Corrective Maintenance

&

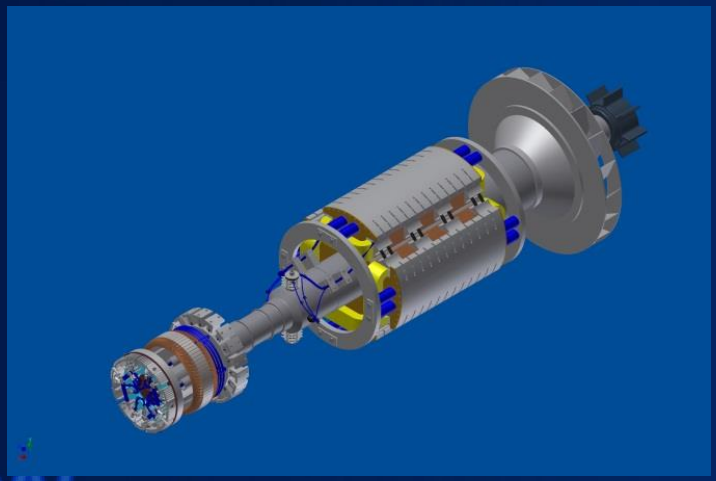
Rotating Electrical Machines

Robert Melaia (LHMarthinusen)

round

Modern perception:

- Corrective maintenance is:
  + Old-fashioned
  + Expensive
  + Ineffective



-There is no (modern) place for ité

- Only practiced by those who don't know better

mentals

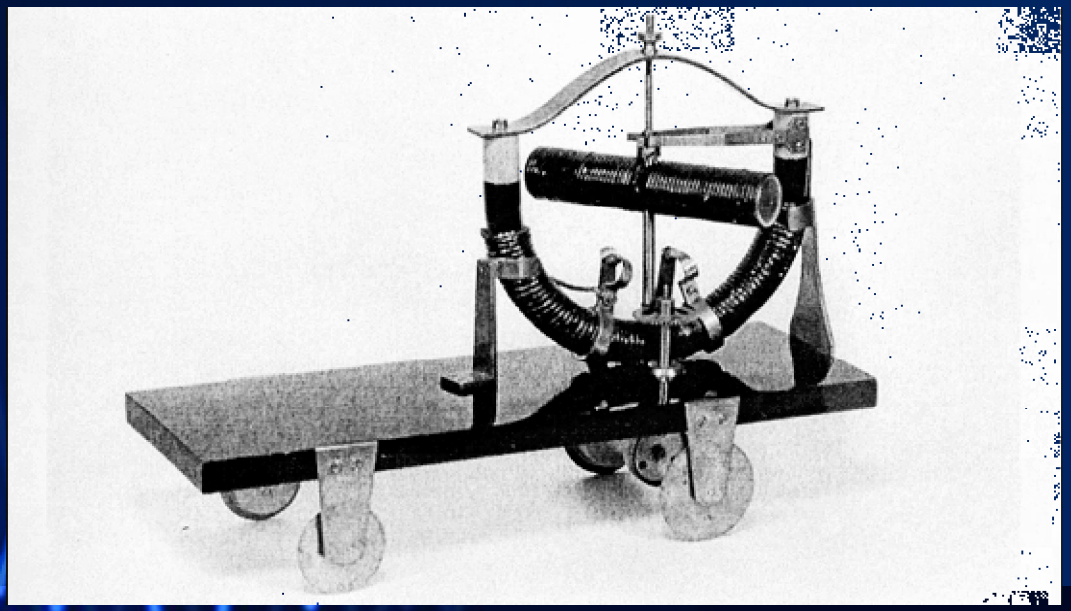
The three maintenance philosophies:

- Corrective
- Preventative
- Predictive (Condition based)

E.g.: Fukushima

ng Electrical Machines – The last 200 years

1828: Jedek's Electric Car



- How much has changed?

s more efficient?

1: Steam driven car

s more efficient?

2: 1970's "Gas Guzzler"

s more efficient?

3: Modern Electric Concept Car

s more efficient?

