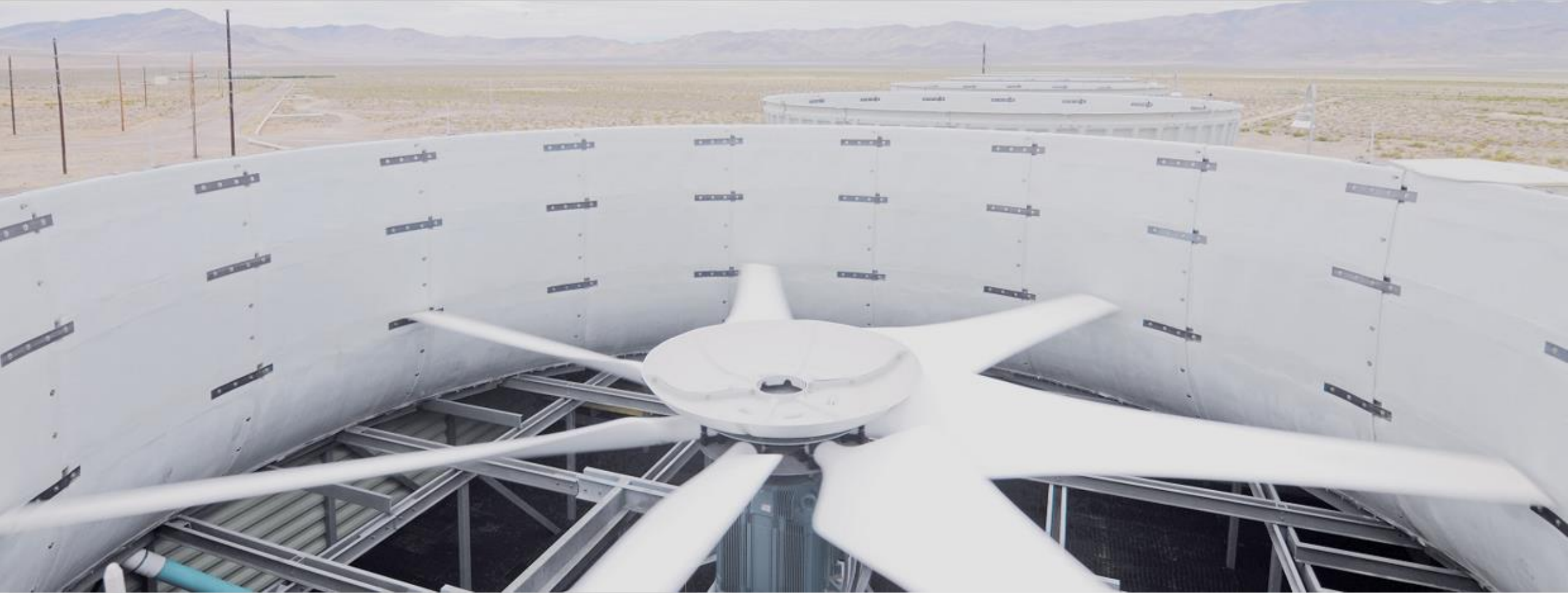

2020.07.09

The Direct Drive Cooling Tower (DDCT)

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

Michael Klein

 Document ID.: Rev.:

