MAGNETIC TREATMENT OF WATER

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Improvement of water treatment technology has become one of the major problems in industry, power production, and water supply. In the search for new water treatment methods, and in particular, methods which do not require the use of reagents, a recent discovery indicates that a magnetic field of some 102 to 103 oersteds (Oe) is effective in preventing the formation of scales & encrustations in boilers and heating systems. After magnetic treatment ("magnetization") natural water does not, when heated, produce a hard scale on the walls of a boiler or in heating pipes, but rather a loose sludge which settles to the bottom and can easily be removed or flushed without acid treatment (1).

A large number of papers pertinent to "magnetization" and to such questions as how a magnetic field acts on water, for what purposes magnetic treatment is effective, and under what conditions it is most effective and efficient, have been published in the Soviet Union over the last 20 years. The answer to the main questions "why does a magnetic field affect the properties water systems?" has not yet been found and thus the problem of magnetic treatment of water is discussed more on the engineering, empirical, and technological level, rather than on a purely scientific basis (1) In practice, however, no one argues whether magnetic treatment is effective or not; in the Soviet Union the magnetic treatment of water is used extensively and with great economic effect. The only argument is on how to explain the observed phenomena correctly; by the changes which take place within the water itself, or solely by the influence of the impurities present in the water (2).

In many recent papers, the effect of a magnetic field on various physical-chemical properties, such as viscosity, boiling point, magnetic susceptibility, electrical conductivity and surface tension, has been investigated not only for natural waters, but also for specially prepared aqueous solutions and distilled water with electrical conductivity ranging between 10-6 and 10-1 ohm. In addition, tests made to see how effective the magnetic method is for the treatment of the artesian-well water used in some power stations indicate that the best results can be obtained by a combination of magnetic treatment and removal of the iron content. A combination of magnetic and ion-exchange methods was also studied with chloride and sulfate ions, and it was found that a magnetic field of 103 Oe increases the absorption capacity of the ion-exchanger by 5-8%, while the field strength of 3-103 increases it by 19-26%. (1)

In some cases, the conclusions drawn by various authors, based on laboratory experiments, have been completely contradictory. The only fact which is generally agreed upon seems to be that a magnetic field reduces the kinetics of crystallization processes and the freedom of movement of charged particles. The limitation of the motion of particles in the field results in an increase of the number of collisions and the formation of crystallization centers. Magnetic treatment is effective only if the liquid is passed between the poles of a magnet which has a sufficiently strong field and magnetic gradient, providing that the temperature of the liquid is not too high (1).

Magnetically treated water, also called "magnetic water" is widely used in boilers for all purposes (everyday hot-water requirements, power, heating systems, river and ocean-going vessels, etc.) and to increase the life of pipes in the oil, coal, and mining industries, since it sharply reduces corrosion and the deposition of organic and inorganic compounds (such as paraffin) in pipes. Magnetic treatment of flotation pulp increases the rate and efficiency of flotation, and "magnetization" of water increases by 40 - 80% its ability to remove the dust in pits, mines, and ore-concentrating plants. Further, the stability of cement prepared with magnetically treated water is increased by about 15-40% (1).

Soviet investigators have advanced many different hypotheses to explain the action of magnetic fields on aqueous systems, and they may be divided into two basic groups:

1. The magnetic field affects the structure of water itself, or
2. It can act only on a suspension or solute.

In general, there are two features characteristic of magnetic treatment: the poor reproducibility of experimental results (especially under laboratory conditions), and the "memory" of its magnetization which water seems to show, i.e., the persistence of the magnetization effects for several hours or even days, if the temperature of the water system is sufficiently low (1).

According to V. Belova, the "magnetization" of water must be regarded as a problem of generalized diffusion, where the anisotropic coefficient of diffusion resulting from the action of the magnetic field is preserved for a certain time only because of the coagulation of the deformed macromolecules of colloidal iron which is always present in water (1). Experience has shown that in laboratory studies of "magnetic" water, there are varying results, probably owing to the fact that magnetic installations do not always work as successfully as they should (3).

The "magnetization" process has come into widespread use and patents have been taken out in almost every industrially developed country for various kinds of equipment for magnetic treatment of water. The manufacture of such equipment on a commercial scale has already begun (1), with several thousand magnetic treatment installations now in operation in the Soviet Union (2).

Based on analysis of existing technical literature on the magnetic treatment of water and its ability to alter water properties, there are many basic areas where the utilization of this method has great practical merit, such as elimination of scales due to high temperature, control of encrustation on equipment, reduction of salt deposits in piping systems, intensification of coagulation and crystallization processes, improvement of the bactericidal function of disinfectants, acceleration of reagent diffusion, increasing the efficiency of ion-exchange resin (ionites) (6), removal of fine particles in the purification or recycling of waste water, extraction of valuable metals from ores by flotation concentrate, acceleration of the solidification of certain cements, increasing the density and strength of casting molds, etc. (2).

In spite of the successful applications of the magnetic water treatment method, for certain processes there are no recent theoretical explanations for the effect of magnetic fields on the diamagnetics of liquid system with phase transformation (6). The construction of magnetic treatment equipment and its subsequent adjustment are generally based on empirics and do not always provide optimum results (6).

