



## Design Considerations for a Direct Drive Motor Retrofit on an ACC

Tom Weinandy September 23, 2014

#### Introduction

- This presentation is focused on reviewing the design concepts for retrofitting an installation with Direct Drive technology.
- Building upon information shared two years ago at ACC Users Group meeting held in Gillette, WY.
- Basin Electric (Dry Fork Station) and Baldor enter in to an agreement for the supply of (2) Direct Drive ACC Motors for a 12-18 month evaluation period. Installation to occur in October 2014.
- Originally, we were trying to meet an early summer installation. Current schedule has an installation schedule of October. The title of the presentation has been changed to reflect the content.



### Agenda

- Project background
- Direct Drive motor technology
- ACC development history
- Points to Evaluate:
  - > Installation
  - > Ventilation/cooling design
  - > Bearing design
  - > Carrier bearing
  - > Lubrication
  - > Weight
  - > Wind
- Drive Control
- Data Collection



#### Background

- Dry Fork Station is a coal fired plant that came on line in November, 2011. 45 cell ACC. 422 MW design capacity (385 MW net) coal fired.
- DF identifies challenges it is facing during our visit two years ago. These include:
  - > Motor bearing failures due to shaft down orientation
  - Requiring 15-20% more air than can be provided with existing motors during peak season. Currently pitched to max amps.
  - > On occasion, do see wind gusts to 80 mph.
  - > 50% of the gearboxes are leaking
  - > Can only lose 1 fan
- Rating is 250 HP at 104 rpm
  - Wanted a design that utilized a carrier bearing. Wyodak provided input that said they believed it helped. Commanche 3 provided similar feedback.



## **Dry Fork Installation**







### **Direct Drive Motor Technology**

- In excess of 80 utility size Direct Drive cooling tower motors in shaft up configuration in wet towers in operation today.
- Features of a utility size direct drive cooling tower motor include:
  - totally enclosed air over enclosure.
    Designed for keeping moisture out.
  - > sealed insulation system
  - > PLS bearing lubrication system
  - generous bearing cavities sized for slow speed operation
  - Weight of motor is 8300 lbs. for traditional utility application. Torque rating is 8800 lb-ft.





# **PM Motor Technology**

Motor power density and increased efficiency

#### **Interior PM design**





#### Saliency: the ability to control rotor position without a feedback device



#### 75 HP, 1800 RPM

| 360T | 9.00" |
|------|-------|
| L280 | 7.00" |
| L250 | 6.25″ |



## **ACC Drive Motor Development History**

- Introduced the Direct Drive technology 6.5 years ago to the cooling tower market.
- Introduced FL5800 frame for large industrial and utility customers starting in 2010.
- Started evaluating ACC market and application needs starting in 2009.
- Presented prototype concepts to Users starting in 2012 (Gillette, WY ACC-UG meeting).
- Received order for prototype unit(s) in 2013 for delivery in 2014.



### **Air Cooled Condenser Direct Drive Motor**

#### "Eliminate the gear reducer to increase reliability and reduce parasitic load"

- 12,625 lb-ft of torque (250 HP @ 104 rpm)
- FL5832 frame
- Vertical shaft down
- Large output shaft (6.875" diameter and 42" long)
- Open blower design for cool operation
  - DPG-FV (drip proof guarded force ventilated)
- Low noise (target 77 dba sound pressure @ 1 meter)
- Carrier bearing for additional protection against side loading
- -30 deg C to 50 degree C ambient
- Designed for use with the ABB ACS880 Cooling Tower drive
- Insulated bearing
- Class II shaft
- 7800 lbs.

The ACC Direct Drive Motor takes advantage of the environment to provide the most cost effective power dense solution available.



### **Installation Challenges**

- Existing trolley system is rated for < 5000 lbs.</li>
- How to install a drive motor that weighs more than the previous individual components?
- How to install a motor that is physically larger?





### **Installation Challenges**





Motor: 7800 lbs Mounting plate: 3300 lbs. Hub: 300 lbs. Fan: 3000 lbs TOTAL 14,300 lbs

 Lifting fan/motor/deck assembly as long as spreader bar is used to ensure the through rods are in pure tension



### **Motor Ventilation**



Air enters top of motor

Air flows through the motor and diverts out through the fan cover to cool the frame

Air exits the bottom



#### Variable speed blower?





- Design utilizes a blower to provide air over and through the motor for cooling.
- If a VFD drive for the blower is provided for variable speed control, would it be of benefit to be able to control the speed and provide additional cooling (and rating) for short periods during peak times?
- Does it make sense to monitor the temperature out of the motor and vary the speed of the blower to maintain a constant temperature?



