The Direct Drive Cooling Tower (DDCT)

A reliable and efficient cooling solution for the food and beverage industry

Michael Klein
Agenda

The cooling tower application
Innovative motor technology to improve cooling tower performance
Proven motor design
Measurements from field installations
Summary
The presenter

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Food and beverage industry uses a lot of cooling towers
Cooling towers
Examples of most typical solutions

**Wet Cooling Tower (CT)**
Over 17,000 packaged tower units in operation with an average of 3,000 retrofits per year only in the U.S.

**Air Cooled Condensers (ACC)**
Global market potential in the power generation industry
Over 20,000 units in service today globally
Opportunity potential based on known maintenance issues with existing mechanically driven technologies

**Air Cooled Heat Exchangers (ACHE)**
Global market potential in the petro-chemical industry
Large banks of ACHE units used in process cooling
Estimated 265,000 units installed in the U.S. and an additional 420,000 units globally
The cooling of circulating water is usually associated with large air conditioning and heat dissipation systems. Referred to as a large heat exchanger or condenser depending on the drive configuration.

DDCT benefits include:

- **Energy efficient design** vs alternative processes or technologies, double digit improvements can be achieved.
- **Reduced noise** – quiet motor operation.
- **Less need for maintenance** – only motor re-greasing is required.
- **Environmentally friendly** – no risk for oil contamination.
- **Critical reliability** – suitable for food plants, hospitals, schools, offices, hotels, power stations, geothermal power plants, etc.
- **Less mechanical stress** - smooth start due to VSD start.
- **Safe to use** – less moving components in use.

How the wet cooling tower works

Added value by using direct drive technology
Direct Drive Cooling Tower Technology
From using gear boxes to using direct drive technology with all solutions inside

Traditional gearbox technology

Converted to direct drive technology

Less parts, less maintenance, reduced noise and improved efficiency
**Direct Drive Cooling Tower Solution (DDCT)**

Increasing efficiency and lowering costs

**Benefits of using an Direct Drive solution**

- Its reliable and requires less maintenance
- No gears in use with no risk for oil leakages
- No driveshaft, nor couplings needed
- No motor - gearbox alignment
- Softer starting torque by using variable speed drives (VSD’s)
- Higher system efficiency and better process control
- Lower level of operating noise and vibration
- Initial cost is slightly higher but payback time is short

Old gearbox technology

New DDCT solution in use
Cargill in Turkey, success story

The Direct Drive Cooling Tower Motor - Easy to install to existing cooling towers
Cooling solutions for the Direct Drive Cooling Tower Motor

An innovative cooling solution

The RPM AC FL4493 DDCT Motor

The finned laminated frame of the permanent magnet motor enables motor to be compact enough for direct drive cooling tower. The finned laminated frame in the fan air stream provides optimum construction for the application.

Innovative solution for increased DDCT motor cooling

A cost-efficient solution to keep the motor cool. Resulting in a smaller motor and less initial cost.
Difference between Permanent Magnet motor (PM) and Induction Motor?

**Induction Motor**
- **Common:** Stator, rotor, diameter, 3 phase power
- **Different:** Can be line started
  - Has slip

**Permanent Magnet motor (PM motor)**
- **Common:** Stator, rotor, diameter, 3 phase power
- **Different:** Requires a drive or similar to start
  - Is synchronous
  - Has no rotor losses (thus more efficient)
Developing the RPM AC Interior Permanent Magnet (IPM)

Magnets are located inside the rotor
Developing the RPM AC Interior Permanent Magnet (IPM)

High-efficiency motor technology

The IPM Rotor technology is used on several different motor designs

Rotor without magnets

The IPM Rotor is skewed

Rotor with inserted magnets

Therefore the magnets are square “chips” that follow the skew
Choosing the right size of motor matters

Size comparison

Seven DDCT frame sizes available to choose from

1. FL25..
2. FL28..
3. FL32..
4. FL36..
5. FL40..
6. FL44..
7. FL58..
## Key features associated with the Direct Drive Cooling Tower Motor

Ensured reliability

<table>
<thead>
<tr>
<th>A completely water proof solution</th>
<th>Proven in harsh environments</th>
<th>Innovative sealing technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealed insulation system used for CT Motors. Stator can be tested at the manufacturing plant submersed in water</td>
<td>Sealed insulation system used for offshore oil drilling applications, provides ultra reliable motor life in hostile north sea environment</td>
<td>Drive end sealing utilizes a slinger and an Inpro seal for superior bearing protection</td>
</tr>
</tbody>
</table>
Improved seals for the Cooling Tower solution

**Original seal design**

- Coalescing Bands
- Unitizing Cap Screw

**New and improved seal design**

- Set Screw
- Conductive O-rings
- Carbon Brush - For potential shaft currents
- Coalescing Bands - Prevent ingress of grease into seal

**Improvements using the new seal**

- Increased Seal Rotor OD, added Taper to Seal Rotor
- Increased internal allowable movement for excess vibration
- Increase the # of O-Rings to the Seal Rotor from 1 to 3, 2 of which are now Conductive
- Added Qty 2 Solid Carbon Brushes
Please note, there are no IEC nor NEMA standards on the Cooling Tower Motors that replace gearboxes.
Clemson University Cooling Tower success story
Improved cooling tower performance, improved efficiency and reduced noise