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

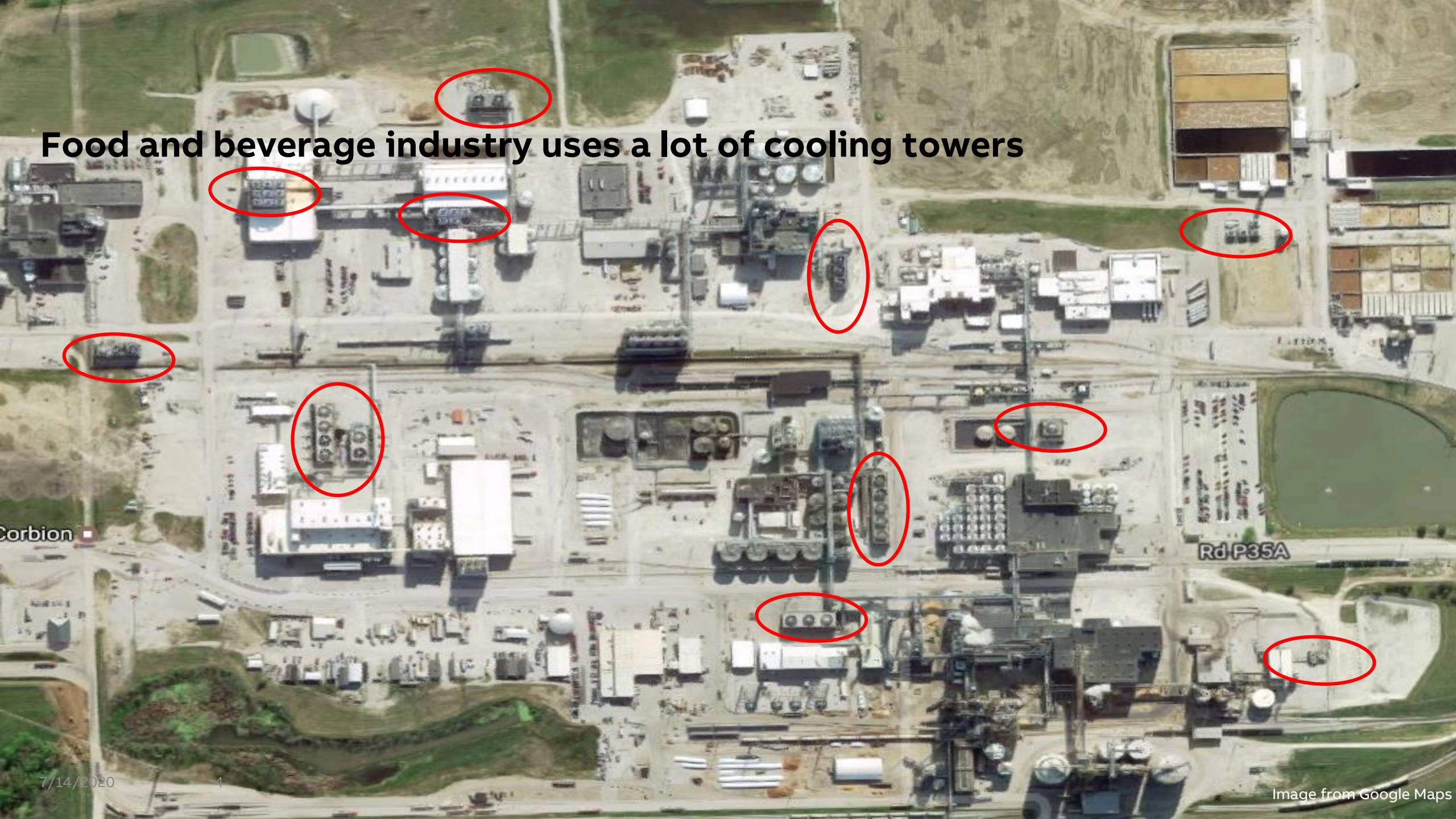


Image from Google Maps

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

How the wet cooling tower works

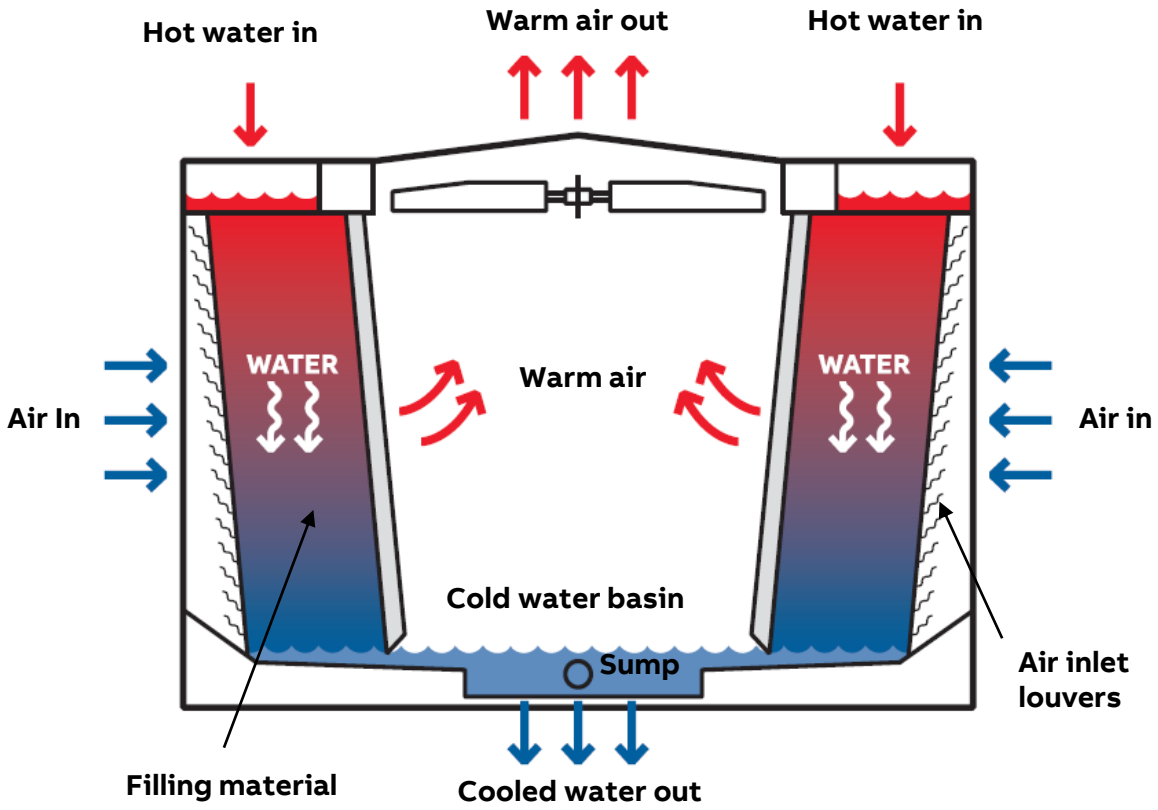
Added value by using direct drive technology

