Permanent Magnet Motors for Cooling Tower Applications

PAUL HUMBERT
TOWER ENGINEERING, INC
Conventional Drive System Arrangement
PM Motor Fan Drive System
Features & Benefits

- Permanent Magnet Technology
- Improved Reliability
- Adjustable Speed Capability
- Quiet Operation
- Built-in Anti-rotation Capability
- Built-in Motor Heater Capability
- Reduced Maintenance Costs
- Improved Safety
- Soft Start Tower Stress Reduction
- Long Term Warranty
- Lower Energy Consumption
One piece end plates on frame for precise bracket fits.

Stator slots integral to laminated frame. One piece frame/stator results in superior heat dissipation.

Welded thru bolts for rugged construction.

Totally finned surface for optimized heat transfer.
Inpro Labyrinth Seal

- Ingress Protection - IP56
  - The first numeral defines the degree of protection against dust.
    - 5 = Dust protected
    - 6 = No Ingress of dust per IEC 34-5 this degree of protection is not applicable to rotating equipment such as motors and generators but applicable to electrical enclosures
  - The second numeral defines the degree of protection against water.
    - 5 = Protected against water jets
    - 6 = High pressure jets from all directions, (limited ingress permitted)
Improved Reliability

- 100% grease fill rate.
  - Eliminates voids.

- Mobil SHC460 & 220 Synthetic Grease.

- 63 & 62 series ball bearings for smaller HP ratings.

- Ceramic coated OD of ODE to prevent current damage. Ceramic sleeve for 5800 frame motors.

- AC bearings for large HP ratings or to increase L10 life.

- Bearing L10 life min 100,000 hrs.

- Re-lubrication interval based on 17,500 hrs of operation 40° C ambient & 750 FPM Min airflow.
  - Goal of lubed for life in future.
Improved Reliability

- Vacuum Pressure Impregnated (VPI) Insulation System
  - Insulation System developed for the most demanding applications. (i.e. Navy Service, Off Shore Oil Drilling, Submersible Motors)
### Quiet Operation

#### Loaded Noise Levels (A-weighted)

<table>
<thead>
<tr>
<th></th>
<th>High Speed</th>
<th>Low Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Induction NEMA</td>
<td>82.3 dBA</td>
<td>74.4 dBA</td>
</tr>
<tr>
<td>Motor Tower</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM Motor</td>
<td>77.7 dBA</td>
<td>69.0 dBA</td>
</tr>
</tbody>
</table>

- Clemson University Test Data
- Data verified by Clean Air Engineering (3rd Party Testing Agency)
Reduced Maintenance Costs

- No Oil Changes or Leaks
- No Gear Reducer Change-outs
- No Drive Shaft Change-outs
- No Flex Disc Change-outs
- No “Tricky” Re-alignment Issues

Substantial Savings on Multi-Cell Cooling Towers
Improved Safety

Conventional Drive Equipment Multi-Component Failure
Increased Efficiency

- Permanent Magnet (PM) motors provide higher efficiencies.
- Limitations of motor control and magnet material performance/cost previously restricted their use.
- Dramatic improvements represent a viable alternative today.

1 - ½ % to 2 - ½% Increased Efficiency
Increased Efficiency

Mechanical Losses

🌟 Conventional Drive Trains lose energy through couplings, drive shafts and gear reducers.

🌟 Gear efficiencies are typically stated at 96% (4% transmission loss).

