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A NEW SYSTEM OF ELECTROCHEMICAL PROTECTION AGAINST CORROSION AND FOULING IN SHIP'S SEA WATER COOLED HEAT EXCHANGERS

Abstract

It has been described the impressed current system of cathodic protection of water chambers in a cluster of ship's cooler. The system was designed by Instytut Morski. It has been presented the general principle of the system and their elements as follows: anodes, multichannel module power unit with microcomputer controlled output voltage, as well as, connections among coolers structure elements and with the power unit. Also are listed operational parameters of the system.

Proposed below new method of electrochemical protection against corrosion in heat exchangers replaces completely so far common used protection by means of zinc galvanic anodes as being, in practice, much more useful from both technical and economical point of view, because:

- it can be effective throughout full ships life (e. g. 20 years), without the necessity of anodes to be replaced (in the case of galvanic cathodic protection the anodes should be replaced yearly or even in shorter time intervals, in the case of full consumption of anode material meanwhile);
- proposed system can also be effective even in the case of using the cooling waters of low salinity – so called brackish waters (in such case the protection by means of zinc or aluminium galvanic anodes is only partially effective);
- helps, indirectly, to keep good heat transfer effectiveness (through antifouling action, which does not take place in the case of galvanic cathodic protection).

This latter property of proposed system comes from the process of molecular chlorine evolution on the applied inert anodes (process of sea water electrolysis). Chlorine dissolves in sea water running through the cooling system and thus to some extent inhibits fouling by plants and animal organisms in chambers and tubes of heat exchangers.

The principle of proposed system of cathodic protection of heat exchanger or set of them placed in an engine room of a ship is presented schematically in the Fig. 1. In chambers (water boxes) of a heat exchanger i.e. intake turning and outlet chambers are mounted,

in the openings made in inspection lids, platinum plated titanium rod anodes (Ti/Pt – Fig. 2). To connectors of the anodes is fed a voltage from positive pole of the source of cathodic protection current (specialised DC supply). Minus pole of the above supply is connected with electrical cable to the „mass" of structure to be cathodic protected i.e. with cast iron covers of heat exchanger's body, walls of heads and walls of intake and outlet chambers, as well as brass tube sheets, including the extremities of brass tubes.

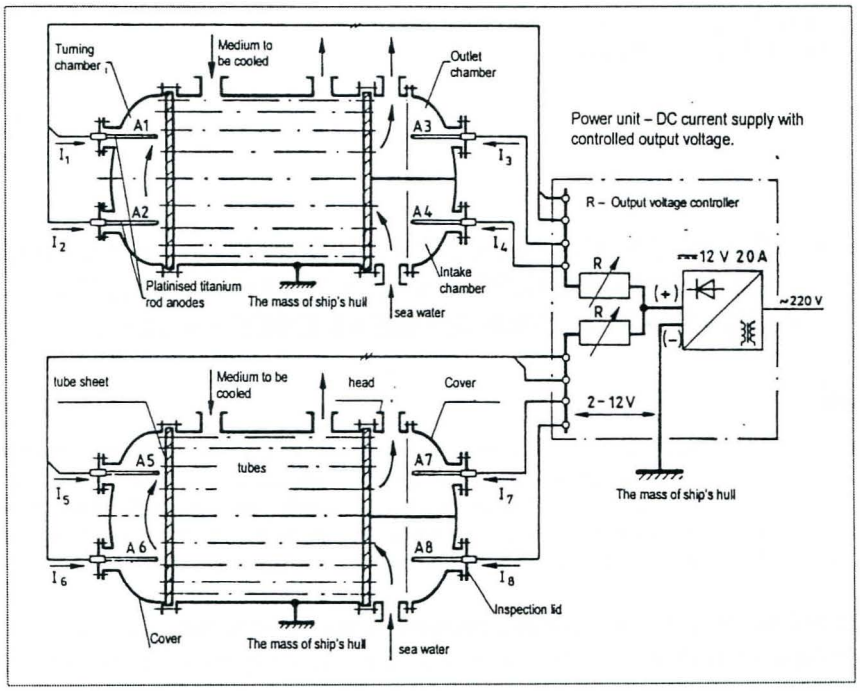


Fig. 1. *Impressed current cathodic protection of water chambers of two heat exchangers*

Fig. 2. *Platinum plated titanium rod anode (Ti/Pt)*

The intensity of cathodic protection current, delivered from current supply is being set automatically by means of microcomputer (micro controller) controlled regulator. In the above automatic control circuit the potential difference between Ti/Pt anode and the body of the structure being cathodic protected is being used as steering signal, when measured during current flow break, for one millisecond. The said (repeated) break of current flow is generated automatically. The anodes, in this short time, are used as the reference electrodes (connected in parallel).

The equipment of cathodic, protective, current supply allows to be made the measurement of currents of the anodes, with the digital panel meter (DPM), as well as, the achieved level of polarisation of the surfaces of water chambers to be protected (the level of protection against corrosion) and also indication of the current flow, or the lack of it, in each anode circuit. Moreover it is possible to change over the mode of regulation, from automatic mode to manual one in which is possible hand setting the protective current intensity (with appropriate knob) and to measure the achieved level of polarisation of the surfaces of water chambers to be protected, by means of right positioning of a switch changing the kind of quantity to be measured with the DPM and manual blockage protective current flow (with push button).

