DEMEAU Workshop

Hybrid Ceramic Membrane Systems

June, 11 2015
Trinkwasseraufbereitungsanlage Roetgen Germany

Emiel Nijhuis
RWB, Almelo
DEMEAU Workshop
*Hybrid Ceramic Membrane Systems*

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- Introduction RWB and META WaTER
- The ceramic membrane filtration system
- Drinking water applications
- Water reuse, recycle and/or reclaim applications
- Summary
Introduction

Red, White and Blue

Company facts

- Founded in 2001, Almelo The Netherlands
- Nett turnover 2014: € 13,7 million
- 64 employees with an average experience of 15 years in water treatment projects
- ISO 9001:2000 and SCC** certified
- Process -, drinking - , waste-water applications
Introduction

**METAWATER**

1919
- Establishment of NGK Insulators, Ltd.

1923
- Establishment of Fuji Electric Manufacturing Co., Ltd.

2007
- Basic agreement of Business merger

- **April 2008**
  - Establishment of METAWATER Co., Ltd.

- **No. of employees**
  - 1.860

- **Head office**
  - Tokyo/Japan

- **Branch offices**
  - Japan (>40)
  - Europe, USA, Korea, China, Vietnam
Introduction

**METAWATER**

- Ceramic membrane has No.1 share in Japan
- 70% of total capacity is the Surface water
- METAWATER has a lot of experiences of surface water treatment.

<table>
<thead>
<tr>
<th>Membrane generation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of plants</td>
<td>99*</td>
</tr>
<tr>
<td>No. of plants</td>
<td>18</td>
</tr>
<tr>
<td>No. of plants</td>
<td>50*</td>
</tr>
<tr>
<td>No. of plants</td>
<td>31</td>
</tr>
<tr>
<td>Total capacity (m³/day)</td>
<td>434.000</td>
</tr>
</tbody>
</table>

As of Mar/2010

<table>
<thead>
<tr>
<th>Capacity</th>
<th>434,000 m³/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of plants</td>
<td>99*</td>
</tr>
<tr>
<td>Total capacity (m³/day)</td>
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The ceramic membrane filtration system

**History**

<table>
<thead>
<tr>
<th>Year</th>
<th>Generation</th>
<th>Dimension</th>
<th>Pore size</th>
<th>Membrane area</th>
<th>Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>1st Generation</td>
<td>30mm O.D. x 1,000mm L</td>
<td>0,1 μm</td>
<td>0,48m²</td>
<td>2,5mm I.D., 61ch</td>
</tr>
<tr>
<td>1997</td>
<td>2nd Generation</td>
<td>180mm O.D. x 1,000mm L</td>
<td>0,1 μm</td>
<td>15m²</td>
<td>2,5mm I.D., 2,000ch</td>
</tr>
<tr>
<td>2002</td>
<td>3rd Generation</td>
<td>180mm O.D. x 1,500mm L</td>
<td>0,1 μm</td>
<td>25m²</td>
<td>2,5mm I.D., 2,000ch</td>
</tr>
</tbody>
</table>

- **1st Generation**: DWTP in Miyazaki (1996, 550m³/day)
- **2nd Generation**: DWTP in Fukui (2001, 38,900m³/day)
- **3rd Generation**: DWTP in Yokohama (171,000m³/day)
The ceramic membrane filtration system

Membrane filtration cell
(φ2.5mm)

Raw water

Filtrate collection cell

Filtrate
The ceramic membrane filtration system

**Backwash**

<table>
<thead>
<tr>
<th>Schematic diagram</th>
<th>Filtration process</th>
<th>Backwashing process</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; step: backwash</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operation Mode</th>
<th>Dead-end filtration</th>
<th>backwash by filtrate</th>
<th>Discharged by air flush</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>5 - 100kPa</td>
<td>max. 500kPa</td>
<td>max. 200kPa</td>
</tr>
<tr>
<td>Duration</td>
<td>1 - 6hr</td>
<td>2 - 20 sec.</td>
<td>a few seconds</td>
</tr>
<tr>
<td></td>
<td>less than 1 min. (in total)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The ceramic membrane filtration system

**Capacity**

<table>
<thead>
<tr>
<th>Year of Order</th>
<th>1st generation</th>
<th>2nd generation</th>
<th>3rd generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

WTP capacity (m$^3$/day)
The ceramic membrane filtration system

**Design Flux**

<table>
<thead>
<tr>
<th>Year of Order</th>
<th>Design Flux (LMH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>80</td>
</tr>
<tr>
<td>1998</td>
<td>120</td>
</tr>
<tr>
<td>2000</td>
<td>160</td>
</tr>
<tr>
<td>2002</td>
<td>200</td>
</tr>
<tr>
<td>2004</td>
<td>240</td>
</tr>
<tr>
<td>2006</td>
<td>280</td>
</tr>
<tr>
<td>2008</td>
<td>320</td>
</tr>
<tr>
<td>2010</td>
<td>360</td>
</tr>
</tbody>
</table>
The ceramic membrane filtration system

