Electric Motors: Repair or Replace?

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Introduction

• Perennial plant maintenance questions:
  – Is it better to repair or replace an electric motor that has failed?
  – Will a repaired motor retain its efficiency?

• We will answer the above, and provide:
  – Better understanding of key criteria to consider when facing this decision
  – Details about EASA Accreditation Program for electric motor repair
Repair/replace decision-making process

• Well-informed decisions involve many criteria
  – Suitability for application
  – Condition of stator core
  – Condition of rotor
  – Efficiency rating; lifecycle costing
  – Availability of funds and replacement motor
  – If it’s not an EPAct (IEC IE2) or NEMA Premium\(^\text{®}\) (IEC IE3), is ROI of replacement acceptable?

• Flowchart on next slide provides overview of process

• Specific applications may add other unique characteristics
Failed motor

Is the motor suitable for the application?

Yes

What is the condition of the stator core?

OK

Has catastrophic failure occurred, or is there evidence of prior catastrophic failure?

No

Is the rotor damaged, or is there severe damage to other mechanical parts?

Yes

Is the cost of repair greater than the cost to replace the motor?

Yes

Are replacement funds available?

Yes

Is replacement motor available?

Yes

Is lead time of replacement motor acceptable?

Yes

Replace motor

No

Investigate replacement with suitable motor (size/enclosure).

No

Significant damage or high losses

Special cases (e.g., very expensive motors)

Is it an EPAct or NEMA Premium® motor?

Yes

Is return on investment of EPAct or NEMA Premium® motor acceptable?

Yes

Repair motor

No

No

No

No

Is replacement motor available?

No

Is lead time of replacement motor acceptable?

Yes

Repair motor

- Additional considerations include increased reliability, life expectancy and benefits of additional features, upgrades or modifications.
Review application

Suitable for application?

Example
Open enclosure may not be practical for paper mill
- Airborne moisture & debris
- Better choice: Totally-enclosed, fan-cooled (TEFC) replacement with the addition of:
  - Weep/drain holes
  - Space heaters
Review application

• Reassess application as part of repair/replace decision
  – Processes and duty cycles can change over time

• Even better approach:
  – Assess all critical applications prior to failure as part of a motor management plan
Multiple decision points

Consider these decision points simultaneously:
• Is the present failure catastrophic?
• Is there evidence of a prior catastrophic failure?
• Is the rotor damaged?
• Are other mechanical parts severely damaged?
• Is it an EPAct (IE2) or NEMA Premium® (IE3) motor?
Catastrophic failure — present

• Evaluate cost of repair vs. replacement
• Catastrophic failures typically do considerable damage to:
  – Stator core
  – Windings
  – Other motor parts including:
    • Rotor
    • Shaft and bearings
    • End brackets
• Replacement may be most economical option (especially if suitability for application is questionable)
Evidence of prior catastrophic failure may be apparent only after motor disassembly, e.g.:

- Damaged stator core laminations
- Damaged rotor core
- Damaged rotor bars or end rings
- Bent shaft that has bent again
Stator core condition

If failed motor suits application:

• Assess condition of its stator core
  – Is damage significant?
  – Did motor exceed rated temperature rise before it failed (e.g., due to high core losses)?

• If core damage is significant, may be more economical to buy new motor
  – Repair of seriously degraded stator core can be expensive
  – Unless motor has special features affecting replacement price or availability
Rotor condition

If failed motor suits application:

• Assess condition of rotor
  – Is damage significant?
  – Did motor exceed its rated temperature rise before it failed (e.g., due to high core losses)?

• If rotor damage is significant, may be more economical to buy new motor
  – Repair of seriously degraded rotor can be expensive
  – Unless motor has special features affecting replacement price or availability
Shaft, frame, bearing housing or other mechanical parts may be damaged beyond repair

- Making new shaft may be economical option
- Cost of buying new may make replacing motor the logical choice (unless motor is very large or has special features)
Root cause failure analysis

- Identify and address underlying causes of failure to prevent recurrence(s)
- Applies to both repair and replace
EPAct (IE2) or NEMA Premium® (IE3) motor

Transition in repair/replace decision process

• Factors to this point have shaped process for over a half-century

• Whether to replace a failed motor with a more energy-efficient model is an important consideration
EPAct (IE2) or NEMA Premium® (IE3) motor

Higher efficiency motors:

• Those covered by earlier U.S. federal regulations (EPAct 1992) — equivalent to IEC motors labeled IE2

• NEMA Premium® motors covered by newer U.S. federal regulations (EISA 2007) — equivalent to IEC motors labeled IE3
EPAct (IE2) or NEMA Premium® (IE3) motor

