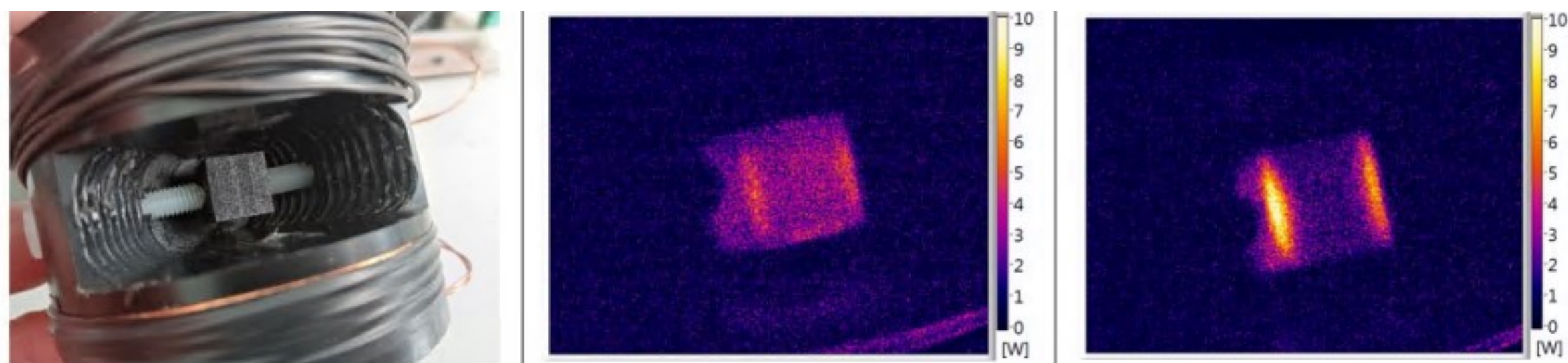
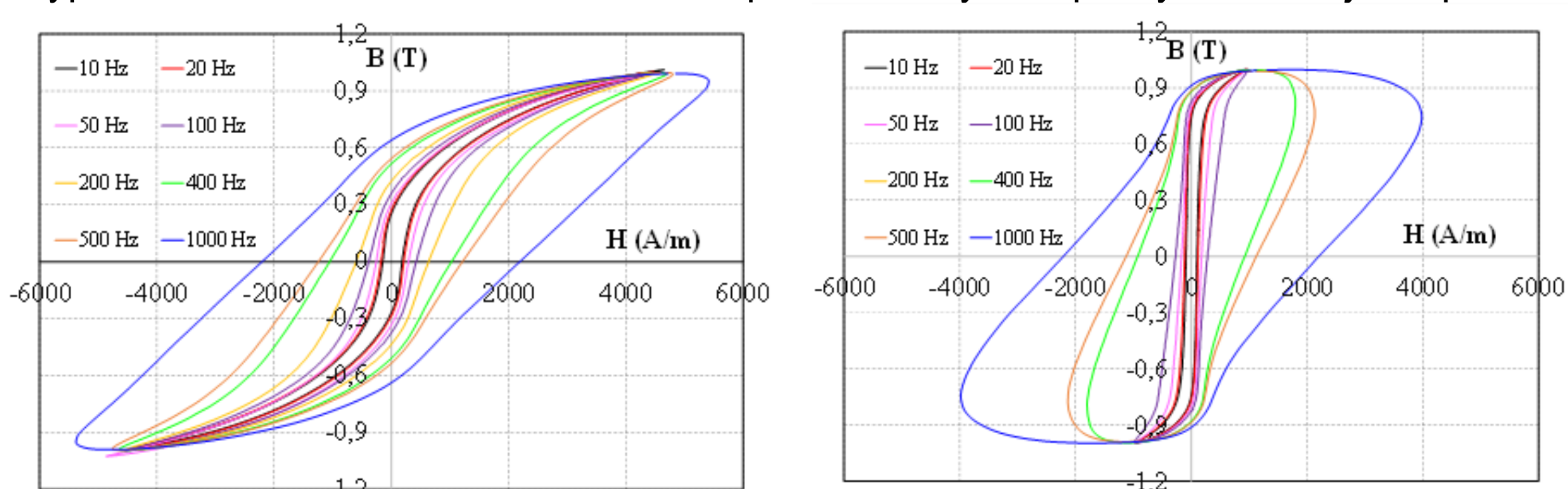


