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FAKULTA STROJNÍ

KATEDRA ENERGETICKÝCH STROJŮ A ZAŘÍZENÍ

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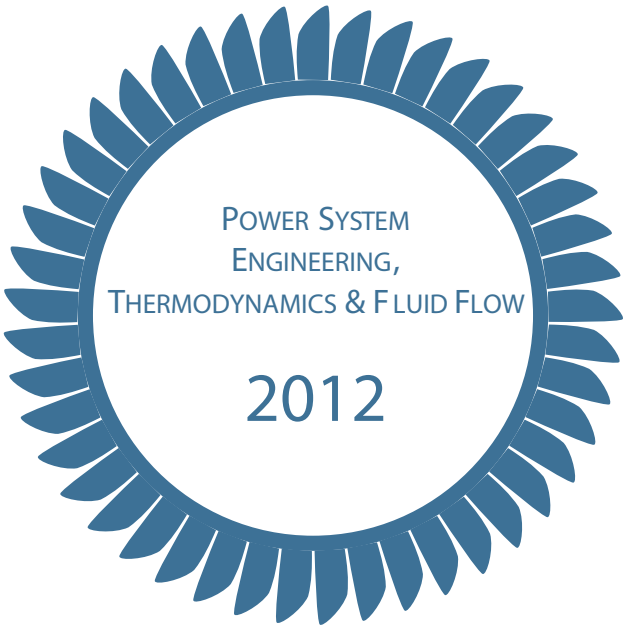

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DEVELOPING OF FORECASTING METHODS OF THE CORROSION RATE IN ELEMENTS OF POWER PLANTS

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In this paper we consider the complex scheme of monitoring of corrosion process in the element of heat power equipment working in aggressive environments, such as seawater. It is based on measurement of corrosion speed and determination of parameters of cathodic protection. Methods of on-line calculation of this processes are also observed.

Keywords: corrosion, monitoring, computer systems

Introduction

The purpose of creation of system is the maintenance at once of several basic kinds of the corrosion control in heat power systems. The described system includes devices for measurement of the primary electrical and electrochemical characteristics and computer programs for processing results of measurements.

To devices concern: the gauge for measurement токового of a parameter of non-uniformity of distribution of a current on an electrode T and device of measurement of total resistance between electrodes R_{el}; the two-electrode gauge for measurement of polarizing dependences. Primary sizes, thus, are the parameters of non-uniformity T and total resistance R_{el}. Experimental cathodic and the anodic polarizing dependences, also, concern to the primary electrochemical characteristics.

2. Algorithms of determination of corrosion speed

As the computer programs the following methods are realized: a method of the joint control specific electroconductivity and specific polarizing resistance a; an express train - method of the control of speed of corrosion on anodes and cathodes galvanic couples (control at external polarization); a method of account of distribution of potential and total density of a current on an electrode under the mixed boundary conditions; a method of account of parameters of an electrical field in приэлектродном a layer of a solution under nonlinear boundary conditions. Techniques of mathematical and statistical processing of polarizing dependences for definition of Tafel constants b_a, b_k and parameters of nonlinear polarizing dependences here concern.

The specified measuring devices are incorporated in the uniform electrochemical gauge, and the specified methods of the control and account form uniform system, as are closely connected among themselves. To be convinced of it, we shall consider in more details algorithms and block diagrams, on which the given methods work.

In a fig. 7.1 the algorithm of a method of the joint control specific электропроводности and speed of general corrosion (fig. 1) is submitted, where the designations of the chapter 2 are accepted. The parameter of non-uniformity T, equal to the relation of a current on a site 1 anode to a complete current on the gauge is measured. The numerical meaning (importance) of this size brings in the computer, where the search of electrochemical parameter m on the given meaning (importance) T is carried out. For this purpose, prior to the beginning work of system

in memory of the computer the second working characteristic of the gauge as two one-dimensional files (file T and file m) is brought. After a presence (finding) m, begins to work the program of search of meanings (importance) (R_{el}), and (R_{el} /a) on the given meaning (importance) m. For this purpose, the same as and in the previous case, prior to the beginning work of system in memory of the computer are brought the first working characteristic of the gauge concerning polarizing resistance (i.e. (R_{el} /a) as an one-dimensional file) and first working characteristic rather electroconductivity (i.e. (R_{el} *) as an one-dimensional file).

