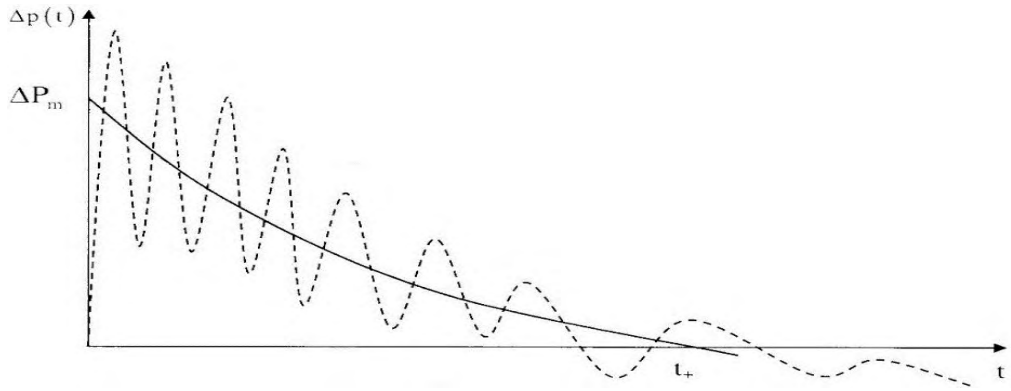

Рисунок 3. Регистрируемый (пунктирная линия) сигнал и обработанный (сплошная)

Профиль ВУВ, учитывая высокую динамичность регистрируемого процесса, на входе АЦП искажен наложением колебаний с собственной частотой датчика.

По обработанный кривой профиля зарегистрированного процесса от собственной частоты датчика и испытательной оснастки определяется полный импульс положительной фазы сжатия ВУВ (профиль зарегистрированного процесса без сглаживания и фильтрации):

$$J_+ = \int_{t_0}^{t_+} \Delta P(t) \cdot dt, \quad (2)$$

где J_+ импульс фазы сжатия воздушной ударной волны;

$\Delta P(t)$ – текущее избыточное давление ударной волны в фиксированной точке;

t_0 – время начала процесса;

t_+ – длительность положительной фазы сжатия импульса.

В настоящее время реализованная на АО «ФНПЦ «Алтай» система является единственным эффективным средством для определения параметров ВУВ в полевых условиях и в настоящее время успешно применяется.

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MEASUREMENT SYSTEM PARAMETERS OF AIR IMPACT WAVES

A.S. Sokolov, D.A. Kondrashov, S.P. Kozharsky, G.A. Bubnov

Federal Research and Production Center "Altai", Biysk, Altai Krai, Russia

The enterprise "Federal Research and Production Center "Altai " develops new compositions and weapon heads. To assess the effectiveness of their performance it is necessary to measure the parameters of the air shock wave. Thus, it became necessary to develop an information-measuring system.

According to the results of scientific and technical research, the strain gauge was found to be the most relevant method to measure the parameters of an air shock wave. Based on the method, an information-measuring system (IMS) was developed for ASW automated working station (AWS).

The system registers the pressure created during the explosion and allows to evaluate the following parameters:

- impulse of air shock wave compression phase, J +;
- excess (peak) pressure at the front propagation of the air shock wave at specified registration points, ΔPm;
- average propagation speed of ASW front of between two registration points along the measurement line, V_f [1].

Based on the obtained results of processing ASW profile, the TNT equivalent of the explosive tested is determined.

The structure of IMS includes:

- methodology for performing ASW measurements during field tests;
- strain gauges;
- measurement unit;
- special software (AWP software).

In the measuring system, the pressure is determined by a strain gauge method based on converting the measured parameter into a change in resistance of the resistance strain gages, followed by conversion to an analog electrical signal, which is then converted with an ADC in the measurement unit (MU) and fed to data digital recording, processing and display systems [2].

Digitized registration results are obtained as voltage values at time points determined by the sensor sampling frequency, and then converted to the current value of the parameter using an individual gauge line (GL). Further, the specialized software of the automated working station calculates ASW parameters: J +, ΔPm, V_f.

The measurement results are given in the form of tables and (or) diagrams and put into the database on completion of the product tests.

Figure 1 presents block diagram of the measuring system.

Figure 1. The block diagram of the measuring system to determine ASW parameters

MU includes ADC (with a report rate up to 2.5 MHz per channel), a laptop computer, measuring line monitoring devices and power supplies. MU is designed as a self-contained device ~ 220 V line-operated.

For user interaction, it is allowed to connect peripheral devices via DVI and USB interface, or remote connection via Ethernet.

The main technical characteristics of the measurement system are presented in Table 1.

The AWS measuring system ASW is intended for operation in the following climatic conditions:

- ambient temperature when taking measurements is from + 5°C to + 55°C;
- relative ambient humidity is up to 90% at temperature of 25°C.

With the developed software and the monitoring unit it is possible to check the state of the measuring line (connection procedure of the sensors, the integrity of the connecting lines, the presence of sensor power) remotely.

Table 1. Technical characteristics of the measurement system

Characteristic	Value
Number of channels for pressure measurement	8
Pressure measurement range, kgf/cm²	0…8
Maximum range of input signals for strain channels, V	±3
Limits of permissible reduced error for potentiometric measuring channels, %	±0,25
Natural sensor frequency, Hz	20000
Maximum conversion frequency of the ADC, MHz	10
Sensor bridge resistance, Ohm	0…400

Figure 2 presents a graph of the air shock wave pressure registered by four gauges located at different distances from the specimen.