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 drive configuration

DDCT benefits include:

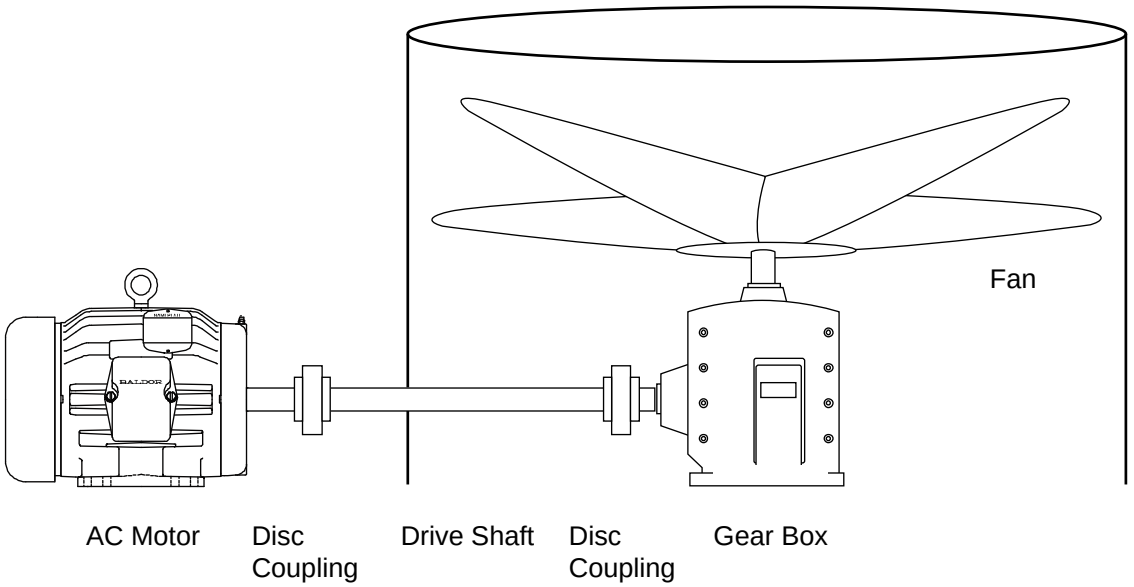
- **Energy efficient design** vs alternative processes or technologies, double digit improvements can be achieved
- **Reduced noise** – quiet motor operation
- **Less need for maintenance** – only motor re-greasing is required
- **Environmentally friendly** – no risk for oil contamination
- **Critical 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