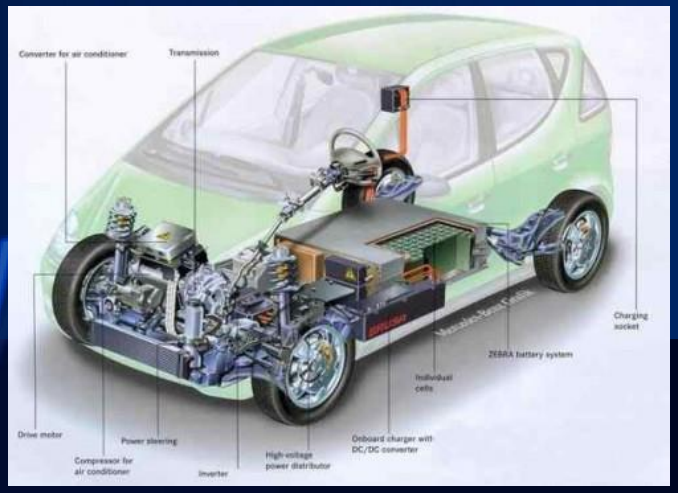
4: South Africa's Electric Car

ncy – The last 200 years

Easy question:

Which is more efficient in the South African context?

- Steam driven car
- Modern Electric vehicle



the detail…

Objective: To share experience

- No hidden agenda

- Partial Discharge Monitors

- Not here to sell anything
- LHM's Vested interest in predictive maintenance

and Formulas

Words of wisdom:

In mathematics you don't understand things, you just get used to them.
J. von Neumann

I have had my results for a long time, but I do not yet know how I am to arrive at them.
Karl Friedrich Gauss

tive versus Predictive

Reality versus theory / ideal:

- We would all like to operate completely on an ideal predictive maintenance based Asset Management system
- Practical Circumstances (human nature)
- Example of Petrochem & Mining
- The realities about motor failures
- How well can failure be predicted?
- Remaining life assessment
- Partial discharge and vibration examples

nvironments 1

Petrochemical:

- Typical long-cycle-time plant (4 years)
- Process plants early adopters of new condition monitoring technology
- Also large-scale adopters of existing accepted condition monitoring tools
- A machine cannot be shut down for inspection
- A single plant trip is catastrophic
- Redundancy is common
- But is predictive maintenance primary?

nvironments 2

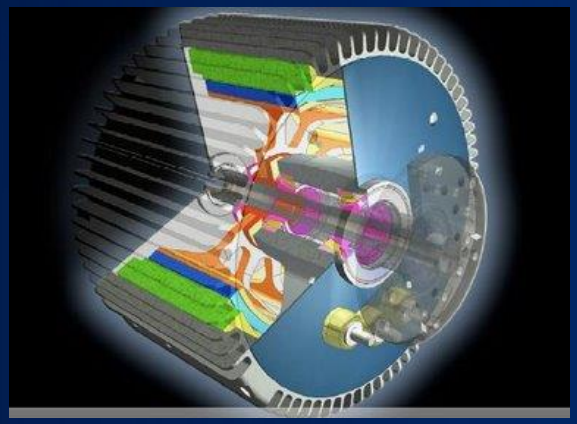
Mining:

- Grinding mill and concentrator plants
- A trip is not catastrophic (nuisance)
- Planned shutdowns (1 to 3 monthly)
- Maximum plant output
- Group or plant spares
- A failed machine can be replaced immediately and this replacement considered as another (planned) shutdown
- The underground considerations are worse!

versus replacement

Replace bigger and bigger machines

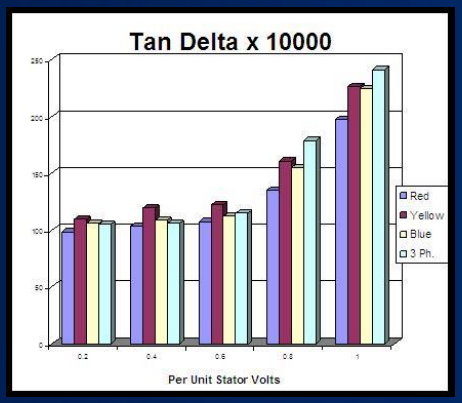
- Used to be at 22 kW
- Now up to 55 kW
- Automatic replacement
- Failure can be anything from bearings to full stator winding failure
- Definitely corrective maintenance irrespective of repair or replace



ble 1: Partial Discharge

The real world

- Motor fitted with PD monitoring
- First two years steady
- Sudden upward PD trend
- What happens?
- Petrochem plant (4 years)
- Increased attention / focus
- Further increase (more than doubles per 6 months)
- Run to shutdown ï and after that?



...le 2: Vibration

The real world (cont.)