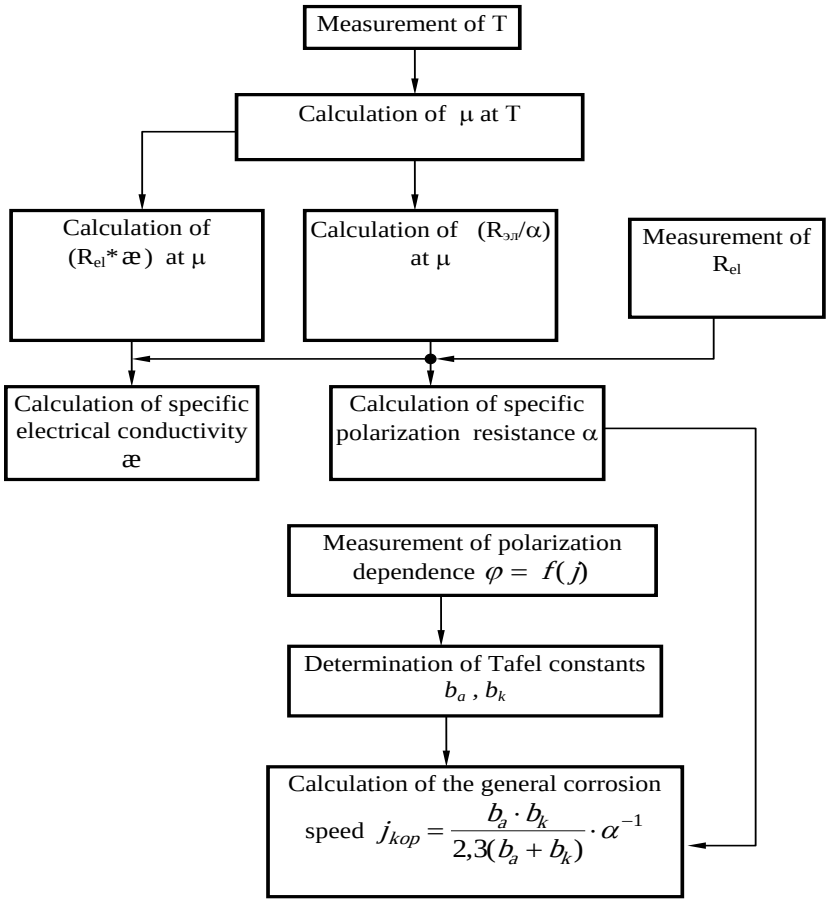

Fig. 1: Algorithm of conjoint control of general corrosion and specific electrical conductivity

In fig. 2 the algorithm of the express train - control of speed of corrosion is submitted at external polarization (fig. 2). In memory of the computer the meaning of external density of a current j* in a researched point is entered which for the given block diagram is entrance parameter. The polarizing dependence is measured, first, to define Tafel constants ba, bk, secondly, for definition of a file specific поляризуемостей a (j). The definition of last size is carried out through the standard program of numerical differentiation of initial polarizing dependence. It is necessary to note, that the numerical differentiation increases mistakes present at experimental definition by a polarizing curve. For reduction of mistakes the standard program of statistical smoothing of polarizing dependence by a method current average is used. Further, is defined (determined) specific polarization, appropriate to the given meaning of density of an external current a(j*).