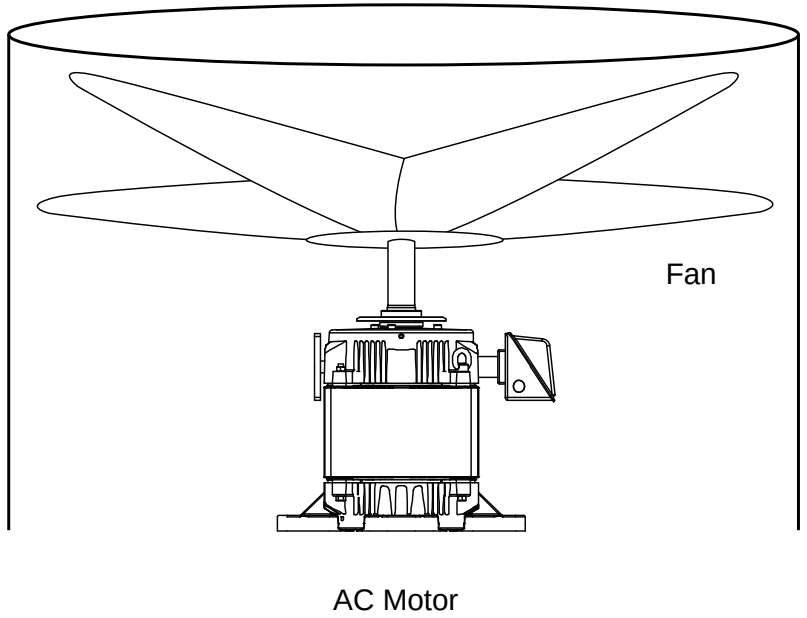
Direct Drive Cooling Tower Technology

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

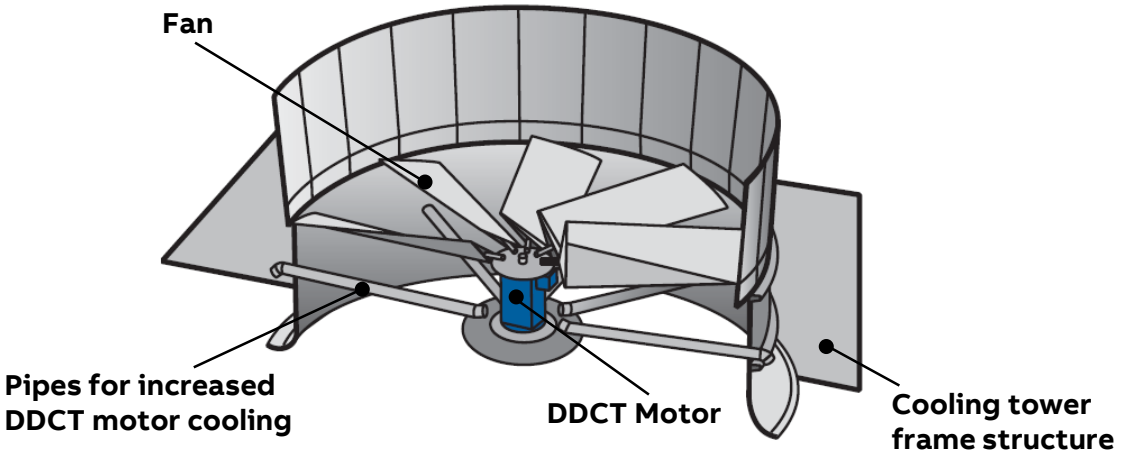
An innovative cooling solution

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.

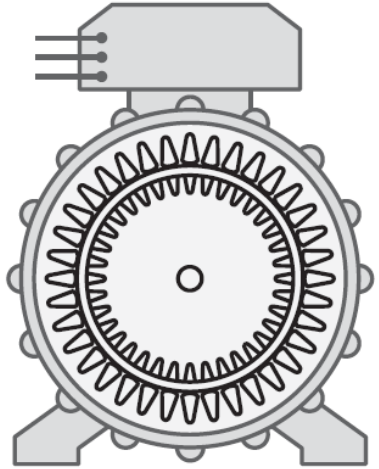
Innovative solution for increased DDCT motor cooling



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

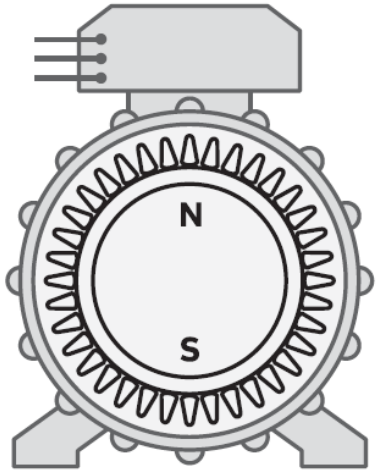


Common: Stator, rotor, diameter, 3 phase power

Different: Can be line started

Has slip

Permanent Magnet motor (PM motor)



Common: Stator, rotor, diameter, 3 phase power

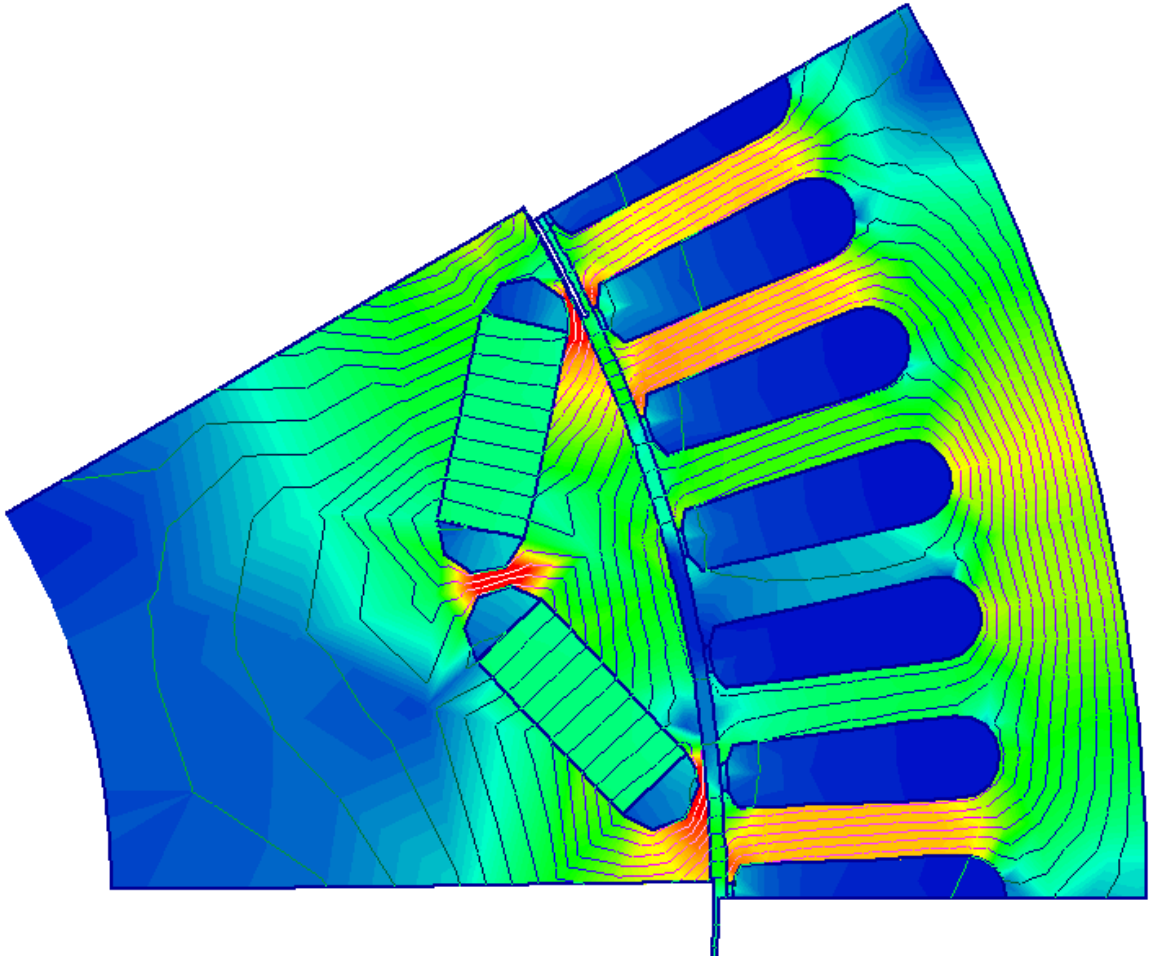
Different: Requires a drive or similar to start

