# MATRIX COMPOSITE SENSOR FOR MEASUREMENT MERE STREAM

**A.A. BAYRAMOV, N.A. SAFAROV**
*Institute of Physics, Azerbaijan National Academy of Sciences*
*Azerbaijan, Baku, Az-1143, H. Javid pr., 33*

For detection and research obvious and latent heat stream in mere has been developed the extended high-resistance sensor made on special matrix technology. Detector measures both temperature of surrounding sea water, and direction of a stream. Signals from the sensor, amplified of the operational amplifier, by dint of the interface input into a computer for the further processing results of measurement and archiving of the data. The software package of processing and archiving of results of measurement is created.

## 1. Introduction

Detection and research obvious and latent heat stream in mere is an actual problem for studying the physical processes proceeding at oceans and the seas. It is the important problem for study and prediction of climate fluctuation for the Earth, for the solution ecological and many other things of problems of a national economy [1,2,3].

Stream at ocean can be watched on indirect indicators - to variation of temperatures or transferred stream by ice, to suspended matters, a phytoplankton (so-called tracers), fixed by means of various sensors of remote sensing in visible and thermal infrared ranges, or the sensor units directly contacting to an aquatic environment. Passive tracers, such as a chlorophyll or temperature, visualize stream in a field of temperature or colour of a sea on space films.

Possibilities of measuring by radar filming performances of stream at ocean or sea were explored repeatedly. However, systems used now are not suitable for such investigations as do not ensure the vector measuring and do not allow receiving the space field pattern of rate.

On radar snapshots the surface developments established by stream are recorded. In areas of interacting of stream there can be fronts, bands of tide rings and choppy seas; these phenomena are detected as a series of ghost lines or spots.

Borders of stream and the structures coupled to stream (fronts, meanders, spurts, mushroom structures and vortexes) are well visible in a field of temperature on snapshots in a thermal infrared range.

Fronts and the frontal areas are the most interesting phenomena at ocean. In the frontal areas intensive dynamic processes, specially there where there are aqueous masses the greatest differences of the physicochemical properties.

In the World ocean major diversity of vortexes and vortex motions is watched. Commonly ooze the frontal vortexes, the vortexes of midocean arising owing to baroclinic instability; the topographic vortexes coupled to a flow of aqueous masses, and synoptic vortexes, generated atmospheric processes, for example, typhoons.

So-called mushroom stream are the vortex formations (or structures) also, its were discovered in the beginning 80th as a result of the analysis of space snapshots. Mushroom stream is a combination of a narrow jet flow and a couple of vortexes of an opposite sign - dipoles because of what this vortex structure likes a mushroom in a slit.

Thus, widescale researches only near-surface stream in oceans and seas are carried out by methods of remote sensing and aerospace filming.

The ultrasonic sounding method is one of widely used methods of learning of surface and subsurface stream [4]. In particular, at usage of this method, the cross flows of the heterogeneous stream bears to fluctuations of an acoustic signal transiting through it. These fluctuations are changed at a frequency change of a signal in connection with a dimensional change of a Frenel zone. Accordingly, these fluctuations of signals on two different frequencies are coherent in a low-frequency spectral range and incoherent in a high-frequency diapason. Thus discontinuity of ocean will be small on matching with a difference in across-sectional dimension of a Frenel zone for various frequencies. Function of a coherence of signals on various frequencies depends on a spatial distribution of a stream. Therefore multifrequent sounding of stream reconstructs of the profile space of a stream. However with increasing of a logging depth the ultrasonic method results to greater errors.

Most precise measurements of a temperature field and a profile of a stream can be carried out only contact methods when the sensor is in an aquatic environment.

## 2. Experiments

There are two main problems at development of the sensor contacting to an aquatic environment:

1) If electrodes of the sensors measuring a heat stream are isolated from water, pressure of water renders destroying influence on the sensor measuring a heat stream.
2) If electrodes of the sensor adjoin to water, the water environment shunts electrodes and brings distortions in physical value of electric parameters of the sensor.

In paper results of development and research of the sensor on the basis of composite materials are given. The sensor is intended for measuring simultaneously temperature fields and the space a profile of the obvious and latent heat stream of an aquatic environment (in three coordinates). Measuring can be carried out both in near-surface areas, and on various depths in an aquatic environment. Usage for this purpose of composite materials allows us extend a research range.

Development of new polymeric composite materials, prediction and improving of their characteristics depends from binding which one is the major component of composite materials. In this connection recently the investigations in the field of a polymeric materials technology in particular conducting polymeric composite materials [5], were increasing.

The purpose of work is development of the sensor for simultaneous measuring a temperature field and the space a profile of the obvious and latent heat stream of an aquatic environment.

