J. Le Besnerais made an industrial PhD thesis in Electrical Engineering at the L2EP laboratory of the Ecole Centrale de Lille, North of France, on the reduction of electromagnetic noise and vibrations in traction machines with ALSTOM Transport. After working as an engineer in the railway and wind turbine industries, he created EOMYS ENGINEERING in 2013, a company providing applied research and development services in electrical engineering.

EOMYS has developed a strong expertise in the analysis and reduction of noise and vibrations due to electromagnetic forces in rotating machines. The company has worked on both synchronous and induction machines, from W to MW range, obtaining up to 40 dB reduction after redesign. Based on its consulting experience, EOMYS has developed MANATEE software, the first simulation software for the fast calculation of variable speed noise and vibrations due to magnetic forces, including NVH root cause analysis and mitigation tools.

ABSTRACT:

e-NVH of Electric Traction Motors: Focus on Physics of Noise and Vibration Due to Magnetic Forces

Electromagnetically-excited noise and vibrations (e-NVH) can be significant in electrified transportation systems, from electric scooters to eVTOL, including electric bikes, electric vehicles and trains. Tackling noise issues after manufacturing can be particularly expensive and may degrade electric powertrain performances such as efficiency, cooling, and weight. Electric motor designers must therefore take into account e-NVH phenomena at early design stage, besides usual electromagnetic and thermal aspects.

This course first reviews all the potential sources of noise and vibration due to electromagnetic forces, both in rotating machines and passive components (inductors, cables, etc). A focus is then done on electrical machines, explaining how Maxwell forces can generate vibrations of active materials. The quadratic nature of magnetic forces is emphasized, as well as two types of excitation forces, namely slotting (related to e-motor design) and switching (related to power electronics design). The acoustic frequency signature of different applications is studied (e.g. turbochargers, pumps, traction motors) depending on speed range and e-motor topologies (slot pole combination, permanent magnet Vs induction machines). Then, resonance phenomena is explained, demonstrating that it is particularly important to identify main magnetic force wavenumbers and frequencies during early electromagnetic design stage of electrical machines. Therefore, the analytic characterization of magnetic forces in some key EV traction motors is carried, namely Interior Permanent Magnet Synchronous Machines (Tesla model 3) and Squirrel Cage Induction Machines (Audi e-Tron). The generation process of electromagnetic force waves, starting from permeance and magnetomotive force harmonics, is detailed.

The course includes sound files, animations and numerical simulation examples coming from MANATEE® e-NVH simulation software. It is mainly made for electrical engineers involved in the design of electrical systems in transportation sector.