Approach to characterize the sound field of pulse-excited ultrasonic sensors using a Laser Doppler vibrometer

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Abstract: It will be presented a new efficient approach to make visible sound fields in front of acoustic sensors in liquids. The goal of this approach is to investigate the sound field characteristic of real manufactured acoustic transmitters particularly by discontinuous excitation like pulse, burst and other. Another point is to analyse the influence of materials and sensor design on the resulting acoustic behavior. This approach has got a particularly importance for the quality assurance of the manufacture of ultrasonic sensors.

MOTIVATION

Different methods to investigate oscillating solid surfaces or sound field characteristics are well known. In the past for this measuring task it is increased the meaning of localized measuring principles, like laser interferometry or hydrophone measuring systems [1,2]. The advantage of this principle is the high resolution to detect the local motion of oscillating objects, i.e. acoustic transmitters. This knowledge is especially interesting for the transducer development. At the ifak it was developed a fully automatic measuring equipment for the computer based recording and visualization of vibrating transmitter surfaces. The second important point for the transducer development was the characterization of the sound field in the front of this transmitter, too.

EXPERIMENTAL SETUP

The experimental setup consists of a Laser Doppler vibrometer and a high-resolution three dimensional positioning system (see figure 1). The precise adjustment of the position will be controlled by a Personal Computer. Using a focused laser beam of the Laser Doppler vibrometer (optical system and controller) it will be scanned the displacement of surface points like a net in a certain period of time. The measuring data from the vibrometer will be digitized by a transient recorder and stored in the Personal Computer. A high performance function generator will be used for the excitation of the acoustic transmitter. So it is possible to generate different signal shapes (pulse-signals, burst-signals) adjustable in amplitude and frequency. An additional wide-band amplifier will be used to amplify the generator signal up to high-voltage RF-signal in a range of 15 kHz up to 20 MHz.

FIGURE 1. Experimental setup
RESULTS

An efficient software tool realizes the signal preprocessing of the measuring information like filtering, averaging and other. This software tool archives the data and calculates the picture of the complex vibration behavior of the transmitter surface, too. The result is a useful and interesting animation representing the sound propagation at the transmitter surface. These investigations will be used to study the influence of constructional details and material properties for a profitable transducer design or the quality inspection of the manufacturing process.

Another important task for the transducer development is the characterization of the sound field in the front of acoustic transmitter contacting a liquid. Using the laser interferometry it will be needed a mean to make the small displacement of the transparent liquid molecules visibly. For this it is used a suitable very thin foil (diaphragm), too. The focus point of the laser beam will be fixed on only one point on the diaphragm. To get the complete sound field it will be scanned the time dependent sound pressure in each grid point sequentially. In order to reduce the measuring errors it will be moved only the transmitter in a liquid box. Figure 2 shows the principle of the sound field scan. The software tool realizes the calculation of the sound field. In kind of an animation it is possible to visualize the sound propagation in the liquid dependent on time or place. The particular goal is to investigate the sound propagation in the front of non-plane transmitter surfaces, i.e. cylindrical transducer as shown in figure 3. Other interesting topics are the characterization of the influence of liquid temperature or gradients and the flow conditions (direction, velocity and other) on the resulting sound field.

FIGURE 2. The principle of the sound field scan

FIGURE 3. The sound field of a cylindrical transmitter (12 µs after the excitation)

SUMMARY

In this contribution it was described an efficient approach and the developed experimental setup to characterize the properties of acoustic transmitters concerning the internal wave propagation and the sound field outside of this transducer contacting a liquid. At the poster some examples will show the sound field in front of a cylindrical focusing transmitter. It will be discussed the influence of different excitation signal shapes on the resulting sound field, too.

REFERENCES


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