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SDI and MFI workshop: conclusions and recommendations

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- Problems of the SDI method and how to solve them.
- MFI (0.45) test as an alternative test for SDI.
- MFI-UF at constant pressure and constant flux as a tool in predicting particulate fouling.
- MFI-UF with different pore size in identifying different types of particulate fouling.
- Standardizing these methods and writing a Manual on Fouling Indices.

Problems with the SDI method and how to solve them

The accuracy and reproducibility of the SDI test is poor due to:

- The procedure of the method itself e.g. low values are inaccurate due to inevitable small errors in the measured time to collect the first filtered 500 mL, e.g. due to pressure variations or inaccurate time reading.
  Proposed remedial action: No suggestions.
- The principal weakness is that the flux decline is not measured after a fixed and certain flux decline has been observed or a certain and fixed volume has been filtered.
  Proposed remedial action: Determine the rate of flux decline over a period in which 75% plugging has taken place or measure the flux decline after a fixed volume has been filtered e.g. 15 L.
- The large effect of the membrane resistance of the membrane on the result of the test—the higher the resistance the lower the measured value.
  Proposed remedial action: Narrow the range of allowable resistance of membrane filters used or apply correction factor as proposed by Alhadidi.
- The absence of a correction for temperature—the higher the temperature the higher the measured value.
  Proposed remedial action: Measure SDI always at 25 °C or apply correction factor as proposed by Alhadidi.
- The observed variations in pore size and pore size distribution in the used membrane filters.
  Proposed remedial action: Identify/select/develop a type (brand) membrane with constant pore size and narrow pore size distribution. Develop simple method to verify these membrane properties.

The principal reason for most of the mentioned deficiencies is that the SDI test does not take into account the filtration mechanisms occurring during the test. As a result the test has no linear relation with colloidal/suspended matter.

MFI(0.45) test as an alternative test for SDI

The MFI test making use of membrane with pores of 0.45 μm has the following advantages:

- The test is based on the occurrence of cake filtration during a certain period of the test.
- The index is normalized for temperature and pressure.
- The membrane resistance does not play a role by definition.
- The MFI has a linear relation with colloidal/suspended matter.

Remark 1: There is a need for identifying a membrane type (brand) with constant pore size and narrow pore size distribution and a need for a method to verify these membrane properties. A method to correct for variations has been developed quite some time ago.

Remark 2: The MFI test needs somewhat more advanced equipment than the SDI test. However, it is much more reproducible and accurate.

Value of SDI and MFI (0.45) tests in predicting fouling RO/NF membranes

The value of SDI and MFI (0.45) in predicting particulate fouling of RO/NF membranes is limited or absent for:

- Fouling of the membrane surface: Translating SDI directly into fouling rate results in unrealistic high fouling rates. Predicting fouling based on MFI (0.45)—assuming cake filtration—results in a too low fouling rate. MFI measured with membranes with smaller pores gives values which result in more realistic rates of fouling.
- Fouling/clogging spacer or membrane bundles: It cannot be excluded that SDI and MFI (0.45) have some predictive value with respect to this type of fouling. However, the dimensions of the openings between membrane surface and spacer, and openings between fibers are 700 and 30 μm, respectively, which is much larger than the pores of 0.45 μm in the membranes applied.

MFI-UF at constant pressure and constant flux as a tool in predicting particulate fouling

MFI measured at constant pressure with membranes having pores down to 5 kDa gives much higher values than measured with membranes with pores of 0.45 μm. The smaller the pores size the higher the MFI.

The value of MFI turns out to be pressure dependant—even after normalizing—indicating that compression of the cake layer occurs. This phenomenon makes it impossible to predict accurately the rate of fouling.

As a consequence, MFI constant flux has been developed. Testing different types of water results in clear evidence that the MFI is flux dependant—the lower the flux the lower the MFI.

The MFI constant flux can be applied—in principal—in predicting the rate of fouling of RO/NF and predicting the rate of fouling of UF membranes system during the first cycle.

Application of MFI-UF with different pore size in identifying different types of particulate fouling

In predicting the rate of fouling of RO/NF membranes requires insight in the fraction of particles arriving at the membrane surface that really deposits. This fraction-called deposition factor cannot be predicted. The only option to know the level of this factor is to measure it in pilot and full-scale plants.

Deposition factors measured in practice vary between zero and one. However, in some cases, values below zero and above are measured. It is recommended to measure the deposition factor in as many plants as possible to get a reliable insight in levels of this deposition factor under practical conditions.

Fractionation of particulates making use of MFI measured with different pore sizes—down to just above nanofiltration—gives potentially new insights in the contribution of small (and organic) particles. The proposed method is recommended for application on different types of water.

Standardizing methods and writing a Manual on Fouling Indices

A strong need has been identified for official standardization of the most practical proposed improvements for SDI and the ''newly'' developed methods based on the principles of MFI.

We will draw the attention of ASTM to the developments presented at the Workshop to suggest that they incorporate the proposed improvements in SDI by incorporating MFI (0.45) officially as a standard method and to incorporating MFI-UF at constant flux as well.

A Guidance Manual on Fouling Indices is planned.