Despite the existing controversy regarding the effectiveness of magnetically treated water and the validity of the method's theoretical basis, "magnetization" research and development in the Soviet Union have been pursued enthusiastically, with considerable economic and industrial benefit. Reviewed below are available technical data on some existing Soviet magnetic water-treatment installations:

1. The Tuymazy Petroleum Construction Trust in the Bashkir ASSR, for magnetic treatment of water utilizes a device (see Fig. 1) consisting of a horseshoe electromagnet powered by a 220-380 volt alternating current. For selection of optimum magnetic intensity, the circuit is equipped with an auto-transformer, and ammeter, and a voltmeter (4).

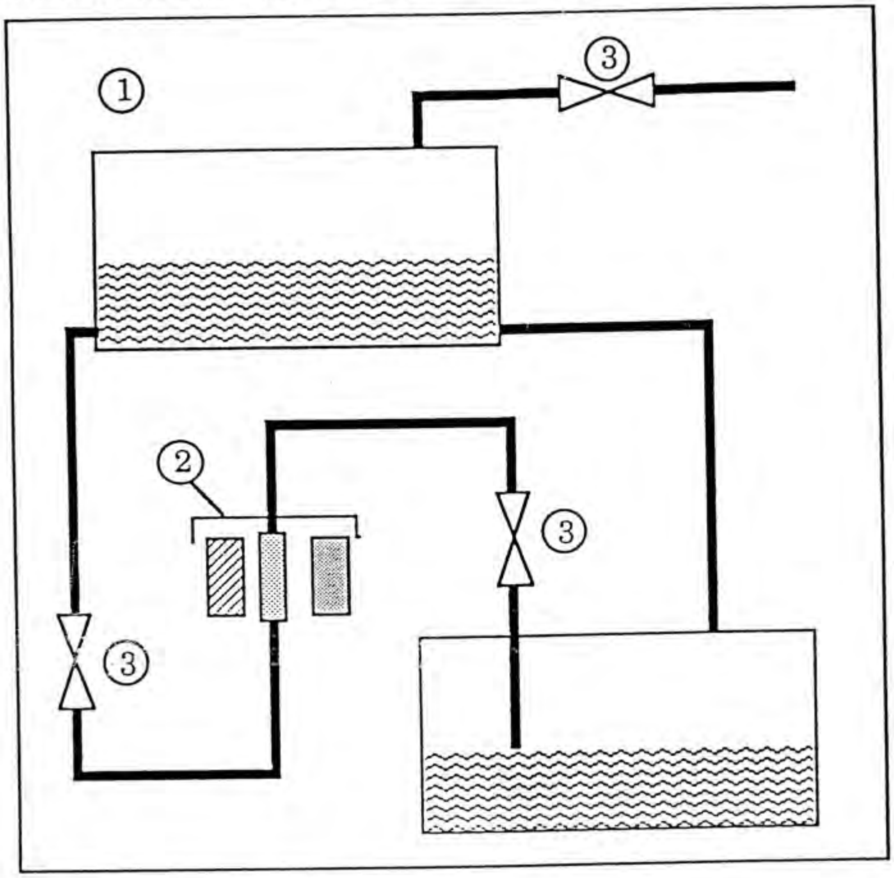

Fig. 1. Schematic of a Device for Magnetic Treatment of water (4).

1 - Intermediate tank;

2 - magnet gap;

3 - flow rate control valve.

In operation, water from intermediate tank (1) flows at a steady rate through the magnetic gap. The water conduit, passing through the magnetic gap. The water conduit, passing through the magnetic gap consists of rubber hoses. The flow-rate valves (3) maintain required water flow rate and the "exposure" time for "magnetization". It has been confirmed that magnetically treated water increases the solubility of fast-setting cement, and considerably increases the hardness of concrete (4).

2. The thermoelectric power station at the Vinnitsa Chemical Plant (Vinnitsa, Ukrainian SSR) is utilizing magnetically treated water to prevent the scaling of turbine cooling systems and condensers. The device for magnetic treatment of water consists of a ferromagnetic core with seven circular grooves for windings. The water to be treated flows through a channel situated between the electromagnet and the installation casing. To improve the process, vertical flow is created by a screw-shaped brass attachment which aligns and regulates the flow in the channel. The device is coupled to the main line of the coolant-charging system which contains 10% of the water circulating in the total cooling system (5).

The efficiency of the unit was rated on the basis of the time between heat-exchanger surface cleanings, as well as on the rate of vacuum decreased in the condenser, on relative changes of water transparency, salinity, hardness, pH and alkalinity at various points in the system, and on a visual inspection of the condition of the heat exchanger surfaces, following disassembly of the system.

