminium as we go from 5 to 18 megacycles is thus indicated. From another paper of Bez-Bardili (1935), it appears as if there is dispersion in copper and brass also. Certain preliminary investigations carried out at the Physics Department of the Andhra University, but unpublished, showed that no such effect could be established at least in the case of brass, if errors arising from the presence of boundaries and other similar causes are suitably eliminated.

The present investigation is taken up with a view to apply the newly developed wedge method of determining ultrasonic velocities to this problem and bring out the significance of coupling effects due to finite size in such studies. Experimental details of the method have been described in several earlier communications and will not be repeated here. A piezoelectric wedge is used as the source for ultrasonic waves and the Debye-Sears diffraction patterns are used to detect transmission frequencies. It is well known that thickness longitudinal vibrations in the case of a plate travel with a velocity which depends on the effective elastic constant and the density alone if the plate is of unlimited size. The velocity, unaffected by the boundaries, may thus be determined, in strict accord with theory only if we use infinitely extending plates, but this is not practicable. Use is, however, made of the fact that optimum thicknesses and sizes which reduce the boundary effects to a minimum can be evolved. Several preliminary experiments have been performed by us in this direction and we have found that 2-inch square plates with thicknesses in the neighbourhood of 2 millimetres exhibit characteristics quite close to what may be expected of infinitely extending plates when we are working in the range of 1 to 10 megacycle frequencies. If the plate is too thin, flexural oscillations complicate the results and if the plate is too thick, the wavelength in the lower harmonic range becomes comparable to the lateral dimensions. The thickness of the plates used by us in the present investigation is worked up to being uniform to within 1 in 100. Our observations are in agreement with what has been recorded by Cady (1946) in his book, namely, " With thickness vibrations, this source of error is eliminated by observing at a high harmonic frequency. The lateral dimensions of the plate should be sufficiently great to avoid coupling with other modes and to permit the use of the theory of infinite plates. A safe minimum value for the ratio of lateral dimensions to half wavelength is perhaps 20." Results for three different thicknesses of aluminium and brass plates of the same size (2″ square) are given below.

Aluminium

Thickness of plate cm.	No. of harmonic n	Frequency mc./sec.	Frequency/ n mc./sec.	Velocity of sound m./sec.	Mean velocity
·252	4	5·118	1·279	6446	6492
	5	6·476	1·295	6527	
	6	7·713	1·286	6480	
	7	9·044	1·292	6512	
	8	10·310	1·289	6495	
·203	4	6·384	1·596	6480	6525
	5	8·070	1·614	6552	
	6	9·672	1·612	6543	
·156	4	8·396	2·099	6548	6535
	5	10·460	2·092	6522	

Brass

·233	4	3·898	·9745	4542	4528
	5	4·858	·9716	4530	
	6	5·812	·9687	4516	
	7	6·781	·9687	4516	
	8	7·784	·9731	4537	
·202	4	4·504	1·126	4537	4524
	5	5·580	1·116	4511	
·158	4	5·792	1·448	4576	4569
	5	7·220	1·444	4562	

It will be noticed that the values for the first, second and third harmonics are not given in the results above. We have found that in the determination of velocity of sound in metals by the thickness vibrations of plates, it is preferable to use the higher harmonics rather than the fundamental and its second and third overtones. This observation is again similar to what has been observed by Cady (1946) and other investigators.

The figures in aluminium, as well as brass, show that the variation from the mean value in any particular case does not exceed about 1%. This is within the limit of experimental error as the thickness itself is uniform to only that order. We have thus to conclude that the valocity of sound is independent of frequency as well as of thickness of plates for brass and aluminium in the region of 1 to 10 megacycles, provided thicknesses likely to give rise to boundary effects and such other complications are avoided.

SUMMARY

It has been experimentally shown, by applying the ultrasonic wedge method, that the sound velocity in brass and aluminium plates is independent of frequency in the range 1 to 10 megacycles. For obtaining this result unambiguously, one has to use plates of proper thicknesses and lateral dimensions and eliminate coupling and boundary effects.

REFERENCES

1. Bez-Bardili .. *Phys. Zeit.*, 1935, **36**, 20.
2. ——————— .. *Zeit. F. Phys.*, 1935, **96**, 761.
3. Bordoni, P. G. .. Publication No. 81, from the *Inst. Naz. Die Electroacustica*, Italy, 1947.
4. Cady, W. G. .. *Piezoelectricity*, 1946, 106 and 318.
5. Druyvesteyn, M. J. .. *Philips Technical Review*, 1941, **6**, 372.