Application of Electrophysical Processes for Solution of Ecological Problems of Power Generation Systems

A. M. Hashimov, H. J. Huseynov, K. B. Gurbanov, I. H. Zekiyeva

Institute of Physics of Azerbaijan National Academy of Sciences,
33, Javid str., Baku, Az-1143, Azerbaijan, e-mail: huseyn-1978@mail.ru

In this article, removal of H_2S from natural gas, sulphur compounds from mazout and hazardous components from fume by using adsorption processes under effects of strong electric fields and gas discharges is described.

Keywords: electric field, gas discharge, mazout, fume, natural gas, technological scheme, adsorption, adsorbent.

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Developments in power generation, chemical industry and other fields of production of the world countries have created certain ecological problems requesting urgent solutions by the end of the XX century. Among these problems are depletion of the ozone layer, global warming and acid rains. Scientific research centres of the developed countries are carrying out perfect scientific reasearch to solve these problems [1–5].

Use of methane as a heat source requests meeting certain ecological demands. If there are H_2S and/or other sulphur components in methane, a pre-treatment is a must. Leackage of methane gas during its production and transmission triggers certain chemical reactions in the atmosphere. Monitoring of methane gas in the atmosphere has its own significance.

Concerning the abovementioned, reasearch work into the effects of power generation on the ecology and preventing this pollution is important. In the light of so far mentioned, in this article the research directed to the solution of ecological problems of power generation by application of adsorption processes under electric discharge condition is described.

In this work, H_2S mercaptan, CO, CO_2, CH_4, mazout, NO_x, SO_x, NaX, CaA substances are used as research subjects. In the experiments, the time-of-flight mass spectrometry is used with an MSX-4 model. It should be noted that there are two ways of obtaining special materials with the application of modern technology: the first method is the synthesis of new chemical compounds and the second one is to make existing materials gain new properties according to demand.

In the first method, new materials are investigated by scientists working in the field of materials science, chemistry, physics synthesizing hundreds of composite mateials. It should be noted that each new material properties created by this way should be fully investigated, experiments should be done and after testing in real situations their technical data sheets should be formed. Although this method has potential for creating new materials according to technical demands, in most cases this method is expensive.

The second prosess is making materials obtain new properties, which is economically feasible and needs shorter time. Usually materials in solid state are made so as to have new properties under extrerne effects, such as mechanical, chemical, biological and physical ones. Recently, strong electric fields and gas dischrges have been widely used as electro-physical effects on materials in agregate states.

Whenever an electric field is applied to a dielectric in solid state, polarization, recrystallisation, chemical composition changes, accumulation of surface and volume electric charges, surface prosesses and other physical-chemical processes are taking place in it, which leads to changes in some properties of the dielectric, such as electrical conductivity, thermal conductivity, special surface and volume resistance, heat capacity, electrical strength, dielectric losses, electrical aging, mechanical strength.

To change any electrophysical property of a dielectric purposely, according to the application field and desired properties of dielectric, physical and chemical prinsiples of processes taking place under gas discharge should be studied and only in this way we can get control of dielectric properties change process.

Partition gas discharge used in research is obained from an ozone generator. Thezone generator consists of two coaxial glass cylinders. The gas discharge distance is 4 mm. A high voltage electrode is placed inside a small diameter cylinder. The outer surface of a big diameter cylinder is covered by an earthed electrode. An adsorbent is placed within the gas discharge distance to activate it by gas discharge. High alternating voltage of the industrial frequency is applied to the system. Experiments are

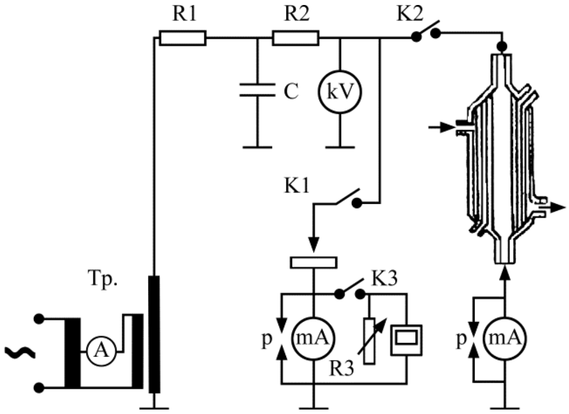

Fig. 1. Scheme of partition gas discharge.