Repair considerations for higher efficiency motors

- Same as for older standard efficiency models
- Efficiency and reliability can be maintained by qualified service centers that
  - Follow good practices of ANSI/EASA AR100 and EASA/AEMT Rewind Study
  - Participate in EASA Accreditation Program
Consider return on investment (ROI) of a higher efficiency replacement before having a lower efficiency motor repaired

• Examples
  – NEMA Premium® (IE3) in place of EPAct (IE2) motor
  – EPAct (IE2) in place of older standard efficiency motor

• Factors
  – Expected life of motor or process
  – Hours of operation
  – Energy costs

• Verify that replacement is higher efficiency than motor being replaced
EPAct (IE2) or NEMA Premium® (IE3) motor ROI

- If analysis favors replacement, determine whether cost fits within budget
- If not, best option may be good practice repair (if it costs less than a new motor)
Next decision: Motor availability

- Motors such as those under EISA rules are usually stock items
- Larger motors or those with special features often have delivery times up to several months
Next decision: Motor availability

If delivery time exceeds your requirements:

• Qualified service center usually can provide a good practice repair of original motor in far less time

• Service center may be able to add special features to a stock higher efficiency motor, e.g.:
  – Convert it to a C-face or D-flange mounting
  – Modify the output shaft
Motor efficiency

Manufacturers improve motor efficiency by reducing losses, primarily through design changes

Breakdown of motor losses

- Stator $I^2R$ losses: 35-40%
- Rotor $I^2R$ losses: 15-20%
- Stator core losses: 5-20%
- Stray load losses: 10-15%
- Friction & windage: 10-25%
Motor efficiency

Ways manufacturers improve efficiency

• Some high efficiency models have longer stator and rotor cores (reduces core losses)
• Some have more copper wire area in windings (reduces copper losses)
• Fans of totally enclosed, fan-cooled (TEFC) designs
  – Use smallest fan that keeps winding within design temperature limit
  – Minimizes power diverted to windage
Repairs with a proven record of maintaining the efficiency of standard and higher efficiency motors

- Good practices found in ANSI/EASA AR100 Recommended Practice for the Repair of Rotating Electrical Apparatus

- And more specific recommendations in EASA/AEMT Rewind Study’s “Good Practice Guide”

- Download both free at www.easa.com/energy
Among good repair practices identified by the two documents are:

- Ensuring that overall length of turns in winding does not increase (more resistance increases loss)
- Increasing wire area when slot fit allows it (lower resistance reduces losses)

Steps above maintain or may reduce winding copper ($I^2R$) losses
Rewinding good practices

- Test for core losses before and after winding removal
- Repair or replace a defective core
Rewinding good practices

Maintain efficiency by:

• Copy-rewinding or improving winding pattern (e.g., concentric to lap)
• Using same or shorter average length of turns
Rewinding good practices

Opportunity to improve efficiency by:

- Increasing slot fill (reduces heating)
- Using larger winding coil wire area (reduces $I^2R$ losses)

Wire Size:     AWG 16  
Bare Dia.   = .0508

Wire Size:     AWG 17  
Bare Dia.   = .0453
Testing good practices

- Measure and compare winding resistance lead to lead
- No-load testing
  - Check exact operating speed
  - Measure no-load current and compare to full-load rating
EASA Accreditation Program

International program for electrical apparatus service centers

• Based on electric motor repair good practices
  – ANSI/EASA AR100 *Recommended Practice for the Repair of Rotating Electrical Apparatus*
  – “Good Practice Guide” of 2003 study, *The Effect of Repair/Rewinding on Motor Efficiency*

• EASA membership not required
Accreditation program overview

Independent auditors evaluate service centers for compliance

• Assure use of prescribed good practices to maintain motor efficiency and reliability

• Repair processes assessed include:
  – Instrument calibration
  – Mechanical measurements
  – Core testing and rewinding
  – Bearing replacement/lubrication
  – Bearing fit rebuilding
  – Electrical testing
Accreditation program overview

Conformance verified by objective third-party audits
- Independent external audits every 3 years
- Supplemented with mandatory internal self-audits
- 70+ criteria checklist used to assess conformity
Accreditation program overview

Three-phase electric motors that conform to repair requirements are labeled by service center with EASA-approved sticker

Accreditation program motor labels

ID No. A–10000 SAMPLE

ID No. B–10000 SAMPLE

Compliance with EASA AR100 maintains efficiency and reliability.

www.easa.com/accreditation
Questions?

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