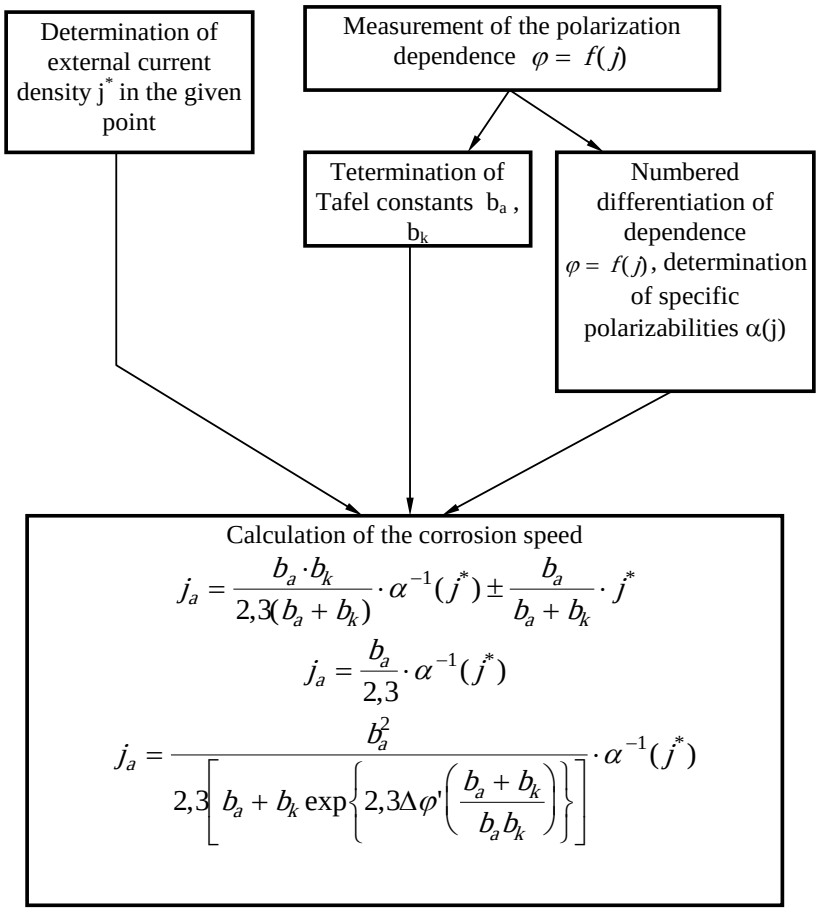

Fig. 2: Algorithm of corrosion speed at external polarization

Comparing the block diagrams 1 and 2, it is visible, that they have common parts, which function, both at the control of common corrosion, and at the control of corrosion on galvanic couples. But the unity of two methods not only in it, and is deeper and consists in the uniform methodological approach to the express train - control of speed of corrosion. This approach assumes definition of speed of corrosion on the basis of measurement specific polarization, irrespective of, whether the speed of common corrosion (self-dissolution) or speed of corrosion is supervised at external polarization.

In a fig. 7.3 the block diagram of definition initial given of account and actually of account of external density of a current on a surface galvanic couples is represented, if the boundary conditions in приэлектродном a layer are mixed (block diagram 3). Under the mixed boundary conditions, on each electrode the linear boundary conditions of the third sort with constant meaning specific polarization a (j) = const are separately carried out which, in view of independence of density of an external current, is equal to polarizing resistance a, измеряемому at performance of algorithm 1. Therefore, the polarizing resistance being in intermediate target parameter at functioning of the block diagram 1, serves entrance parameter of the fig. 3. The same is related to specific electroconductivity. Being in target parameter of algorithm 1, it serves entrance parameter of algorithm 3. In it the interrelation of a method of the joint control electroconductivity both polarizing resistance and method of account of parameters of an electrical field consists under the mixed boundary conditions.

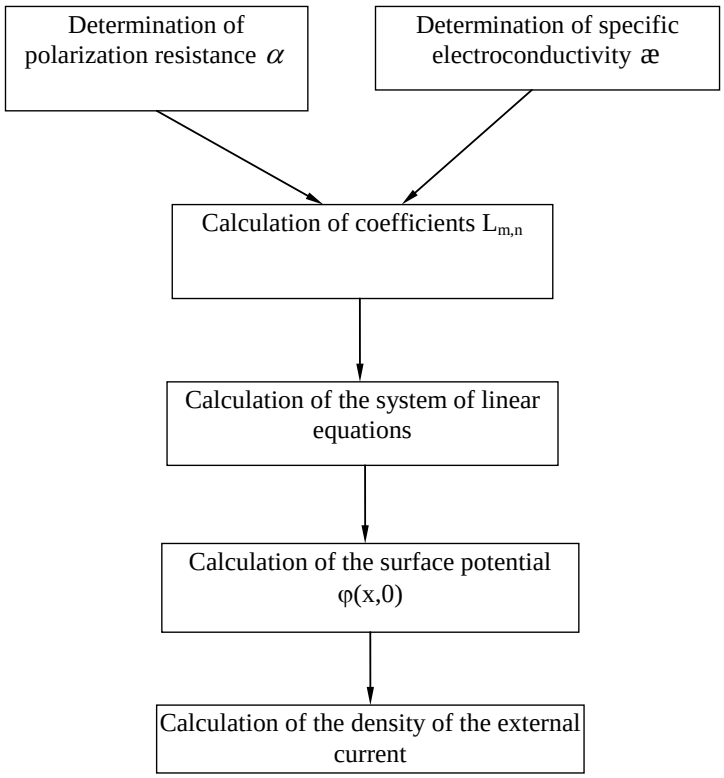

Fig. 3: Algorithm of determination of initial data and calculation of density of external current at combined boundary conditions

