THE MEASURING OF ULTRASOUND PROBES

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ABSTRACT

In this paper, there is described the measuring of different ultrasound probes. The radiated ultrasound fields is represented as a three-dimensional visualization of the ultrasound pressure distribution in a space. This enables to get a more complex view than in two-dimensional case. The results will be used for classifying the field and for a determination of the ultrasound intensity.

1 INTRODUCTION

There are different types of ultrasonic (us) probes used in pulse-echo imaging methods. The physical scanning process can be effected in two basic ways. Either by actual movement of a transducer having a fixed beam axis, or by electronically controlled movement of the beam axis relative to a transducer array. The former category is obsolete and an ultrasound beam steering was usually realized by a scanning arm or a rotating wheel, also a beam focusing was mechanically performed by placing an acoustic lens on the surface of the transducer or using a transducer with a concave face.

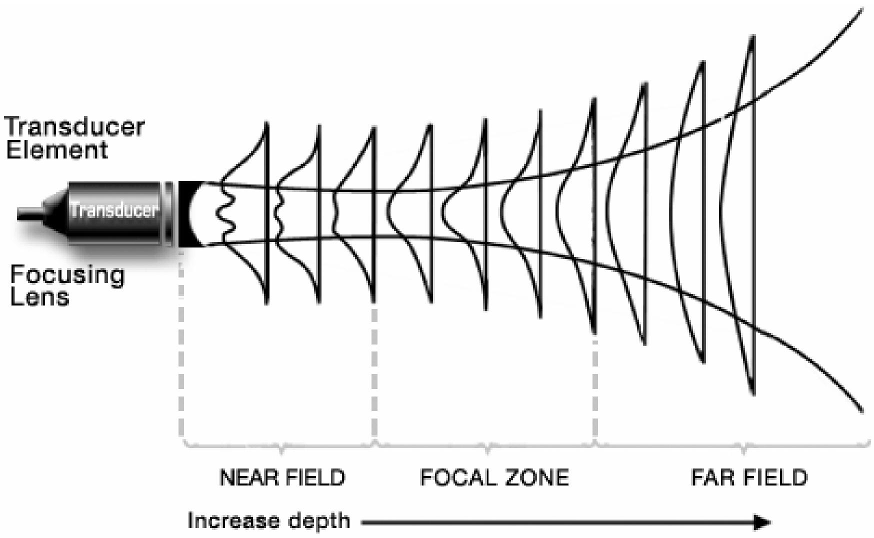


Fig. 1: *Profile of the ultrasound field*

These types were replaced with the latter category, which includes so-called linear and phased multi-element transducer arrays. Principles of ultrasound beam steering and focusing are directed by sequentially stimulating each element. This feature creates the sector scan by rapidly steering the beam from left to right to give the two dimensional cross sectional image.

The radiated field of ultrasonic probes is commonly defined by three zones (fresnel, focal, fraunhoffer). The center of interest is concentrated to focal zone where are often highest values of positive, negative pressure respectively. It is the region where the beam diameter is most concentrated giving the greatest degree of focus, see fig.1.

2 THE ULTRASOUND MEASURING SYSTEM

There was designed and realized an unique ultrasound measuring system to verify theoretical premises and model studies of radiation of ultrasonic probes. This system enables to check radiation characteristic of elementary transducers and systems of ultrasonic probes too. The measuring system acquires data of pressure characteristic at each point of the required space. The system contains an ultrasonic tank, a hydrophone and a control computer. The measuring proceeds in a water bath of the ultrasonic tank. There is hydrophone MH28-5 used for a scanning of an acoustic pressure generated by the us probe. This probe which generates us field has stationary position, vice versa hydrophone is fixed to position system. It allows a movement at three orthogonal directions.

During measuring, the three-dimensional scanning of a tank space is performed. Acoustic signal from the hydrophone is amplified and sequentially sampled by the measuring card located inside the control computer. The control of hydrophone position system is supported by the control computer. The communication of the position system with control computer goes on a CAN bus.