The material of the matrix (the belt shape) sensor unit-exemplar consists of three components:

1) Polymeric component of an exemplar, for collimating to an exemplar of pliability, a technological Q-factor and provision high resistive of the sensor unit;

1) A piezoelectric filling compound in the form of slurry in the sensor unit (comminuted and mixed in a polymer), for amplification of accumulation of charges on surfaces of a matrix and direction finding of a motion of an aquatic environment;

2) thermo-filling - a semiconductor filling compound in the form of magnetic character slurry for provision thermosensitivity of an exemplar.

As a polymer it is possible to take polytetrafluoroethylene (teflon-4) or polyethylene. On insulating properties teflon-4 belongs to best of known dielectrics. In table 1 basic characteristics of teflon-4 and polyethylene are given.

Table 1

| | Resistivity, $\rho$, Ohm·м | Dielectric factor at $f$=1MHz and $t^o$=20°C | Dielectric loss tgδ at $f$=1 MHz and $t^o$=20°C | Temperature stability, °C | Ultimate tension, MPa | Relative elongation, % | Density, kg/m$^3$ |
|---|---|---|---|---|---|---|---|
| Teflon -4 | $10^{15}$÷$10^{16}$ | 1,9÷2,2 | (2÷2,5)·$10^{-4}$ | -260 ÷ +250 | 15÷30 | 250÷300 | 2300 |
| Polyethylene | $10^{13}$÷$10^{15}$ | 2,1÷2,4 | (3-5) ·$10^{-4}$ | -70 ÷ + 90 | 10÷15 | 300÷750 | 910÷970 |

Teflon-4 is more chemical persistent than noble metals that allows to use it at manufacture of the isolation working in corrosive environments. Teflon-4 is not combustible, is not hydroscopic, is not wetted with water and other fluids. Polyethylene is more technological, relative a low-cost and more polarizable material. As the piezoelectric filling compound we used PKR-8, PKR-3 or CTS-300 because a coefficient $d_{33}$ is high. The piezoelectric modulus $d_{33}$ characterizes a density of charge formed on plates of an exemplar at action mechanic exertion in a direction, previous polarization. For example, CTS-300 has a density of charge $d_{33}$ = 280pC/N, $\varepsilon$ =100, $t_к$ = 330°C. For getting the sensor unit semiconductor heat-sensitive and piezoelectric materials immix on special technique with powdered polystyrene before achievement of homogeneous mixture. Current-output electrodes in the form of an elastic strip are superimposed in a uniform work cycle. The got exemplar is enveloped by a clean polymeric material for removal shunting in an aquatic environment (Fig.1).

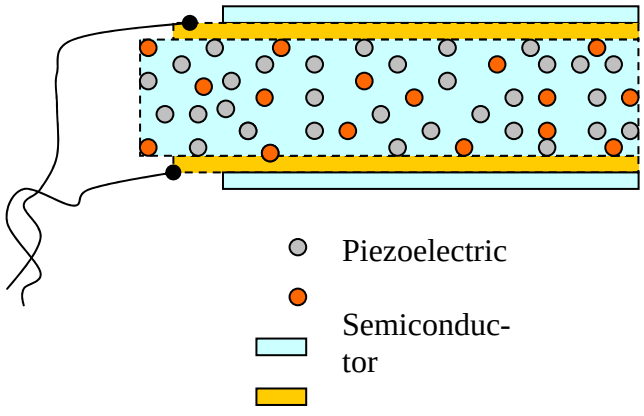


*Fig. 1.* Cross-section of a matrix sensor.

On fig 2 the operating principle of the matrix (belt) sensor unit is displayed in one plain. Under action of a stream the matrix detector is bended on angle Δφ from a planar state. Depending on direction of the stream $\Delta\varphi > 0$ or $\Delta\varphi < 0$, and dependence as on amplitude $I = f(\Delta\varphi)$, and in a direction *sign (I) = sign* (Δφ) occurs. Therefore at measuring output current $I$ depending on a time $t$, $I = F(t)$, we get the diagram displayed on Fig.3. The direction of current variation $I$ displays a streamline of current of an aquatic environment (on Fig.6 its are visible in the form of sharp plus (up) or subzero (down) spikes). A degree of current $I$ increase is proportional to temperature $T$ of an aquatic environment. Calibrating a matrix sensor in standard basins with known streams and temperatures it is possible to plot graphics $I = f(\Delta\varphi)$ in absolute units.

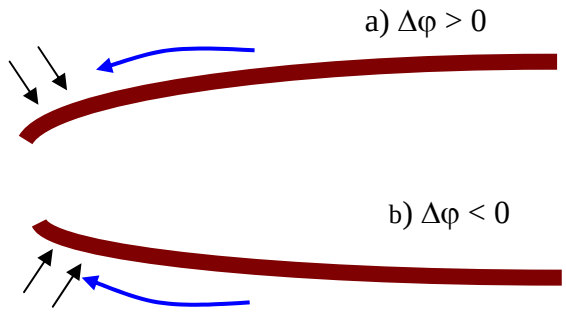


*Fig 2.* Operating principle of a matrix sensor in one plain.

For measuring the space of a profile of a stream in three plains (coordinates) the modulus from three matrix sensors had in three directions is agglomerated.