The interrelation of the block diagram 2 both block diagram of 3 and two methods realized in these block diagrams, consists that use of the given methods allows to solve two aspects of a uniform problem of the control of speed of corrosion at external polarization. The first aspect is connected to definition of speed of corrosion in the given point of a surface, if total density of a current j* in this point known&. This part of a task is solved with algorithm 2. But how to define j *, taking into account extreme non-uniformity of distribution of density of an external current? This question is solved with algorithm 3. Target parameter of the block diagram 3 (density of a current j (x) in any point of a surface) is entrance size at work of algorithm 2. Thus, only at association of algorithm 2, definition, deciding an only electrochemical task, of density of a current of anodic dissolution on size of density of an external current, and algorithm 3, account, deciding an only physical task, of distribution of parameters of a stationary electrical field, it is possible in complete volume to solve a problem of the control of corrosion at external polarization.

On fig. 4 the algorithm of definition initial given of account and actually of account of potential and density of an external current on a surface is submitted under nonlinear boundary conditions. The interrelation of the given algorithm with algorithms (fig. 1, 2) consists at the presence of a common link of measurement of polarizing dependence j=f (j). But more essential is that, as well as in the previous case, for the complete decision of a task of the control of speed of corrosion at polarization in the field of nonlinear dependence поляризующего of potential from density external, the algorithms 2 and 4 should be incorporated, as target parameter of the diagram 4 (j (x), j *).

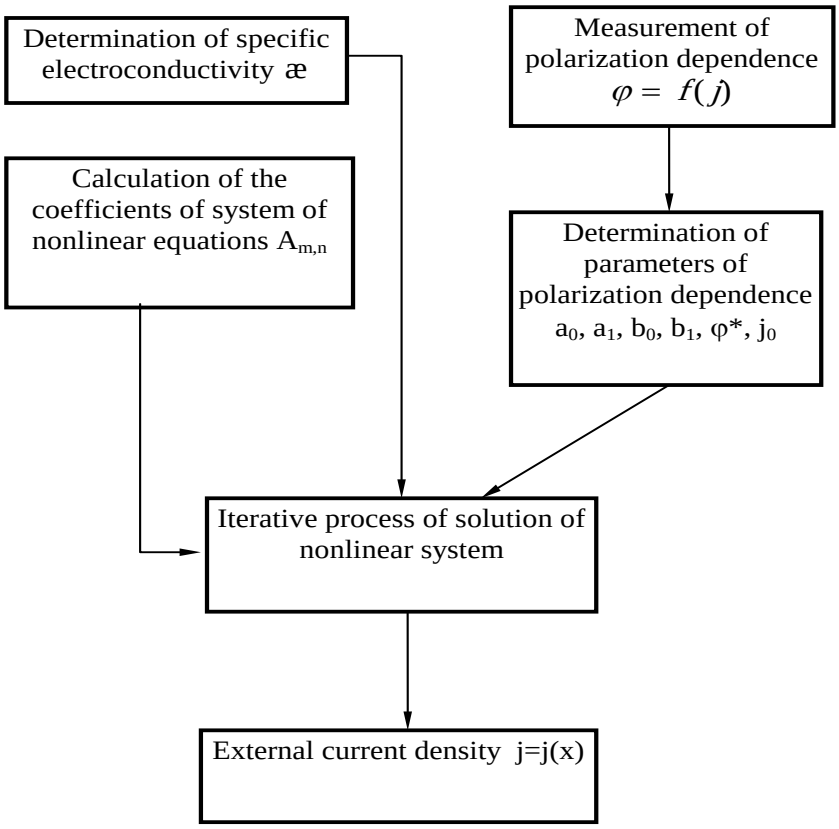

Fig. 4: Algorithm of determination of initial data and calculation at nonlinear boundary conditions

Between algorithms 2 and 4 there is also return dependence, in case of account of radius of action of the anode or протектора of system катодной of protection. The communication (connection) between the block diagrams 4 and 1 consists that specific electroconductivity, being in target parameter of work of 1-st algorithm, serves entrance - for algorithm 4.