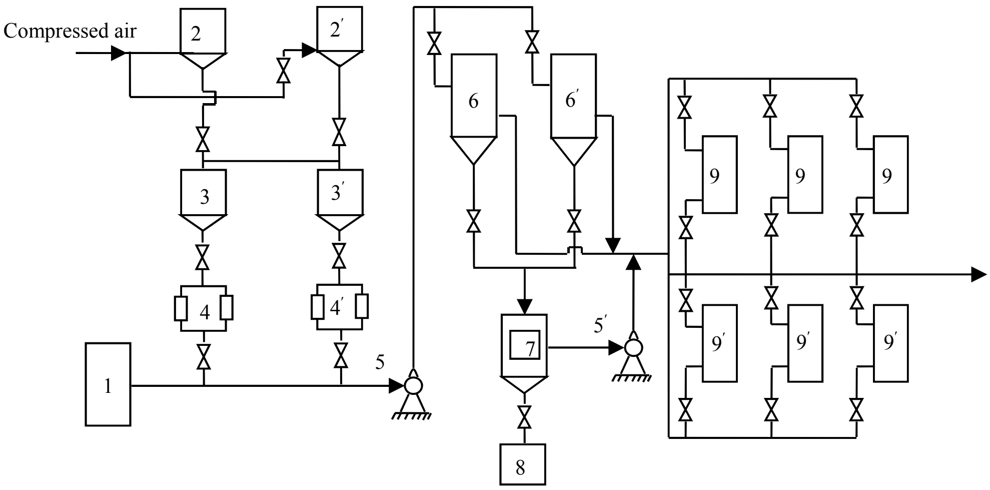

Fig. 2. Schematic diagram of apparatus for removing sulphur compounds from mazout. 1 – preliminary precipitation volume; 2, 2′ – reagent preparation volumes; 3, 3′ – volumes for mixing solutions; 4, 4′ – quantity adjustment pumps; 5, 5′ – centrifugal pumps; 6, 6′ – precipitation volumes; 7 – centrifugal apparatus; 8 – precipitation concentration volume; 9, 9′ – adsorbtion reactors.

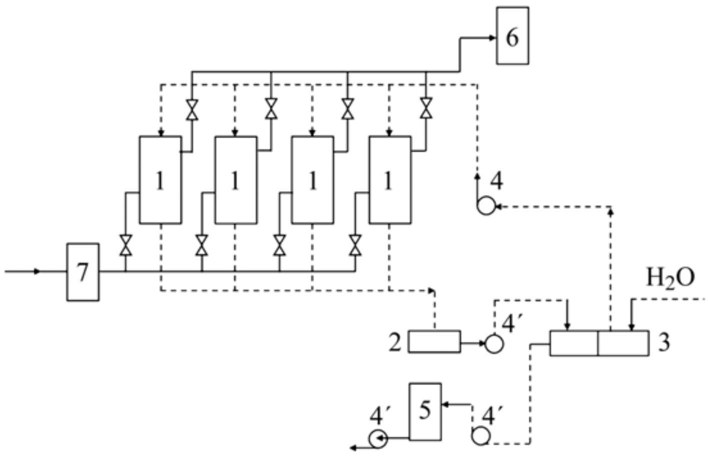

Fig. 3. Scheme of technological apparatus for treatment of waste gases of thermal power plant. 1 – adsorber equipment; 2 – precipitation volume; 3 – water and acid solution volume; 4, 4′ – pumps; 5 – presipitation volume; 6 – gas exist pipe; 7 – dust filter.

conducted under the atmospheric pressure. The adsorbent undergoes gas dichare during 60 minute (Fig. 1).

Formation of electrically charged states in adsorbents exposed to gas discharge is determined by measuring thermostimulated currents.

Following the subject of reasearch, activation of adsorbents in the treatment processes of fuels such as natural gas, mazout and fume by the abovementioned methods is studied.

Experiments of removing sulphur compounds from mazout by using an apparatus similar to one in Fig. 2 are made.

Using centrifugal pumps, mazout is tranferred from volume 1 to volumes 6, 6′ together with the solution. After treatment by a reagent, mazout is

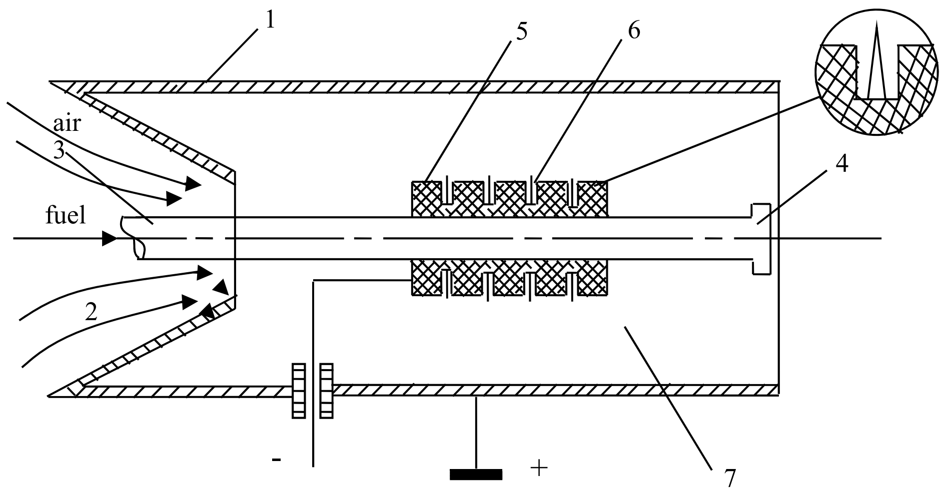

Fig. 4. Experimental burner. 1 – metal pipe; 2 – conical air passage; 3 – fuel passage; 4 – pulverizing head; 5 – dielectric; 6 – needlike electrodes; 7 – discharge space.

