

De Anza ES 73 Electric Motors and Drives – Lecture #2

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Today's Lecture

- ◆ Discuss Field trip logistics
- ◆ Review Homework
- ◆ Introduce MotorMaster 3+
- ◆ Discuss Motor Controls
- ◆ Review Variable Frequency Drives
- ◆ Putting together a motor plan

Review

- ◆ Basic terminology
- ◆ Load types
- ◆ Motor parts
- ◆ Simple calculations
- ◆ Energy efficient motors
- ◆ Motor over sizing

Field Trip Logistics!

- ◆ Gates Bldg Mechanical room at Stanford University.
- ◆ Meet at 3:30PM, March 10th on the steps to the main quad just off "The Oval".
 - http://campus-map.stanford.edu/campus_map/index.jsp
- ◆ We will walk to the Gates bldg.
- ◆ Bring a Notepad, you will be expected to include your notes and observations in your journal.

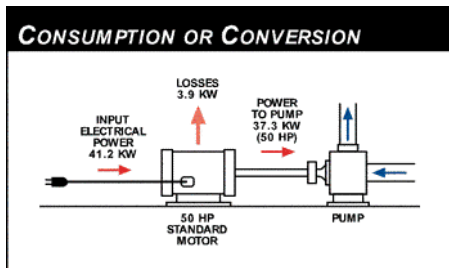
MotorMaster 3+

Motormaster + 3
<http://www.energy.wsu.edu/cfdocs/mmdownload/register.cfm>
Download free

- Large documentation File
- Large database of existing motors
- Compare function
- Lifecycle cost information
- Inventory Capability
- Reports

Motor Loss and Loss Management

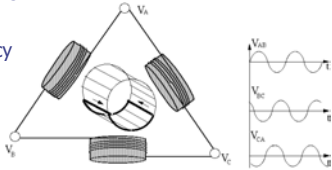
- ◆ Minimize Loss



Unbalanced Electric Supply

◆ Unbalanced electrical supply can significantly:

- Reduce performance
- Shorten motor life
- Increase heat
- Reduce efficiency



Field Measurement of Motor Loads and Efficiency

◆ Why is this important?

- Motor efficiency can vary from name plate data.
- Difficult to guess actual load and duty factor conditions.



How are motors Controlled & Protected?

◆ Motor Control Center

- Starter – must also provide overcurrent protection
- Controller – On off vs.. Speed/Torque control
- Addition protection is available for phase imbalance, overvoltage, etc. The more expensive the motor, the more protection is justified.

How are motors Controlled & Protected?

- ◆ Overload protection
 - Prevents motor & distribution from drawing too much current fault.
 - Motor "Trips" offline
 - Fused Disconnect vs. Relay/Breaker

Soft Start Devices

- ◆ Review Locked Rotor AMPS (LRA) or inrush current
- ◆ Controls starting voltage to increase slip avoiding large inrush current.
- ◆ Can increase life on motor and associated equipment.

Motor Controls Basics

- ◆ Speed control should match the characteristics of the load
- ◆ Controls range from 2 speed to infinitely variable.

Types of Motor Controls

- ◆ Multi speed Motors (2,3, or 4 speed)
 - Need room to accommodate two or more windings
 - Lower efficiency than for comparable sized single speed motors
 - More expensive than single speed motors

Types of Motor Controls -- Two-Speed Motors

- ◆ Two Speed Motors
 - Most common of multi-speed motors
 - Good for 24 hour facilities (for example) that have lower load requirements for part of the day.
 - Good energy savings
 - Soft start capability – avoids large inrush current

Types of Motor Controls – “Pony” Motors.

- ◆ Pony Motor arrangements
 - Use two separate motors for a single application.
 - Could be used in parallel pumping applications (for example).

Types of Motor Controls --DC Drives

◆ Advantages

- Provides good speed control

◆ Disadvantages

- Expensive, DC motors not as reliable as AC motors
- Must convert AC to DC
- May be more cost effective to switch to AC motor and use a variable speed drive.