Thus, the algorithms realizing four developed methods of the control and account, should be incorporated in the uniform monitoring system. It is connected to the following circumstances:

1) They have uniform elements;

2) The target parameters at work of one algorithms are entrance sizes for others;

3) The algorithms and methods, in them realized, are connected by the general (common) methodological approach to a problem of the control and account of speed of corrosion, namely: 1-st and 2 algorithms are incorporated by the uniform approach to the express train - control of speed of common corrosion and corrosion at external polarization, which consists in the control on the basis of measurement specific polarization; only association 2, 3-it and 4-th algorithms allows to solve electrochemical and physical parts of a uniform task of definition of speed of corrosion at external polarization.

Uniting elements of the block diagrams on functional purpose, have developed system of the corrosion control, which circuit submitted in a fig. 7.5. It consists of four functional blocks: the block of measurement of electrochemical parameters (A), the block of mathematical and statistical analysis of polarizing dependences (B); the block of account of external density of a current both potential (C) and block of the settlement formulas for definition of density of a current of anodic dissolution on size of density of an external current and specific polarization.

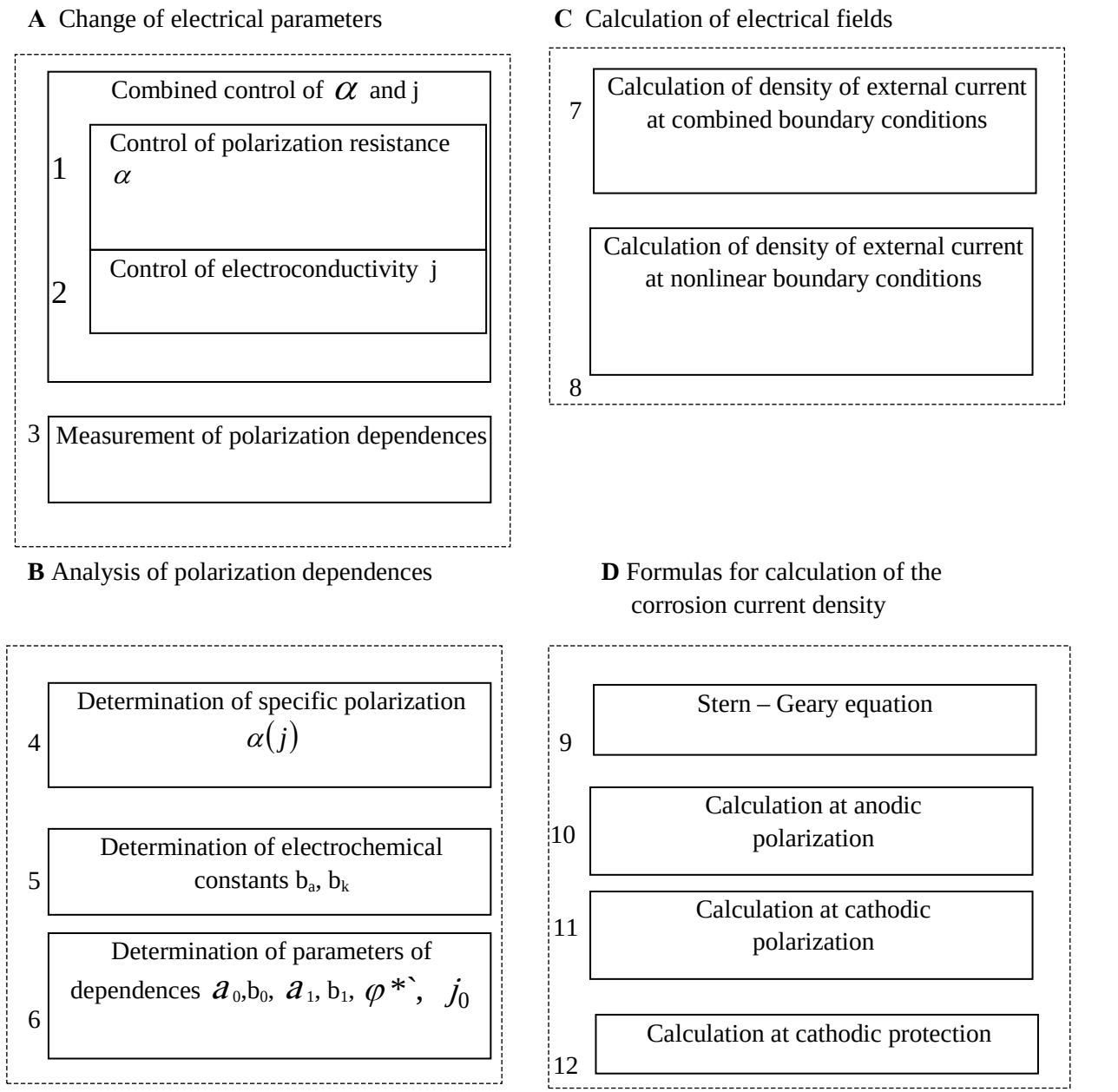

Fig. 5: System of corrosion monitoring

It was above marked, that the majority of elements of the monitoring system are multifunctional, as are used at various kinds of the control. The part 1 is carried out at the control of general corrosion and at account of parameters of an electrical field, when the boundary conditions are mixed. The part 2 is used at the control of corrosion aggression of

environment (control general salinity), it provides definition of the initial data (электропроводности) at account of parameters of a field in parts 7 and 8. The part 3 is used at definition of constants Тафеля, at definition specific поляризуемости, at a presence of parameters of polarizing dependence. The multifunctionality of parts allows to switch by their various image and, depending on it, to carry out this or that kind of the control.

2. On-line calculation of corrosion speed