- Motor has vibration monitoring fitted
- Runs steady 2 mm/sec
- Sudden increasing trend
- What happens now?
- Spectrum analysis
- Increased attention
- Machine sent for assessment
- Bearing damage / bearing report
- Other root cause (load, gearbox etc.)
- Where is the predictive maintenance?

ple 3: Mine hoist motor

Suspect earth fault

- Definite indication of intermittent earth fault
- What happens?
- Machine has to run
- Downtime cost too high
- Run to final failure
- Replace after that

- Corrective maintenance is not a forced last-resort option but the method that is most cost-effective for these environments (undergound)

e 4: 26 MW 3000 rpm motor

Rotor exciter overcurrent on start

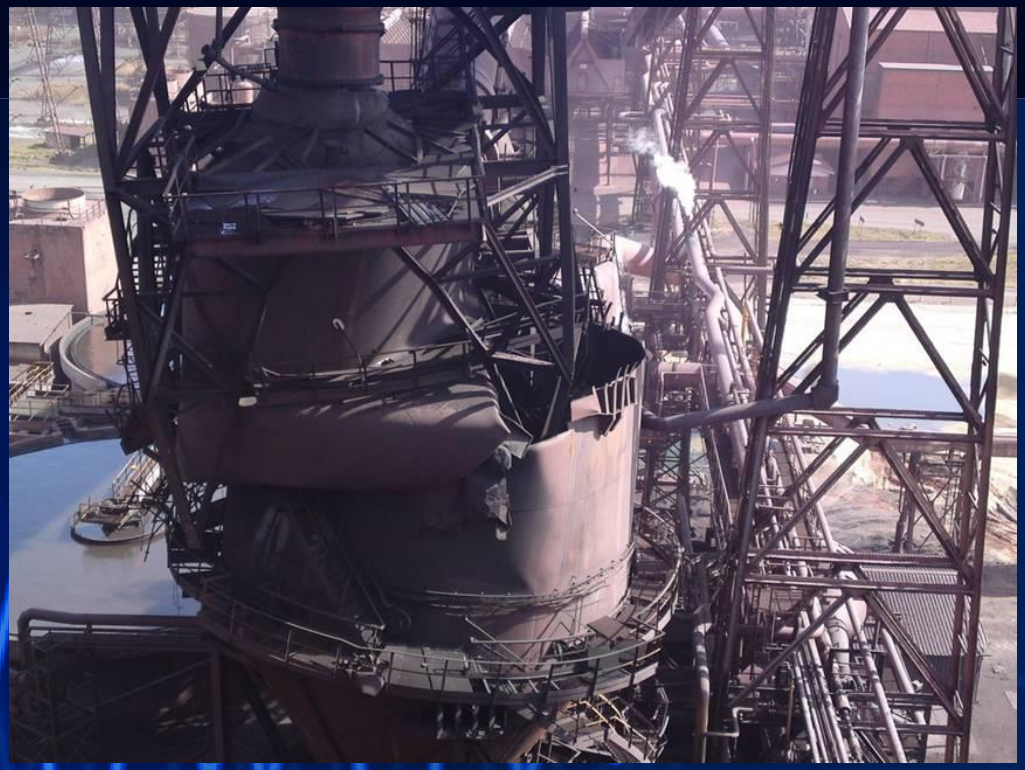
- VSD start: Trip at 1150 rpm every start
- No spare ï R1M / day downtime
- Root cause: Earth fault
- OEM: Full rewind only
- End-user: Not possible!
- Repairer: Make a plan
- Result: Motor still operating 2 years later
- Has end-user learned a lesson?
- Spare rotor on-site BUT not installed!
- Conclusion: Corrective maintenance

le 5: 26 MW 3000 rpm motor

Exciter rotor overcurrent damage

- Same example as before
- Power electronics root cause
- Exciter rotor burned
- End-user: Need machine
- OEM: New exciter
- Repairer: Rewind
- End-user: Desperate (R1M / day downtime)
- Repairer 2nd attempt: Make a plan and run exciter rotor as is with some repairs
- Rotor still operating as is for > 4 months
- Spare exciter / rotor not installed yet!

ical SA reliability



Steel furnace cyclone filter failure (SA, 2011)

PdM*SA* 2011

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& Rotating Machines

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SCHOOL OF ENGINEERING AND MAINTENANCE

ical condition assessment

This is in a controlled workshop ï not a plant!

