Water membranes

Drying of water treatment membranes

The long term storage of PVDF-based membranes can lead to drying out, affecting performance and causing costly reimpregnation. This article discusses the problem of water treatment membranes stored for a long time and gives a possible solution for a cost saving method of keeping factory warranty.

PVDF-based membrane is a sponge-like polymer where the porous structure formed during the coagulation and the pores are filled with a solution of glycerol and water, which will remain there to maintain the formed state. Due to the nature of the membranes, water is dissipated thru the membrane wall from the solution after a period of time, so long storage can lead to drying out and therefore to performance degradation. According to the original equipment manufacturer's current policy, after one-year storage reimpregnation is necessary, what is costly for the customer, so we are looking for a solution to measure the permeability, and re-impregnate the membranes in case of need only.

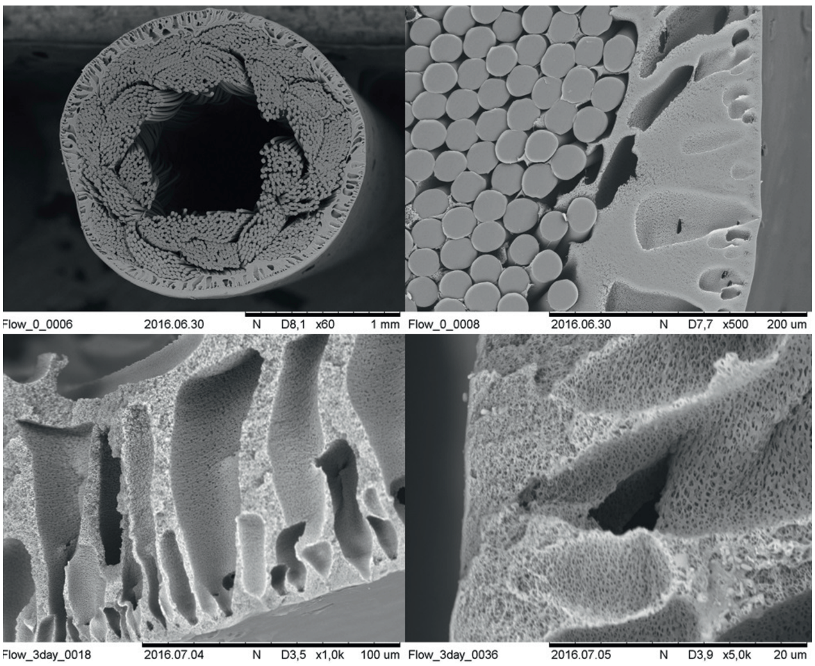

Figure 1. SEM pictures.

PVDF based membranes

Popularity of membrane water treatment technology started in the 40's of the last century and is still unbroken (Pendergast and Hoek, 2011). Its scope of use is extremely wide, including municipal wastewater treatment plants, drinking water facilities, seawater desalination plants, and industrial water production.

The key element of this technology is the membrane itself which determines the area of application, and has a direct impact on the capacity and efficiency of the process. In our days, almost without exception, in every industrial scale application, organic polymer based membranes are used. The importance of PVDF (polyvinylidene-difluoride) is outstanding. In recent years exceptional attention has been paid to this material

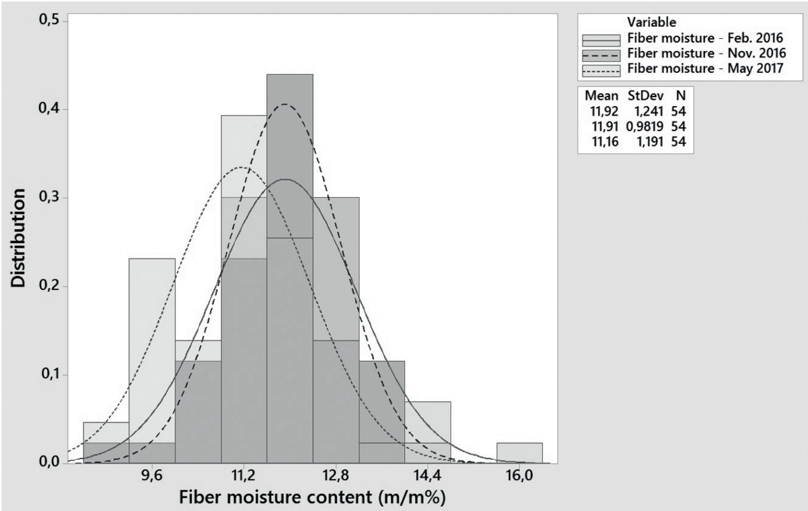

Figure 2. Histogram of fiber moisture.

by researchers and producers (Liu, et al., 2011).

