Joint presentation with Singapore District Cooling Pte Ltd
The challenge of continual improvement on energy efficiency through a case study – Cooling Towers
District Cooling Service
The challenge of continual improvement on energy efficiency - case study

Topics
- Introduction District Cooling Service Case Study
- The economics of resource efficiency on motor drives system
- Work Details – Cooling Tower System in SDC ORQ Plant 1
- Physics on fan application – Variable Torque with VSD
- Solution & Consideration
  - Safety & Productivity
  - Optimizing & Protecting Existing Investment
  - Cooling & Ventilations
  - Automation Integration
  - Return of Investment
- Conclusion
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The challenge of continual improvement on energy efficiency - Case Study

Cooling Tower Fan Application

- **Scope of Work**
  - Retrofitting of 18nos cooling tower fan motors from fixed speed to variable speed drives (VSD).
  - Integration with plant’s automation system for closed loop controls.

- **Challenges to meet:**
  - **Safety & Productivity**
    - Minimum disruptions to operations
    - Operational Health & Safety needs
  - **Optimizing & Protecting Existing Investment:**
    - Minimize use of expensive floor area
    - Reuse existing equipment as far as possible
  - **Cooling & Ventilation:**
    - Managing heat loss from the variable speed drives
    - Return of Investment as fast as possible!

- **Results:**
  - Energy saving ≈ 591,300 kWh/year
  - Reduced CO₂ emissions ≈ 260,000 kg / yr
  - Equivalent to the emissions of 42 family cars in one year.
  - Return of Investment – 2 years
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The economics of resource efficiency on motor drives system

Energy Cost

- Energy supplied via drives to motor
- Energy supplied via drives to motor
- Energy supplied via drives to motor

OPEX Cost Saved

- Energy Cost for VSD System Heat Loss
- Energy Cost of Ventilation & Cooling
- Floor Area Cost for VSD
- VSD maintenance & repair cost

Optimization with Controls

- Engineering Optimization
- Investment of an engineered Drives System with automation, instrumentation & controls

CAPEX Expenditure

- Investment of VSD System
- Investment on Harmonics Mitigation

Fixed Speed Control VS Typical Variable Speed Drives (VSD) Control VS Engineered Variable Speed Drives (VSD) with Automation, Instrumentation & Control

10th Year Cycle

OPEX Expenditure

Others Operational Cost

Others Operational Cost

Others Operational Cost

*For Illustration - Not to Scale
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Work Details - Cooling Tower System in SDC ORQ Plant 1

The VSDs modules were installed in existing switchboard panel in the Electrical Room to drive the fan motors at variable speed.

Total System Capacity –
- Group A – 10 units of cooling fan
  - MCC5 – CT1 to CT6 (6 units)
  - MCC6 – CT7 to CT10 (4 units)
- Group B – 8 units of cooling fan
  - MCC7 – CT16 to CT17 (2 units)
  - MCC8 – CT18 to CT23 (6 units)

Group A
Group B
Electrical Room

75kW, 415V, 139A, 1475rpm
Cooling method – TEFC
Starting method – Auto-transformer starter
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Physics on variable torque – fan application

Usually fan tends are dimensioned to meet system need in worst case operation condition, speed can nearly always be reduced in most normal operating condition.

Flow \( \propto \) Speed,
Torque \( \propto \) Speed\(^2\)
Power \( \propto \) Speed\(^3\)

Just 7% speed reduction gives 20% energy saving
District Cooling Service – Case Study
Physics behind of slowing multiple fans to optimize speed saves more energy

Flow $\propto$ Speed
Power $\propto$ Speed$^3$

VSD Calculations
Flow = 0.5
Therefore speed = 0.5
Power = Speed$^3$
Power = 0.5$^3$ x 1350 kW
= 0.125 x 1350 kW
= 168.75 kW

675 kW 168.75 kW

To get Flow = 50%
Run 9nos of 75kW Motors

To get Flow = 50%
Run 18nos of 75kW Motors
@ 50% Speed
Safety & Productivity
Professional Project Management is the key - Example
Optimizing & protecting existing investment
Challenges on existing installations

- Limited floor area available for new equipment.
  - Not enough space to fit new floor standing drives cabinet in existing switch room
  - A spare room is available but it means expensive investment on additional floor area and installation work.