**Benefits**

- No membrane breakage / long during 100% integrity
- Long service life / 10 year - 100% guarantee
- Low CIP frequency
- Robustness against raw water fluctuations
- High recovery rate & easy handling of backwash waste
- Less malfunction and break down
- Low power consumption and low O&M cost
- Excellent chemical resistance
- High reduction of bacteria and viruses in combination with PACI
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Drinking water applications
Andijk 3, pilot phase 1 (2006)
Drinking water applications

Drinking water applications
Andijk 3, pilot phase 3 (2012) C-200

199 membrane elements

108 membrane elements
Drinking water applications
*Andijk 3, 2014 (The Netherlands)*
Drinking water applications

Andijk 3, innovative

CeraMac®

*an innovative ceramic block design*

- reduced foot print
- reduced use of stainless steel
- reduced number of valves
- lower energy consumption (backwash)
- higher productivity at short backwash intervals
Drinking water applications
South West Water (UK),
Pilot Six® - CeraMac® (2013-2014)
Introduction RWB and METAWATER

The ceramic membrane filtration system

Drinking water applications

Water reuse, recycle and/or reclaim applications

Summary
Water reuse, recycle and / or reclaim Technologies

Cost reduction mechanism

<table>
<thead>
<tr>
<th>Ceramic Membrane</th>
<th>Polymeric Membrane</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>w/o ozonation</strong></td>
<td></td>
</tr>
<tr>
<td>Coagulation</td>
<td>Coagulation</td>
</tr>
<tr>
<td>Ceramic membrane</td>
<td>Ceramic membrane</td>
</tr>
<tr>
<td>w/ ozonation</td>
<td>w/ ozonation</td>
</tr>
<tr>
<td>Ozonation</td>
<td>Ozonation</td>
</tr>
<tr>
<td>Coagulation</td>
<td>Coagulation</td>
</tr>
</tbody>
</table>

*Flux doubled*
Water reuse, recycle and / or reclaim

Operation results

Effect of pre-ozoneation and coagulation

Fig.1 Pre-ozoneation effect on TMP increase rate

TMP increase rate became 1/4 by pre-ozoneation.
Design condition: pre-ozoneation

Fig.2 Coagulation effect on TMP increase rate

TMP increase rate became 1/10 by coagulation.
Design condition: coagulation
Water reuse, recycle and / or reclaim
Singapore demoplant
Water reuse, recycle and / or reclaim

Singapore demo plant

Phase 1: clarified water

- September 2011 – Februari 2012

- Found optimal operation:
  - flux : 200 l/m h
  - BW-frequency : 2/h
  - EBW-frequency : 2-3/d (NaOCl 100 ppm)
  - : 0-1/d (HCl pH=2 with 100 ppm H2O2)
  - CIP frequency : >90 days
  - water recovery : >95%
Water reuse, recycle and / or reclaim
Singapore demoplant

Phase 2: clarified water with O3

- July – December 2012
- Target ozone concentration on membrane surface 0.5 mg/l
- Ozone dose 1.3 – 1.8 mg/l

- Found optimal operation;
  - flux : 350 l/mh
  - BW-frequency : 2/h
  - EBW-frequency : 0-1/d (HCl pH=2 with 100 ppm H2O2)
  - CIP frequency : >90 days
  - water recovery : >95%
RE-use of backwashwater  PS Wierden
Comparative pilot test 2009

Re-use of backwash water
Comparative study of 6 MF/UF membranes
Water Re-use 3.0
Vitens PS Wierden

conventional       water re-use 1.0       water re-use 2.0       water re-use 3.0

Ceramic
Process parameters

- Iron content feed: 80 – 200 mg/l
- Iron content permeate: < 0,03 mg/l
- Turbidity: < 0,2 FNU
- Microbiological analyses: according to Dutch regulations
- E-coli reduction: > log 4
- Recovery: >98 %
- Flocculant dosing: 2-4 mg/l
- Flux nominal 85 lmh
- Flux maximal 115 lmh
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*Ceramics the best option in different applications!*

- Start with a cost – benefit analysis
- Proven technology in drinking water
  - No membrane breakage / 100 % integrity
  - Low CIP frequency and low O&M costs
- First full scale water reclaim projects
  - High flux especially with dosing of O₃
  - 10 year 100 % guarantee
  - Robust system during fluctuations
- CeraMac®
  - Reduced foot print / valves / stainless steel
  - High productivity at short backwash intervals
Future options for ceramics

- Oil contaminated water
- Ballast water
- Manure / digestate treatment
- Swimming pools
- MBR side stream applications

Full scale design based on pilot tests!