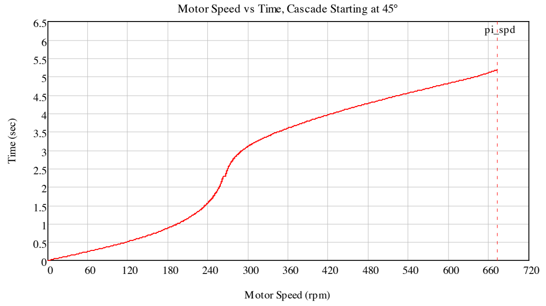
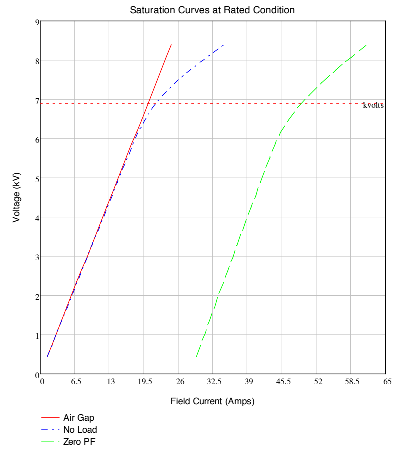
INDUCTION AND SYNCHRONOUS MOTOR DESIGN (CONT)

Using EMEGEN, the full range of performance curves for a synchronous motor design can be created

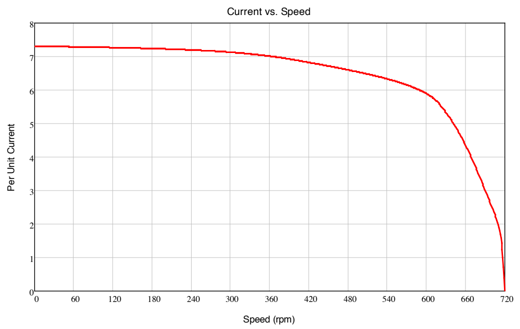
Acceleration



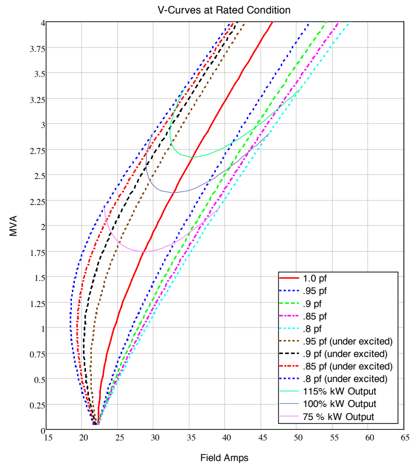
Saturation



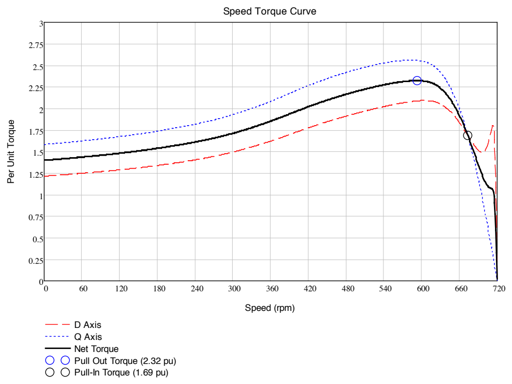
Current vs. Speed



V-Curve



Speed-Torque



Special Projects

As Machine Designers that understand all types of motor designs and construction, we are uniquely capable of designing specialty systems to support non-standard or First Of A Kind evolutions