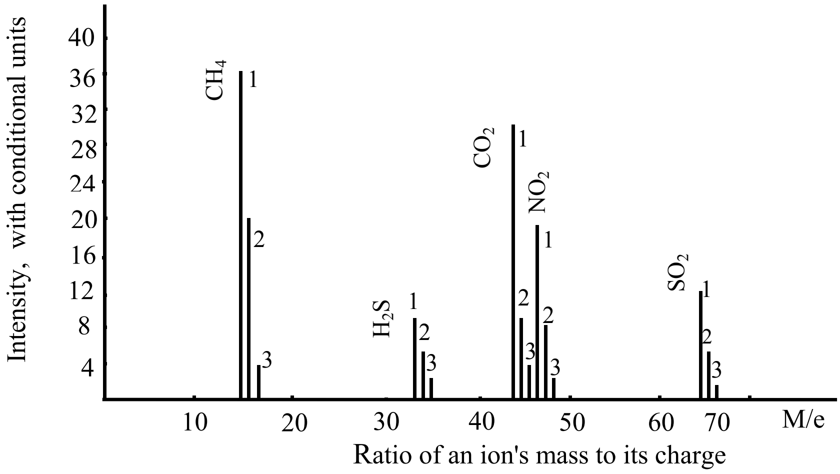

Fig. 5. Mass spectrograph of the process of removing nitrogen, sulphur, carbon dioxides and H_2S gas from natural gas. 1 – composition of initial gas mass; 2 – treatment by thermoactivated adsorbent; 3 – treatment with thermally and electrically activated adsorbents.

further treated in volume 9 to remove sulphur compounds and the solution residual.

By applying the apparatus depicted in Fig. 3, the removal of nitrogen, sulphur and carbon dioxide from fume gases of a thermal power station is realised. Big volumes of waste gases from the plant demand optimizing the removal process.

System in Fig. 1 includes a high voltage transformer as a power source, a gas discharge reactor (ozone generator), a milliampere meter, dischargers and other necessary elements.

In order to investigate how strong electric fields and gas discharges effect the process of fuel burning in thermal boilers a special apparatus has been manufactured. The burner is schematically presented in Fig. 4. When a voltage applied between needlike electrodes and its corpse, a flame-shaped discharge is observed in the discharge space.

In Fig. 5, experimental results showing the adsorbent adsorption ability are given. As it is seen from this Figure, when adsorbents are exposed to gas discharge, effectivness of the adsorption process is remarkably increased.

In order to understand the reason for the rise in effectiveness of theadsorption process, adsorbents exposed to gas discharges are studied. Thermostimulated currents are recognised in adsorbents exposed to electrical effects. In Fig. 6, current-time diagram of absorbents exposed to the partition gas discharge during thermostimulating is shown. As it can be seen, three maxima are recorded on the spectrum. The spectrum is characterised by a low-temperature maximum (~ 46°C) and two high-temperature maxima (350°C, 500°C). The electric charge in the spectrum corresponding to the first maximum is $Q_1 = 4{\cdot}10^{-7}$ C, to the second – $Q_2 = 6{\cdot}10^{-6}$ C and to the third – $Q_3 = 2\cdot10^{-7}$ C.

Electrical effects are realised by the partition gas discharge. The electrical gas discharge is obtained at u = 10 kV and affected adsorbents during 10 minutes. The sample was heated from room temperature to 600°C.

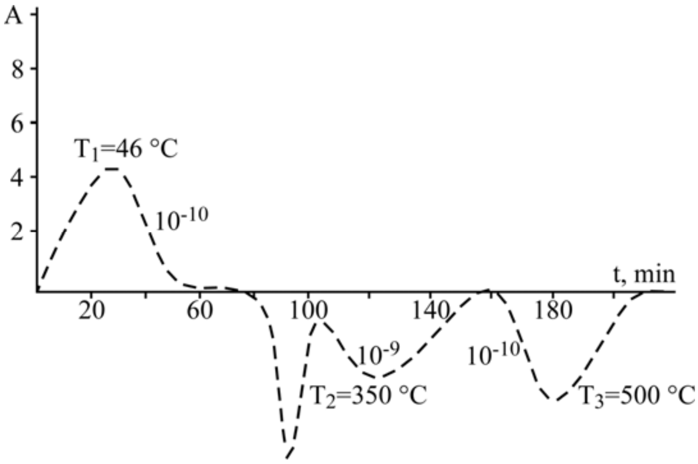

Fig. 6. Thermostimulated current curve of seolit adsorbent.

