ADVANCED MOTORTECH LLC
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Early Registration Discount!

UNIQUE COURSE!

Thermal Design of Motors & Generators

-Taking Theory to Practice

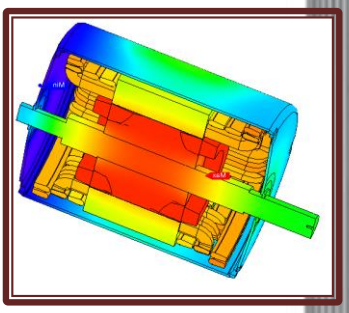
Includes all types of motors and generators; a practical design engineering course
(This is Hardware Design, not just analysis, software sales or software training)

Join Us October 16-17-18, 2019 in CHICAGO Area at Sheraton Suites-Chicago Elk Grove, near O'Hare Airport!

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**
- ☑ **Deciding Which 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 thermal design techniques & decisions 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:

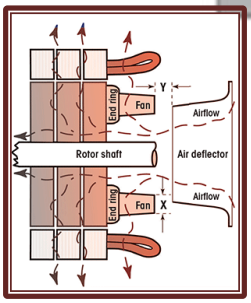
- **Understanding Heat Sources and Sinks, Heat transfer, Temperature, Building your own Model**
- **When to choose Natural Convection versus Forced Convection Cooling versus Liquid Cooling**
- **New Analysis Techniques, Computer-Aided Engineering (CAE), Quick Approximations**
- **Thermal Design Trade-offs 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^2R 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
  - ○ Slot insulations
  - ○ Wire insulations
  - ○ 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 design engineering and applications, 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 Suites Chicago Elk Grove
121 Northwest Point Blvd,
Elk Grove Village, IL 60007 USA
Phone: +1 847-290-1600
+1 888-236-2427 (toll free)
(Free O'Hare Airport Shuttle, Free Parking, Free Internet)

Enrollment: Limited seating; Register Early!

☐ Yes! Please enroll me in the 3-day course: **Course ID: THRM – 1910**
Thermal Design of Motors and Generators, October 16-18, 2019
Fee: $1875.00 (USD only)
Early Registration Fee: $1775.00 (USD only); Payment received by Sep 15, 2019
(We reserve the right to not enroll anyone considered to be a competitor, at our sole discretion.)

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.

New Course!
One-of-a-Kind
in the World!

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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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