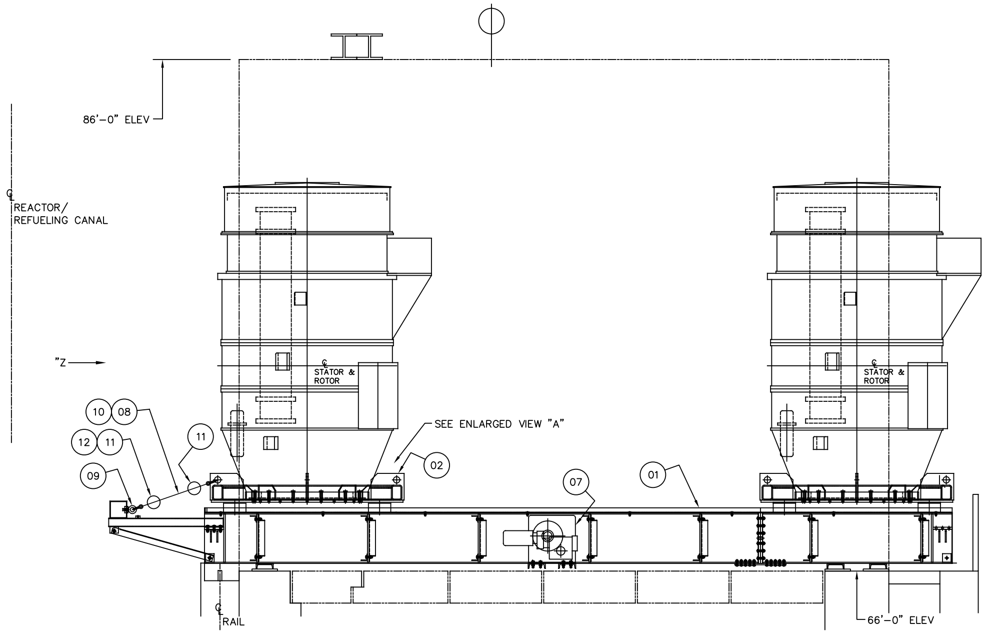
RCP Motor Transfer System

Issues

- In Containment Steam Line interfered with lift
- 11-1/2ft.dia. motor needed to move vertically through 12ft.dia. Equipment Hatch
- Transfer System needed to be designed such that individual components could be hand carried into containment during plant cool down (<80 lbf each)

Solution

- Low Profile track and roller system – utilized motor lower bracket as strong-back to reinforce thin plate
- Individual beam sections, each less than 80 lbf bolted together to create bridge



EME

Powering Engineered Solutions

Our Vision

Leverage the EME Machine Design, Power Engineering and Vibration Analysis Capabilities to be the leading Custom Design Builder of Projects which require innovative systems development and integration of Electrical & Mechanical engineering solutions

Our Mission:

Provide cost effective engineered solutions for Complex Projects

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ElectroMechanical Engineering, Associates

INDUCTION AND SYNCHRONOUS MOTOR DESIGN

EME Proprietary Software, EMEINDUCT & EMEGEN, enable clean-sheet induction & Synchronous motor design & analysis

- Calculate steady state rotor and stator temperatures using a half tooth-half slot model of the rotor and stator.
- Combine distributed losses (copper I2R losses include resistance-temperature relationship) , thermal resistances (conductivity through materials and forced convection using calculated heat transfer coefficients) into a finite difference model.
- Combine Finite Difference Model with results of the Ventilation Modeling – include details of the air flow distribution through the machine
- Establish the air temperatures and the heat transfer coefficient at each convective node in the model.

Item	Description	Units	Item	Description	Units	Item	Description	Units
HP	Rated Power Output	hp	wss	Width Stator Slot	in.	Gap	Single Air Gap	in.
Margin	Pull-Out Margin	p.u.	TPC	# of Turns in Coil	#	Did	ID of Rotor Punching	in.
Vt	Terminal Voltage	Volts	C	# of Parallels	#	S2	# Rotor Slots	#
V1	Phase Voltage	Volts	Pitch	Stator Coil Pitch	Slots	Drs	Depth of Rotor Slot	in.
F	Frequency	Hz	Ns	Strand deep in turn	#	wrs	Width of Rotor Slot	in.
P	Number of Poles	#	Ngr	Grps in Transposition	#	Bo	Width Rotor Slot Opening	in.
Ds	Dia Stator Bore	in.	Hs	Strand Thickness	in.	Ho	Height Rotor Slot Opening	in.
Dod	Dia Frame Bore	in.	Bs	Strand Width	in.	Ht	Bottom Opening to Bar Top	in.
L1	Length of Core	in.	Gw	Groundwall Thickness	in.	Wrb	Widt of Rotor Bar	in.
Bv	Stator Vent Width	in.	Binder	Binder Thickness	in.	Drb	Depth of rotor Bar	in.
Nv	# of Stator Vents	#	Stri	Strand Insulation Thickness	in.	MLCr	Length of Rotor Bar	in.
Vft	# Vent Finger/Tooth	#	Cond	Conductor Insulation Thickness	in.	ODring	OD of Shorting Ring	in.
s1	# Stator Slots	#	Slfin	Side Filler	in.	IDring	ID of Shorting Ring	in.
dss	Depth of Stator Slot	in.	Tcl	Slot Air Film Thickness	in.	Wring	Thickness of Shorting Ring	in.
dsw	Depth Stator Wedge	in.	Rtdtk	RTD Thickness	in.			