## Research context and motivation

- Additive Manufacturing (AM) aim at becoming the new way of producing personalized components beyond the limits of geometry and location. AM has already established itself in the aerospace, energy, medical sectors as reliable technology, and many companies are already investing in series production plants based on AM.
- The growth of this technology on the industrial market has allowed the production of new alloys for applications in various sectors for example ferromagnetic materials (FeSi, FeNi, etc.) and conductive materials such as Pure Copper and its alloys.
- The aim of the work is to study possible application of this production technology for the electrical sector such as electromagnetic shield, transformers, rotors etc.
- The reason that drives the use of Additive Manufacturing for the production of electromagnetic or electromechanical components consists in the versatility of this technology in creating components with complex geometry and through a study of topological optimization to lighten and improve the properties of the printed object.

## Addressed research questions/problems

- Optimization of the printing process parameters in order to obtain a component with 100% density.
- Study of the influence of the orientation of the piece on the microstructure and therefore on the electrical and magnetic properties.
- Evaluation of the type of heat treatment to be carried out to reduce residual stresses and increase the magnetic properties of the printed material.
- Research of techniques to be adopted to reduce eddy currents due to the creation of massive objects instead of laminates.
- Types of non-destructive tests to be adopted to verify the quality of the objects produced



## Submitted and published works

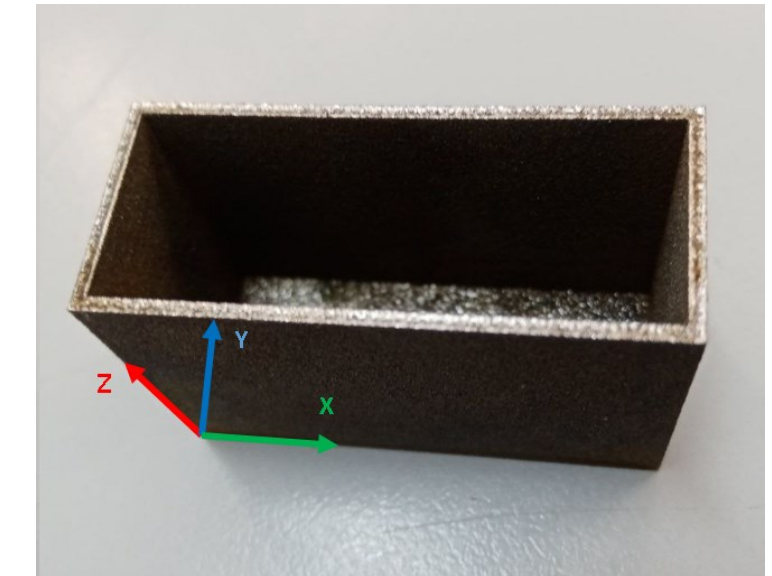
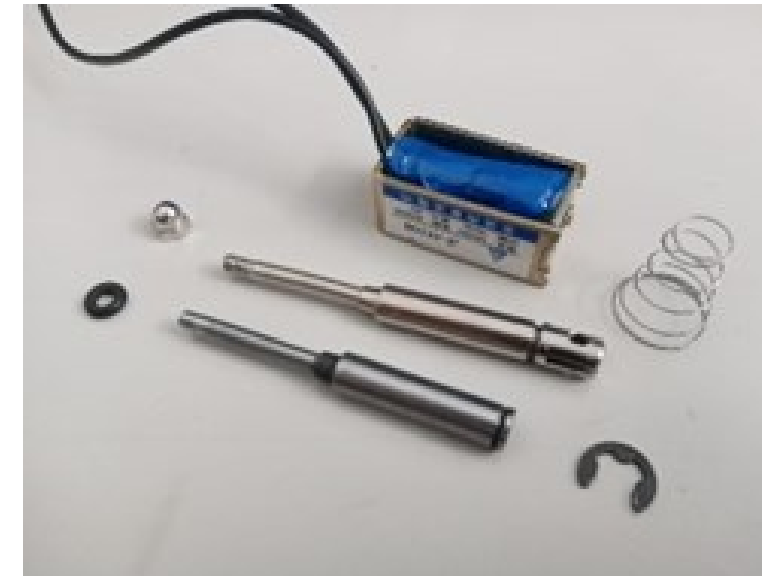
- Canova, A.; Campanelli, F.; Quercio, M. Flywheel Energy Storage System in Italian Regional Transport Railways: A Case Study. *Energies* 2022, 15, 1096. <https://doi.org/10.3390/en15031096>
- Lazzaroni, P.; Mariuzzo, I.; Quercio, M.; Repetto, M. Economic, Energy, and Environmental Analysis of PV with Battery Storage for Italian Households. *Electronics* 2021, 10, 146. <https://doi.org/10.3390/electronics10020146>
- Canova, A., Grusso, G., & Quercio, M. (2021). Characterization of electromagnetic device by means of spice models. *International Journal of Emerging Technology and Advanced Engineering*, 11(9), 12-22. doi:10.46338/IJETAE0921\_02
- Michele Quercio, Francesco Galbusera, Emir Pošković, Fausto Franchini, Luca Ferraris, Aldo Canova, Giambattista Grusso, Ali Gökhan Demir, Barbara Previtali, Functional characterization of LPBF produced FeSi<sub>2.9</sub> Soft Magnetic Material, ICEM 2022XXV International Conference on Electrical Machines, Valencia, 58 Settembre 2022, 2022

