Research of the possibility of using filter materials with orthotropic structure based on woven nets for cleaning diesel fuel

Aliaksandr Ilyushchanka[1, 2], *Ruslan* Kusin[2], *Iryna* Charniak[2, *], *Aliaksei* Kusin[2], *Vyacheslav* Kaptsevich [3], and *Natalia* Rutkovskaia[3]

[1]*State* Research *and Production Powder Metallurgy Association, 220005 Minsk, Platonov str.41, Republic of Belarus*
[2]*State Scientific Institution "O.V. Roman Powder Metallurgy Institute", 220005 Minsk, Platonov str.41, Republic of Belarus*
[3]*Educational establishment "Belarus State and Agrarian Technical University", 220023, Minsk, Nezavisimosti ave. 99, Republic of Belarus*

Abstract. A comparative analysis of the characteristics of experimental samples of filter materials with an orthotropic structure based on woven meshes (FMTS) and standard paper filters was carried out, which confirmed the possibility of using filter elements from FMTS for fine purification of diesel fuel in automotive equipment. Promising directions for further research in the development of effective FMTS are given.

1 Introduction

The machinery and equipment of modern enterprises of the agro-industrial complex cannot do without cleaning liquid and gaseous media with filter materials (used as participants in the technological cycle in the manufacture of products or consumer goods), which ensures the achievement of the required quality of the products produced with their help or the trouble-free operation of machines and mechanisms [1, 2]. It was shown in [3] that a promising material for filtering liquids and gases is a filter material with an orthotropic structure based on woven meshes: while maintaining the advantages of traditional mesh materials (combination of high strength and permeability, stability of the porous structure, which excludes the migration of FM particles into the medium high heat resistance, ability to multiple regeneration), FMTS has 100% regenerability (when the filter element is disassembled, the circuit of the elementary filter cell becomes open, and contaminants on the filter material of the filter element are retained only by adhesion forces), and a spontaneous change in the cell size in the light during regeneration does not affect the fineness cleaning. In case of urgent need in case of repair or maintenance, the product from FMTS, in the presence of original meshes, can be manufactured at any mechanical site using available tools. In addition, in case of loss for any consumer properties reason, the filter material with an orthotropic structure based on woven meshes can be returned to production without any problems by using it as a raw material at metallurgical enterprises.

At the moment, a fairly large amount of work has been done in the FMTS development: promising designs of filter materials with an orthotropic structure based on woven meshes have been described, a material model has been developed with a simple regular structure (or FMTS with a simple laying of meshes, when mesh layers are stacked on top of each other in the same spatial orientation), on the basis of which equations were developed for calculating the structural and hydrodynamic properties [3]; the possibilities of using 3-D modeling and 3-D printing to study the properties of FMTS, in particular, with the structure described above, are disclosed, which can significantly reduce the complexity of the research process [4, 5]; on the basis of FMTS, a filter for coarse cleaning of herbicides and a drainage element for the catalytic treatment unit in a water deironing plant were developed, manufactured and implemented [3, 6]; a systematic approach has been developed for compiling an experiment planning matrix to establish the relationship between technological characteristics and FMTS properties[7].

The work aim is to substantiate the possibility of using filter materials with an orthotropic structure based on woven meshes for diesel fuel purification.

2 Experimental results and discussion

To substantiate the possibility of using filter materials with an orthotropic structure based on woven meshes for cleaning diesel fuel, a regular (paper) filter DIFA 6101/1 used in the fuel supply system of D-240/245 autotractor engines was chosen as an analog for comparing characteristics. Figure 1 shows the DIFA 6101/1 filter assembled and disassembled.

Then, by the method of displacement of liquid (ethyl alcohol) according to GOST 26849 86, the dimensions of the maximum pores of the filter element installed in the standard filter were studied and, based on the results

* Corresponding author: irinacharniak@tut.by

of the studies, the FMTS was selected for the manufacture of an experimental sample on its basis with the same pore sizes (experimental samples of the FMTS (EO) are a package of grids in in the form of a rectangular parallelepiped with a height of 50 mm, having a square with a side of 40 mm at the base.) To study the properties of EO, a tooling was made, a 3-D model of which, assembled with a sample, is shown in Figure 2.

Fig. 1. Filter DIFA 6101/1 assembled and disassembled.

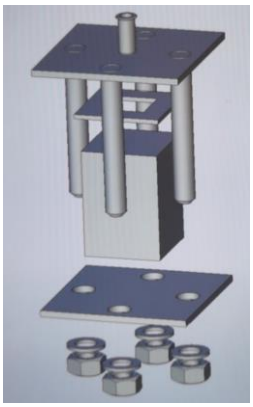


Fig. 2. 3-D sample fixture model.

Figure 3 shows the tooling in disassembled form (in the process manufacturing, it was decided to change the location of the holes) and the original woven meshes, in Figure 4 - tooling assembly with EO FMTS, and in Figure 5 - the process of determining the maximum pore sizes on a standard filter element and EO FMTS.

