DEVELOPMENT OF POROUS MEDIA AND FILTERS HAVING FUNCTIONAL GALVANIC COATINGS

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Porous media are widely used in engineering for heat and mass transfer processes, catalysis, and separation of dispersions and suspensions. In many cases, preparation of porous media and filtering elements with tailor-made properties and structures directly from original material presents difficulties. To maintain a specified geometric structure and provide a desired coating or finish may be practically impossible. A flexible, economic, and efficient procedure for preparing porous media with a specific structure and a surface having desirable properties consists of applying a functional galvanic coating on the original materials. In particular, it is this method that allows preparation of filter elements for purification of electrolytes and chemically active fluids.

Novopolotsk Polytechnic Institute developed porous media having new structures and new manufacturing methods that permit production of cheap and efficient porous elements for different applications (Galushkov and Yelshin, 1990).

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INTRODUCTION

As far as separation of dispersions and suspensions is concerned, the main criteria used as a basis for development of porous media were the following:

- Possibility to use filtering elements for purification and recovery of electrolytes.
- Use of filtering elements as electrodes for precipitates of metals when necessary.
- Possibility to regenerate the elements by electrochemical and chemical means.
- Extraction of settled metals and contaminants.

ELECTROCHEMICAL PRODUCTION OF FILTER ELEMENTS

The Novopolotsk research involved production of filtering elements and porous media by direct electrochemical method of electrolytic metal deposition on a substrate maintaining the conditions required for dendrite formation followed by imparting required surface properties to a porous structure (Galushkov and Yelshin, 1989A). Filter elements are made on a porous substrate, e.g., on screen 1 having a smooth galvanic coating as shown in Fig.. 1. The porous substrate (screen) side facing the suspension being filtered (direction of filtration shown by arrow 3) is coated with an additional galvanic layer in the form of electrochemically deposited metallic dendritic crystals. The suspension being filtered is fed to a filter and moves in the direction from coating 2 to substrate (screen) 1. At this time, particles of contaminants, 4, contained in the suspension penetrate into the additional layer, 2, and remain in its pores. The biggest particles deposit on the layer and metal dendritic crystals, surface 2. Due to a substantial inner volume of porous coating, the contamination capacity of the filter element is increased.

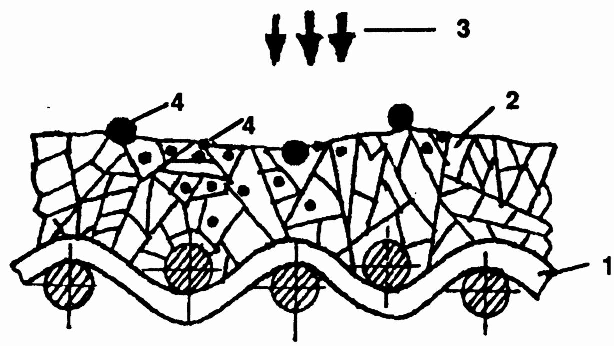

Figure 1. Porous element with a layer of dendritic crystals of electrochemically deposited metal.

The filter cake can be removed from a filter element in the process of recovery by dissolving part of the coating of the metallic dendritic crystals, 2; in this case, the screen can be repeatedly used to make a filtering layer of deposited metal dendritic crystals.

COMPOSITE MEDIA

Production of composite porous media and filter elements can be accomplished using a mixture of electroconductive and non-conductive particulate or fiber materials. In this case, the galvanic functional coating is applied on the electroconductive phase only; at the same time, this galvanic coating keeps non-conductive particles in place. Composite material may comprise hydrophobic and hydrophylic components of a dispersed phase. The amount of electroconductive particles should not be less than 60-70% to make rigid the continuous frame inside the porous material.

The process of making such porous materials consists of the following stages: the original mixture of electroconductive and non-conductive materials is shaped into a half-finished product of required size; the above product is put into a galvanic bath containing electrolytes; here it serves as a cathode and is placed between anodes. Then metal is deposited to bind particles of dispersed materials (Galushkov and Yelshin, 1989B). To increase the homogeneity of metal distribution within the depth of the half-finished product and to control the porosity, electrolytes can be pumped through it at some speed.