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

A completely water proof solution

Sealed insulation system used for CT Motors. Stator can be tested at the manufacturing plant submersed in water

Proven in harsh environments

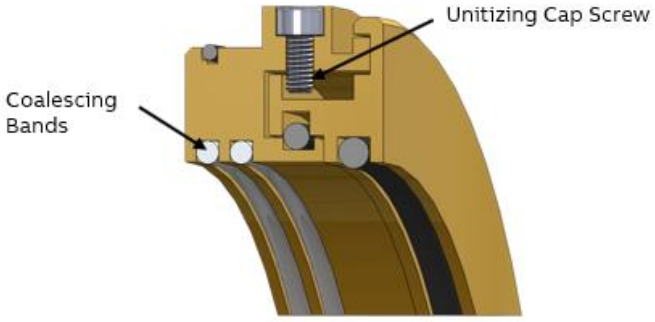
Sealed insulation system used for off shore oil drilling applications, provides ultra reliable motor life in hostile north sea environment

Innovative sealing technology

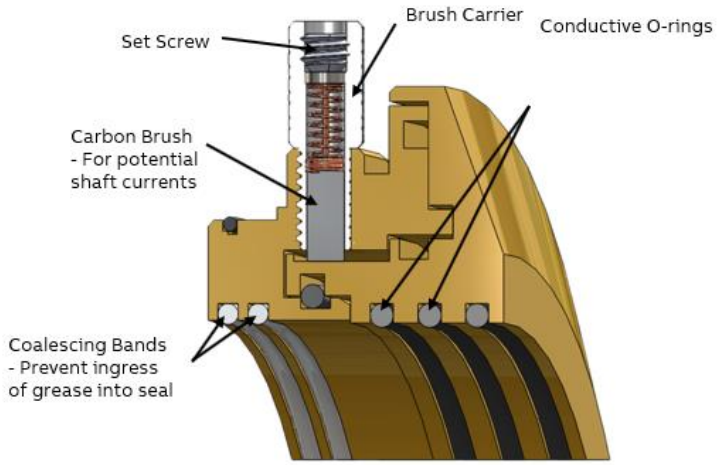
Drive end sealing utilizes a slinger and an Inpro seal for superior bearing protection