- Assess Impact of Changes
- Create Design Basis for New Machine

EMEINDUCT calculate the parameter necessary to solve the Equivalent Circuit for a motor design

R1 – Primary R, ohmic value Winding

R2 – Secondary R, rotor bar & end ring

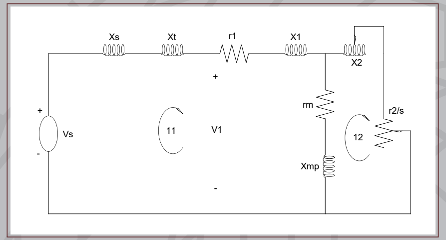
RM – Iron loss R, Fundamental Frequency losses, stator teeth/core & High Frequency surface losses

Xmp – Magnetizing Reactance

X1 – Primary Leakage Reactance, slot, zig-zag, & end leakage

X2 – Secondary Leakage – same components as X1 – accounts for rotor slot style

Xs,Xt – System & Transformer Reactance



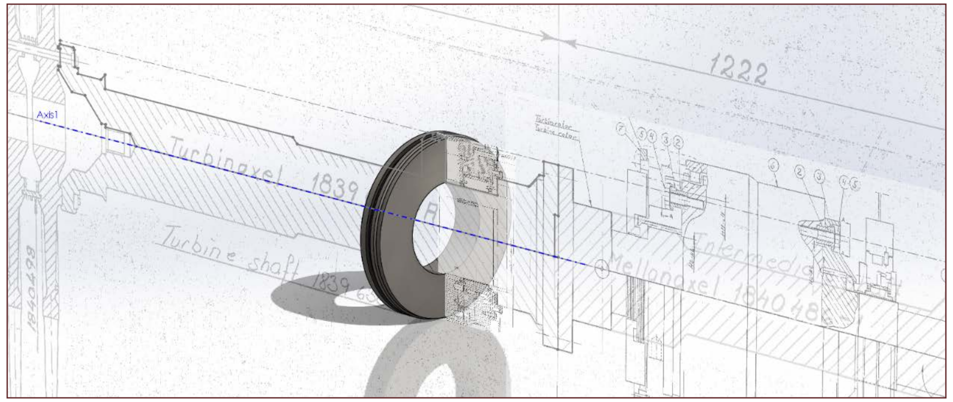
Vibration Diagnostics & Rotor Dynamics Field testing

Field testing

- Acoustic testing
- Modal testing
- Operating deflection shapes of structures

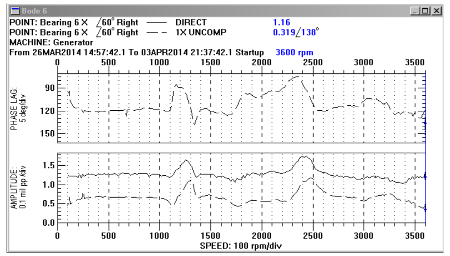
Seismic Analysis

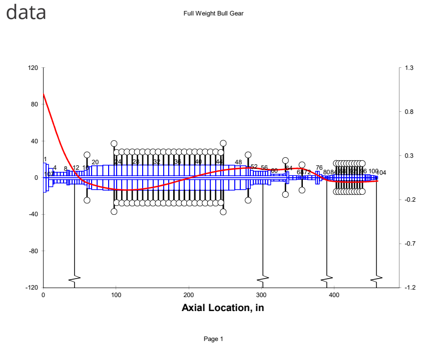
- Rotating element
- Static structure
- Or a combination (pump & housing/bearings)



