Additive technology for filter membranes

IOP Conf. Series: Materials Science and Engineering **570** (2019) 012003 doi:10.1088/1757-899X/570/1/012003

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Abstract. Separation methods using membranes are used in many industries, in particular, in the field of environmental protection for the production of drinking water and the treatment of industrial liquid waste, in the chemical industry, petrochemistry, pharmaceuticals, food industry and in the field of biotechnology. In the framework of this research, new methods for membranes manufacturing are proposed, which in comparison with the known technical solutions from the point of view of reliability and performance, make it possible to obtain more results and also provide greater variability in the choice of substrate shapes and channels inside the substrate. The most effective technology is a method of manufacturing a membrane for tangential filtration of a fluid, and this membrane contains: a substrate having a three-dimensional structure and formed by a monolithic ceramic porous body in which paths are made to circulate the fluid being filtered, and at least one separating filter layer deposited on the wall of the circulation paths.

Introduction

At present, a more detailed analysis of the latest scientific research shows that in the field of additive technology, an ordinary technical and technological process will take place in the future, however, the science needs to cope with a lot of challenges before it reaches these boundaries. Therefore, state and departmental scientific organizations ought to take urgent and concrete measures. The problems of additive technologies of the present time are described by the following economic factors: the high cost of polymeric materials, the complexity of the process at all stages of technical and technological solutions [1,2,3]. The purpose of this work is a more detailed analysis of the known technical and technological solutions using additive technology to obtain filtration membranes. The work presented relates to a number of filter elements and the essence consists in the preparation of a membrane and includes a modified tangential filtration of a fluid. At the same time, the indicated membrane can and must also contain in the technical solution: a substrate having a three-dimensional structure and formed by a monolithic ceramic porous body, in which the main paths are made for the circulation of the filtered fluid and the separation filter layer deposited on the wall of the circulation paths, in which the three-dimensional structure of the substrate is obtained by means of additive technology.

Material and research methods

According to the well-known technology, the proposed three-dimensional structure of the substrate is cut into sections using a computer-aided design program, while these sections are created alternately in the form of elementary layers located one above the other and sequentially functionally connecting them between themselves.

Research results and discussion

The known technology for obtaining filtering membranes demands the strict observance of the following two steps. At the first stage, a uniform continuous layer of powder of constant thickness is intended to form a ceramic porous body over an area exceeding the cross-sectional pattern of the specified formed porous body at the reservoir level. In the second stage, in accordance with the pattern and determined for each layer, a part of the applied material is locally compacted to create an elementary layer. At the same time, these two stages are repeated in order to simultaneously associate the elementary layer formed in this way with the previous layer, gradually increasing the required three-dimensional shape. Separation methods using membranes are used in many industries, in particular, in the field of environmental protection for drinking water and processing industrial liquid waste, in the chemical industry, petrochemistry, pharmaceuticals, food industry and in the field of biotechnology [4; 5; 6]. The developed filtering membrane forms a selective barrier and, under the action of a transfer force, ensures the passage or retention of certain components of the medium or liquid being processed. The passage or retention of the components may depend on their size relative to the pore size of the membrane, which behaves like a filter. Depending on the pore size of the filtration membrane, these technologies are called microfiltration, ultrafiltration or nanofiltration. There are membranes with different structures and textures. As a rule, the membranes contain a porous substrate, which provides the mechanical strength of the membrane and gives it shape, that is, determines the filtering area of the membrane. One or several layers with a thickness of several microns are applied to this substrate, which provide separation and are called separating filter layers, separating layers or active layers. During the separation, the filtered fluid flows through the separation layer, then this flowable fluid spreads through the porous texture of the substrate, after which it moves to the outer surface of the porous substrate. This part of the treated fluid that has passed through the separation layer and the porous substrate is called the filtrate (permeate) and is collected in a collecting chamber enclosing the membrane. The other part is called a concentrate (retentate) and is most often sent back to the treated fluid at the inlet of the membrane using a closed circulation loop. Usually, a substrate of the required shape is made first by extrusion, then it is sintered at a certain temperature and for a sufficient time to provide the required hardness, while maintaining the necessary open and interconnected porous texture in the resulting ceramics. This method forces to perform straight channels, inside which a separating filter layer or separating filter layers are then applied and sintered [1]. Thus, using this technology, the filtering membrane is subjected to at least two sintering operations. Organic binders added to the paste prior to sintering, burn completely during sintering of the substrate. This method is satisfactory, but it is still necessary to achieve an increase in the profitability of the method and the maximum limitation of conceptual flaws. In the framework of this research, new methods for the membranes manufacturing are proposed, which make it possible to obtain a gain in terms of reliability and performance in comparison with the known technical solutions, and also provide greater variability in the choice of substrate shapes and channels inside the substrate.

Conclusion

The most efficient, economically and laboriously, technology is a method of manufacturing a filtering membrane for tangential filtration of a fluid, while this membrane contains:

- a substrate having a three-dimensional structure and formed by a monolithic ceramic porous body in which the paths for the circulation of the filtered fluid are made, and
- at least one separation filter layer deposited on the wall of the circulation paths, in which the three-dimensional structure of the substrate is obtained by additive technology. Next, the three-dimensional structure of the substrate is dissected into sections using a computer-aided design program, while these sections are created alternately in the form of elementary layers located one above the other and successively interconnected by repeating the following two stages, in which:

1) a uniform continuous layer of powder of constant thickness is applied, intended for the formation of a ceramic porous body on an area exceeding the cross-sectional pattern of the specified formed porous body at the reservoir level;

2) in accordance with the pattern and determined for each layer, a part of the applied material is locally compacted to create an elementary layer, while these two steps are repeated in order to simultaneously associate the elementary layer formed in this way with the previous layer, gradually increasing the required three-dimensional shape.

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