Improved seals for the Cooling Tower solution

Original seal design



New and improved seal design



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

Direct Drive Cooling Tower Product Matrix - RPM AC DDCT

IEC160 IEC180 IEC200 IEC225 IEC250 IEC280 IEC355

Speed															
500	FL2562	FL2570	FL2578	FL2578	FL2882	FL2898	FL3213	FL3213	FL3614	FL3614	FL4034	FL4046	FL4058	FL4440	FL5818
475	FL2562	FL2570	FL2578	FL2882	FL2882	FL2898	FL3213	FL3213	FL3614	FL3614	FL4034	FL4046	FL4421	FL4440	FL5820
450	FL2562	FL2570	FL2578	FL2882	FL2890	FL2898	FL3213	FL3213	FL3614	FL3614	FL4034	FL4046	FL4429	FL4440	FL5820
425	FL2562	FL2570	FL2578	FL2882	FL2890	FL2898	FL3213	FL3213	FL3614	FL3614	FL4046	FL4046	FL4429	FL4440	FL5820
400	FL2562	FL2570	FL2578	FL2882	FL2890	FL3203	FL3213	FL3213	FL3614	FL4034	FL4046	FL4058	FL4429	FL5818	FL5822
375	FL2562	FL2570	FL2882	FL2882	FL2890	FL3203	FL3213	FL3698	FL3614	FL4034	FL4046	FL4058	FL4440	FL5820	FL5822
350	FL2562	FL2578	FL2882	FL2890	FL2898	FL3203	FL3213	FL3698	FL3614	FL4034	FL4046	FL4421	FL4440	FL5820	FL5824
325	FL2570	FL2578	FL2882	FL2890	FL2898	FL3203	FL3698	FL3614	FL3614	FL4046	FL4058	FL4421	FL4440	FL5822	FL5824
300	FL2570	FL2578	FL2882	FL2890	FL2898	FL3213	FL3698	FL3614	FL4034	FL4046	FL4058	FL4429	FL5818	FL5822	FL5826
275	FL2570	FL2578	FL2890	FL2898	FL3203	FL3213	FL3698	FL3614	FL4034	FL4046	FL4421	FL4429	FL5820	FL5824	FL5828
250	FL2570	FL2882	FL2890	FL2898	FL3203	FL3213	FL3614	FL3614	FL4034	FL4058	FL4429	FL4440	FL5822	FL5826	FL5830
225	FL2578	FL2882	FL2890	FL3203	FL3213	FL3698	FL3614	FL4034	FL4046	FL4058	FL4429	FL4440	FL5822	FL5828	FL5832
200	FL2578	FL2882	FL2898	FL3203	FL3213	FL3614	FL3614	FL4034	FL4046	FL4421	FL4440	FL5820	FL5824	FL5830	ACC
175	FL2578	FL2890	FL2898	FL3213	FL3698	FL3614	FL4034	FL4046	FL4058	FL4429	FL4440	FL5822	FL5828	FL5832	ACC
150	FL2882	FL2898	FL3203	FL3213	FL3614	FL4022	FL4034	FL4046	FL4421	FL4440	FL5820	FL5824	FL5830	ACC	ACC
125	FL2882	FL2898	FL3213	FL3698	FL3614	FL4034	FL4046	FL4058	FL4429	FL5820	FL5824	FL5826	ACC	ACC	ACC
100	FL2890	FL3213	FL3698	FL3614	FL4034	FL4046	FL4058	FL4421	FL4440	FL5822	FL5828	FL5832	ACC	ACC	
HP	10	15	20	25	30	40	50	60	75	100	125	150	200	250	300
KW	7.5	11	15	18.5	22	30	37	45	55	75	90	110	150	186	225

Please note, there are no IEC nor NEMA standards on the Cooling Tower Motors that replace gearboxes

Clemson University Cooling Tower success story

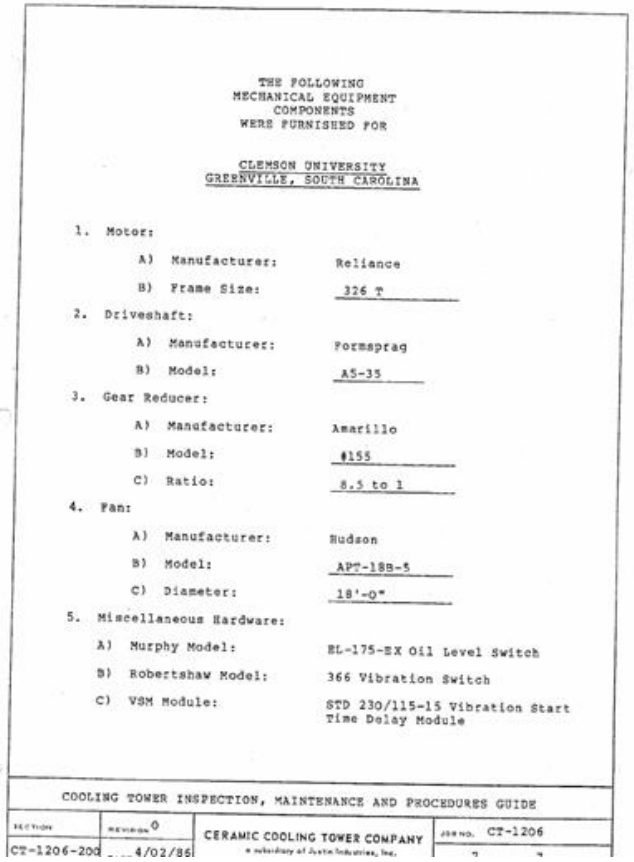
Improved cooling tower performance, improved efficiency and reduced noise

The cooling tower

Built in 1986

Made by Ceramic Cooling Tower, Texas

Concerned 2 Fan Units



THE FOLLOWING
MECHANICAL EQUIPMENT
COMPONENTS
WERE FURNISHED FOR

CLEMSON UNIVERSITY
GREENVILLE, SOUTH CAROLINA

1. Motor:
   - A) Manufacturer: Reliance
   - B) Frame Size: 326 T
2. Driveshaft:
   - A) Manufacturer: Formsprag
   - B) Model: A5-35
3. Gear Reducer:
   - A) Manufacturer: Amarillo
   - B) Model: #155
   - C) Ratio: 8.5 to 1
4. Fan:
   - A) Manufacturer: Hudson
   - B) Model: APT-188-5
   - C) Diameter: 18'-0"
5. Miscellaneous Hardware:
   - A) Murphy Model: EL-175-EX Oil Level Switch
   - B) Robertshaw Model: 366 Vibration Switch
   - C) VSM Module: STD 230/115-15 Vibration Start Time Delay Module