3 VISUALIZATION OF MEASURED FIELDS

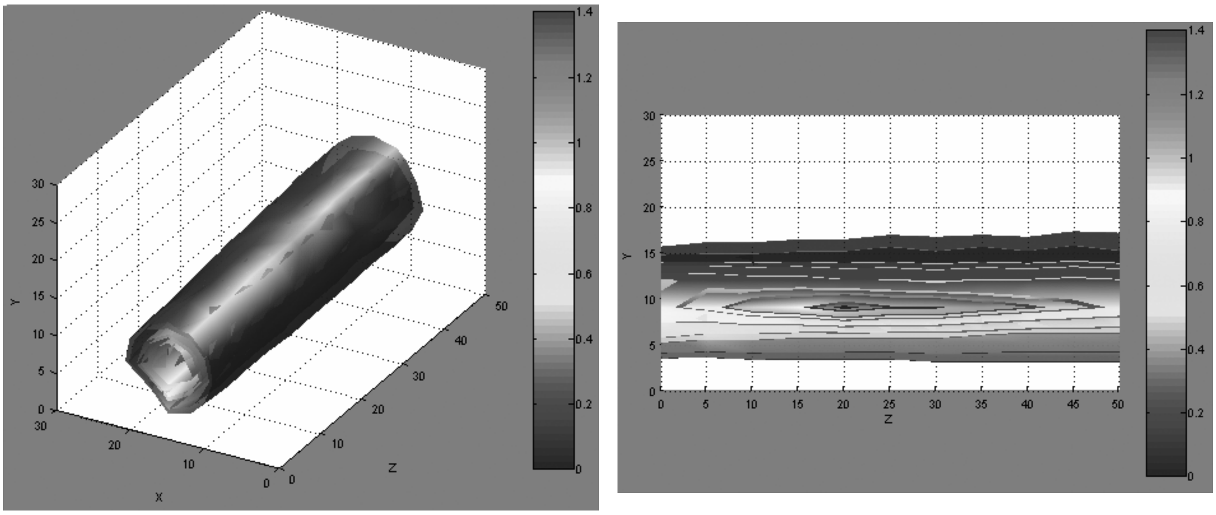
There were measured several ultrasonic diagnostic systems for an experimental examination of the ultrasound measuring system, such as:

- ADR 4000 3.5MHz linear probe with scanning arm,
- SonoSite 180 Plus, microconvex wideband probe (C15/4-2),
- GE medical systems SystemFive, 2.5 MHz linear wideband phased array (128 el/19 mm).

Maximum, resp. minimum, voltage measured values are used to visualize ultrasound field with isosurfaces, resp. isolines. A gradient of an alternation is presented by a different distance of individual isosurfaces. Color scale describes a level of a measured voltage that is proportional to a pressure. The software allows to change many parameters of visualization such as an elevation, an azimut, direction of light, type of projection, a count of isosurfaces eventually count of planes of isolines etc.

The measured field was 1 cm far from a head of probes and a number of measuring points were 11 at every axis. The distance between two points was 3 mm at X, Y axis and 5 mm at Z axis for ADR system. For the others, there was the distance 5 mm at X, Z axes and 2.5 mm at Y axes. Dimension of spatial axes is in milimeters.