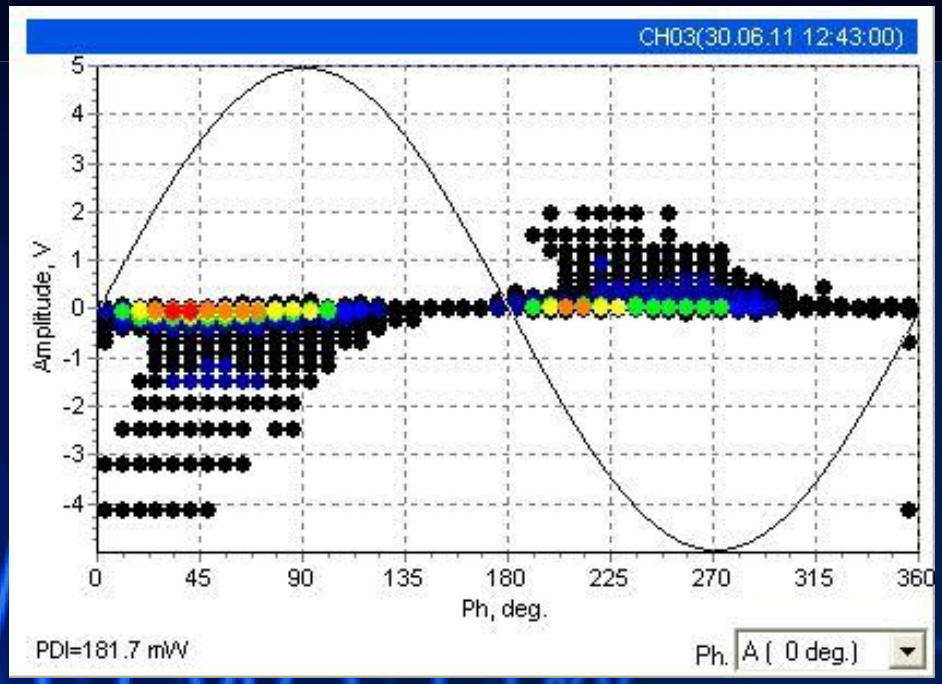
ical maintenance

Fractured shaft; note condition of motor

ical maintenance 2

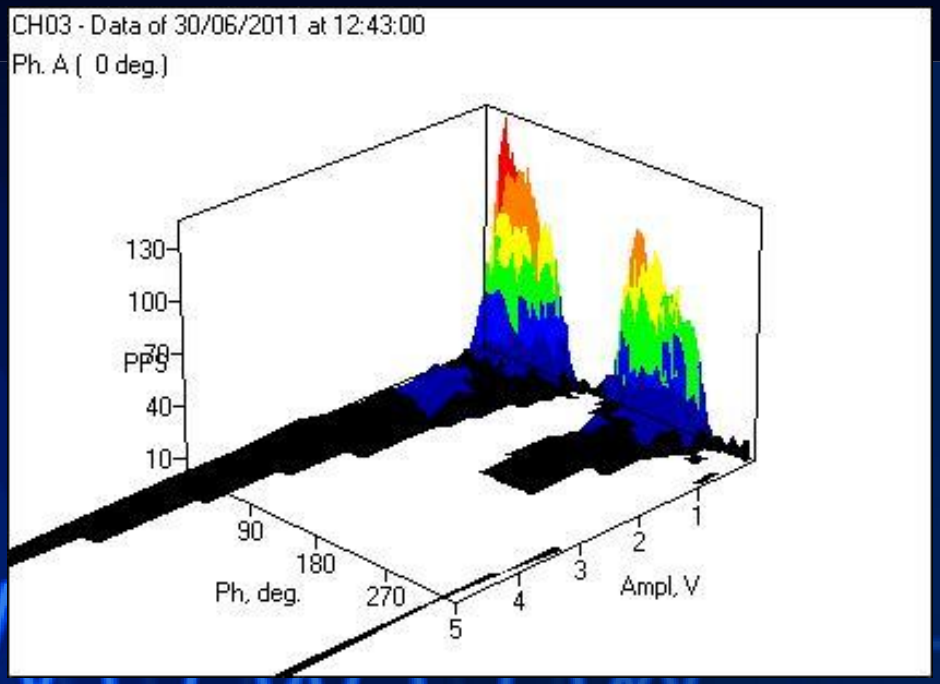
- Now wonder the shaft failed?
- Re-design, modification, FEA, Program?

ation Assessment - 1



Partial Discharge phase distribution 6.6 kV motor

ation Assessment - 2



Partial Discharge phase distribution 6.6 kV motor