

ADVANCED MOTORTECH

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Practical design concepts
you can't get from books
or software training!

NEW
COURSE!

Thermal Design of Motors & Generators

-Taking Theory to Practice

*Includes all types of motors and generators; a practical design engineering course
(not software sales or training)*

Join Us in Clearwater, FL. at the Sheraton Sand Key Hotel!
January 30 – 31, February 1, 2019

Learn **THERMAL DESIGN** Principles and Methods for Induction Motors, PM Motors, Reluctance Motors, & DC Motors by applying practical experience, academic theory, material characteristics, manufacturing practices:

Thermal Design Principles and Methods for Electric Machines

- ☑ Practical Thermal Principles and Analysis Techniques for Motors
- ☑ Selecting Materials, Frame Design, Cooling
- ☑ Temperature & Loss Calculations That Work
- ☑ Realistic Practice & Expectations; Options to improve
- ☑ How to Calculate & Test for Parameters & Performance

Objectives & Benefits:

This is the FIRST course of its kind anywhere in the world! Learn the “How-to” for application-oriented thermal design for all types of motors & generators. Learn electric machine thermal design techniques based on academic theory and years of practical experience, taking manufacturing and costs into account.

You will learn about practical Thermal Design Methods and the latest trends, including:

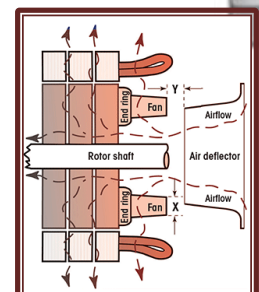
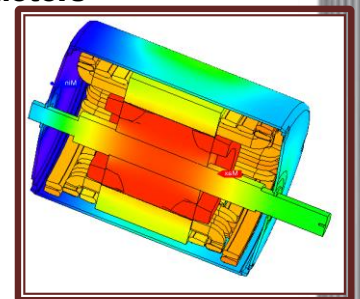
- ◆ Understanding Heat Sources and Sinks, Heat transfer, Temperature, Building your own Model
- ◆ When to choose Natural Convection versus Forced Convection Cooling versus Liquid Cooling
- ◆ New Analysis Techniques, Computer-Aided Engineering (CAE), Quick Approximations
- ◆ Thermal Design Trade-offs affecting Efficiency, Power Density, Thermal Target, Cos, Reliability
- ◆ Design using New Materials, New Manufacturing Methods, New CAE Tools

The material in this course is engineering you can't find in a book, & you can't get from software training! Presentations include specification requirements, design steps, balancing cost and thermal performance, good rules of thumb, analysis approaches & test methods. The course material applies to motors and generators used in industry, hybrid electric drives, traction and propulsion systems, wind turbines, home appliances, aerospace applications. The material applies to radial flux, axial flux and linear machines.

This **NEW COURSE** is a combination of the latest thermal design concepts & computer techniques, with a heavy dose of experience. You will learn the major similarities & differences of cooling systems, fabrication methods, choices of materials, and analysis tools. The MotorCAD® software will be used for illustration purposes to help understanding, but this is NOT a software course.

Those who will benefit:

- ◆ Motor & Generator Design Engineers
- ◆ Drive & Control Engineers
- ◆ Application Engineers, for Industrial, EV, HEV, UAV, Wind Energy, High Efficiency
- ◆ Suppliers to Motor Manufacturers
- ◆ Engineering & R&D Managers
- ◆ Others Who Specify, Design, Manufacture or Service Motors and Generators
- ◆ Electric Machine Professors & Graduate Students



You should know basic electric motor and generator principles, operation & construction. Understanding of basic thermal behavior in machines is very helpful, but advanced thermodynamic theory & motor theory is not essential.

Course Schedule

Day 1:

7:45-8:15 Registration

8:15 Session Begins

1. Fundamentals of Electrical Machines

- Comparison of Motor Types
- Design Envelope, Key Characteristics
- Rotor Configurations, & Why
- Equivalent Circuits, & Why
- Using Models to Predict Performance
- Machine Design Steps, Using CAE

2. Fundamentals of Thermal Design

- Cooling Method: Type, Air, Water, Oil
- Cooling Hardware
- Characteristics of Cooling Systems
- Building Equivalent Thermal Circuit
- Thermal Models, Temperature, Heat Flow
- Thermal Design Software

3. Heat Sources, Effect of Temperature

- Heat Sources Overview, Location & Effect
- Joule Losses, AKA $I^2 R$ Losses
- Core Iron Losses
- Windage & Friction Losses
- Stray Load Losses
- Core Loss Prediction & Loss Coefficients

4. Material Considerations for Thermal Design

- Stator Materials, Impregnation
- Rotor Materials
- Magnet Materials
- Motor Housing Materials & Configuration
- Potting Materials, Composite, Processes

5. Thermal Estimation and Analysis

- Thermal Analysis Principle
- Thermal Analysis – Design Example
- Fan Cooling System
- Water Cooling Calculation
- IPM Motor Thermal Modeling

16:45 Session Ends

Day 2:

8:15 Session Begins

6. Thermal Considerations, Winding & Stator Design

- Current Density of Wire, Slot Fill Factor
- Wire Stranding, Copper Wire AC Losses
- Coating Configuration
- Slot Insulation
- Concentrated Winding Tradeoffs
- End Turn, Axial Heat Flow
- Laminations; Vent Ducts

7. Thermal Consideration, Rotor Design

- Induction Motor Rotor Bars
- PM Motor Magnet Segmentation
- Rotor Core; Vent Ducts
- Rotor Coils and DC Armature
- Rotor Cage Fins and Internal Fan