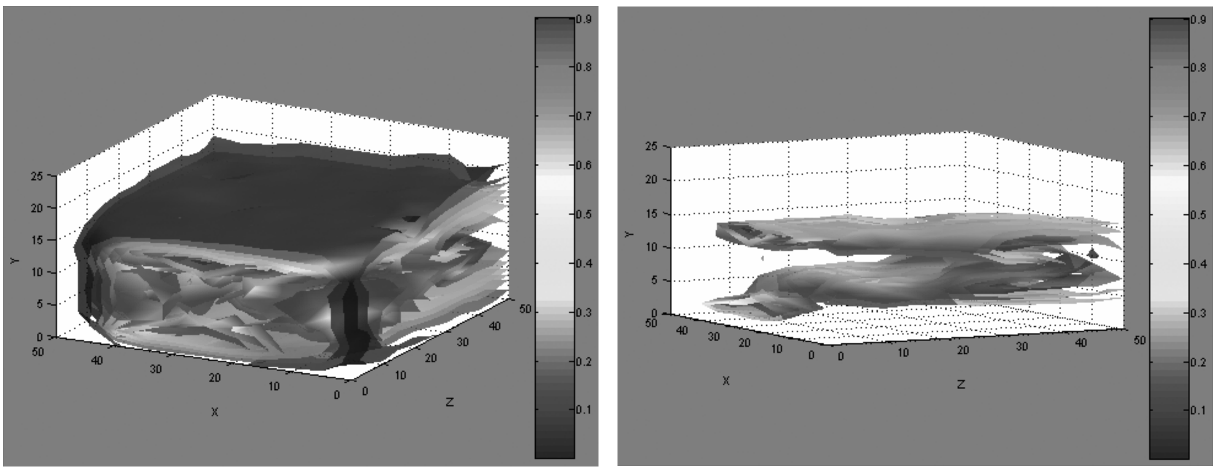
Following figures are showing 3D representation of ultrasound fields of three different probes from both above-mentioned categories. The figure 2 represents a simple round transducer without the motion and mechanically focused to point, for the reason that the graph is axially symmetric, fig.2a, and there is the clear point of a focusation at the distance 3 cm from a head of a probe, fig.2b.



a) *b)*

Fig. 2: *3.5MHz linear probe in TM mode: a) global view, b) cross-section.*

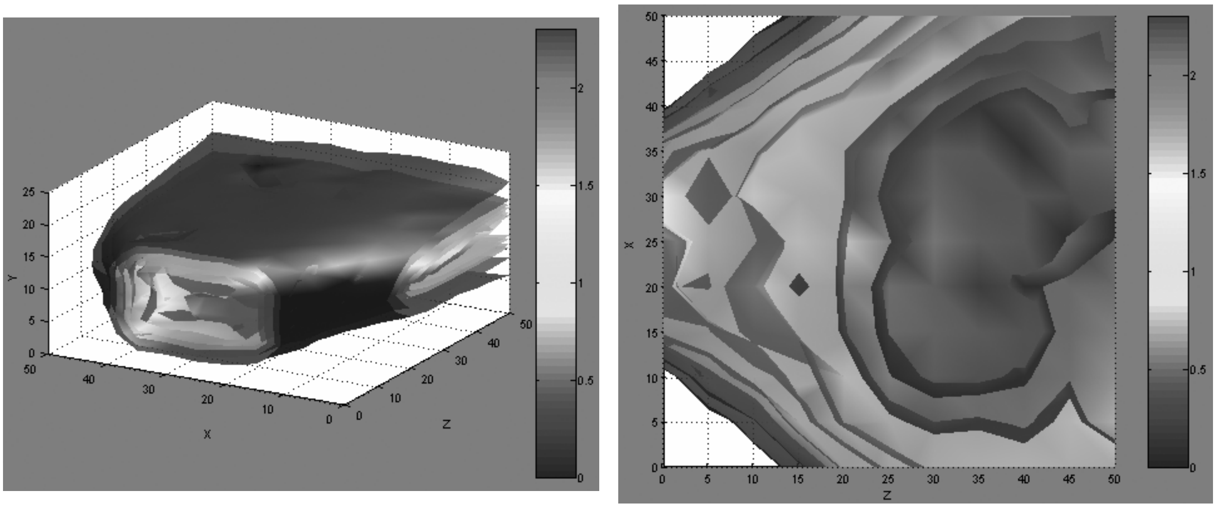
A category of multi-element arrays is represented in fig. 3, 4 and 5. The array of elements of microconvex probe is curved with a certain radius, what can be seen on wide opened global view, fig.3a. It is possible to reduce number of isosurfaces in a graph. This is useful to uncover isosurfaces with higher pressure value. Then there are seen two main lobes manifested in y-axis, (fig.3b), and hence this probe's array has probably two rows of elements to get higher depth of focusation. Maximum value of depth attributed by SonoSite is 24.6 cm.



