TECHNOLOGICAL MILESTONES IN BEER MEMBRANE FILTRATION

DEVELOPMENTS SINCE THE START-UP OF THE BMF IN MADRID IN 2004

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CONTENT

• Introduction Membranes

• Beer & Membranes – The Development Phase

• The experiences of Heineken Madrid with the BMF

• The technology roadmap till today

• Challenges of the future – Directions for tomorrow
FRANKLIN’S QUOTE

"IN WINE THERE IS WISDOM –
IN BEER THERE IS FREEDOM –
IN WATER THERE ARE BACTERIA"
SMALL & LARGE MEMBRANES – EXAMPLE WATER

The Pen - 0.008 l/s

Sulaibiya - Kuwait

Full-Scale Plant – 4,000 l/s
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MARKET DRIVERS

- CONSISTENCY OF THE BEER QUALITY
- NEED TO REDUCE OPERATIONAL EXPENDITURES IN GLOBAL COMPETITIVE ENVIRONMENT
- AMBITIOUS SUSTAINABILITY GOALS TO REDUCE WATER, ENERGY AND SOLID WASTE FOOTPRINTS
- NEED FOR MORE FLEXIBILITY IN THE BREWING PROCESS DUE TO PRODUCT DIFFERENTIATION
BEER & MEMBRANES - DEVELOPMENT

CHOICES TO MAKE...

- Membrane material ~ Water Filtration → PolyEtherSulphon
- Pore size ~ Beer quality
- Cross-flow speed ~ Run volume – Energy consumption
- Flux optimization
- Cleaning /Regeneration ~ Run volume – Chemical consumption

...PRODUCTS TO CHOOSE FOR!
THE FIRST BMF’S

• Heineken Madrid (Spain)
• Heineken Warka (Poland)
• Oettinger (Germany)
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Technological milestones in beer membrane filtration

Developments since the start-up of the BMF in Madrid in 2004
2013 Madrid Brewery overview

- Volume packaged 2,525,000 hls
- Main brands, Amstel (35%), Heineken (20%) and Cruzcampo (15%)
- Non-alcoholic beers represented 26%
- Great complexity at BBT cellar, 32 different beers
- Two filtration lines, Kieselguhr (400 hl/h) and BMF (400 hl/h)
- BMF 2013 volume 1,090,000 hls (undiluted beer) → 47% total
2013 BMF Performance. Skid 1 runlenght

**Skid 1 2013**

<table>
<thead>
<tr>
<th>Permeate Flow</th>
<th>100</th>
<th>hl/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume filtered (undil.)</td>
<td>280242</td>
<td>hls</td>
</tr>
<tr>
<td>Nº Backwash</td>
<td>951</td>
<td>294,7 hls/BW</td>
</tr>
<tr>
<td>Nº CIP</td>
<td>68</td>
<td>4121,2 hls/CIP</td>
</tr>
</tbody>
</table>

- Average first running time 48 hours
- In volume means (4 skids) 20,000 hls before CIP
2013 BMF Performance. Costs *

CIP Liquids
Real  0,028 €/hl
Caustic (50%)  0,017 €/hl

Utilities
Water (CIP)  0,001 €/hl
DAW  0,034 €/hl
CO2  0,001 €/hl
Electricity  0,013 €/hl

Other cost
Membranes  0,047 €/hl
Security filter  0,011 €/hl
Extract losses (0,30%)  0,040 €/hl

TOTAL  0,191 €/hl

* Data for undiluted beer
BMF Madrid 10 year experience

*FOPI Madrid week 10/2013

<table>
<thead>
<tr>
<th>Year</th>
<th>Membranes total time installed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
</tr>
</tbody>
</table>

Strengths:
- No quality issues since very first day !!!
- Environment and Healthy, no more kieselguhr !!!
- Membranes lifetime increased *
- Easy operation, no activities out of control *
- No special maintenance requests

Weaknesses:
- Impact of betaglucans in filterability
- Too long beer changes time *
- Dilution factor due to Backwash

HEINEKEN
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PROCESS CHOICES – GOING FOR THE LOWEST TCO

- First BMF’s are continuous
- More focus on batch lines - Capex
- Now batch & continuous – 90% is batch

- To centrifuge or not to centrifuge
## IMPROVEMENTS IN THE LAST 10 YEARS

<table>
<thead>
<tr>
<th>IMPROVEMENT</th>
<th>BENEFITS</th>
<th>€($)</th>
<th>M2</th>
<th>FLEXIBILITY</th>
<th>SUSTAINABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back Flush → Soak Back Flush</td>
<td>No water tank – Smaller pipe diameter – Smaller pump – Lower water consumption</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Synflux → REAL</td>
<td>One CIP tank less – Longer life time membranes — Simpler CIP process</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Jet stream pump for chemical dosing (‘Venturi’)</td>
<td>Robust dosing process – Low maintenance costs</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simpler design membrane skid</td>
<td>Lower amount of components – Standardized filtration area</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module End cap 8” connection</td>
<td>Better design – More hygienic</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Compact concept for up to 250 hl/h</td>
<td>Plug &amp; Play – Prefab &amp; Tested – Highly Standardized – Integrated Carboblender</td>
<td>✓</td>
<td>✓</td>
<td></td>
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</tr>
</tbody>
</table>
CLEANING OF THE MEMBRANES

Till 2009

• Hypochlorite with a specific katalysator (Synflux) for oxidation of polysaccharides
• Back Flush at high flow

Reasons

• Hypochlorite is aggressive towards stainless steel and membranes
• Halogenated organic compounds

Deliverables

• Larger run volume
• Longer life time membranes (2-3 years)
• Lower water consumption
• No water tank & No specific CIP tank → 25% lower footprint

From 2009

• REAL at 70oC – oxidative agent – better removal of fouling
• Soak Back Flush – contact is more important then flow
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TARGETS OF TODAY - CHALLENGES OF TOMORROW

WHAT

• Low Capex and low Total Cost of Ownership – More and more due to consolidation in the brewing industry

• Sustainability - Water & energy consumption – (Solid) waste streams

• Voice of the customer - A product fitted to the specifications & conditions of the brewer – ‘Fit for purpose, fitness for use’ (Joseph Juran)

HOW

• Simplicity in process & design – Minimum of hardware and components and a maximum of ease of operation

• Maximized output - Optimal cleaning process and the best membranes

• Optimal fit to all kind of breweries – Compact, batch & continuous filter lines – Craft brewers

• Efficiency - Standardization