On the base f Moscow Power Engineering Institute (MPEI) there was created the calculation server for engineers, which is constantly advancing and contains data on specific volume, enthalpy, entropy, isobaric tension, dynamic viscosity, thermal conductivity, Prandtl number etc.

Calculation methods which are presented at the web-site may be used as a reference hand-book for engineers and research workers or may be the algorithm for solving concrete engineering tasks.

Advantages of on-line computing:

• simplicity of use;
• access to the various methods of calculation of the needed parameters;
• effective operations with information;
• possibility to download the “users functions”;
• possibility of fast avoiding of errors and renewal of information.

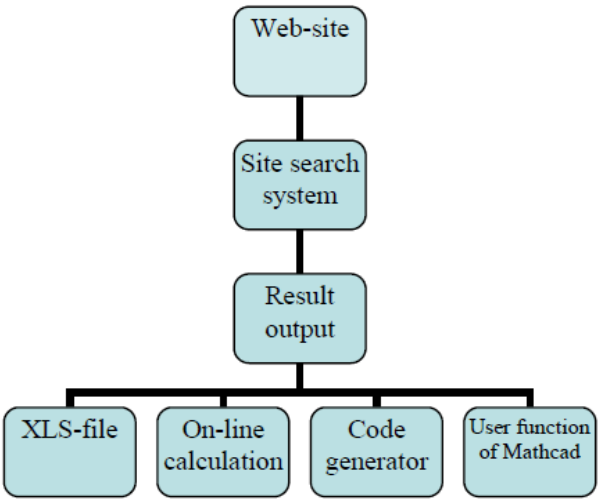

Fig. 6: On-line computing structure

The server represents all the equations used to calculate the tables. The heading of each table shows the addresses of the Internet sites enabling interactive work with these equations.

Thus, Fig. 2 shows transparent interactive network calculation of the properties of superheated steam (region 2 of formulation IAPWS-IF97 [5]).

All calculations at the web-site are executed with control of physical dimensions. User of the site can choose units of measurement and calculate the answer in needed dimension [7]. This world-wide tendency is connected with flexible approach to the units of physical measurement and refusal of one system of units which can not be only one.

If user needs more than one point in calculation, he may download deeded function to his own computer. At that it is possible to use not only MathCAD, but Mathlab, C#, C++, Java as well. Also user can download XLS-file with the table and properties of the matter/mixture/material.

At present, we elaborate on-line system of corrosion forecasting. In this case user doesn’t have to calculate all intermediate data. He needs only to input the initial values and receive the result.

Conclusion

The described methods allow to determine corrosion speed and effisieincy of cathodic protection. The complex scjeme, which is described above, can be applied for corrsion control in the elements of marine techniqes, for the elements of power equipment (both ship and stationary) which work in agressive environment.

For providing the correct and effectiuve calculations it is presumed to use the Cloud calculation server of Moscow Power Engineering Institute.

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