### Submitted Works

- Canova, A., Quercio, M. A shielding system proposal for the cabling of electric glass melters, *IEEE Open Journal of Industry Applications*

## Novel contributions

- New applications have been presented for this kind of material FeSi<sub>2.9</sub> produced by Additive Manufacturing. In particular, a plug of a traditional electromagnet was compared with the same one produced using the LPBF technique to verify the performance of the latter.
- Furthermore, for the first time, the application of an electromagnetic shield made of ferromagnetic material produced by AM was presented.
- The method of active thermography was applied to verify the losses in the material and to derive the electrical properties through the thermal properties using empirical formulas



## Adopted methodologies

- The technology used for printing is the Laser Powder Bed Fusion (LPBF) because compared to the Electron Beam Melting (EBM) technique it allows to obtain a good surface finish as well as being easier to use.
- Several cubic samples were produced (DOE) for the characterization of the machine parameters.
- Toroidal samples were produced to characterize the different heat treatments applied to evaluate the influence on the magnetic properties of the material.



## Future work

- The work carried out lays the foundations for future research on the construction of a reluctance motor for electric traction. The goal will be to make both the active and passive parts using the LPBF technique. The study will also concern the recycling methodologies of the various parts in order to conclude the production cycle of a green production system.
- The interest in this technology will be expanded by studying copper components for applications such as rotor windings, inductor for induction heating etc.
- New techniques in addition to LPBF will be used to study new alloys and technology the production of electromagnetic components.

## List of attended classes

- 02LWHRV-Communication-(24/11/2019-1)
- 01NKUNC- Elettromagnetismo applicato-(01/03/2021-10)
- 01SHMRV- Entrepreneurial Finance-(24/11/2019-1)
- 01PJMRV- Etica informatica-(04/05/2020-4)
- 01UIXRV- Laboratory of wireless power transfer for electric vehicles-(24/01/2020-2)
- 01RGBRV-Optimization methods for engineering problems-(15/06/2020-6)
- 01SFURV- Programmazione scientifica avanzata in matlab-(25/05/2020-4)
- 08IXTRV- Project management-(22/11/2019-1)
- 01RISRV-Public speaking-(25/11/2019-1)
- 01SYBRV- Research integrity-(25/11/2019-1)
- 02RHORV- The new Internet Society: entering the black-box of digital innovation-( 27/11/2019-1)
- 01SWPRV- Time management-(12/11/2019-1)
- 02LGXRV- Valutazione di impatto ambientale di campi magnetici ed elettrici a-(19/07/2021-4)
- 01QORRV-Writing Scientific Papers in English-(26/03/2020-3)