RESEARCH UNIT NAME: UNIVERSITÀ DEGLI STUDI DI PAVIA, Gruppo di ricerca "Macchine elettriche ed energetica elettrica"

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RESEARCH TOPICS

- Diagnostics of electrical machines and drives
- Parameter Identification of High Efficiency PMA Synchronous Reluctance Motors
- Industry 4.0. Algorithms for the inclusion of electrical drive systems in Intralogistics industrial plants.
- Energetics of industrial and power systems

TITLE OF RESEARCH TOPIC #1: DIAGNOSTICS OF ELECTRICAL MACHINES AND DRIVES

Keywords: electrical fault detection, current measurement, discrete wavelet transforms, induction motors, magnetic flux leakage, pulse width modulation inverters, spectral analysis.

The research has been focused on the diagnostics of rotating electrical machines, experimentally investigated in laboratory on three-phase induction motors, in order to early detect a fault or a multiple fault. The weaker and more stressed components of these machines are the stator winding insulation and the bearings, especially if they are driven by electronic converter, since they suffer the reflected wave phenomenon due to the high frequency of their supply, which produce harmful effects on the insulation system (partial discharges) and on the bearings (shaft currents). Besides the evaluation of appropriate diagnostic techniques, the research is also focused on the evaluation of advanced design and manufacturing technologies, able to mitigate these effects, both on the machine side (appropriated insulation systems, hybrid bearings, etc.) and on the converter side (special modulation techniques, etc.).

References

[1] L. Frosini and E. Bassi, "Stator current and motor efficiency as indicators for different types of Bearing Faults in Induction Motors", *IEEE Transactions on Industrial Electronics*, Vol. 57, N. 1, Jan. 2010, pp. 244-251

[2] L. Frosini, C. Harlişca and L. Szabó, "Induction machine bearing faults detection by means of statistical processing of the stray flux measurements", *IEEE Transactions on Industrial Electronics*, Vol. 62, N. 3, Mar. 2015, pp. 1846-1854.

[3] L. Frosini, M. Magnaghi, and A. Albini, "An improved diagnostic system to detect inter-turns short circuits in low voltage stator windings", in *Proc. WEMDCD 2015*, 26-27 Mar. 2015, Turin (Italy), pp. 220-225.

[4] L. Frosini, M. Magnaghi, A. Albini, and G. Magrotti, "A new diagnostic instrument to detect generalized roughness in rolling bearings for induction motors", in *Proc. SDEMPED 2015*, 1-4 Sept. 2015, Guarda (Portugal), pp. 239-245.

[5] L. Frosini, S. Zanazzo, and A. Albini, "A wavelet-based technique to detect stator faults in inverter-fed induction motors", in *Proc. ICEM 2016*, 4-7 Sept. 2016, Lausanne (Switzerland), pp. 2919-2925.

[6] L. Frosini, S. Zanazzo, A. Albini, and M. Ferraris, "An experimental investigation of the high frequency effects in low voltage electrical drives", in *Proc. SDEMPED 2017*, 29 Aug.-1st September 2017, Tinos (Greece).

[7] L. Frosini, F. Beccarisi, and A. Albini, "Detection of torque oscillations in induction motor drives by linear discriminant analysis", in *Proc. SDEMPED 2017*, 29 Aug.-1st Sept. 2017, Tinos (Greece).

TITLE OF RESEARCH TOPIC #2: PARAMETER IDENTIFICATION OF HIGH EFFICIENCY PMA SYNCHRONOUS RELUCTANCE MOTORS

Keywords: SyRM; PMASyRM; PMSM; Parameter identification, Model Reference Control.

The research aims at identifying the design parameters of a PM Assisted Synchronous Reluctance Motor (PMASyRM), by using cheaper magnets (e.g. hard ferrites) than those used for a similar Permanent Magnet Synchronous Motor (PMSM) which will be taken as a reference. A dedicated, open code software (Syr-e) has been used in order to create and compare the model of both the reference and the novel solutions. After a validation based on comparison with commercial PMSM, a similar model has been used, with proper adaptation, to design a novel motor, with similar dimensions and performance, still based on cheaper material. The model obtained after this identification procedure can be also employed for implementing model reference control techniques.

TITLE OF RESEARCH TOPIC #3: INDUSTRY 4.0. ALGORITHMS FOR THE INCLUSION OF ELECTRICAL DRIVE SYSTEMS IN INTRALOGISTICS INDUSTRIAL PLANTS

Keywords: Industrial IoT, Logistics, Intralogistics, Lean Factory, Industrial Ethernet, Motion Control, Industry 4.0

The Industry 4.0 paradigm devises a comprehensive interconnection of the devices installed in an industrial plant, so that the process information is widely spread in real time. Such an intelligent network, mostly based on Ethernet basic layers, when properly conceived, should be able to add relevant value to the plant operation. The research Topic is aimed at exploring the actual implementation of this principles mostly in the logistic concept of real industrial plant. The work shared with Lenze Italia (Milano) is a strategy for the coordination of a number of Storage and Retrieval Machines (S/RM) trajectories, to reduce energy consumption and installed power. A second application case, is based on the collaboration with Braas Monier Building Group, a multinational company producing and supplying products and systems for pitched roofs, both tiles (in cement and brick) and components for roofing. For the new automation lines of the process it has been proposed an improved version of the Value Stream Mapping techniques, which is one implementation tool of the Lean Automation Theory.