Rotor Dynamics Analysis

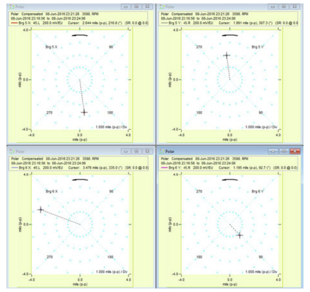
- Typically modeled with purpose made rotor dynamics software
- Can use other methods as appropriate
- Often calibrated with field acquired coast down data

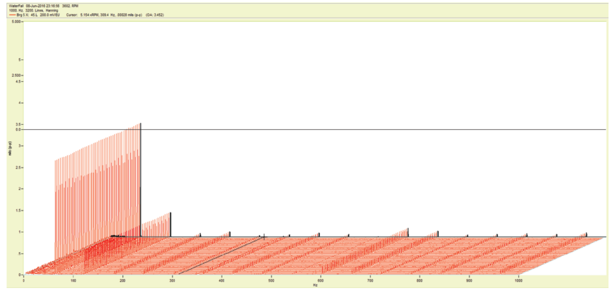




Field Testing

- Acquire data from installed plant equipment
- Portable stand-alone instrumentation setup when needed

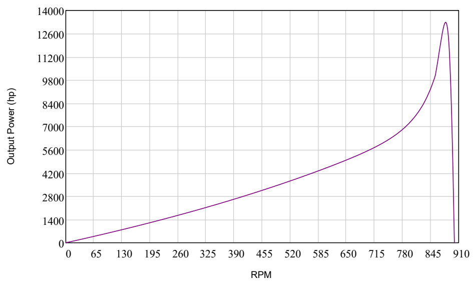


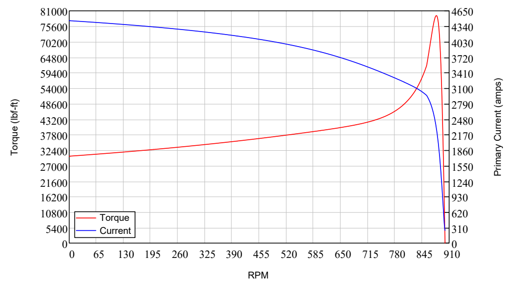


ID Fan Motor Up-Rate Case Study 5000hp to 6000hp

EME Routinely supports customers with Up-Rate Analysis by performing a complete performance and thermal analysis on design changes

- No Dimensional Changes to core – balance of flux density unchanged
- Reduction in Turns/Coil and Coil Throw – increase in flux density of 9.3% across Air Gap, Back Iron & Teeth
- Consider impacts to Core Heating and Coil Heating
- Flux Density within acceptable saturation region, however core losses increase during normal operation
- Evaluate change in Coil Pitch for winding induced harmonics





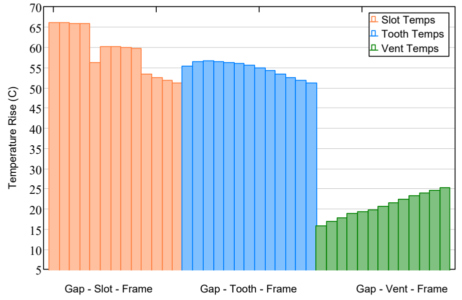


Table 6 – 6,000 HP Rating Operating Parameters

Name	Value
Speed	895.18 RPM
Primary Phase Current	776.1 A
Secondary Phase Current	701.5 A
Power Factor	0.854
Efficiency	97.38 %
Stator Winding Current Density	2,244.1 A/in^2
Rotor Bar Current Density	796.4 A/in^2
Locked Rotor Current	4,452.6 A (573.7 %)
Torque	35,202 lbf-ft
Breakdown Torque	79,345.9 lbf-ft (225.4 %)
Locked Rotor Torque	30,306 lbf-ft (86.1 %)