COOLING TOWER INSPECTION, MAINTENANCE AND PROCEDURES GUIDE

CT-1206-200 | 4/02/86 | CERAMIC COOLING TOWER COMPANY | Job No. CT-1206

Clemson University Cooling Tower success story

Subtitle

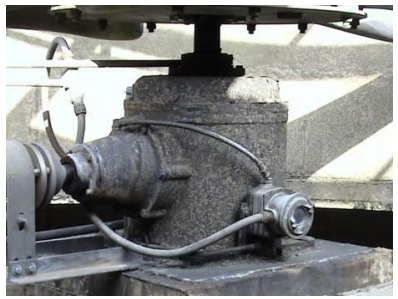
The motors in use

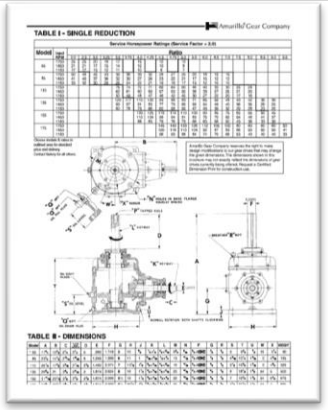
Over 20 year old motors in use

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

..with existing gearbox





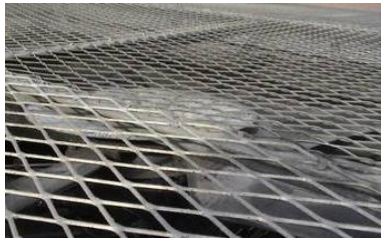
2x Amarillo Model 155 (single reduction)

Gear Ratio: 8.5 to 1

Pinion: 8 Teeth

Ring Gear: 68 Teeth

and fan



2x Hudson fan model APT-18B-5

Diameter: 18’ – 0” (approx. 5.45 Meter)

Clemson University Cooling Tower success story

Results

Data regarding efficiency

	2-Speed, 326T Induction Motor	RPM AC, FL4493 PM Motor
Fan Load	41.5 Hp	41.5 Hp
Gearbox and couplings Efficiency	90.2%	N/A
Motor Horsepower	46.0 Hp	41.5 Hp
Motor Efficiency	90.0%*	93.1%
Drive	N/A	98.8%
Input HP	**51.1**	**45.1**
Total Efficiency	**81.2%**	**92.0%**

6 HP Savings

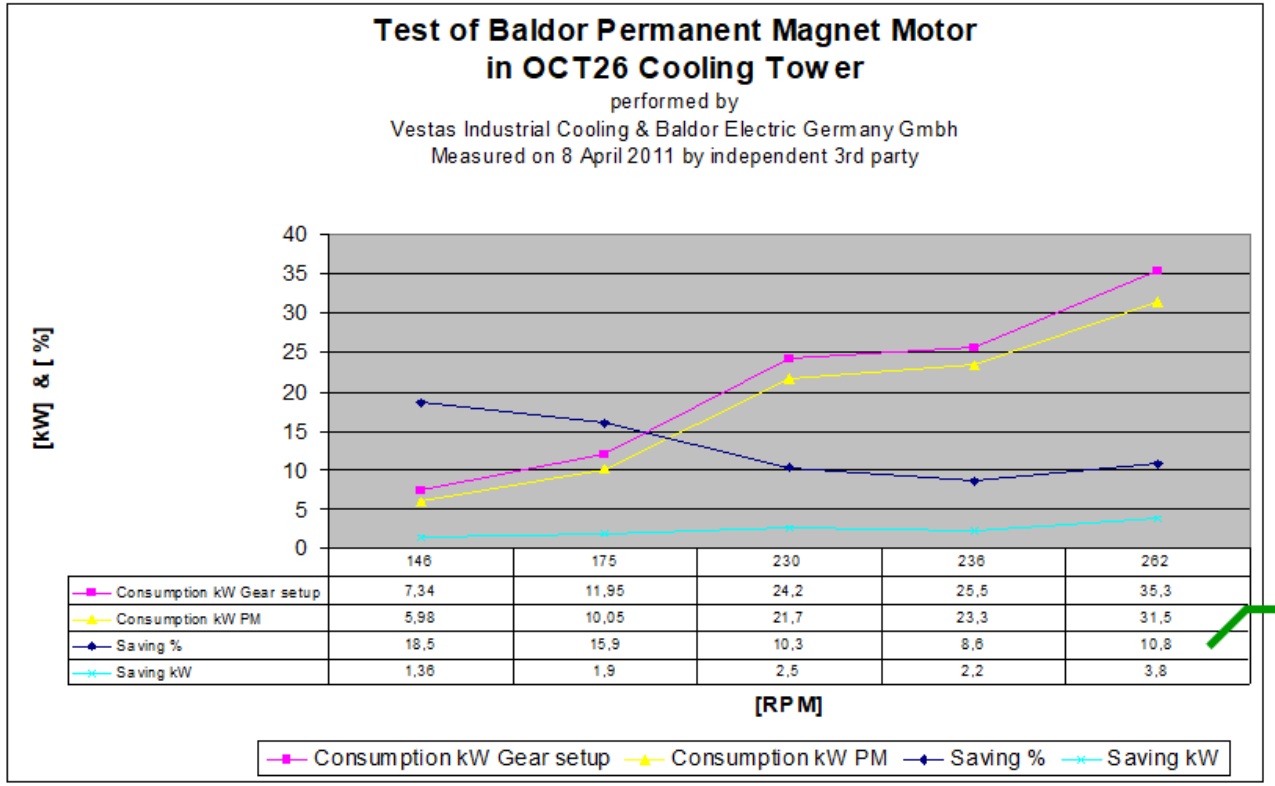
Existing motor is 22 years old
The new induction motor today is 93.6% efficient Information.
Gearbox manufacturer states gearbox efficiency at 96%, but test data indicates mechanical system (gearbox, couplings, driveshaft) is 90.2%.
Data verified by Clear Air Engineering on site at Clemson University.

