INTERACTIVE STRUCTURE OF NANOFIBER FILTER

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Abstract:
This paper is concerned on the very interesting phenomenon of the polyurethane nanofiber filter used for liquid filtration. During tests of nanofiber layer in flowing water were observed extensive changes of water permeability during the time. These changes are reversible and therefore very interesting for cleaning phase of the filter. It is possible to say that this material acts as the "smart" filter.
Key words:
Nanofibers, water permeability, filters

1. Introduction:

An electrospinning technology is able to produce fibers with diameter in submicron range and created materials can filter off dangerous bacterias and viruses but also the tobacco smoke. The technology of the industrial nanofiber manufacturing was developed at the Technical University of Liberec, Department of nonwovens. The nanofiber materials usually used for filtration are: polyvinylalcohole (PVAL), polyurethane (PU) and polyamide (PA).
The greatest advantage of nanofibers is the rapid increase of the filtration efficiency with less significant decrease of the filtration permeability or less significant pressure drop derived from the filtration permeability [1].
This paper is concerned on the very interesting phenomenon of the polyurethane nanofiber filter used for liquid filtration. During tests of nanofiber layer in flowing water were observed extensive changes of water permeability during the time. These changes are reversible and therefore very interesting for cleaning phase of the filter. It is possible to say that this material acts as the "smart" filter.

2. Theory:

Structure of nanofiber web:
The nanofiber web made by "nanospider method" [2] is very thin web with surface isotropis structure (see fig.1) . For filtration application of this web is suitable to assume the pore as the incircle among the fibers. For liquid filtration applications we have to assume that the structure of nanofiber web is changing due to capillary forces. The wetting liquid draw fibers together and the structure is more tight and partly more non-uniform. These forces are important because the surface of nanofibers is great. When the filter is strapped it leads to reducing of it´s thickness.

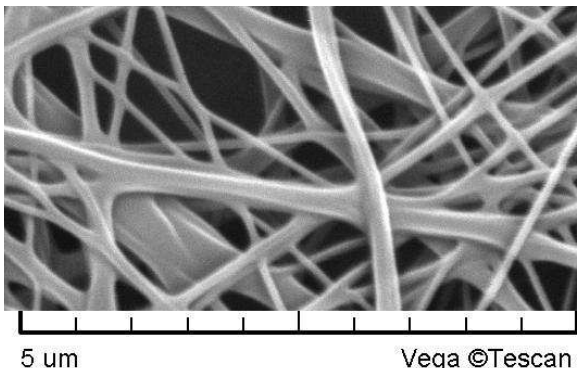

Figure. 1: Polyurethane nanofiber layers used for liquid filters.

Water permeability

Water permeability and pressure drop of the filter is very important attribute of the filtration process. It is inaccurate to recount the water permeability from the more common tested air permeability. Therefore it was developed testing device named WPT-1 (Water Permeability Tester – 1) where it is possible to set water flow in range 0 – 17 l/min and test pressure drop of the filter (see fig. 2). The procedure of the permeability test is following: The filter sample is placed on the cartridge holder. Then the water pump is turned on and the required value of water flow is set. After the stabilization of the flow the pressure drop is measured. Typical time of the stabilization is 10 – 60 seconds. This procedure is repeated for diferent values of water flow. Very important is the type of filter holder. It is patron filter, which is the most common for liquid filtration (see fig.3).

Figure. 2: Dynamic water permeability tester WPT-1

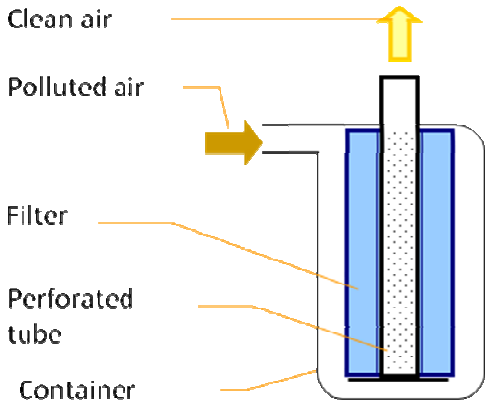

Figure. 3: Used filter holder

3. Experiment

Historical background:

The water permeability was successfully tested for a lot of filter samples include some samples with PA, PVA or PI nanofibers. Nevertheless the PU nanofiber layer was different.

When the water flow through the PU nanofibers started the value of pressure drop didn´t stabilised after 10 second but after 30 minutes and the value increased two times against the initial value. It looked that the filter was clogged by captured particles. Testing device was then switched off and left (it happened in lunchtime). After lunch when the water started again flow through the same sample – what surprise! The pressure drop was similar to initial value from the former experiment. The effect of slow increasing of the pressure drop has been observed again.

Description and discussion:

The effect of the change of pressure drop was repeated for different water flow. The values of pressure drops vs. different water flow for different time are shown in Fig. 4. From the test results we can name three main conclusions:

1) The relation between the pressure drop and water flow is not linear, which is assumption for the most common D´Arcy´s law. It looks, that the Hagen-Dupuit-Darcy´s law is more suitable [4]
2) The pressure drop for the same water flow is changing during the time and the stable value we obtain roughly after 25 minutes. Bigger difference was observed for higher values of water flow.
3) The change of the pressure drop during the time is repeatable – it means that the pressure drop increase is not caused by the filter clogging. Repeated change of pressure drop in time is shown in fig. 5.