At occurrence of a stream in an aquatic environment the elastic strip of the sensor unit bends in the same direction and electrodes are polarized (a direction of polarization depends on a direction of a bend). The occurred charges are read out from electrodes, amplified by charge-sensitivity, converted by an Analog-Digital Converter and move on an input of a computer. The special program in a computer analyses the signals entered from the modulus of sensor units, defines temperature of an aquatic environment and a profile of a stream of current and records in a data bank. In the subsequent these data are used for construction of a temperature field and a stream of current in an aquatic environment.

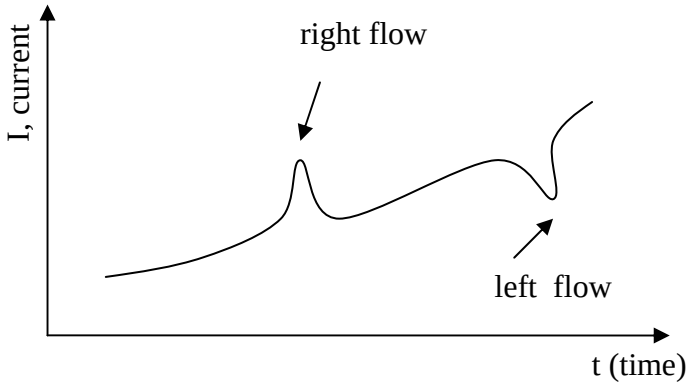


*Fig.3.* Variation of output current *I* from a time *t*.

The function chart of a measuring system is given on fig.4.

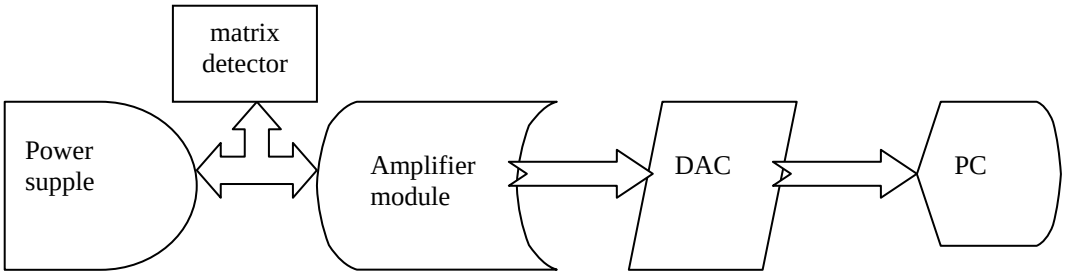


*Fig.4* The function chart of a measuring system: DAC – Digital Analog Converter, PC - Personal Computer.

### 3. Conclusion

Detection and research obvious and latent heat stream in mere is an actual problem for studying the physical processes proceeding at oceans and the seas. There are two problems for researchers:

1) If electrodes of the sensors measuring a heat stream are isolated from water, pressure of water renders destroying influence on the sensor measuring a heat stream.

2) If electrodes of the sensor adjoin to water, the water environment shunts electrodes and brings distortions in physical value of electric parameters of the sensor.

With the purpose of the decision of these problems, has been developed the extended high-resistance sensor made on special matrix technology and measuring both temperature of surrounding sea water, and direction of a stream. Signals from the sensor, amplified of the operational amplifier, by dint of the interface input into a computer for the further processing results of measurement and archiving of the data. The software package of processing and archiving of results of measurement is created.

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**A.A. Bayramov, N.A. Səfərov**

**SU SELİNİN ÖLÇÜLMƏSİ ÜÇÜN MATRİSA TİPLİ KOMPOZİT DETEKTOR**

Su mühitində görünən və görünməyən suyun axmasının aşkar və tədqiq edilməsi üçün xüsusi matrisa texnologiyasından istifadə olunmuş yüksək müqavimətli elastik sensor işlənilib hazırlanmışdır. Detektor eyni zamanda ətraf dəniz suyunun temperaturunu və axımın istiqamətini ölçməyə qadirdir. Sensordan gələn siqnal gücləndirilir, sonrakı emal və arxivdə saxlanılmaq üçün interfeys vasitəsi ilə kompüterə daxil olunur. Ölçü nəticələrinin emalı və yaddaşda saxlamaq üçün proqram paketi işlənib hazırlanmışdır.

**А.А. Байрамов, Н.А. Сафаров**

**МАТРИЧНЫЙ КОМПОЗИТНЫЙ ДАТЧИК ДЛЯ ИЗМЕРЕНИЯ ВОДНОГО ПОТОКА**

По специальной матричной технологии разработан и изготовлен высокоомный, эластичный детектор для определения видимых и неявных течений в водной среде. Детектор одновременно измеряет температуру и направление течения воды. Сигналы от детектора усиливаются операционным усилителем, посредством интерфейса передаются в компьютер для дальнейшей обработки результатов измерений и архивации данных. Создан пакет программного обеспечения для обработки и создания банка данных.

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