

MAGNETIC CONTROL OF HYDROGEN CORROSION

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Introduction

Hydrogen corrosion results in irreversible changes of the material's magnetism [1]. In spite of different character of the corrosion process at different stages of its development the main magnetic value which undergoes changes is a material coercive force. The change of coercive force at the initial stage of hydrogen corrosion doesn't exceed 5-7% and that results in the change of magnetic leakage field by the value of 2-5 A/m on the wall surface of a controllable object with the width of 30 mm. It is practically impossible to register such small magnetic fields on the surface of operating industrial installation with the use of devices having attached transformers.

Results and discussion

The arrangement of continuous magnetic leakage field control over controllable industrial installation surface is the way of solving the task mentioned. For realize it a magnetic sensor which is fastened to the walls of the installation and takes the topography of a magnetic field of a controllable section has been developed.

To get actually objective data about the state of the installation wall material, diagnostics should be made at the installation under working rate. And the temperature of the installation outer wall may go up to 70-140°C. It doesn't seem real and expedient to cover all the surface with sensor. It is sufficient to set sensors in the most dangerous and strained sections of the structure which were found out in the operation a calculated. We have one more task of fastening sensor to the installation surface without their damage, taking information from sensors and their power supply. Because of a big size of the controllable installation, its spreading over large surface, safety conditions, cable link and supply line turn out to be unreliable (from mechanical and information point of view) and their laying and maintenance require a great labour input.

Taking into consideration the requirements mentioned above, an autonomous magnetic sensor

has been developed, which consists of a magnetizing system (fig.1), a magnetic sensitive elements unit and a pretreatment of their output signal. A sensor contains a storage battery and a receiver-transmitter which allows to transmit data and receive instructions from the basic computer through radiochannel. For magnetizing a controllable section, a coil consist of 3 sections which help to synthesize uniform magnetic field by induction of 0,1 Tl with non-uniformity not more than 6% on the surface occupied by a sensor 50 mm deep. Magnetic-sensitive elements are actually ferroprobes (up to 60 pieces in number) and are placed along diagonals of the coil. Ferroprobes operate under pulse regime of excitation with compensation for their initial unbalance [2], that allows to have a threshold of sensitivity of about 0,3-0,5 A/m. Simultaneously, pulse conditions provide high noise-immunity and low power consumption. It is especially important for autonomous working rate of a sensor. A sensor is fastened to the surface of installation with the help of magnetic 'suckers', place in the distance of 150-200 mm from a sensor case in order not to interfere with its work.

Current impulse is fed into the magnetizing coil and the magnetic field is created which magnetizes section of the controllable installation. After taking data of bias field with the help of ferroprobes, which are in turn examined according to the scanning method, the magnitude of remanent magnetization of the controllable section is measured. The data received is transmitted to the basic computer complex, where two-dimen image of distribution remanent magnetization of controllable section is created and coercive force of the material is calculated. These data is stored in the block memory of the main computer and compared with new results of measurements. If any disturbance occurs the magnitude (depth and opening) of the defect is calculated according to the developed patterns as well as the dynamics of its change is followed.

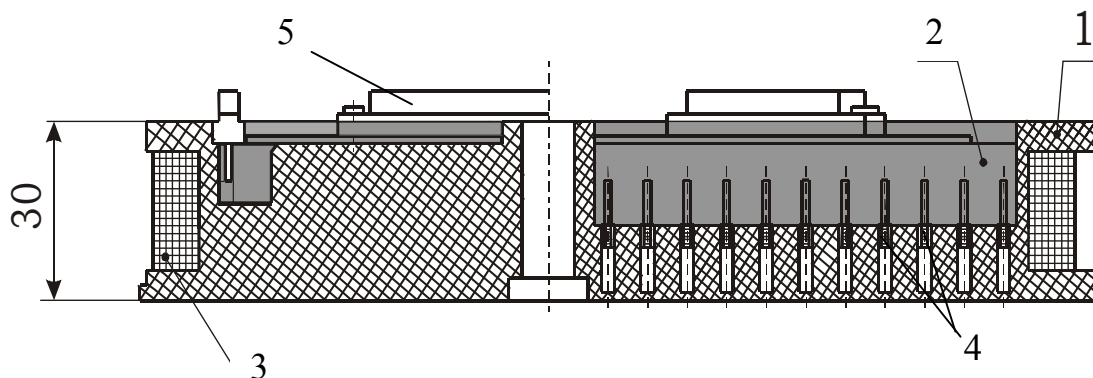


Fig. 1. Plate of sensors: 1 – foundation; 2 – compound; 3 – coil of bias; 4 – ferropubes; 5 – cutoff point of interface cables.

Taking into account that a defect develops under influence of hydrogen corrosion from inter wall to outer wall it is possible to calculate remaining resource of the equipment operation following the dynamics of its development.

In order to get the objective data on hydrogen corrosion progress in the installation a necessary number of sensor are set in the sections subject to corrosion. Taking into consideration that a sensor's operating time is 3-5 sec, the main computer complex is able to serve up to a thousand of sensors, the resource of their work is about 3 years without characteristics changes.

While calculating the defect parameters it is necessary to know a number of initial data about material magnetism, pre-history of its magnetizing and to have a mathematical pattern to calculate defect characteristics in the real range of time.

Available mathematical patterns of defects leakage field are either very simple without consideration of physical-mechanical properties of materials, therefore having a great inaccuracy of calculations, or rather complicated ones which realize algorithm of non-linear integral equations solution. Calculation time according to these patterns goes up to 30-40 minutes, and the problem of their convergence is not solved. That's why for calculating leafage field defects in the real time range reductive mathematical dependencies of field defect from its geometrical dimensions are received. These dependencies were received by the method of orthogonal composition planning of the second order for two factors, which are: depth h and opening of a defect $2b$. Calculation of the rest of defect parameters and installation magnetizing control is done through correcting functions, in this case density of leakage field is determined by $H_m = M_0 F_k F(2b, h)$, where F_k – is a correction

function dependent on coercive force, initial magnetizing, angle of slope, roughness of a defect wall; $F(2b, h)$ – is a basic function.

Discrepancy of obtained values of leakage field defects according to reductive dependencies is not more than 5-7% with the values, calculated according to patterns given in famous works of Arkadiev V.K., Zatsepin M.M., Muzhistkiy V.F. [3], that confirms correctness of obtained mathematical pattern of a defect field under machine time calculation not more than 2-3 seconds.

Conclusions

Thus, complex method of the task given solution which comprises development of the design of autonomous magnetic sensor and its software, with a high trustworthiness allows to follow the process of hydrogen corrosion resulting in prognostication of residual resource of equipment operation.

References

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