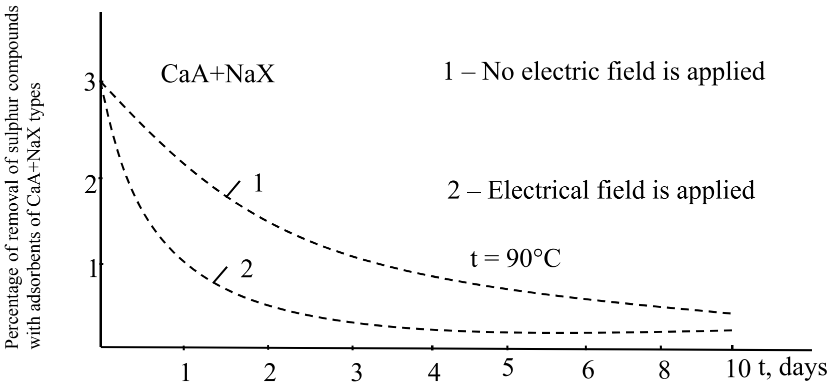

Fig. 7. Time dependence of removal of sulphur compounds (mercaptain) from mazout.

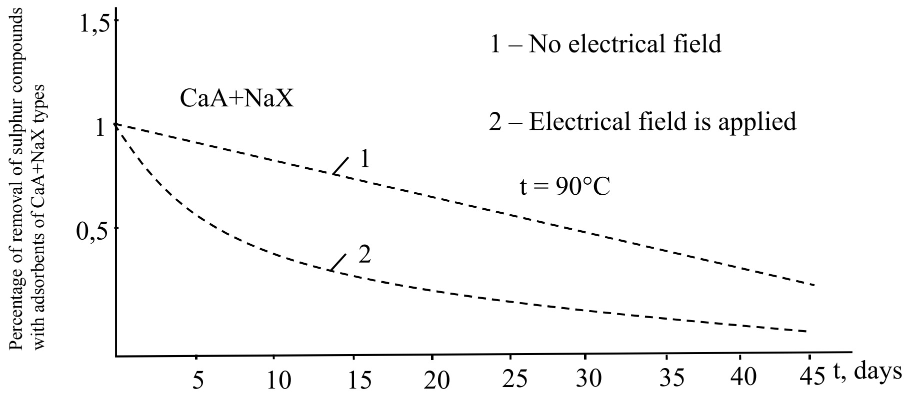

Fig. 8. Time dependence of removal of sulphur compunds (sulphur oxide of carbon) from mazout.

In Figures 7 and 8, curves characterizing kinematics of removal of sulphur compounds from mazout are presented.

It is seen from those Figures that sulphur containing mercaptan is adsorbed faster than sulphur oxide of carbon and it gives a higher degree of removal.

The results of this study are important for petroleum and gas industries, petrochemistry, water treatment, production of polimers and other related fields.

This work presents the results of investigations of the processes of natural gas purification and of usage of liquid hydrocarbon as combustible material. This study had the following aspects: activation and modification of the surface adsorbent under various influences, in particular, under the use of an electrical charge; control of the sorption processes; intensification processes of purification of gases and liquids; activation of reagents; study of adsorption and stripping processes occurring under the influence of electrical charging.

In the work it was experimentally accepted that during electrical charging of absorbents in processing there is also the process of adoption of electrical charging on the surface and in the capacity of adsorbent. The high temperature picks appeared in the curve of the thermo stimulated current, evidencing on deep levels of adoption of charges. Integrated in the adsorbent electrical charges most probably develop additional adsorption centers and at the same time increase the efficiency of stripping processes.

On the base of the received results, new sufficiently effective technological processes of purification of natural gas from the impurities of CO, CO_2, NOx, and H_2S, from wetness as well as the processes of purification of masut from sulfuric contaminations, and of wastewaters of the industrial entities, in particular, thermal power stations.

It has been identified that under the action of an electric field and electrical charges on the process of burning of fuel in a burner, ther is a possibility to raise the efficiency of burning the fuel and, at the same time, to minimize the qaunity of harmful substances in the contaminations going up into atmosphere.

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Реферат

В статье изложены результаты исследований процесссов очистки природного газа от сероводорода, мазута от сернистых соединений и дымовых газов от вредных состовляющих с применением адсорбционных процессов в условиях воздействие сильных электрических полей и разрядов.

Ключевые слова: электрическое поле, газовый разряд, мазут, дымовые газы, природный газ, технологическая схема, адсорбция, адсорбент.