8. Thermal Considerations, Housing & EndBell Design

- Frame Types, Materials and Heat Removal
- Core and Housing Assembly; Orientation
- Forced Air Cooling Calculation; Fin Design
- Liquid Cooling Systems in Housing
- Aggressive Cooling Methods: Oil Mist, Shaft Cooling, Blower Ventilation, Compressed Air

9. Sizing & Scaling Laws

- Key Sizing Factors, Figures of Merit
- Current Density & Electric Loading
- Flux Density, MMF Drop
- Ke, Kt, Maxwell Shear Stress
- Scaling: Varying Diameter, Axial Length

10. Thermal Design of Electric Motors

- Typical Heat Transfer
- Improving Heat Transfer by Design
- Induction Motor Thermal Simulation
- Thermal Parameter Calculation
- Induction Motor FEA Modeling

11. Advanced Analysis (Transients)

- Analytic vs Transient Thermal Analysis in MotorCAD
- Transient Thermal Analysis – 3HP Induction Motor with FEA

16:45 Session Ends

Day 3:

8:15 Session Begins

12. Integrating Motor Design, Thermal Modeling & Simulation

- Analytic vs. Finite-Element Methods
- Motor Design Software & Books
- One Way Thermal Simulation
- Coupled Magnetic-Thermal Simulation
- Overview of CFD Analysis

13. Practical Thermal Design

- Methods to Reduce Losses
- Methods to Improve Internal Heat Transfer
- Methods to Improve External Heat Transfer

14. Testing: Losses & Modeling Thermal Parameters

- Testing Core Loss and Mechanical Loss
- Harmonic Effect on Loss Prediction
- Calibrating Models to Experimental Data
- Thermal Evaluation of Materials and Processes

15. New Trends & Technologies – What, Why, When

- EV Copper Rotor
- Super Conductor
- High Thermally Conductive Materials
 - o Slot insulations
 - o Wire insulations
 - o Encapsulation compounds
- New Manufacturing Methods

Practical design you can't get from books or software training

15:00 Closing & Adjourn

We will keep you nourished!

Daily schedule includes:

Early Coffee & Juice (7:30)

Mid-morning break (10:00)

Lunch (12:00-13:00)

Afternoon break (15:00)

**Day 2 – PM
Tentative Special Extra
FEA Thermal Design Demo**

**Course content is subject to change. All listed material may not be covered in class, contingent on time used for Extended Discussion, Questions, and Answers.*

Instructor:



Dr. Keith W. Klontz is President and CEO of Advanced MotorTech LLC, an engineering services company with emphasis on electric machine design. He holds BS & MS degrees in Electrical Engineering from the University of Illinois, Champaign-Urbana, and a PhD in Electrical Engineering from the University of Wisconsin-Madison. Dr. Klontz is a world-recognized expert and instructor in electric machine design and has over 50 years of hands-on experience with electric machine applications and design engineering, from concept to performance to repair and failure analysis. He has been involved in the research, development, prototyping, testing and training of very high performance machines from 10 Watts to 50 MW, with speeds ranging from angle positioning torque-motors to 90,000 rpm machines. Recent work includes design of extremely high efficiency PM and induction motors, very high power density machines, permanent magnet alternators, brushless d.c. traction motors, brush d.c. motors, and low cost manufacturing.

Tuition Fees Include:

- Extensive Training Manual (Full Color)
- Mid-Morning & Afternoon Break w/ Refreshments Each Day
- Lunch Each Day
- Signed Certificate of Course Completion



Host Hotel Location:

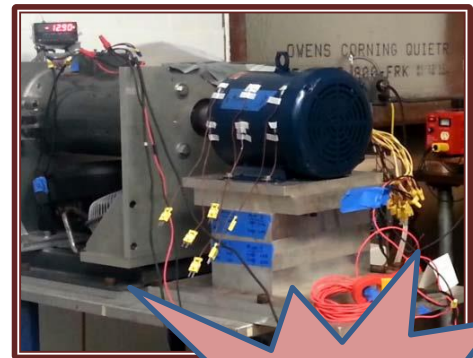
Sheraton Sand Key Hotel & Resort
1160 Gulf Boulevard
Clearwater Beach, Florida 33767 USA
Phone: 727-595-1611, or toll free (800) 456-7263
(Free Parking, Free Internet, No Resort Fee)

Accommodations:

A block of rooms at an excellent rate has been reserved at the beautiful Sheraton Sand Key Hotel & Resort, directly on the Gulf of Mexico. Reservations should be made **before January 8, 2019**. Please reference **CODE AL02AA**, and identify yourself as a participant of the **Advanced MotorTech Short Course** to reserve a room of our block.

Enrollment: Limited seating; Register Early!

- Yes! Please enroll me in the 3-day course **Course No. THRM - 1901**
Thermal Design of Motors and Generators, Jan 30-31, Feb 1, 2019
Fee: \$1875.00 (USD only)



Payment: (*Deadline: Payment must be received prior to start of course)

- MasterCard VISA AMEX

- Cardholder Name _____
- Card No. _____
- Exp ___/___ Billing Zip _____ Security Code: _____

Check enclosed (payable to Advanced MotorTech, LLC)

Bill my company Purchase Order

* Please note payment deadline above; no exceptions; subject to approved credit.

Name _____

Title _____

Company _____

Address _____

City _____ State _____ Zip _____

Phone () _____ Email _____

How did you hear about us?

- Email/Constant Contact Electrical Apparatus Magazine
- Social Media (Facebook/Twitter/LinkedIn) Other (Please Specify) _____

* Cancellations received earlier than 14 days before the course are subject to a 15% late cancellation fee. Cancellations made within 7- 13 days before the course starts are subject to a 50% cancellation fee. Cancellations made 6 or less days before the course starts are subject to the full fee. We reserve the right to exclude any competitor, at our sole discretion.

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