4.5.5. APPLICATION OF PHYSICAL SCALED MODELS FOR DEVELOPMENT OF ULTRASONIC LONG RANGE NDT TECHNIQUES FOR INSPECTION OF LARGE OBJECTS

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Ultrasonic long range inspection based on exploitation of guided waves already is used for testing of pipelines. However application of this advanced technique on other objects usually leads to many problems, mainly due to the features of guided waves such as presence of many modes, dispersion and mode conversion on any obstacles on the way of propagating waves. Additionally the guided waves are affected by various parameters of the object: geometry (thickness), material, uniformity and boundary conditions between the object and a surrounding medium. Of course in development of guided waves techniques numerical modelling is widely used. Mainly it enables to answer to the most general questions related to the dispersion curves, propagation velocity and in some sense interaction of the waves with typical defects. However, some factors such as influence of real boundary conditions on attenuation of waves or multiple modes conversion of waves on non-uniformities or edges of the object is complicated to simulate due to the lack of the knowledge about real conditions or due to limitations of models. On the other hand in the development of NDT techniques the samples containing natural or artificial defects are used. However in the case of a long range ultrasonic testing these samples should be big and expensive in manufacturing because this technique usually is applied for the inspection of large structures. So, it was proposed to use for this purpose scaled down physical models of the objects under a test simultaneously changing the parameters of NDT system in a corresponding way also.

The objective of the work presented was to investigate how valid these scaled down physical models are and what requirements they should meet.

The object under investigation was a floor of a large fuel tank. As it is known due to safety requirements the storage tanks should be inspected regularly. However, inspection of the tank floor requires emptying and cleaning of the tank before the inspection personal can enter it. This is a very expensive procedure and a cost of inspection itself is only a small part of it. In the previous our publications it was proposed to use for inspection of a tank floor the guided wave transmission tomography. The modelling and experiment in situ demonstrated principal possibilities of the proposed approach. However, many essential questions are not answered yet: which technique is most suitable for efficient excitation of the necessary guided wave, the necessary number of measurement points around the tank, the achieved spatial resolution of the technique, influence of sediments and etc. In order to answer these questions the model of the storage tank with the scaling factor 1 : 8 was designed and manufactured.

In the first stage of investigation the validity of scaling was verified and tested. For that purpose the guided wave parameters (propagation velocity and leakage losses) in the plate possessing original (8 mm) and scaled down (1 mm) thickness were measured in corresponding frequency ranges. The losses on the lap joint weld were measured and compared in both cases also. Most complicated question was to determine if excitation and reception conditions are identical or at least similar in the real size and in the scaled

down cases. By numerical modelling and experimental investigation it was demonstrated that the most critical, complicated in implementation part are the dimensions of the transducers and the coupling conditions. Two types of transducers were developed. The first one was used for excitation of guided waves in a real thickness plate, the second- in the scaled down model. The ultrasonic guided wave fields were measured in both cases. It was demonstrated that transducer characteristics and the measured ultrasonic fields are comparable taking into account the scaling factor.

In the second stage of investigations the experiments were carried out on the scaled down physical model of the tank in order to estimate the parameters of the floor inspection technique. For that purpose the signals were measured in-plane of the floor of the storage tank model in a few cases: the empty tank, the tank on sand, the tank filled with liquid (water), the tank with sediments. The measurements in the case of introduced virtual defects were performed also. The analysis of acquired data using the tomographic reconstruction algorithm enabled to estimate accuracy limits and to determine the reasonable number of measurement points.

In general investigation carried out proved validity of the scaling down physical models approach and demonstrated that it can be widely used in the development of long range ultrasonic inspection techniques of large industrial structures.