UDC 004.9:531.7

V.A. Mashchenko, PhD
(Odessa State Academy of Technical Regulation and Quality, Ukraine),
V.P. Kvasnikov, Dr. Sci. Tech.
(National Aviation University, Ukraine)

Information-measuring system for determination of elastic parameters of composite polymeric and heterogeneous materials

An information-measuring system for measuring the velocity distribution of longitudinal and transverse ultrasonic waves and their absorption coefficients in composite polymeric and heterogeneous materials has been developed. According to the results of experimental research the calculation of the complex of elastic parameters of such materials is carried out.

The acoustic ultrasonic methods occupy an important place in the methods of determining the mechanical quantities (Young's modulus, shear modulus, volume deformation module, Poisson's ration) of composite polymeric and heterogeneous materials [1]. In order to ensure high accuracy of their measurement and information processing, it is necessary to take into account a number of technical, physical and mathematical factors, which is impossible without the use of information-measuring systems (IMS) with means of artificial intelligence.

The work of the IMS to determine the elastic parameters is based on the passage of longitudinal and transverses ultrasonic oscillations though a sample of material immersed in the immersion fluid, and allows in one step, to determine the rates of their propagation and absorption coefficients.
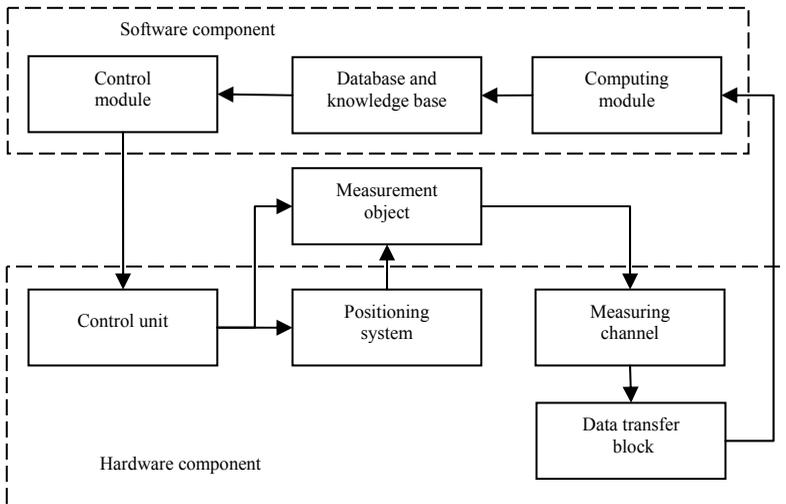

Fig. 1. Structure of the information-measuring system

The block diagram of the IMS is shown in Fig. 2 and contains hardware and software.

```
                    ┌─────────────────┐
                    │   Beginning     │
                    └─────────────────┘
                             │
                             ▼
              ┌──────────────────────────────┐
              │ Getting information about the │
              │   initial setting of the IMS  │
              └──────────────────────────────┘
                             │
                             ▼
              ┌──────────────────────────────┐
              │ Measurement of the passage    │
              │ time of the probe impulse and │
              │ its amplitude in a container  │
              │ with an immersion fluid       │
              │ without a sample              │
              └──────────────────────────────┘
                             │
                             ▼
```

The software component of the IMS

Measurement of the passage time of the probe pulse and its amplitude in a container with the immersion fluid and sample → Determination of the velocity of the propagation of the longitudinal wave and the theoretical calculation of the critical angle and angle of rotation

Rotate a sample to a given angle and measure the passage time of the probe pulse and its amplitude → Determination of the critical angle and velocity of the transverse wave propagation