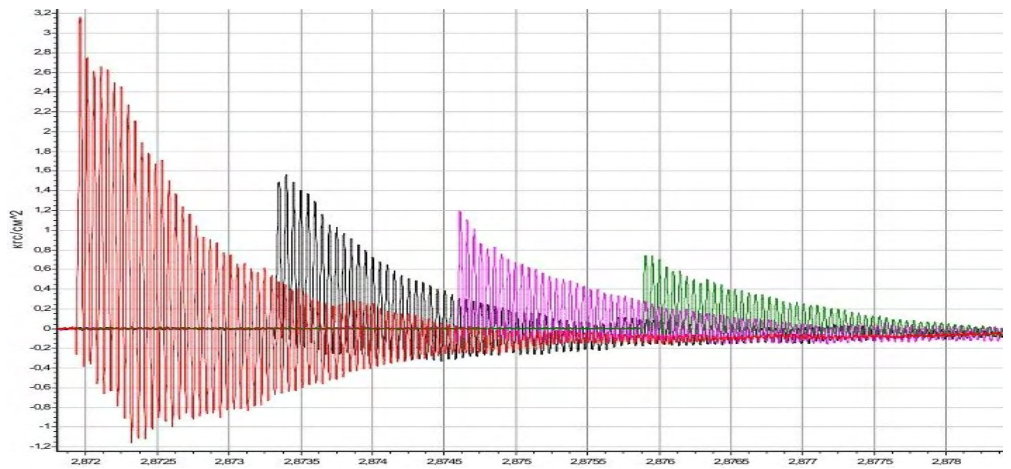

Figure 2. Pressure diagrams of the air shock wave registered by four gauges

The results of the parameters measurements performed with the evaluation products are shown in Table 2.

Table 2. Measurement results

Sequence number	1	2	3	4
ASW arrival time, sec.	2,8719	2,8733	2,8745	2,8758
Peak pressure, kgf/cm²	1,61	0,86	0,56	0,37
Impulse, kgf*μs/cm²	523,40	382,31	321,47	264,52
Compression phase duration, μs.	955,95	1346,97	1770,98	1921,02
Front propagation speed, m/sec		469,65	433,41	427,02

The measurement error corresponds to the calculated data.

The processing of measurement results is carried out according to the registration data of the process, the initial data entered at ASW automated working station, the calibration results of measuring instruments and includes the following steps:

- conversion of the registered voltage values to the parameter values for each measuring channel;
- calculation of ASW parameters for each measuring channel;
- presentation of the processing results in the form of graphs and tables and recording measurement results in the database.

Assessment of the measurement quality of ASW parameters is evaluation of the shock wave profile. ASW profile for compact caseless explosive charges is described with the following empirical equation when $\Delta P < 8$ kg / cm^2:

$$\Delta p(t) = \Delta P_m \cdot \left(1 - \frac{t}{t_+}\right) \cdot e^{-\alpha \frac{t}{t_+}}, \quad (1)$$

where $\Delta p(t)$ – is current overpressure of the shock wave;

ΔP_m – is maximum (peak) pressure in the air shock wave front;

t_+ – is duration of the positive compression phase of the air shock wave;

α – is a dimensionless coefficient that is dependent functionally on ΔP_m and t_+.

Figure 3 shows the discrepancy between the recorded signal (dashed line) and the processed one (solid line).

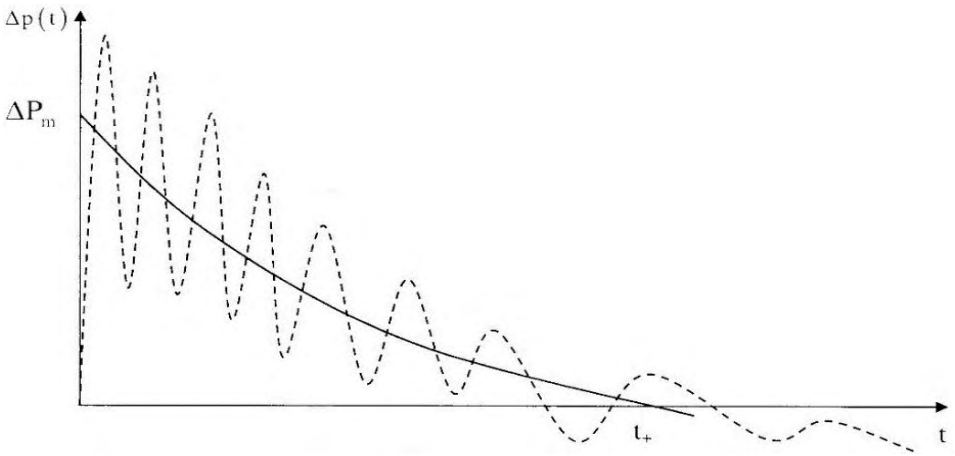

Figure 3. The recorded signal (dashed line) and the processed one (solid line)

ASW profile is distorted by the imposition of oscillations with a natural frequency of the sensor at the input of the ADC taking into account a high dynamics of the recorded process.

With the processed curve of the process profile to be registered and the natural frequency of the sensor and test equipment the full impulse of the positive compression phase of the air shock wave (a profile of the registered process without smoothing and filtering) is determined:

$$J_+ = \int_{t_0}^{t_+} \Delta P(t) \cdot dt, \quad (2)$$

where J_+ – is the compression phase impulse of the air shock wave;

$\Delta P(t)$ – is a current pressure excess of the shock wave at a fixed point;

t_o – is start time of the process;

t_+ – is duration of the positive compression phase of the pulse.

At present, the system implemented at JSC "Federal Research and Production Center "Altai" is the only effective means for determining the air shock wave parameters in field conditions and is being applied successfully up to date.

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