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



Same as USA

Clemson University Cooling Tower success story

Reduced noise levels

Noise level data

Loaded Noise Levels (A-weighted)		
Average	High Speed	Low Speed
Induction NEMA Motor Tower	82.3 dBA	74.4 dBA
Laminated Frame IPM Tower	77.7 dBA	69.0 dBA

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

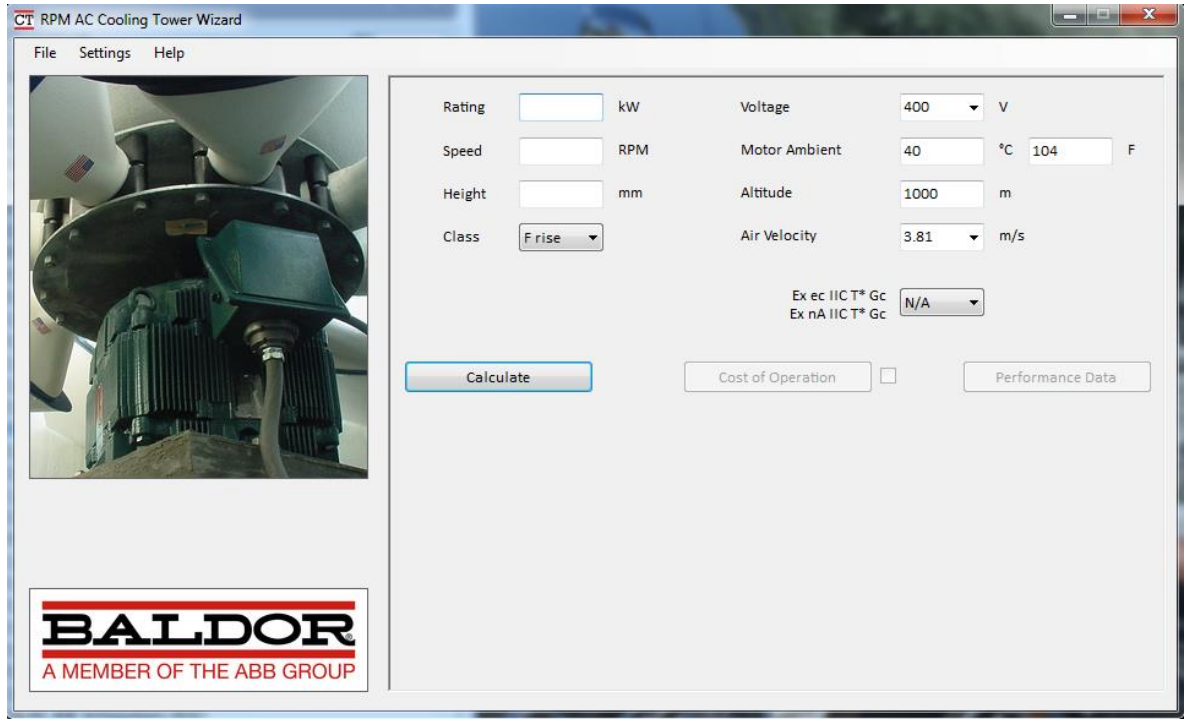
Links and sites

Websites:

- http://new.abb.com/drives/segments/cooling-tower
- http://www.baldor.com/brands/baldor-reliance/products/motors/ac-motors/variable-speed-ac/cooling-tower-motors

Selection tool:

- Cooling Tower Wizard Selection Program



Summary

Advantages of using the DDCT solution

Energy efficiency:	Double digit improvements can be achieved by removing gearbox
Noise reduction:	Very quiet motor operation without gearbox
Maintenance reduction:	Only motor re-greasing is required
Environmentally friendly:	No risk for oil contamination
Reliability improvement:	Well proven motor design in use
Less mechanical stress:	Smooth start due to VSD start
Safe to use:	Less moving components in use

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.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