a) *b)*

Fig. 3: *Microconvex probe C15/4-2: a) global view, b) view of lower-bounded isosurfaces*

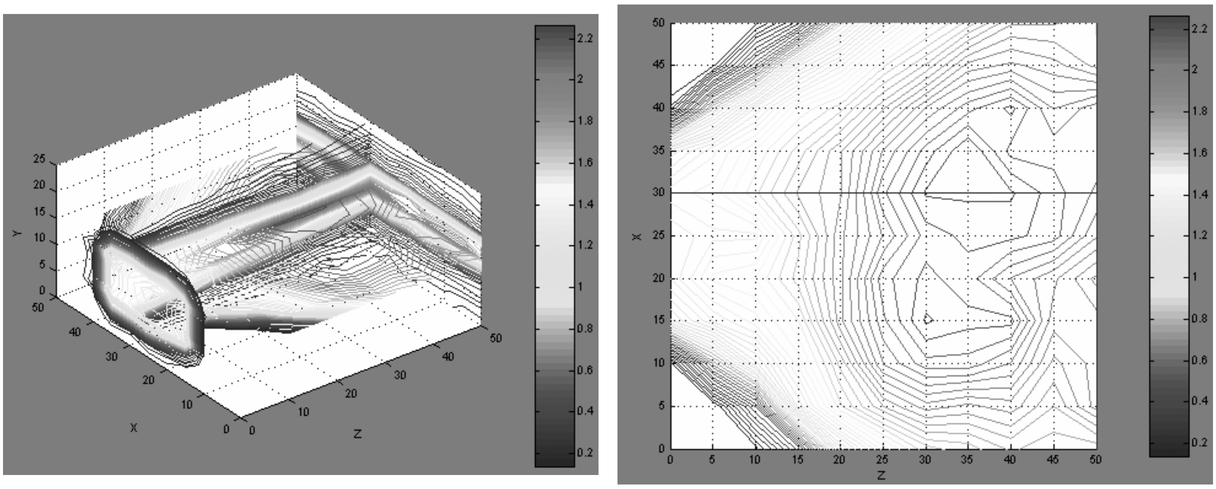
Figure 4 shows the pressure distribution of linear probe. There is evidently smaller angle of a scanning sector than of the microconvex probe even so the length of the array is longer by 4 mm. From wave interference conditions and division of zones (fig.1), it can be supposed that the area, in fig. 4b, with the highest pressure distribution, can be called a focal zone.



a) *b)*

Fig. 4: *2.5MHz linear wideband probe: a) global view, b) longitudinal section.*

The same view of pressure distribution is in fig.5, this is represented by planes of isolines. There are visualized planes with the highest pressure distribution. The gradient of a spatial pressure is shown in fig.5b.



a) *b)*

Fig. 5: *2.5MHz linear probe represented by isolines*

CONLUSIONS

Three-dimensional representation in built-up software was found as a more interactive and complex view of ultrasound maps. Experimentally, there were measured fields generated by three ultrasonic probes of different ultrasonic diagnostic system in a pulse mode and were found their characteristic properties, especially their focal zone. The focus of probes from the head of probe were approximately measured at these distances, 3 cm of 3.5MHz linear probe, 4.5 cm of 2.5MHz linear wideband probe, and in case of microconvex probe C15/4-2 is beyond measured field, so it could not be determined. Results of a further research certainly contribute to sanitary standards specification of ultrasound diagnostics.

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