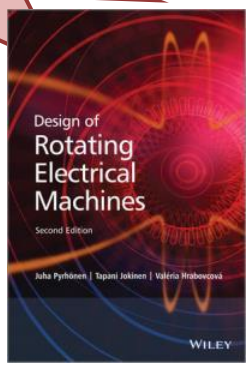
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Includes Book--
Design of Rotating Machines
by Juha Pyrhonen

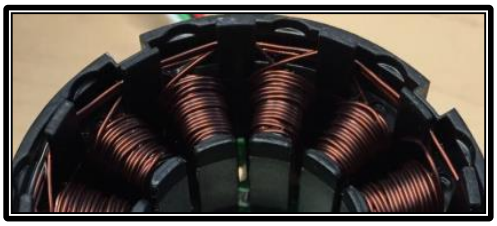


3-DAY SHORT COURSE
ADVANCED MOTOR DESIGN
--TAKING THEORY TO PRACTICE

May 13th, 14th, & 15th, 2020 in Tampa, FL

Learn Advanced Topics in Motor and Generator Machine Design Engineering by understanding the issues, solution choices and procedures, and practical use of the results--all based on academic theory, design experience, and manufacturing practice.
6 of the Key Challenging Topics in 3 days:

- **Core Loss — Advanced Analysis, Prediction, Minimization, & Testing**
- **Advanced Winding Design—Fractional SPP, Layout, Harmonics**
- **Advanced Thermal Design for Motors**
- **Motor Design Optimization**
- **Advanced Induction Machine Design**
- **Advanced IPM Motor Design**



Objectives and Benefits:

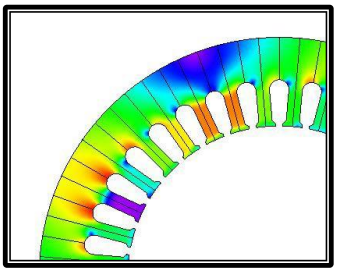
This course provides advanced, but practical, design engineering methods for all types of ac motors and generators. Key motor design difficulties are addressed in six fast-paced, half-day sessions. You will learn to understand the problem, choose solution methods, and interpret the analysis and test data.

We will apply academic theory, computer-aided engineering tools and practical experience to solve difficult motor design issues. The Works-Shop structure will provide 'How-to', with emphasis on quick answers, deep analysis where warranted, expectations & benefits, parameter sewnsitivity, performance differences. Included are new analysis techniques, new design methods, and the latest concepts and practice being used by design engineers and research labs. Similarities and differences of induction, PM machines, reluctance machines, and wound-field synchronous machines, is a common theme.

More-so than ever, this Advanced Course is the engineering material that you can't find in any book, and you can't get from software training! Our acclaimed trainng is a combination of motor design theory and computer tools, inlcuding a heavy dose of many years of practical experience. Each topic area includes design steps, analysis goals and limits, useful rules of thumb and reality checks, interpretation of data, and test methods. The topics apply to the design of all types of machines, especially traction drives, high speed machines, high efficiency, and high power density, as well as cost reduction.

Those who will benefit:

- **Design Engineers of Motors and Generators**
- **Electrical, Mechanical, and Manufacturing & Managers**
- **Research Engineers, Professors, Test Technicians**
- **Control & Drive System Engineers**
- **Inventors, Marketing & Business Development Senior Staff & Managers**
- **Motor Manufacturing Equipment Sales Staff and Engineers**



Course Schedule

7:45-8:00 Registration
8:15 Session Begins

Day 1 AM: ADVANCED CORE LOSS PREDICTION

1. Concepts of Magnetic Materials, Lamination Model

- ☑ Understanding Magnetic Materials: domains, walls, inclusions, orientation, manufacture
- ☑ Material Chemistry: why BH curves are different, oriented and non-oriented electrical steels
- ☑ Understanding Epstein test and Toroid test to get BH curve and loss data
- ☑ Strength of materials; high speed rotors, magnetostriction & noise

2. Hysteresis & Eddy Currents, and Loss Calculation

- ☑ Hysteresis & Eddy Currents for different materials; what matters for motor cores
- ☑ Basic and advanced methods to model and calculate saturation
- ☑ Basic and advanced methods to model and calculate hysteresis, & eddy currents losses
- ☑ Understanding the effects of frequency, saturation and non-sinusoidal excitation

☑ 3. Effects of Manufacture for Laminations and Core Stack; Testing and Correlation

- ☑ Making Cores: burrs, sheet coatings, Franklin Test, anneal process, grinding
- ☑ Effect of core stack: clamping pressure, bonding methods, radial pressure
- ☑ Special laminations: Segmented laminations, hinged laminations
- ☑ Testing for losses, Correlation to determine Ke and Kh coefficients

Day 1 PM: ADVANCED WINDING DESIGN

4. Winding MMF – Analysis & Model

- ☑ MMF of windings, winding factors
- ☑ Winding harmonics, differential leakage field
- ☑ Influence of saturable teeth on gap flux
- ☑ Fractional Slots/Pole/Phase (SPP) , how to lay out winding

☑ 5. Variations in Winding Design

- ☑ Lap vs. Concentric windings Effect of consequent poles
- ☑ Wye vs. Delta, short & long jumper, leads – impact on performance
- ☑ Random vs. bobbin vs. form coils

6. Concentrated Coil Winding Design

- ☑ Harmonics & performance for SPP =1
- ☑ Harmonics & performance of Fractional SPP
- ☑ How to minimize harmonics, maximize torque for Fractional SPP
- ☑ Using harmonics to predict torque ripple and noise

16:45 Session Ends

We will keep you nourished:
Mid-morning break (10:00)
Lunch (12:00-13:00)
Afternoon break (15:00)