- Plan to utilize existing equipment as much as possible like feeder switch boards, feeder transformer, motors and cabling to optimize investment cost.

- VSD should be compatible for existing cabling, motors and transformers
  - Consideration of Bearing Current in the motor
  - Insulation system on the motor
  - Cooling of the motor itself
  - Managing of Harmonics
  - Managing of EMC (Electromagnetic Compatibility)
Optimizing & protecting existing investment
An Engineered Solution

- Utilize and modify existing auto transformer starters panel for Variable Speed Drives installations.

- Challenges encountered
  - Limited cabinet space for Variable Speed Drive
  - Cabinet Ventilation & Cooling
  - Integration of protection scheme for Variable Speed Drive. Eg Fusing, main contactor controls & emergency stop.
  - Maintenance access for the retrofitted system
Optimizing & protecting existing investment
Compact footprint solution made it possible

- The old way to do it...

...the solution - Compact All in One

Built-in:
- RFI filter, swinging chokes,
Cooling & ventilations
Existing switchboard modified with forced ventilation

Proper switchboard ventilation design ensure effective heat dissipations of the system and impact on long term system reliability.
Cooling & ventilations
Remember to upgrade the switchroom to handle additional heat dissipation

Potential Heat Generation Calculations from VSD for 18nos of VSD in this project
All Equipment in Energized and running in full load condition
- 18nos of VSD x 1940W = 34920W
- 4nos of 1250KVA Transformer x 4700W = 18800W
- Total = 53,720W

Normal Operations with all VSD in speed controlled half load condition
- 18nos of VSD x 1200W = 21600W
- 4nos of 1250KVA Transformer x 3200W = 12800W
- Total = 34,400W

Switchroom was upgraded with air conditioning capacity to handle additional heat loss from VSD.
Maximize Return of Investment!
Engineered solution ensure system optimized with controls intelligent

- Automation, instrumentation & controls provides an intelligent platform of closed loop control which maximize the system performance under dynamic of changing operations condition.
  - All the 18 units of VSD were integrated to the plant main automation system via fieldbus.
  - This also enable system operation parameters and data available for analysis and optimization of system setpoint for continual improvement.
Maximize Return of Investment!

The results

- Energy costs reduced by 590 MWh annually, which translates into an annual energy savings of SGD 120,000 per annum
- Savings represent 40 percent of energy consumed by the existing cooling tower application
- Return on investment in only 20 months, better than initial estimated payback time of 36 months
- Overall improved cooling tower efficiency
- Improved accuracy & precision in process control
- Soft start reduces maintenance of motor bearings, fan bearings and fan belts
- With the energy saving implementation, Singapore District Cooling will now achieve a carbon dioxide gas reduction of 280 tonnes per year, equivalent to the emissions of 42 family cars in one year.
- The job was completed in two months with minimal disruption to the plant’s operation.
Conclusion

Professional attention is the key for economics of resource efficiency

- Consideration factor on implementing VSD project on Energy Efficiency in an industry environment
  - An engineered solution with professional project management
  - Space & footprint of the installation
  - Compatibility of existing installation hardware (motors, cables, transformer)
  - Managing Power Quality - Harmonics & EMC
  - Cooling & Ventilation
  - Automation, Instrumentation & Controls
  - Maintenance & lifecycle management of the installation

- Energy efficiency is a process with a starting point but without an end point. An engineered drives solution with automation, instrumentation and controls provides an enabling platform for continual improvement. Professional attention on a continual basis is the key to ensure sustainability of the energy efficiency process.
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