Fig. 2 shows the structure of porous material produced this way. The filter medium has increased rigidity and a structure which is stable to large pressure differentials. In addition, the surface potential of the electroconductive composite material particles can be controlled so that an additional effect on the separation efficiency of the dispersed system results.

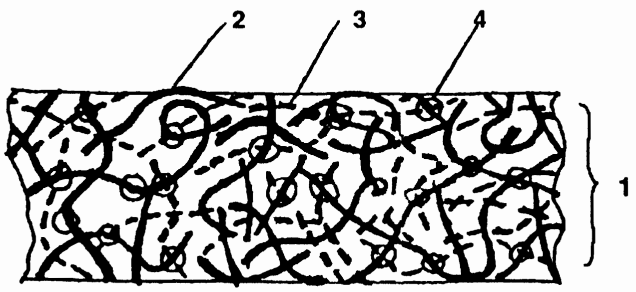

Figure 2. Porous composite material structure. 1–porous material; 2–electroconductive particles; 3–non-conductive particles; 4–points of contacts of heterogeneous particles where they are bound to each other by a layer of deposited metal.

Binding the mixture of dispersed materials by means of the metal coating deposited on the electroconductive surface makes it possible to produce composite materials under normal conditions at a temperature of 20-50°C. That makes it possible to use non-conductive synthetic materials with different melting temperatures. The non-conductive material is bound to the electroconductive layer by mechanical adherence and by ingression into the deposited metal in the contact region with electroconductive material that assures strong fixation, avoiding heat treatment.

USE OF MAGNETIC MATERIALS

Composite porous media with a desired structure can be produced using a magnetically sensitive electroconductive material or a mixture of electroconductive magnetically sensitive and non-magnetic materials. There is provided a method of porous media formation by orientation of magnetic particles in a magnetic field and applying a galvanic coating to keep them in place. Cheap magnetically sensitive materials are used as raw material. Porous media are formed in layers, and each layer is secured by electrochemically deposited metal, which in addition, protects the layers.

Figure 3 shows the scheme of porous material made by the magnetic method. The material consists of an electorconductive screen, 1, and layers , 2-6, comprising the particles held by the metal deposited in different directions corresponding to the lines of magnetic force shown by arrows in Fig. 3B.lines

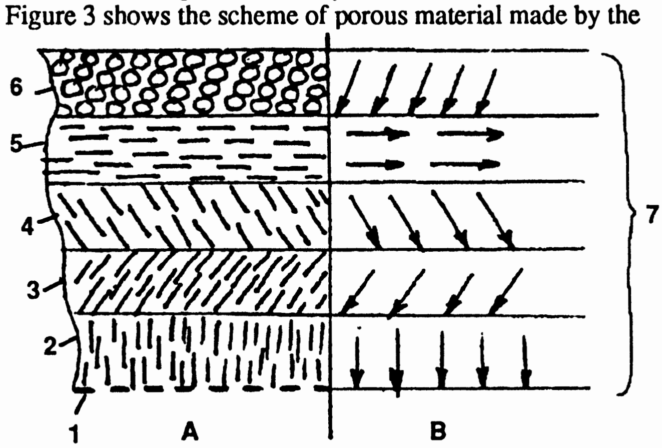

Figure 3. Porous material made of magnetic particles (A) and lines of magnetic force applied to a layer of material during its manufacture (B).

The process of making multilayer porous media consists of the following stages:

1. A mold with a sublayer of porous electroconductive material 1, which will later play the part of a cathode, is filled with a layer of magnetic particles.
2. The mold is put into a an electrolytic cell where a magnetic field with desired direction of lines of force is created. Particles orient along lines of force and are found in this position during the electrochemical coating. To increase the electrochemical coating quality, an electrolyte can be directively transferred through a cathode.
3. After a layer of particles has been fixed in place, another portion of particles is introduced into the mold. At the same time, the direction of the magnetic field is changed and the process of electrochemical fixation of magnetically oriented particles is repeated. When necessary, each layer can be formed from particles of different size and shape.

