Permanent Magnet DC Motor Design
Course Outline

I. Theory

A. Forward
B. Introduction
C. Properties of ferromagnetic materials
D. Self and mutual inductances
E. Magnetic circuits
F. Examples of magnetic circuit calculations
G. Field mapping using curvilinear squares
H. The PMDC motor
I. Armature reaction
J. Reactance voltage and commutation
K. Torque - speed characteristics
L. Permanent magnets for dc motors
M. Efficiency of dc motors
N. Energy approach
O. Unit conversions
P. Conversion table
Q. Thermal analysis for a PMDC motor

II. Performance Calculations

A. Introduction
B. PMDC construction
C. Performance curves
D. Prediction of air gap flux
E. Carter's coefficient
F. Permeances
G. Permeance coefficient
H. Total flux supplied
I. Armature calculations
J. Net slot area
K. Armature conductors
L. Armature slot fill
M. Inertia
N. Magnetic circuit
O. Trickey factor
P. Armature reaction and brush shift
Q. Commutation
R. Output
S. Losses
T. Current density
U. Motor constants
V. Design analysis procedure
W. Motor calculation example

III. Practical Design Considerations

A. Introduction

B. Motor construction
C. Magnets

1. Material types
2. Hysteresis characteristics
3. Core loss in permanent magnets
4. Material characteristics
5. Demagnetization
6. Magnetization

D. Housings

1. Magnetic circuit
2. Magnetization curve

E. Laminations

1. Hysteresis loop
2. Power loss - hysteresis
3. Power loss - eddy
4. Flux densities
5. Material properties

F. Commutators

G. Brushes

H. Commutation

1. Brush pressure
2. Neutral zone
3. Commutation zone
4. Commutation to neutral zone ratio
5. Brush current densities
6. Brush resistance - contact drop
7. Performance evaluation
8. Brush dust-slot packing

I. Shafts

J. Bearings

1. Ball bearings
2. Needle bearings
3. Sleeve bearings

K. Shaft-bearing systems

L. Magnet wire

M. Insulation

N. Armatures

1. Lap winding
2. Wave winding
3. Flux densities
4. Balance
5. Cogging torque

O. Thermal considerations

1. Heat transfer
2. Thermal resistance
3. Thermal time constant
4. Current density

P. Electromagnetic interference

1. Filters

Q. Clean sheet design approach

R. Velocity profiles

Attendees will learn how to:

- **calculate motor performance**
- **select motor size and materials**
- **analyze motor performance problems**
- **reduce engineering and production costs and enhance market responsiveness**

Instructor:

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William H. Yeadon, P.E., Yeadon Energy Systems., Iron River, Mich., has over 37 years experience in the electric motor industry including work in design and development, production, quality assurance and engineering management. Prior to starting his consulting firm in 1993, he worked at A.O. Smith, Warner Electric and Barber-Colman Co., Motor Div.