8:15 Session Begins

Day 2 AM: ADVANCED MOTOR THERMAL DESIGN

7. Thermal Analysis Issues for Motors Construction

- ☑ Distributed heat sources and cooling System
- ☑ Understanding thermal result of manufacturing processes
- ☑ Improved heat transfer by design
- ☑ Cooling in TEFC (IP55) Frame
- ☑ Water and Oil cooling calculations

8. Realistic Thermal Modeling

- ☑ Thermal modeling in lumped circuit, mixed-mode quasi 2D/3D
- ☑ Thermal modeling in FEA
- ☑ Calibrating Models to test data
- ☑ Forced cooling calculations In-slot winding methods

9. Advanced Thermal Analysis

- ☑ Steady state thermal analysis – 3 hp Induction Motor
- ☑ Transient thermal analysis – 3 hp Induction motor
- ☑ Methods & tricks to improve internal heat transfer
- ☑ Methods & tricks to improve external heat transfer

Day 2 PM: MOTOR DESIGN OPTIMIZATION

10. Concept & Goal of Motor Design Optimization

- ☑ Understanding the specifications and objectives
- ☑ Understanding limitation due to manufacturing processes
- ☑ Initial scaling and figures of merit
- ☑ Optimization Procedure, Sensitivity Analysis
- ☑ Interpreting results, practical limits

11. Optimization Methods and Practice

- ☑ Optimized batch calculations and demonstrations
- ☑ Perform optimization in FEA
- ☑ Design for maximum torque
- ☑ Design for minimum magnet material

12. FEA Demonstration

- ☑ Surface Magnet Motor Design
- ☑ Motor Design –Cogging torque
- ☑ Motor Design – Harmonics
- ☑ Trends for more advanced analysis

16:30 Session Ends

Day 2, 16:30-18:30
Special Extra:
FEA Capabilities Demonstration, Followed by Refreshments

8:15 Session Begins

Day 3 AM: ADVANCED INDUCTION MOTOR DESIGN

13. Advanced Induction Motor Design Choices & Models

- ☑ Unique principles of induction motor design; magnetization issue
- ☑ Equivalent Circuit & DQ Analysis in non-sinusoidal environment
- ☑ Understanding the stator slots/ rotor bars choice, harmonic torques
- ☑ FEA Analysis, including core losses and motor controller

14. High Performance Induction Motor Design

- ☑ High frequency, high speed rotor design
- ☑ Problem of proximity effect losses
- ☑ Design for traction drive
- ☑ Design for concentrated coil winding
- ☑ Rotor bar design to lower losses

15. Key Efficiency and Thermal Issues for Induction Motors

- ☑ Reducing stray load loss, Achieving flat efficiency curve
- ☑ Efficiency map calculation
- ☑ Thermal design of Induction Rotors
- ☑ Trends in induction motor design

Day 3 PM: ADVANCED IPM MOTOR DESIGN

16. Advanced IPM Motor Design Choices & Models

- ☑ Unique design and operation principles of the IPM motor
- ☑ Equivalent Circuit and DQ Analysis, DQ current vectors; demagnetization
- ☑ Understanding the bridge, magnet layer & barrier choices
- ☑ FEA Analysis, torque ripple

17. IPM Rotor Design

- ☑ V-Shape Magnet vs. Straight Magnet
- ☑ Design for Reluctance Torque/ Magnet Torque ratio
- ☑ Alternative Magnet Layers, Bridges and spokes in Rotor Design
- ☑ Rotor Structural Analysis
- ☑ The Line-Start IPM motor

18. IPM Motor Design Issues

- ☑ Efficiency map calculation
- ☑ Thermal designs of IPM rotor
- ☑ Maximum torque/ampere vs. maximum efficiency
- ☑ Trends in IPM Motor Design

16:45 Closing & Adjourn

**Course content is subject to change. All issued material may not be*

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 5 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 design for low cost

Tuition Fees Include:

- ☑ Hard Cover Book "Design of Rotating Electrical Machines" by Pyrhonen, Jokinen, and Hrabovcov
- ☑ Extensive Training Manual (full color)
- ☑ Mid-Morning & Afternoon Breaks w/ Refreshments
- ☑ Lunch Each Day in Session
- ☑ Signed Certificate of Course Completion



Training Host Location:

Tampa Airport Marriott
4200 George J Bean Parkway
Tampa, FL 33607, USA
Phone: +1 813-879-5151, or +1 800-564-3440

Hotel Accommodations:

Walk off the airplane, and into the hotel! A discounted block of rooms with an excellent rate has been reserved at the beautiful **Tampa Airport Marriott** in Tampa, Florida USA. Reservations should be made **before April 12th, 2020.** Just identify yourself as an attendee of the Advanced MotorTech group.

Onsite training is available!
Send inquiries to
sales@advancedmotortech.com

Enrollment:

☐ Yes! Please enroll me in **Advanced Motor Design – MAY 13-14-15, 2020**

Fee: $1925.00 (USD only) **Course No. AMD-20-05**

Early Registration Fee: $1800.00 (USD only); Payment received **by April 12, 2020**

(We reserve the right to not enroll anyone considered to be a competitor or unsuitable, at our sole discretion.)

PAYMENT: (Deadline: *Payment must be received before start of course)

☐ MasterCard ☐ Visa ☐ AMEX

- Cardholder Name _____
- Card No. _____
- Exp ____/____ Billing Zip_____ Security Code: _____

☐ Check enclosed (payable to Advanced MotorTech, LLC) ☐ Purchase Order

Name _____

Title _____

Company _____

Address _____

City _____ State _____Zip _____

Phone ( ) _____ Email_____

Next Offering of our One-Of-A-Kind Course!

* 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, or credit towards a later course.

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