1.3.9. INVESTIGATION OF THE TRANSDUCER ARRAYS FOR LONG RANGE ULTRASONICS

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The guided waves propagate in large, elongated objects such like pipes, rails, ropes and etc. Such objects are at least in one direction much longer than in other ones. These waves possess relatively small losses so can propagate relatively long distances. The guided waves are already used for pipe inspection. One of the factors which complicate application of these waves for other objects is multi mode character of them.

The most promising technique for generation of the selected modes is application of transducer arrays. The transducer arrays or ultrasonic phased arrays used in medicine and non-destructive testing (NDT) are widely investigated, however the performance of transducer arrays in the field of guided waves is not investigated sufficiently. The main difference is relatively low frequency range and as a consequence relatively long wavelengths. This leads to the fact that each of transducer array elements is small enough to consider it as a point source of ultrasonic waves. Another difference is that in a conventional transducer array the waves are generated in front direction with respect to the transducer surface. In the case of guided waves transducer element can be attached to the object along propagation direction, so waves propagates not in the front direction, but underneath of the transducer array. So, the attached transducer elements can affect boundary conditions and as a consequence the parameters of propagating waves.

The objective of work presented was investigation of transducer arrays used for generation and reception of guided waves, determination of regularities and estimation of optimal parameters for efficient generation of the desired mode of guided waves.

The following questions were analyzed: influence of boundary conditions between the transducer and the object; influence of the spacing between array elements (in general, configuration of the transducer array) on the amplitude and directivity of the generated guided wave mode; influence of presence of the object boundaries close to the transducer array position.

The investigations were carried out using numerical modelling and experimental verification of results. The regularities of excitation of the Lamb waves by single longitudinal and shear type transducers elements in plate like structures has been determined using numerical modelling. It was demonstrated and verified by experiments that in the case of the longitudinal type excitation S_0 and A_0 modes are generated almost uniformly in all directions. In the case of the shear type excitation three mode waves are generated a_0, s_0 and s_H (shear- horizontal). It was demonstrated that all of them possess directivity patterns close to the directivity pattern of the dipole. Using the determined directivity patterns of a single element the directivity of the transducers arrays having different configurations have been investigated. It was found out that the main problem is not the generation of guided waves, but generation of the desired mode of a guided wave with a relatively low level of the amplitude of undesired modes. The obtained results revealed several configurations of the transducer arrays which enable generation only of the desired mode of the Lamb wave with a relatively low level of the parasitic, e.g., undesired waves. It was also demonstrated and explained the difference between application of the longitudinal and the shear type transducers in ultrasonic arrays. It was pointed out the advantage of the delay time technique of excitation of transducer arrays comparing to the simultaneous excitation of all elements of the array.

However, the investigation also demonstrated that the configuration of the transducer array affects essentially the directivity patterns and amplitudes of generated wave modes and both spacing and delay time should varied in order to obtain the optimal ration of amplitudes of desired and undesired wave modes and this should be done for each object separately. The optimal delay time used for excitation of the transducer array elements should be determined experimentally for each object under investigation also.