ADVANCED MOTORTECH LLC
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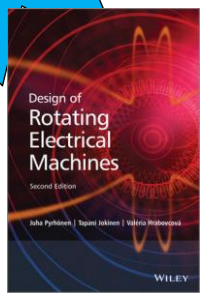
Includes Book,
Design of Rotating Electrical Machines



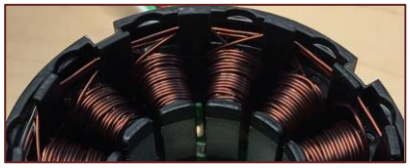
NEW COURSE--FIRST TIME OFFERED!

June 14th, 15th, and 16th in Pittsburgh, Pennsylvania

Advanced Motor Design Training–
Taking Theory to Practice

Learn about <u>Advanced</u> Motor and Generator Machine Design topics 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 Topics in 3 days:

- **Core Loss— Advanced Analysis and Testing Methods**
- **Advanced Winding Design-Winding and Slot Harmonics**
- **Advanced Thermal Design for Motors**
- **Motor Design Optimization**
- **Advanced Induction Motor Design**
- **Advanced IPM Motor Design**



Objectives and Benefits:

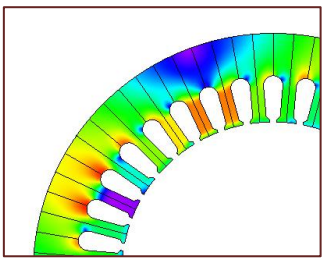
This course provides advanced, but practical, design engineering methods for all types of motors and generators. Key motor design issues are addressed in six fast-paced, half-day sessions. You will learn to understand the problem, choose solution methods, and interpretation of the analysis and test data.

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, performance differences, and evaluation of the results. 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.

<u>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!</u> It is presented using our acclaimed combination of motor design theory and computer technology, with a heavy dose of many years of experience. Each topic area includes design steps, analysis advantages and limits, useful rules of thumb and reality checks, interpretation of data, and test methods. The topics are useful and important for the design of all types of machines, especially applications such as traction drives, high speed machines, high efficiency, and high power density, as well as cost reduction.

Those who will benefit:

- **Motor & Generator Design Engineers**
- **Application Engineers**
- **Suppliers to Motor Manufacturers**
- **Control Engineers**
- **Engineering and R&D Managers**
- **Research Engineers, Test Lab Technicians**



You should have some background and experience in electric machine principles and design such as the equivalent of a B.S. degree in engineering. Understanding of magnetic circuits and harmonic analysis is needed, but advanced motor and control theory are not essential.

Course Schedule

AM Times 8:15-12:00 EACH DAY, PM Times 13:00 – 17:00 EACH DAY

DAY 1 AM: Tuesday, June 14, 2016-Workshop 1: CORE LOSS Analysis and Calculation

1. Advanced Concepts for Magnetic Materials, Laminations

- ☑ Understanding Magnetic Materials: domains, walls, inclusions, orientation, manufacture
- ☑ Material Chemistry: why different BH curves, oriented and non-oriented manufacture
- ☑ Understanding Epstein test and Toroid test to get BH curve and loss data
- ☑ Strength of materials; high speed rotors, magneto-striction & 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 saturation
- ☑ Basic and advanced methods to model hysteresis, eddy currents, calculate losses
- ☑ Understanding the effects of frequency, saturation and non-sinusoidal excitation

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

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

DAY 1 PM: Tuesday, June 14, 2016 - Workshop 2: ADVANCED WINDING DESIGN: Winding and Slot Harmonics

4. Winding MMF – Analysis & Model

- ☑ MMF of distributed windings, winding factors
- ☑ Winding harmonics, differential leakage field
- ☑ Influence of saturable teeth on gap field
- ☑ Odd coil grouping: Slots/Pole/Phase (SPP) >1, how to lay out winding

5. Variations in Winding Design

- ☑ Lap vs. Concentric windings – is there a difference, trade-offs?
- ☑ Effect of consequent poles
- ☑ Wye vs. Delta, short & long jumper, leads – impact on manufacturing
- ☑ Random vs. bobbin vs. form coils