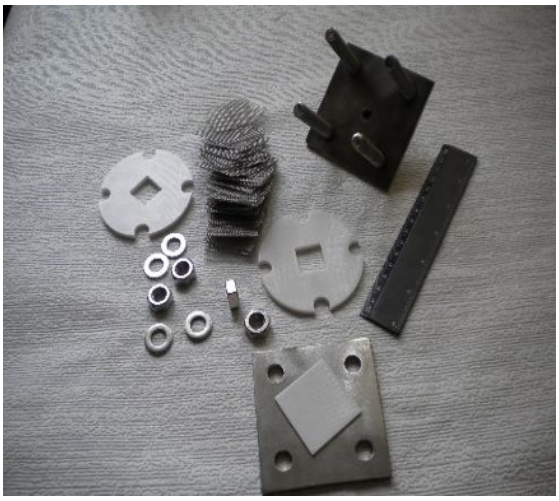


Fig. 3. Exploded rigging and original woven meshes.

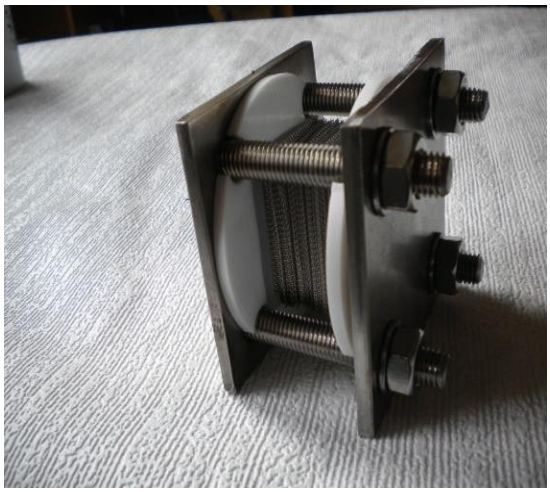
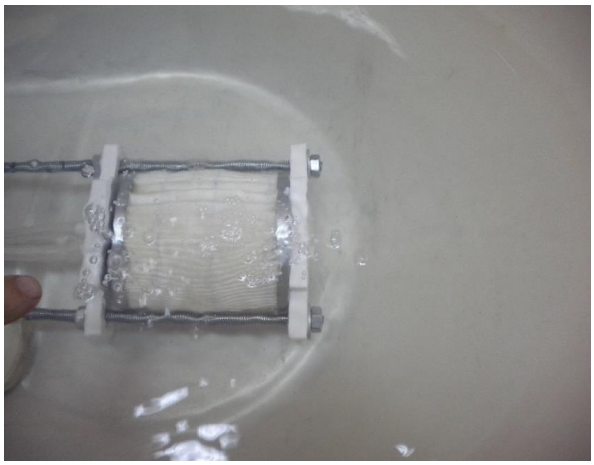
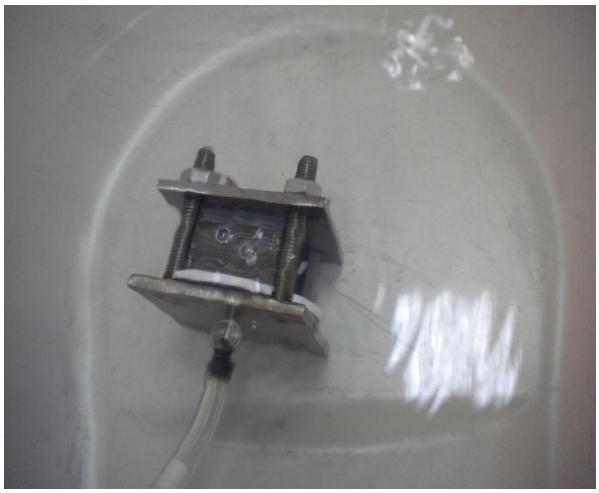


Fig. 4. Tooling assembly with EO FMTS.

Then, according to GOST 25283-93, the viscosity coefficient of permeability of EO FMTS was determined, which made it possible to calculate its throughput. As a result, it was found that the characteristics of the experimental sample from FMTS correspond to the conditions of use for its intended purpose: with the same cleaning quality (estimated by pore size) with a standard filter element, FMTS provides the required fuel consumption (7.5 l/h) when converted to the filtration area, corresponding to the volume of the standard filter housing. That is, as a result of the research, the possibility of using FMTS filter elements for cleaning diesel fuel in agricultural machinery was confirmed. The next stage of work is planned full-scale tests of a prototype in the field.



a)



b)

Fig. 5. Determination of the maximum pore sizes on a standard filter element (a) and EO FMTS (b).

At the same time, in the process of conducting research, a range of tasks was determined to be solved in the field of developing FMTS and products made from them. So, in the manufacture of an experimental sample, it was found that, although the manufacture of a sample from FMTS with the simple regular structure described above (Figure 6 illustrates the laying of grids in this case) is possible, it is accompanied by technological difficulties due to the instability of the structure during assembly (compression) - grids tend to take a more stable position, spontaneously shifting in neighboring layers by half the size of the cell to the light (Figure 7). Such a structure of the FMTS (let us call it a dense regular structure or a structure with a dense packing of grids) was realized by us in our studies.