🌟 Actual transmission losses are greater ...**up to 15**%. 
## Lower Energy Consumption

<table>
<thead>
<tr>
<th>Clemson University</th>
<th>2-Speed, 326T Induction Motor</th>
<th>PM Motor FL4493</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan Load</td>
<td>41.5 Hp</td>
<td>41.5 Hp</td>
</tr>
<tr>
<td>Gearbox and couplings Efficiency</td>
<td>90.2%</td>
<td>N/A</td>
</tr>
<tr>
<td>Motor Horsepower</td>
<td>46.0 Hp</td>
<td>41.5 Hp</td>
</tr>
<tr>
<td>Motor Efficiency</td>
<td>90.0%***</td>
<td>93.1%</td>
</tr>
<tr>
<td>Drive (VFD)</td>
<td>N/A</td>
<td>98.8%</td>
</tr>
<tr>
<td>Input kW</td>
<td>38.1</td>
<td>33.6</td>
</tr>
<tr>
<td>Total Efficiency</td>
<td>81.2%</td>
<td>92.0%</td>
</tr>
</tbody>
</table>

- **Clemson University Test Data**
- Existing motor is 22 years old; new induction motor is 93.5% efficient.
- Gearbox manufacturer states gearbox efficiency at 96%, but test data indicates mechanical system (gearbox, couplings & driveshaft) is 90.2%.
- Data verified by Clean Air Engineering (3rd Party Testing Agency).

*** Published data.

4.5 kW Savings
Lower Energy Consumption

Alcon Laboratories
North Cogen Plant
Ft Worth, TX

Two Cells
› One with existing geared solution
› One with a Direct Drive Solution

100 HP Direct Drive Motor
› Speed 217 rpm

<table>
<thead>
<tr>
<th>Arrangement</th>
<th>Fan Design</th>
<th>Fan Speed</th>
<th>Fan Pitch (Average)</th>
<th>Present Motor HP</th>
<th>Measured Power Full Load Full Speed</th>
<th>Equivalency Ratio</th>
<th>Full Load Estimated Power Usage</th>
<th>Energy Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Drive</td>
<td>16KW10</td>
<td>217</td>
<td>15.6°</td>
<td>100</td>
<td>80 KW</td>
<td>1X</td>
<td>80 KW</td>
<td>8.31%</td>
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<tr>
<td>Geared</td>
<td>16H10</td>
<td>223</td>
<td>7.2°</td>
<td>125</td>
<td>87.25 KW</td>
<td>1.983X</td>
<td>87.25 KW</td>
<td></td>
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</tbody>
</table>
Test of Baldor Permanent Magnet Motor
in OCT26 Cooling Tower
performed by
Vestas Industrial Cooling & Baldor Electric Germany Gmbh
Measured on 8 April 2011 by independent 3rd party

<table>
<thead>
<tr>
<th>[kW] &amp; [%]</th>
<th>146</th>
<th>175</th>
<th>220</th>
<th>236</th>
<th>262</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption kW Gear setup</td>
<td>7.34</td>
<td>11.95</td>
<td>24.2</td>
<td>25.5</td>
<td>35.3</td>
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<tr>
<td>Consumption kW PM</td>
<td>5.98</td>
<td>10.05</td>
<td>21.7</td>
<td>23.3</td>
<td>31.5</td>
</tr>
<tr>
<td>Saving %</td>
<td>18.5</td>
<td>15.9</td>
<td>10.3</td>
<td>8.6</td>
<td>10.8</td>
</tr>
<tr>
<td>Saving kW</td>
<td>1.36</td>
<td>1.9</td>
<td>2.5</td>
<td>2.2</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Test of Baldor Permanent Magnet Motor
Baldor FL4485 Frame
37kW, 250 RPM, 400 V operating conditions at full load.
Hansen Gearbox on old solution referenced to be 97% efficient.
Energy savings ranged from 8.6% - 18.5% depending on speed.

Lower Energy Consumption
Merck ran efficiency studies of their existing towers against the installed CTD products. $53K Savings in Energy over three months.
Lower Energy Consumption

**Cooling Tower Installation Comparison**

*Energy Savings*

- **Denmark NL Pharmaceutical application**
  - Cell 5: average = 35.06 kW Traditional solution
  - Cell 4: average = 31.14 kW Baldor Solution
    - Saving 3.92 kW = 11.2%

- **Cargill – Turkey**
  - Analysis - Avg over 2 month period
  - 21kW vs 25kW which will be around a 16%
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Questions?