Nominal cathodic protective current for one heat exchanger amounts 10 A. This value is sufficient to gain, in practice, full protection against corrosion, even in the largest heat exchangers met in engine rooms of most ships (the diameter of tube sheets up to 1 m.) and in most severe circumstances of cathodic protection process of water chambers, in which it is to be conducted.

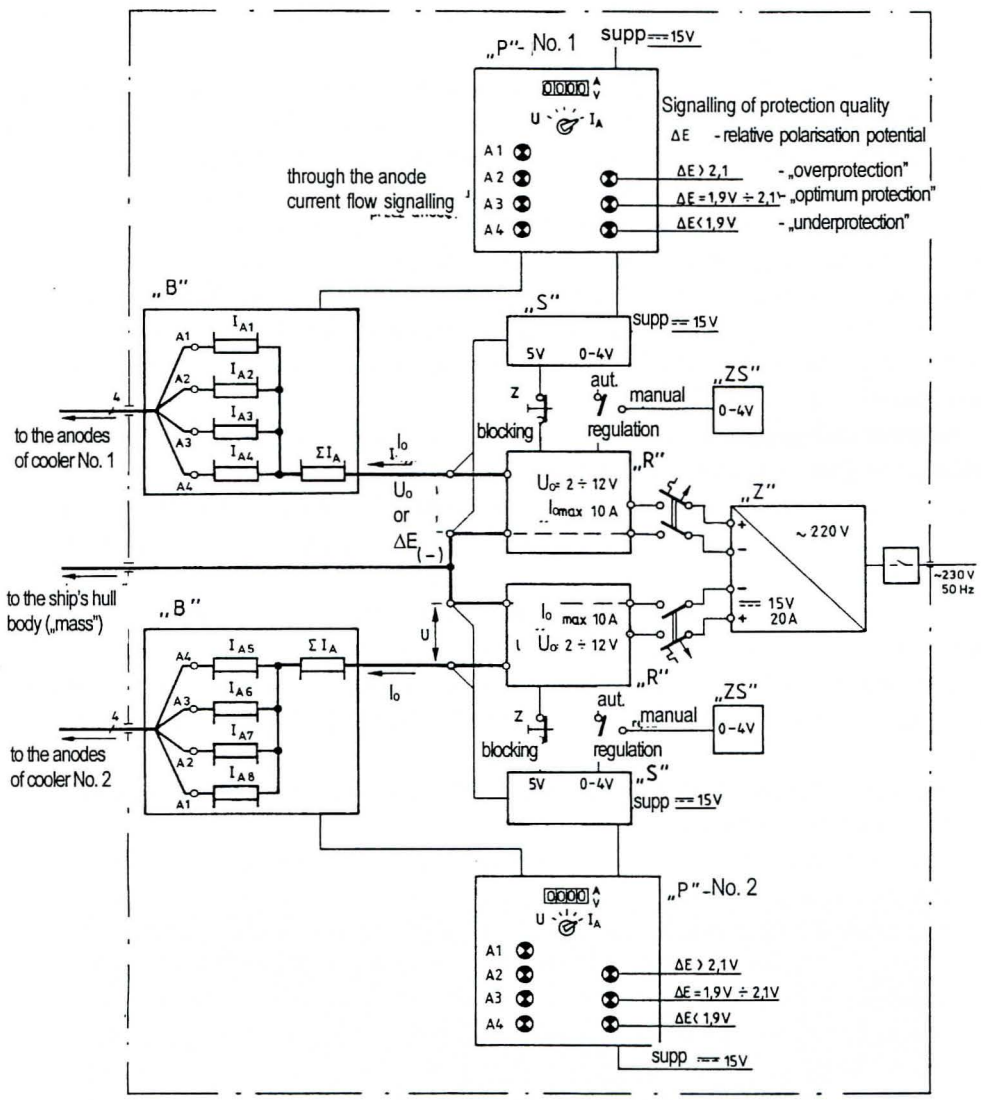
Electrical circuit diagram of power supply for protection system of water chambers of the set of two heat exchangers is presented in Fig. 3.

The view of the front panel of power unit, supplying the current to the cathodic protection system of one heat exchanger, is presented in photograph Fig. 4. In front panel there are:

- digital panel meter (DPM) with the switch of the kind of quantity to be measured (current intensity – voltage),
- lamps signalising the work of each anode (4 lamps placed in the diagram printed on the panel),
- lamps signalising the achieved level of cathodic polarisation of the surfaces of water chambers, thus actual effectiveness of protection against corrosion can be checked;
- switch enabling change over between the automatic and manual mode of regulation,
- setting the value of protective current – multiturn potentiometer used in manual mode of regulation.

All sub assemblies of power unit are housed in steel sheet enclosure (cabinet) with glazed front doors, enabling the checking of the working parameters of protective current supply (Fig. 5). The enclosure can be hung on the wall or fastened to the brackets in an engine room or in one of other nearby technical compartments of the ship.