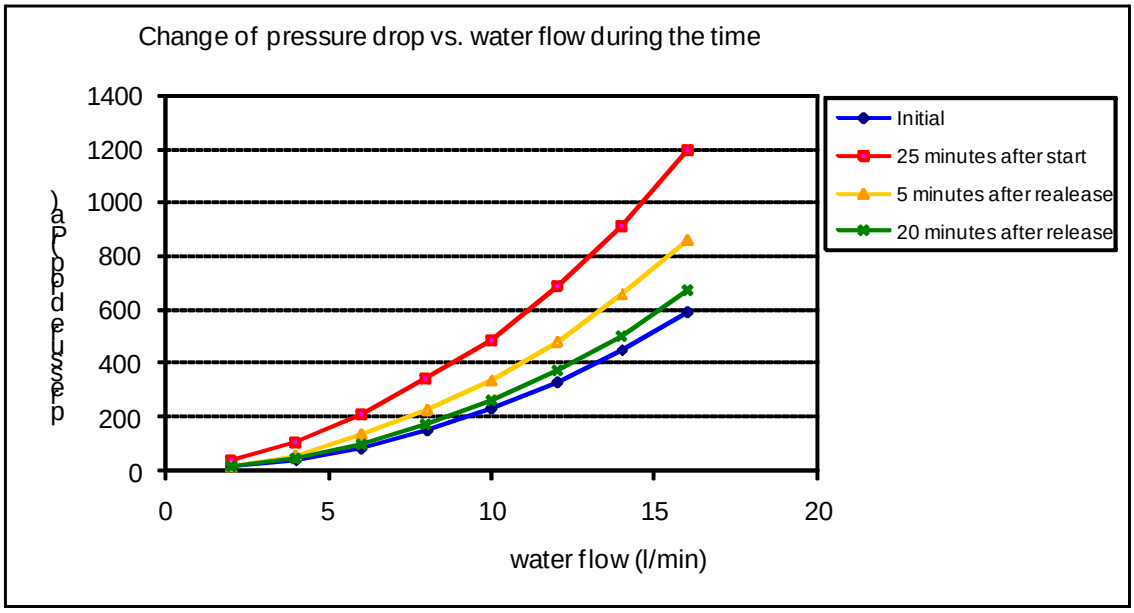

Figure. 4: Change of pressure drop of PU nanofiber layer

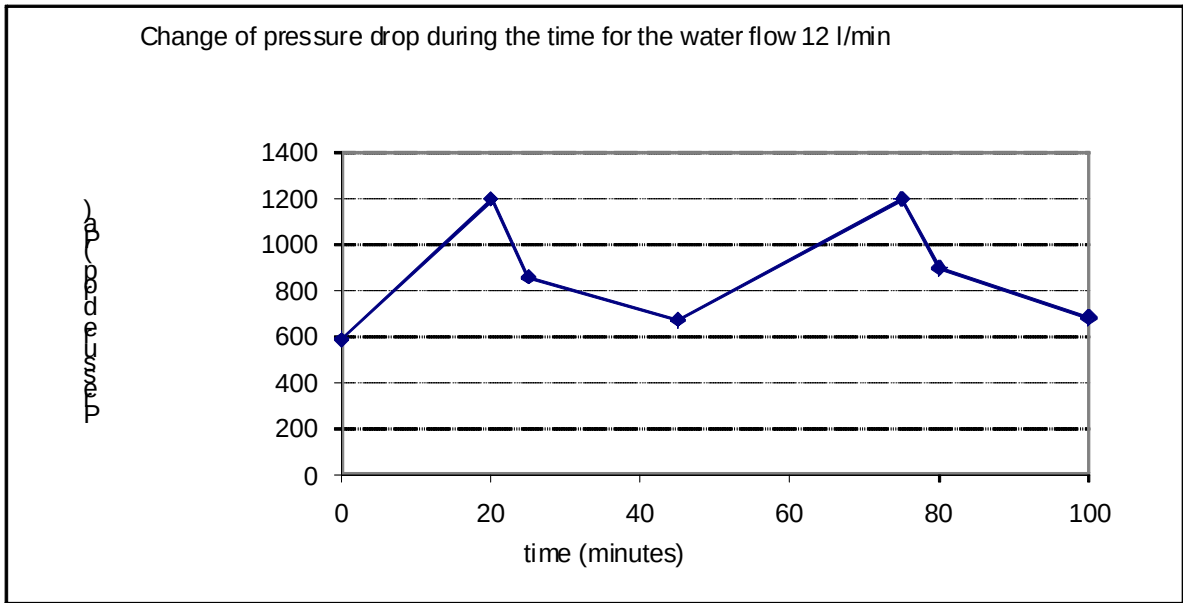

Figure 5: Change of the pressure drop during the time.

3. Conclusion:

For the liquid filtration efficiency is very important pore size. Particles are usually captured on the surface and creates so-called "filter cake" so it is suitable to clean filter after some time. During the filtration process it is necessary to have dense structure with small pores and high pressure drop. Nevertheless during the cleaning process it is necessary to have as much open structure as is possible. For this demand is very suitable described nanofiber filter with reversible variable structure. It is possible to say that the observed PU nanofiber layer works as a "smart" textile.

4. References:

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