Vehicle Electrification System Standards

V. Phase Drive Motors and Generators

V.d Permanent Magnet Electric Machines

Description:

3-Phase electric machines are the central component of an electric powertrain system and it provides propulsion and generated electrical power to HEV, PHEV, and BEV architectures. Understanding the construction, operation, failure modes, and diagnostic processes for Permanent Magnet electric machines is foundational in preparing students for a service career in the electrification service space.

Outcome (Goal):

Students will be able to describe and illustrate how Permanent magnet electric machines operate in all modes of vehicle operation; describe how PM electric machines are constructed; analyze and evaluate the condition of PM electric machine technologies by using various diagnostic techniques and tools..

Objective:

Students shall be able to:

1. Identify and Define IM and PM electric machine internal components
2. Describe how PM electric machines are constructed
3. Explain the concepts of how PM machine Lead, Lag, and Zero Torque is produced
4. Compare and contrast Constant Torque and Constant Power
5. Demonstrate how to analyze and evaluate the condition of IM using a serial data (scan) tool, oscilloscope, milliohmmeter, insulation tester, and specialized analysis testers.

NSF / ATE Grant Award # 1700708
Northwest Engineering and Vehicle Technology Exchange (NEVTEX)

Task:

Students will be able to describe how vehicle PM electric machine propulsion, regenerative braking, and coasting modes; identify powertrain architectures and powertrain components; perform testing and analysis using live vehicles or test stands; define the term power density in the provided pictures or diagrams, using OEM vehicle service, component supplier information, and DOE/NREL/INL/ANL vehicle electrification website information while using proper technical terminology, acronyms, and definitions.

Construction and Manufacturing

- Housing
- Stator Core
  - Laminations
  - Lamination Slot Configurations
  - Slot Fill
  - Round Wire – Random Distributed Windings
  - Hairpin Distributed Windings
  - Concentrated Windings
  - Series and Parallel Winding Configuration
  - Number of Poles vs Torque and Speed
  - Stator End Turn Cooling
  - Stator Temp Sensor
- Rotor
  - Rotor Diameter - as it relates to Torque
  - Rotor Length - as it relates to Torque
  - Interior Magnet Rotor
    - "V" Shape
    - Double "V" Shape
    - Skewed
    - Rare Earth
    - Ferrite
    - Halbach Array
    - Rotor Shaft Bearings
    - Rotor Shaft Currents
    - PM Machine Spin Loss

Traditional PM vs Reluctance Torque PM Machines		
	Traditional PM Electric Machines	
	Reluctance PM Machines	
Electric Machine Operating Regions		
	Constant Torque	
	Constant Power	
PM Machine Torque & Speed Control Operation		
	Concept of Sine Wave Lead and Lag	
	Speed (rpm)	
		Base Speed
		How Max rpm is Determined
	Torque	
		Vector Lead
		Zero Lead-Lag
		Vector Lag
	Software Flux Vector Tables	
		Flux Vector Table Control Strategy
		Flux Vector vs. Stator Current Control
PM Machine Failure Modes		
	Stator	
	Rotor	
	Bearings	
Diagnostics & DTCs		
Servicing PM Electric Machines		

To comment or offer suggestions on this standard, contact Ken Mays:

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