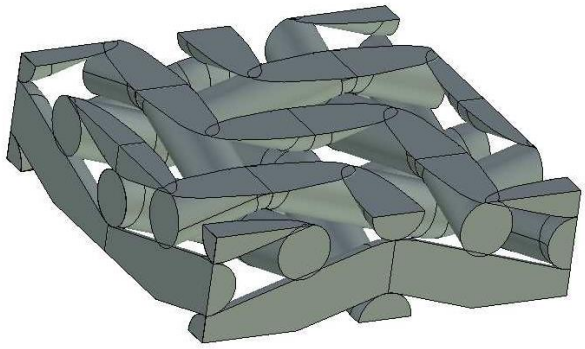


Fig. 6. 3D-model of the simple regular FMTS structure.

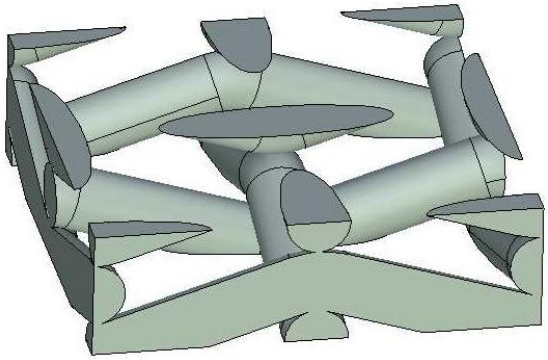


Fig. 7. 3D-model of the dense regular structure of FMTS.

It should be noted that it is advisable to use the initial meshes for the manufacture of products from FMCS with such a structure in the form of squares or rectangles - in this case, there is no need to manufacture special stamps or use expensive technologies for cutting blanks. Accordingly, the problem arises of developing a FMTS model with a dense regular structure and equations based on it for calculating the structural and hydrodynamic properties of a material.

At the same time, the products design from FMTS of a cylindrical shape with a centering longitudinal hole and an element tightening the flanges located in it (in the form of a stud, a perforated pipe with a thread, etc.) also has its advantages. It seems that a chaotic arrangement would be appropriate in this case neighboring grids with respect to each other (chaotic structure of FMTS or FMTS with chaotic grid laying), which also requires the development of an appropriate model and equations.

3 Conclusion

A comparative characteristics of experimental samples of filtering materials with an orthotropic structure based on woven meshes and standard paper filters used for fine purification of diesel fuel in automotive and tractor equipment analysis has been carried out. It's shown that FMTS with the same fineness of cleaning are able to provide the required fuel consumption. Promising

directions for further research in the development of FMTS are given.

References

1. M.A. Yablokova, E.A. Ponomarenko, Promising methods for cleaning diesel fuel from water and mechanical impurities, Scientific Review. Technical Science, 2014, No. 2.
2. V.P. Kovalenko, A.A. Ilyinsky, Fundamentals of technology for cleaning liquids from mechanical impurities (Moscow, Chemistry, 1982).
3. A.Ph. Ilyushchanka, I.M. Charniak, V.M. Kaptsevich, V.M. Korneeva, R.A. Kusin, I.V. Zakreuski, P. Chyhayeu. *Modeling filter material with an orthonotropic structure based on woven wesh*. In MATEC Web of Conferences, (Vol. 317, 06001) (2020). Power Transmissions 2020.
4. A.Ph. Ilyushchanka, I.M. Charniak, A.R. Kusin, V.M. Kaptsevich, R.A. Kusin, N.V. Rutkovskaya, D. Shamal. The application of rapid-prototyping in the studing of samples of filtering materials based on woven nets, IS J. Machines. Technologies. Materials. 2021 Sofia, Bulgaria, Year XV, ISSUE 7.
5. I.M. Charniak, Kusin A.R., Kaptsevich V.M., Kusin R.A., Rutkovskaya N.V., Shamal D.V. Investigation of the filtration of liquid media through filter materials with an orthotropic structure based on woven meshes / Powder metallurgy / Republican Interved. collection of scientific papers / - 2021. - Issue 44.
6. A.Ph. Ilyushchanka, A.R. Kusin, I.M. Charniak, D.I. Zhehzdryn, R.A. Kusin, N.V. Rutkovskaya, E.N. Eremin, Ts.D. Dikova. Equipment for catalytic water purification with a gas-saturated reactor. In: Rackov, M., Mitrović, R., Čavić, M. (eds) Machine and Industrial Design in Mechanical Engineering. KOD 2021. Mechanisms and Machine Science, vol 109. (doi.org/10.1007/978-3-030-88465-9_17).
7. A.Ph. Ilyushchanka, I.M. Charniak, A.R. Kusin, M.M. Dechko, R.A. Kusin, N.V. Rutkovskaia, *Selection of factors and preparation of an experiment planning matrix for modeling filter materials with an orthotropic structure based on woven meshes*, In MATEC Web of Conferences Vol. **366**, 05001 (2022). Power Transmissions 2022. (doi.org/10.1051/matecconf/202236605001)/