The cooling tower

Built in 1986
Made by Ceramic Cooling Tower, Texas
Concerned 2 Fan Units
Clemson University Cooling Tower success story

Over 20 year old motors in use

Motor 1 - S/O: 1MOF26353-G1-WM
Motor 2 - S/O: 1MOF26353-G2-WM

Frame size: 326T; Rating 50HP @ 1765RPM / 12.5HP @ 885RPM / 460V / 3 Phase / 60Hz

2x Amarillo Model 155 (single reduction)
Gear Ratio: 8.5 to 1
Pinion: 8 Teeth
Ring Gear: 68 Teeth

2x Hudson fan model APT-18B-5
Diameter: 18’ – 0” (approx. 5.45 Meter)
Clemson University Cooling Tower success story

Results

Data regarding efficiency

<table>
<thead>
<tr>
<th></th>
<th>2-Speed, 326T Induction Motor</th>
<th>RPM AC, FL4493 PM Motor</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</td>
<td>90.2%</td>
<td>N/A</td>
</tr>
<tr>
<td>Efficiency</td>
<td></td>
<td></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</td>
<td>N/A</td>
<td>98.8%</td>
</tr>
<tr>
<td>Input HP</td>
<td>51.1</td>
<td>45.1</td>
</tr>
<tr>
<td>Total Efficiency</td>
<td>81.2%</td>
<td>92.0%</td>
</tr>
</tbody>
</table>

Existing motor is 22 years old
The new induction motor today is 93.6% efficient information.
Gearbox manufacturer states gearbox efficiency at 96%, but test data indicates mechanical system (gearbox, couplings, driveshaft) is 90.2%.
Data verified by Clear Air Engineering on site at Clemson University.
Clemson University Cooling Tower success story
Results from a similar Cooling Tower in Denmark

Comparison data regarding efficiency

Comparison data of Vestas Industrial Cooling in Denmark Second Level
Clemson University Cooling Tower success story
Reduced noise levels

Noise level data

<table>
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<tr>
<th>Loaded Noise Levels (A-weighted)</th>
<th>Average</th>
<th>High Speed</th>
<th>Low Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction NEMA Motor Tower</td>
<td>82.3 dBA</td>
<td>74.4 dBA</td>
<td></td>
</tr>
<tr>
<td>Laminated Frame IPM Tower</td>
<td>77.7 dBA</td>
<td>69.0 dBA</td>
<td></td>
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Data verified by Clear Air Engineering on site at Clemson University
Latest Sound Pressure Test results of CT Motors is depending on Frame Size between 59 – 62dB(A)
50 HP @ 207 RPM - CT Motor weight 1670 lbs. (approx. 760kg)
Clemson University Cooling Tower success story

Key findings

A laminated Frame Interior PM motor technology enables Direct Drive gearless system.
- Gearbox low speed lubrication issues are eliminated
- Gearbox high speed sealing issues are eliminated
- No drive shaft is needed
- No couplings are needed
- No guards are needed
- No alignment is needed

The motor can be configured to then replace it with the gearbox, as was the case at Clemson University.
- It took 6 hours in total to do the replacement work

A vastly simplified system will greatly improve reliability and maintenance.

Significant improvements were achieved in overall system efficiency

Eliminating the gearbox provided biggest improvement in overall fan drive system efficiency

The ABB ACS880+N5350 industrial drive (VSD) improved efficiency (a VSD is required to control the direct drive solution)
- The majority of cooling towers are being retrofitted with VSD's for overall cooling tower system efficiency improvement.

The Direct Drive motor solution reduced noise level of the cooling tower.
More information
Subtitle

Links and sites

Websites:

Selection tool:
- Cooling Tower Wizard Selection Program
## Summary
Advantages of using the DDCT solution

<table>
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<th>Advantage</th>
<th>Description</th>
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<tr>
<td><strong>Energy efficiency:</strong></td>
<td>Double digit improvements can be achieved by removing gearbox</td>
</tr>
<tr>
<td><strong>Noise reduction:</strong></td>
<td>Very quiet motor operation without gearbox</td>
</tr>
<tr>
<td><strong>Maintenance reduction:</strong></td>
<td>Only motor re-greasing is required</td>
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<tr>
<td><strong>Environmentally friendly:</strong></td>
<td>No risk for oil contamination</td>
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<td><strong>Reliability improvement:</strong></td>
<td>Well proven motor design in use</td>
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<td><strong>Less mechanical stress:</strong></td>
<td>Smooth start due to VSD start</td>
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<td><strong>Safe to use:</strong></td>
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**Recommendations - next steps**

1. Quantify your annual maintenance cost of the traditional cooling tower motor + gearbox design per cooling tower
2. Evaluate the option to modernize the traditional cooling tower design with the cooling tower direct drive solution
3. Quantify the potential savings with the cooling tower direct drive package solution and proceed with the retrofit of one unit on phase 1
4. Document the improvements and move forward with phase 2 to upgrade all inefficient motors and gearboxes with the cooling tower direct drive package solution.