The laboratory research and experimental testing of the above unit yield the following basic parameters for magnetic water treatment: field strength 0.8 x 105 a/m: flow rate through the unit 0.1 - 1 m/sec. River water with hardness between 5 and 7.5 mg-equiv/1 was used during the test. Preheating of the water was done partly in a reboiler having an area of 56 m2 but mainly in a condenser with an area of 900 m2. The temperature of water entering the system ranged between 15° and 20° C, and 40°C at the condenser outlet. The sludge separated from the water did not settle on the heat-exchanger wall, since proper flow rate (up to 1.0 m/sec) allows minimum possibility for contact of the particles with the walls of the condenser. Actually, all sludge passing through the condenser dropped into the cooling tower, either settling to the bottom or depositing on the trickling elements (5).

Within 2 - 3 months of operating the cooling system with standard water (not magnetically treated), salt encrustation forms a 1.5 - 2 mm thick layer on the walls of the heat-exchanger. On the other hand, magnetically treated water reduces the amount of sludge and increases the operating time (without stoppage for cleaning) to 6 months (5).

The antisludge process can be improved by adding ferromagnetic admixtures, i.e., by introducing 0.4 mg/1 of ferromagnetic iron oxide into the turbulent flow. In this case, the periods between cleaning can extend up to one year, representing an annual savings of about 15,000 rubles (5).

3. The Kharkov's Institute of Municipal Construction Engineers in the Ukrainian SSR designed an experimental device (see Fig. 2) for magnetic treatment of water. Water passes through a 2.5 mm wide annular channel (1) located between a brass tube (5) and a steel core (2). The magnetic field is developed by twelve electromagnetic coils (3) connected to a panel (6) having terminals for the magnetic windings. The electromagnets are housed in a steel casing (4). The device is fed by direct current from a selenium rectifier (6).

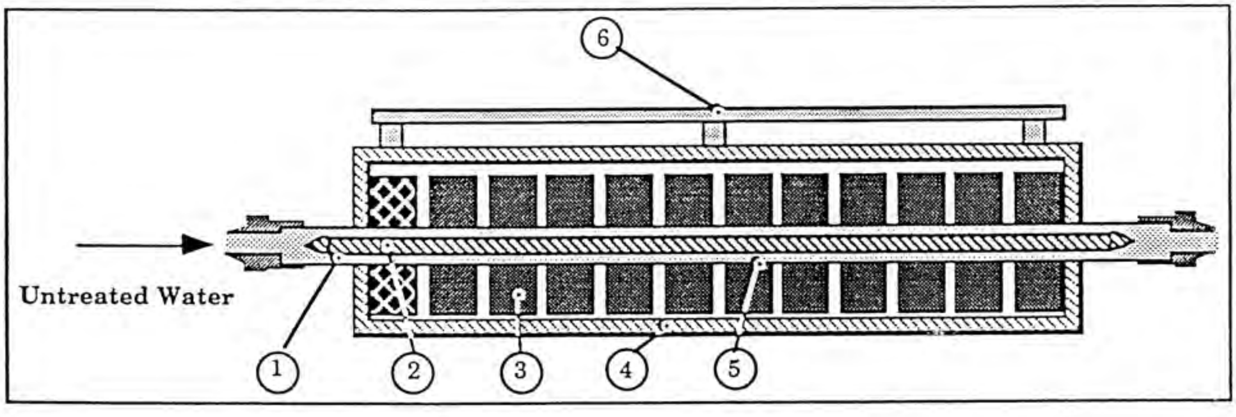

Fig. 2 Electromagnetic Device for Magnetic Treatment of Water.

1 - annular channel; 2 - steel core; 3 - electromagnetic coil;

4 - steel casing; 5 - brass tube; 6 - panel.

It has been established that the most suitable field strength in the annular channel is 500 oe and time required for water treatment is about 0.6 sec. For maximum effect, it is best to use an intermittent magnetic field, with the distance between coils equal to the width of electromagnets. This, in effect, can be accomplished by simply reversing the polarity of every other magnet (6).

Many researchers quote very favorable results of this "magnetization" method for industrial application in eliminating scales, preventing salt encrustation on the walls of oil wells, improvement of nonferrous ore dressing methods, etc. (6).

For compounds having greater scaling effect, such as CaSO4-H20 and Ca(HCO3)2-H20, magnetic treatment accelerates the thermic decomposition process of bicarbonates and increases the crystallization rate of the insoluble salts (6).

Through experiments conducted by the above institute, it has been established that in magnetically treated water, the coagulation rate for hydroxides increases. As a result of magnetic treatment of water, the percentage of suspended material settling at a rate of 0.75 mm/sec or more increases 1.2 to 1.9 times; the absorption capacity of aluminum and iron hydroxides increases by 30 - 40%. Also, it has been reported that the magnetic field has a bactericidal effect on intestinal bacteria (6).

4. In research conducted by the Chemistry and Water Technology Department of the Ukrainian Academy of Sciences, magnetically treated water was used to accelerate crystallization and reduce adhesion of gypsum in pipes and equipment, resulting from the lime neutralization processing of industrial waste acid at chemical processing plants (6).

The review above represents a quick, partial view of the total information presently available on magnetic water treatment. Other references, including non-Soviet articles, have been noted, providing additional information and insight into such areas as hardening of concrete, corrosion prevention, purification of potable water, etc.

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