AMB Industry Trends, Challenges and Opportunities
Who is Waukesha Bearings?

1972
Magnetic Suspension Research Group is founded at University of Sussex (U.K.).

1987
Glacier Magnetic Bearings is founded with a technology transfer from the University of Sussex to Glacier Metal Company.

1990-95
A U.S. magnetics branch is established. The company begins development work for the U.S. Department of Defense.

1998
The company becomes the sole magnetic bearing supplier for 23MW motors and compressors for Groningen, Europe’s largest natural gas field.

2001
Glacier RPB is acquired by Waukesha Bearings and becomes Waukesha Magnetic Bearings.

2008
Magnetic bearing projects lead Waukesha Bearings to establish a branch in Russia. 46 compressors in operation.

2017
WMB celebrates 30 years of operation.
Why this talk? (Personal reflections)

Exciting toys!

Natural Gas Pipeline Compressor

Smart people across a wide range of engineering!

1.5 tonne AMB test rig
Why this talk? (cont.)

It comes with a smile

“What we do is magic”
Why this talk? (cont.)

Original University Controller (circa 1987)

Industrial Controller (circa 1992)
Core Technologies (competencies)

Mechanical

Rotor Dynamics and Control

Electronics & Electrical

Embedded Software
What a range of applications!

- Oil
- Natural Gas Transmission
- Steel Industry
- Hydrogen
- Waste Water
- Military
- Semi-Conductors
- Energy Storage
- Nuclear
- Sub-sea
- HVAC
- Waste Heat Recovery
- Hydrocarbon Processing
- Medical
- Space
- Machine Tools

**Legend:**
- Mature Technology
- Qualified Technology
- Prototype Technology
- Mature Market
- Fast Growth Market
- Slow Growth Market
- Declining Market
Unfulfilled Potential?

Rolling Element Market

Fluid Film Market

AMB Market
Why the false starts?

**Inherent factors**

- AMB vs FF equivalent load capacity
- Custom Engineering =
- Diverse skills requirement

**External factors**

- Compliance Concerns
- Global Economy
- Supply Chain
- Competition for Skilled Labour
Net Zero Objectives for key industries
## AMB contribution towards net zero

### How AMBs Can Contribute

- Improved efficiency of existing machines and systems
- Enabling of new technologies
- Carbon capture and sequestration

### High Efficiency HVAC Centrifugal Compressor

![Image of High Efficiency HVAC Centrifugal Compressor](image)

### CO2 Re-Injection Compressor

![Image of CO2 Re-Injection Compressor](image)
Nuclear

Fuel Ball Blower

Helium circulator
Hydrogen

**H2 Production**
- Renewable energy sources
- Electrolysis
- Green H2
- SMR (Semi-Sweet Mash Refining)
- Blue H2
- CO2 Capture

**Transport**
- NG Blend
- H2 Pipeline
- Liquefaction
- LHOC
- Ammonia/Methanol
- CH4/H2 Blend

**Utilization**
- 10-30% H2 Gas Turbine
- Industrial
- Chemical Feedstock
- Mobility Applications
- 100% H2 Gas Turbine
- Power Generation
- Building H&P
- NH3/Methanol Gas Turbine

**Key**
- Reciprocating Compressor
- Centrifugal Compressor
- Gas Turbine

Copyright © 2023 Waukesha Bearings Ltd. 18th International Symposium on magnetic bearings, Lyon, France
Flywheels

From ISMB 15 Keynote by Calnetix Technologies, by permission of Calnetix Technologies
How can we support those industries?

- Controller & Sensor Technology for very high speed machines
- Efficient Implementation of existing Nuclear technology
- Innovative designs for challenging H2 rotor-dynamics
- Materials for H2
Price / Technology?

Traditional String with Plain Bearings
- Low speed synchronous motor
- High speed compressor
- Oil lubricated bearings
- Dry gas seals
- Cellar depth 1 m

VSCU: L x B x H = 16 x 4 x 4, total weight 113 ton
Compressor building: L x B = 34 x 13, max. height: 8 m

Dry-dry system with mag. bearings
- Noise isolation on equipment
- L x B x H: 10.3 x 4.3 x 4.2

Main items:
- Low speed compressor
- High speed synchronous E-motor
- Direct air cooled E-motor
- Active magnetic bearings
- Dry gas seals
- Weight: 89 ton

Compressor Building

Compressor without Building

Investment Costs Comparison

<table>
<thead>
<tr>
<th></th>
<th>BC + EM</th>
<th>AL + EM</th>
<th>BC + GT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor</td>
<td>AMB</td>
<td>AMB</td>
<td>AMB</td>
</tr>
<tr>
<td>Driver</td>
<td>AMB</td>
<td>AMB</td>
<td>AMB</td>
</tr>
<tr>
<td>Building</td>
<td>AMB</td>
<td>AMB</td>
<td>AMB</td>
</tr>
</tbody>
</table>

Total Cost of Ownership (%)

<table>
<thead>
<tr>
<th></th>
<th>BC + EM</th>
<th>AL + EM</th>
<th>BC + GT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investments</td>
<td>AMB</td>
<td>AMB</td>
<td>AMB</td>
</tr>
<tr>
<td>Fuel</td>
<td>AMB</td>
<td>AMB</td>
<td>AMB</td>
</tr>
<tr>
<td>Maintenance</td>
<td>AMB</td>
<td>AMB</td>
<td>AMB</td>
</tr>
<tr>
<td>Emissions</td>
<td>AMB</td>
<td>AMB</td>
<td>AMB</td>
</tr>
</tbody>
</table>
Retrofit Considerations

- Sensor Compatibility
- Amplifier voltage
- Magnet current
- Field Cable re-use – yes/no
- Customer Logic Interface
- Input Power systems
- Footprint
What happened to IIoT?

AMB: Naturally born IIoT ...COVID Resistant
Standardization and Interoperability

**AMB System Architecture**

- Sensor Drive
- Digital Controller
- Amplifiers
- Input Power System

**Interoperability**

- Vendor A
  - Input Power
  - Amplifier
  - Sensor drive
  - Digital Controller

- Vendor B
  - Input Power
  - Amplifier
  - Sensor drive
  - Digital Controller
Closing remarks

The Future is Bright for AMBs

Acknowledgements

Andrea Masala – who co-authored this presentation.