As a result, the shape and direction of channels in the porous material, the porosity, and kind of layered packing can be controlled in the process of manufacture. The method can be extended to a production of porous composite material where non-conductive layers are interposed between the layers of electroconductive particles (Yelshin and Galushkov, 1890). In this case, non-magnetic current conductors are evenly secured on the porous substrate surface (screen) (Fig. 4) to increase the structural rigidity and homogeneity of current supplied to the porous electroconductive surface. Current conductors can be of different configuration, e.g., straight, helical, zigzag, etc. Non-conductive layers are interposed between the screen and out magnetic particles layer (Electroconductive, non-magnetic particles may be used also). To hold the layers of fiber, non-conductive material, electric

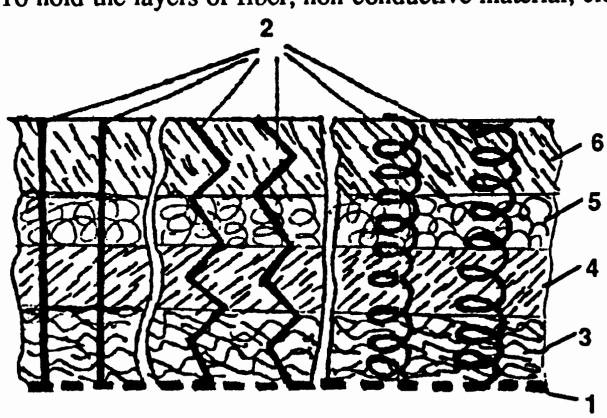

Figure. 4. The scheme of porous composite material made of alternating layers of electroconductive and non-conductive materisl. 1–porous substrate (screen); 2–electric current conductors; 3-5–non-conductive layers; 4-6–electroconductive and magnetic particles layer.

current conductors can be made in the form of springs which are extended at the time of putting a fiber layer and recovered by clamping fibers in between the turns of a spring conductor. When making multilayer porous material, conductors projecting over the surface of the electroconductive particles are coated by a di-electric layer. This reduces the electric field distortion during application of the electrochemical coating.

SCREEN BOUND BY GALVANIC COATING

Porous media of a prescribed shape can be produced by binding a galvanic coating to a screen package possessing the desired geometric form (1989E). To control the porosity, the original material is bound by electrochemical metal deposition on ready-made and fixed porous materials which are parallel to one or two anodes. In this case, the porous material can be asymmetric to the anode, and the original material can be galvanically precoated. Metal screens, chips, fibers, powders, etc., can be used as the original material. By properly selecting the degree of asymmetry of the porous half-finished product in relation to the anode and by selecting the electric current magnitude, one can produce materials of various porosities and pore sizes within the thickness of the filter element.

It is possible to improve filtering media with dendritic metal layers:

a) to filter and further dispose the suspension, solid phase particles of which contain radioactive inclusions;
b) to filter suspensions containing hazardous solid phase if it is necessary to keep contaminants inside the filtering layer.

To extract particles containing radioactive inclusions, a layer of electrochemical deposited dendrites of lead can be made. When the filtration is over, this filtering layer of lead with entrained contaminants is easily pressed by mechanical means. Meanwhile, the radiation level due to the absorbing power of the lead is reduced and the pressed cake is available for storage in a safe place.

For hazardous solid phase suspensions, there exists two ways of keeping contaminants in a metal filter media:

1) After filtration is over, the filter media is treated by an electrolyte where by an additional metal layer is formed with an electrochemical or chemical method which fixes the contaminants.
2) Suspension to be filtered is mixed with an electrolyte; and at the same time, filtration and electrochemical metal deposition is being carried out to form an additional metal layer in the filter media. This layer fixes particles of suspension.

The use of the latter method is limited to a substantial degree.

Composite filters are another group whose use can be widened. First, they can be used to make filters containing both hydrophobic and hydrophylic filter media. It is possible to control the electric potential of the filter conductive layers and to assure the same or different potential in every layer. The production method for a laminated filter with homogeneously distributed current conductors can be used to fix fiber layers made by aggregation which makes it possible to backflush the aggregated layer as well as to accomplish cross-flow filtration.

Thus galvanic techniques can be used to produce filtering media with various performance properties, and they can be interesting for filtration.

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