References

[8] Benzi F., Anglani N., Bassi E., Frosini L. 2011. Electricity Smart Meters Interfacing the Households, IEEE Trans. in Industrial electronics, Vol 58, Issue 10, Pages 4487-4494

[9] S. Farné, E. Bassi, F. Benzi, F. Compagnoni, "IIoT based Efficiency monitoring of a Gantry Robot", *in Proc. Of 14th IEEE International Conference on Industrial Informatics (INDIN 2016), July 2016, Poitiers*.

[10] F. Calegari; G. Federico; E. Bassi; F. Benzi, "Parameter identification of an high efficiency pma synchronous reluctance motor for design and control", *in Proc. of IEEE International Symposium on Sensorless Control for Electrical Drives (SLED), Sep. 2017, catania, Pages 31 - 36.*

[11] F. Benzi, R. Clava & E. Bassi, "Increasing the value stream mapping potential in an industrial process, with a dynamic model, based on data from an industrial ethernet bus", *in Proc.ECEEE Industrial Efficiency Conference 2015, 11-13 June. 2018, Berlin.*

TITLE OF RESEARCH TOPIC #4: ENERGETICS OF INDUSTRIAL AND POWER SYSTEMS

Keywords: Optimization of microgrid, industrial energy conversion systems, energy planning

Modelling extensive or circumscribed energy conversion systems is the common ground of this research, which is based upon the use of optimization techniques, matching needs on long term horizon or on short term ones. We try to answer to questions related to the sustainability of the energy systems not only from energy but

also environmental and economic standpoints. The focus changes according to the issue to face like minimization of fossil fuel consumption, improvement in the use of electric storage, minimization of emissions, improvement of the quality of the service, identification of the most suitable configurations to achieve set targets on renewable penetration, CO_2 emission reduction, minimization of installed facilities power, investigation on the role of more electric vehicles relying on the grid, sustainability issues linked to energy conversion and use for developing countries.

References

[12] Oriti, A. L. Julian, N. Anglani and G. D. Hernandez. **2018**. "Novel Economic Analysis to Design the Energy Storage Control System of a Remote Islanded Microgrid", accepted for publication in IEEE Transactions on Industry Applications.

[13] Fattori, F. Anglani, N. Staffell, I. Pfenninger, S. **2017**. *High Solar Photovoltaic Penetration in the Absence of Substantial Wind Capacity: Storage Requirements and Effects on Capacity Adequacy*. Energy, Vol. 137, pp 193-208, ISSN: 03605442 DOI 10.1016/j.energy.2017.07.007

[14] N. Anglani, G. Oriti and M. Colombini, **2017**. Optimized Energy Management System to Reduce Fuel Consumption in Remote Military Microgrids, in IEEE Transactions on Industry Applications, vol. 53, no. 6, pp. 5777-5785, Nov.-Dec. 2017. doi: 10.1109/TIA.2017.2734045

[15] Fattori, F. Albini, D. Anglani, N. **2016**. *Proposing an open-source model for unconventional participation to energy planning*, Energy Research & Social Science, Vol:15, pp 12-33, ISSN: 22146296 DOI: 10.1016/j.erss.2016.02.005.

[16] Quartarone G., Anglani N. **2016**. Improving the Energy Efficiency of Air Compressor Rooms: A Methodological Tool for the Topology Optimization of Air Compressor Rooms, IEEE Industry Applications Magazine, January/February, Vol 22, issue 1, pp 40-50, ISSN:1077-2618.

[17] Quartarone G., Anglani N. **2015**. Simulation and performance comparison of a real time controller for a fixed speed multipressure compressor, IEEE Transactions on Industry Applications, Volume: 51 Issue: 1, pp 1-9, ISSN: 0093-9994.

[18] Anglani N., Colombini M.. **2015**. Sistemi di espansore con compressori a vite. Industria della Carta. Vol: Sett-Ott. ISSN 0019-7548.

[19] Pendieu M.K., Anglani N. **2015**. Hybrid Energy Systems for Remote Areas and the Role of Storage. IEEE-ICIT 2015, Siviglia 16-18. Pp 1031-1038 DOI 10.1109/ICIT.2015.7125233

[20] Fattori, F. Anglani, N. Muliere, G. **2014**, *Combining photovoltaic energy with electric vehicles, smart charging and vehicle-to-grid*, Solar Energy, Volume 110, December 2014, Pages 438-451, ISSN 0038-092X, http://dx.doi.org/10.1016/j.solener.2014.09.034.

[21] Giusi Quartarone, Marco Liserre, Friedrich Fuchs, Norma Anglani, Giampaolo Buticchi. **2014**. Impact of the modularity on the efficiency of Smart Transformer solutions. IEEE-IECON2014 IEEE-IES, In:2014 IECON. October 29 - November 1, DALLAS, TX, Pp 1512-1518 DOI 10.1109/IECON.2014.7048702

[22] Muliere G., Anglani N. **2011**. *The Impact of Renewable Energy and Energy Efficient Technologies, what to choose in case of limited supportive actions: a case study. International Journal of Energy and Environmental Engineering*. Vol. 2 (5), pp 83-94 ISSN: 2008-9163.

[23] Anglani, N., Muliere, G. **2009.** *Answering the question of local biomass deployment: The use of energy modelling with case study for non-industrial customers*. Chemical Engineering Transactions, 18, pp. 659-664. DOI: 10.3303/CET0918107.