Reverse algorithm for measuring the passage time of the probe pulse and its amplitude to the initial position of the sample → Conducting calculations of elastic parameters, obtaining estimates of accuracy and reliability of measurement results
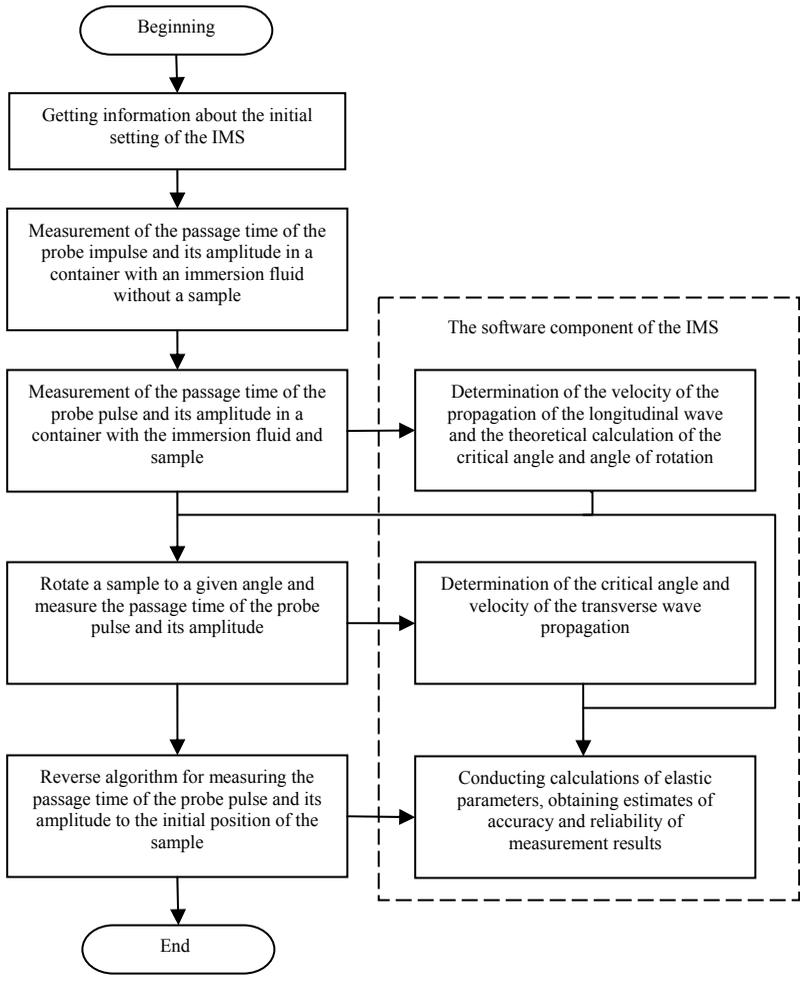
End

Fig. 2. Algorithm of the process of measurement and determination of elastic parameters

The algorithm of the measurement process (Fig. 2) is based on the principles of functioning of expert systems and provides the optimal duration of the process of measuring and processing information.

The program part of IMS performs the following functions:
- controls the initial settings of the IMS;
- decides on the start/continuation of or stopping the algorithm for measuring the time intervals for passing the ultrasonic probe impulse and its amplitude;
- accepts data and transfers commands to the control unit;
- defines optimal data processing algorithms;
- conducts calculations of the velocities of the propagation of longitudinal and transverse waves and the critical angle of incidence of the ultrasonic wave on the dividing line of the immersion liquid – composite polymeric/heterogeneous material;
- determines elastic sample parameters;
- controls the intermediate parameters in the measurement process;
- visualizes the results of measurements and calculations.

The hardware part performs the following functions:
- forms a probing impulse;
- detects the received signal and measures its amplitude;
- determines the time of passing the probe impulse;
- transmits the received data to the PC for further processing;
- accepts commands for performing the following steps of the measurement algorithm and generates appropriate control signals for the positioning system of the test sample;
- indicates the status of the work of the IMS and measurement parameters.

The hardware part of the IMS is executed in the form of an electronic block with an analogue-digital structure based on Atmega 48 microcontroller. The electronic unit includes amplifiers of input and output signals that are excited and received by piezoelectric converters, comparators, logic level converter, converter of interfaces COM-USB and a scheme for controlling a sample positioning device.

For the hardware part of the IMS, the measurement database, the knowledge base of the measurement processing algorithms, an intelligent interface has been developed. As a result, the research engineer receives signal characteristics and measurement results with the estimation of their errors in the form of comparative tables and graphs.

Conclusion

The developed information-measuring system will avoid the subjective factor in the measurement process and will provide high accuracy of measurements when determining the complex of elastic parameters of polymeric composite and heterogeneous materials.

References

1. Физическая акустика / Под. ред. У. Мезона. Том. 1. Методы и приборы ультразвуковых исследований. Часть А. – Москва: Мир, 1966. – 592 с.