PVDF is a semi-crystalline substance composed of (CH2CF2) units. It has a high mechanical and chemical resistance, quite stable under higher temperatures and extremely resistant against ageing. All of these features make this material a superb raw material for sheet and fiber membranes, too (Liu, et al., 2011).

Most commonly, its production is based on free radical or adjusted radical polymerization process of gaseous vinylidene difluoride molecules. Application of the material can happen via injection molding, sheet- and fiber membrane production (Zaviska, et al., 2013). Its use is not limited to micro- and ultrafiltration, but includes bioreactors, gas separation, and desalinating equipment, too (Kang, et al., 2014).

In case of the PVDF ultrafiltration membranes mentioned in this case study, pore size is between 0.01 – 0.1 microns. At Figure 1 a scanning electron microscopy (SEM) was used to show the structure of a PE braid supported membrane. These types of membranes are applicable for filtering virus and bacteria, separation of water and oil, and extraction of metal hydroxides, proteins, colloids, and other large molecule substances from water (Morao, et al., 2001).

Immersion

The main problems of PVDF membranes include fouling and drying. Fouling can be prevented by backflow or backwash with filtered clean liquid, and by the help of mechanical effect of air bubbles (Mulder, 1996). Drying can be prevented by impregnation, most widely used agent is water-glycerol mixture, or ensuring an environment with appropriate moisture content. The former one can be obtained by replacing the liquid phase in the pores (glycerol solution instead of pure water) while the latter by packing the membranes in wet state with a moisture-retaining material. Filtration capacity is a major issue for users, so they must be sure that the membrane is in the same condition as in the time of production.

Storage policy

When the product is stored on the end user's site in dry condition, the usual procedure is a full reimpregnation to keep the product's warranty. Generally, this process is made on the producer's factory, thus it is costly for the customer, and it also entails a high environmental load, since every cassette requires a cargo of a crate about 8 m3 cubic meters and 2 tons, to thousands of kilometers distance, and then prepares for further storage by using hundreds of kilograms of glycerol. This is the reason, why we try to find a way to decide on a sample based investigation if a membrane is acceptable or not, without moving the cassettes between countries.

With light of the above, the goal of investigation was to determine the moisture content and permeability of membranes delivered by manufacturer in 2013 and stored by customer, due to different business and economic reasons, two years longer than the warranty period. With data obtained from these measurements, and comparing them to values measured in production, expected working performance of membranes can be estimated, and thus, costly and unjustified rejection can be avoided.

Long-term storage

Membranes stored 12-20 month beyond producer's recommendation were investigated in the largest city of Oman Sultanate, Muscat, in the south-east region of the Arab Peninsula. Climate of the country is extremely hot, maximum summer temperature can reach a peak around 50 °C, and during winter, temperatures above 30°C are not uncommon. Yearly amount of precipitation in desert areas similar to that of the region chosen for storage is very low, about 100 mm (www.climateandweather.com, 2017).

The inspection was conducted in several phases. Product delivery finished by beginning of 2014. According to company

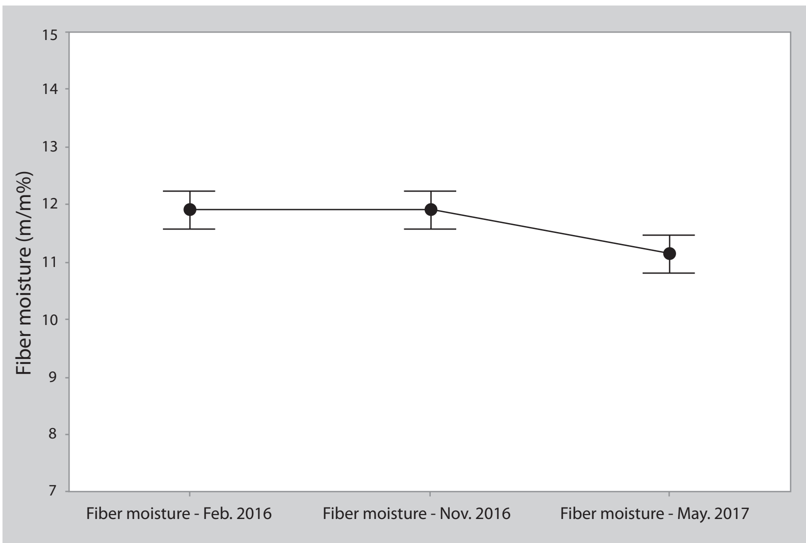

Figure 3. Interval plot of fiber moisture.