Type of Motor Controls -- Magnetic Coupled Drive

- ◆ New version of old technology "eddy current drives" or "frictionless clutch."
- ◆ An electro magnetic coupling mounts on the shaft between the motor and the load to vary speed.
- ◆ Current is applied to the electromagnetic coupling (creating a magnetic field) to vary the speed of the motor
- ◆ Avoids harmonics and voltage problems

Variable Frequency Drives (VFDs)

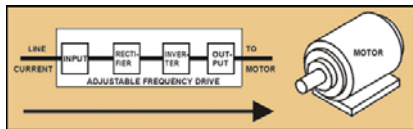
- ◆ VFDs, also called Adjustable Speed Drives (ASDs), are the dominant speed control technology.
- ◆ Pumps, fans, and compressors are the most common applications.
- ◆ VFDs can provide precise control for other applications such as conveyor belts.
- ◆ Significant energy savings can accrue where part load conditions repeatedly exist.

Variable Speed Drives

How they work

- ◆ Pulse width modulated (PWM)
 - Step 1) Solid state electronics (rectifier) converts AC power to DC
 - Step 2) DC power is filtered in DC link
 - Step 3) Inverter uses the DC power supply to create an adjustable-frequency, adjustable-voltage waveform by releasing short steps or "pulses" of power.
- ◆ The speed of the motor changes in proportion to the frequency

VFD Diagram



From www.cutler-hammer.eaton.com

Types of VFDs

- ◆ Inverter based
 - Most common
- ◆ Cycloconverters
 - Converts AC frequency without a DC link
 - Found in industrial applications
- ◆ Voltage Level Controls
 - Does not vary frequency of power supply
 - AC supply voltage is varied – low efficiency and potential for high harmonics

Variable Speed Drives (VFDS)

◆ Benefits include

- Energy savings
- Precise control
- Soft starting
- Power factor improvement

VFDs cont.

◆ Potential downsides include:

- Heat from motor and drive.
- No energy savings at full load.
- Conversion losses.
- Early VFDs had poor power factor and generated harmonics.

Variable Speed Drives – Cost Benefit

- ◆ VFDs cost around \$100 to \$150 per hp
- ◆ Installation is around 15% of equipment cost
- ◆ Energy Savings are approximately 15 to 50 %.

Cube or "Affinity" Laws

- ◆ Applies to loads where fans and pumps are used to move fluids – air and water.
 - Flow is proportional to the speed.
 - Pressure is proportional to the speed²
 - Power is proportional to the speed³
 - For example:
 - If the fan speed is doubled, the power required increases eightfold .
 - Conversely, reducing the fan speed by 20% reduces the power requirement by half.

Inverter Duty Motors

- ◆ Designed specifically to work with VFDs
 - Special "Class H" insulation
 - Special Warranties

Belts

- ◆ V-Belts
 - Most common – slip under high torque conditions. Roughly 93% efficient.
- ◆ Cogged Belts
 - Perpendicular slots reduce bending resistance.
 - Use same pulley as V-belts but 2% more efficient.
- ◆ Synchronous Belts
 - "Toothed" and require similar drive sprocket
 - Roughly 98% efficient
 - Noisy, transfer vibrations, and won't work with shock loads.

Motor Repair

- ◆ Rewinding is a common way to repair failed motors.
- ◆ Is it better to rewind or install a new Energy Efficient Motor?
 - Economics depend on duty factor and the size of the motor.
 - Rewound motors often fall below minimum efficiency standards (and nameplate). Rewound motors should be tested to verify efficiency since the quality of the repair varies from shop to shop. Industry standards are needed!
 - Good time to verify if motor is oversized for additional energy savings.

Motor Repair Cont.

- ◆ When to rewind
 - Original motor is high efficiency.
 - Price of electricity is very low.
 - Rewind shop can guarantee high efficiency.
 - Low motor duty factor.
 - Motor is a special type and difficult to find in an energy efficient model.
 - Large motors (greater than 125 hp).

Motor Rewinding

- ◆ Inspection/Testing.
- ◆ Electrical and mechanical appraisal.
- ◆ Repair/Replace stator windings, bearings.
- ◆ Balance rotor, replace lead wires.
- ◆ Clean, paint, reassemble.

Case Study: Motor Survey

- ◆ Initial survey to determine cost benefit potential
- ◆ Detailed survey and testing
- ◆ Payback analysis
- ◆ Implement cost effective changes
- ◆ Verify savings

Additional Resources

- ◆ <http://www.sea.siemens.com/step/default.html>
- ◆ <http://cutler-hammer.eaton.com/>
 - Go to "Learning"
 - 101 basics series
- ◆ <http://www.baldor.com/pdf/brochures/PR2525.pdf>
 - Various motor topics covered

Review

- ◆ Motor Controls
- ◆ Variable Speed Drives
- ◆ MotorMaster 3+