6. Concentrated Coil Winding (CCW) Design

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

DAY 2 AM: Wednesday, June 15, 2016 - Workshop 3: Thermal Analysis for Motors

7. Thermal Analysis

- ☑ Distributed heat sources and cooling System
- ☑ Improved heat transfer by design
- ☑ Cooling in TEFC (IP55) Frame
- ☑ Water cooling calculations

8. Thermal Modeling

- ☑ Thermal modeling in lumped circuit, quasi 2D/3D
- ☑ Thermal modeling in FEA
- ☑ Calibrating Models to experimental data
- ☑ Forced cooling calculations

9. Advanced Thermal Analysis

- ☑ Steady state thermal analysis – 3hp 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: Wednesday, June 15, 2016 - Workshop 4: Optimization

10. Concept of Optimization

- ☑ Understanding the specifications and objectives
- ☑ Initial scaling and figures of merit
- ☑ Optimization, Procedure, Sensitivity Analysis
- ☑ Interpreting the 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 materials

12. FEA Demonstration

- ☑ Surface Permanent Magnet Motor Design
- ☑ Motor Design – reduce cogging torque
- ☑ Motor Design – harmonic minimization
- ☑ Trends for more advanced analysis

DAY 3 AM: Thursday, June 16, 2016 - Workshop 5: Advanced Induction Motor Design

13. Advanced Induction Motor Design

- ☑ Principles of induction motor design
- ☑ Equivalent Circuit & DQ Analysis, including harmonics
- ☑ Understanding the stator slots/ rotor bars choice
- ☑ FEA Analysis, including core losses

14. Special Induction Motor Design

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

15. Efficiencies and Thermal

- ☑ Efficiency map calculation
- ☑ Thermal analysis of Induction Motor
- ☑ Reducing stray no-load & full-load loss
- ☑ Trends in induction motor design

DAY 3 PM: Thursday, June 16, 2016 - Workshop 6: IPM Motor Design

16. Advanced IPM Motor Design

- ☑ Principles of interior permanent magnet (IPM) motor design
- ☑ Equivalent Circuit and DQ Analysis, current vector
- ☑ Understanding the magnet layer & barrier choice
- ☑ FEA Analysis, including torque ripple

17. IPM Rotor Design Choices

- ☑ V-Shape Magnet vs. Straight Magnet
- ☑ Design for Reluctance Torque, Magnet Torque ratio
- ☑ Magnet Layers and Rotor Design
- ☑ Rotor Structural Analysis

18. IPM Motor Design Issues

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

General Information

New Course!
First time offered anywhere!

Tuition Fees Include:

- ☑ Extensive Training Manual (Full Color with Large Pictures)
- ☑ Hard Cover Book "Design of Rotating Electrical Machines" by Pyrhonen, Jokinen, and Hrabovcova
- ☑ Mid-Morning & Afternoon Break w/ Refreshments Each Day
- ☑ Lunch Each Day in Session
- ☑ Signed Certificate of Course Completion

Host Hotel Location:

Marriott Pittsburgh Airport
777 Aten Road
Coraopolis, Pennsylvania 15108 USA
Phone: 412.788.8800

Accommodations:

A **reduced-rate block** of rooms has been reserved at the convenient **Marriott Pittsburgh Airport** for reservations made **before May 30th**. Identify yourself as a participant in this course to reserve a room at the reduced rate. Additional directions and information will be sent with your enrollment confirmation. Please make your own reservations

Enrollment:

☐ Yes! Please enroll me in **Course No. AMD-0616**
Advanced Machine Design, June 14-16, 2016
Fee: $1825.00 (USD only)
We reserve the right to not enroll anyone considered to be a competitor, at our sole discretion.

Payment:)

☐ 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_____

This course surpasses any academic or software training!

* Cancellations received 14-30 days before the course are subject to a 15% late cancellation fee. Cancellations made 7-13 days before the course starts are subject to a 50% cancellation fee. Cancellations made less than 7 days of the course beginning are subject to the full fee.

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