There are two models of power supplies one is destined to supply the cathodic protection circuits of 2 pieces set of coolers and the other is for 6 pieces set. In the photograph (Fig. 6) is presented a view of power supply intended to supply and independent regulation of cathodic protection parameters in the set of 6 coolers.



„Z" – transformer-rectifier
„R" – output voltage (U_o) regulator
„S" – microcomputer controller
„P" – assembly for measurement of current intensity, voltages and for signalling
„ZS" – manual setting of U_o
„B" – shunts assembly

Fig. 3. *Functional (block) diagram of power unit SOK OCh 2 × 10 A/12 V type*

Fig. 4. *View of the front panel*

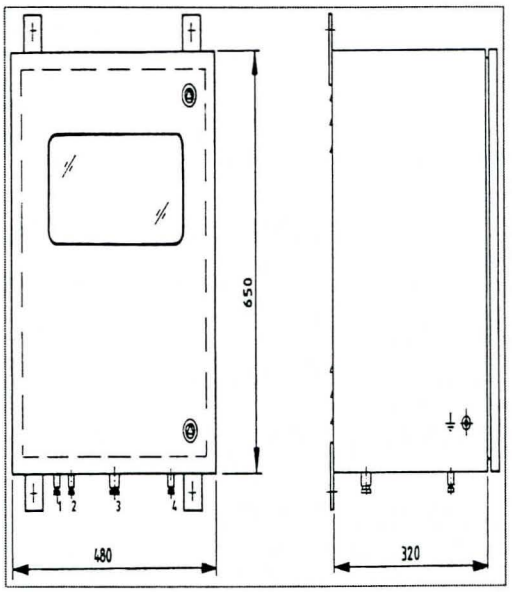


Fig. 5. *The case of type SOK OCh 2 ×10 A/ 12 V power unit. Glands 1& 2 are for cables to the anodes. Gland 3 is for cable to the cathode, i.e. to the body of ship's hull. Gland 4 is for the power supply cable ~230 V*

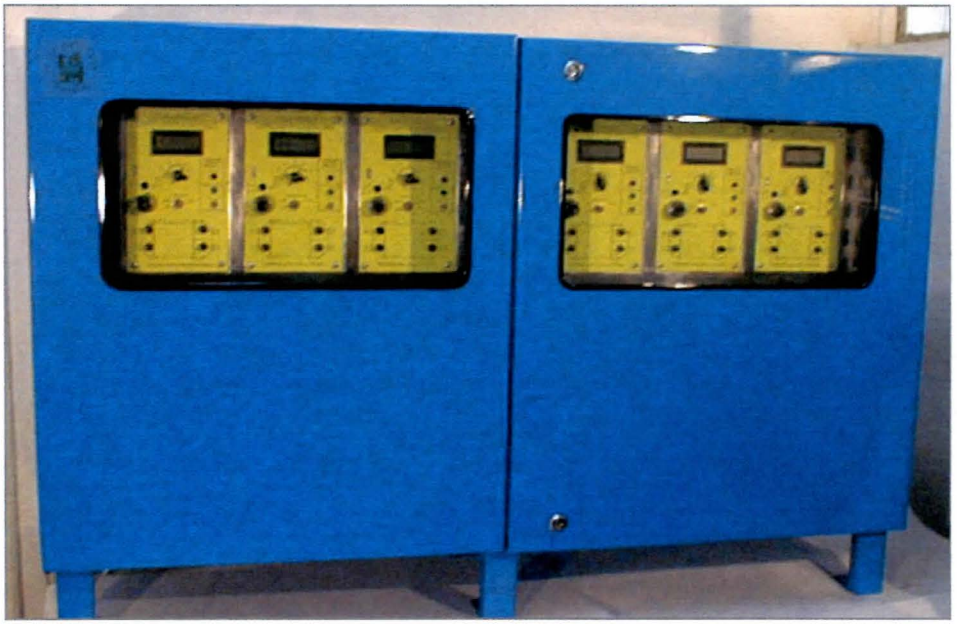


Fig. 6. *View of power supply and independent regulation of cathodic protection set of 6 coolers*

Technical data of both models of power supplies are summarised in the following table

	Type SOK – ChO 2 × 10A/12V power supply for the set of 2 coolers	**Type SOK – ChO 2 × 10A/12V power supply for the set of 6 coolers**
Dimensions of enclosure breadth × depth × height	480 × (320+20) × 650 mm	1250 × (320+20) × 650 mm
Grade of internal proofing	IP22	IP22
The number of independently supplied and regulated circuits of cathodic protection	2	6
Maximum intensity of output current	2 × 10 = 20 A	6 × 10 = 60 A
Output voltage to be regulated in the range	2 – 12 V	2 – 12 V
Ship's mains parameters	230 V; 47–63 Hz	230 V; 47–63 Hz
Maximum power consumption	350 VA	1000 VA
Protective potential to be automatically maintained	- 0,8 to - 1,0 V (versus Ag/AgCl reference electrode)	- 0,8 to - 1,0 V (versus Ag/AgCl reference electrode)