5 hp 1800 rpm

6.8 amps







#### **Bearing geometry**





- What does 50 mph wind gusts mean to a motor manufacturer?
  - > Developed methodology to calculate wind effects in pounds on a motor shaft.
- Dry Fork design loading is based on 100 mph wind gusts.
- Deep groove ball on drive end provides greater clearance and bearing element is more forgiving than a cylindrical bearing.
- Design based on shaft diameter + length + 4140 shaft



#### **Carrier Bearing**



Grease fitting

6200 series deep groove ball bearing

 Designed with greater clearance; only comes in to play when motor sees wind gusts



### **Motor Bearing Design & Lubrication**



- Tapered roller pair on opposite drive end and deep groove ball bearing on drive end.
  - Allows operation horizontally without axial loading
  - > Allows shipping horizontally
- Designed for 100,000 hours L10 on both drive end and opposite drive end
- Based on air flow, bearings are extremely cool running. Bearing temperature rise will be 80 deg C total temp or less based on 50 deg C ambient.
- Generous bearing cavities
- Use Mobil SHC460 synthetic lubricant. Based on these temps, we are looking at a 12 month relubrication schedule.



### Weight comparison



A MEMBER OF THE ABB GROUP



### **VFD Benefits**

#### Reduced Transient Torque





### ACC Fans – Benefits of variable speed

What if I only need 80% cooling in a certain area?



- Example 1: run 10 fans at full speed, need 80 % capacity. Shut two fans off. Operational costs are the running of those 8 motors at full speed.
- Example 2: run all 10 fans at 80% speed. Using affinity laws, 20% reduction in load equates to 50% reduction in power. which represents a 38% savings in power.









1 Speed or 2 speed starter is common and is installed in 1 complete vertical section. Need to fit within 38" wide, 48" tall and < 20" depth. Enclosures are typical MCC structures.



## **ACC Drive Control**

- Matched Performance Drive & Motor
- Previously was Baldor design, now ABB
- Proven Technology Design focused on:
  - > Ease of startup, reduced feature set
- Utilizes unique control algorithms
  - > Interior Permanent Magnet (IPM) Motor Control
  - > Sensorless Vector algorithm
  - > Smooth, low speed operation
  - Maximize Efficiency (optimized control to motor)
- Provides small amount current to motor when not in use
  - Eliminates condensation in the motor no space heaters required
  - Additional benefit of providing anti-wind milling torque (locks shaft)
  - Automatically occurs after stopped for preset period



## **ACC Single Drive Configuration**



| HP  | Amps | WL   | Size |
|-----|------|------|------|
| 200 | 240  | 3300 | R8   |
| 250 | 302  | 4200 | R9   |
| 300 | 361  | 4800 | R9   |
| 350 | 414  | 6000 | R9   |

|    | Total HT | HT less terms | Width | Depth |
|----|----------|---------------|-------|-------|
| R8 | 37.9"    | 26.8"         | 11.8″ | 15.2" |
| R9 | 37.6"    | 26.7"         | 15″   | 16.3" |

- Zero stacking capability
- 40 deg C ambient; higher with derate
- Filters required over 400 ft lead length



#### **ABB MACHsense-R Data Collection CBM**



#### ABB MACHsense-R

- Development by ABB R&D
- Real time condition monitoring
- Monitor stator RTDs, bearing RTDs and accelerometers to be monitored. Dual outputs for use by both DF and Baldor.

# Measurements & Analysis of Data & Report

- Measurements and analysis are automatically performed by installed data collection system.
- Key Condition Parameters are transmitted wireless to server
- Monthly report is later delivered by Local Service Center(LSC)



### Summary

- Incorporated features based on feedback received/ lessons learned from other Users.
- We would be interested in your opinion on:
  - > Variable speed blower motor
  - Locating the motor closer to the fan will help reduce the shaft stress imposed by the wind. Is this achievable?
- Provide update in the future to those who are interested.



