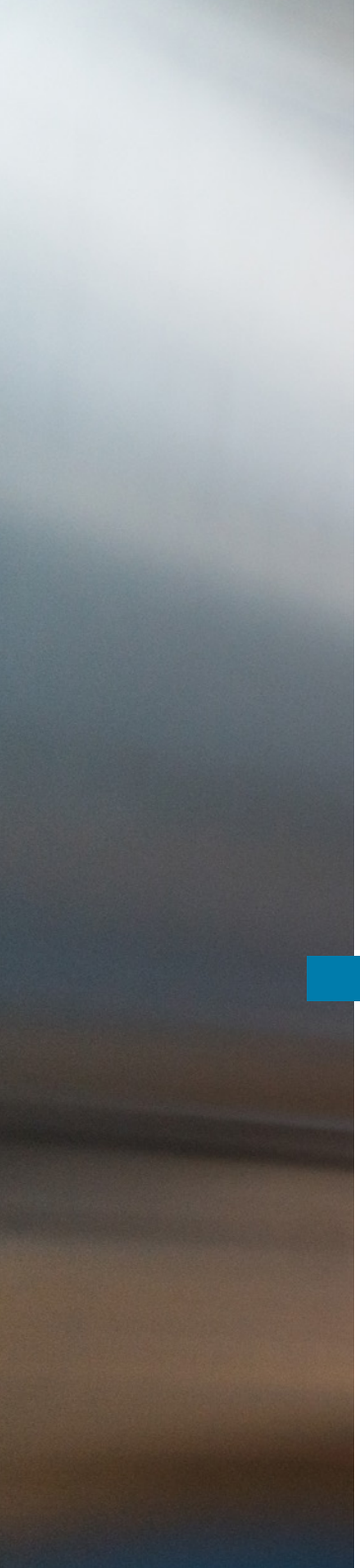
Electrical steel

RINA

Our experience. Your growth.



RINA offers innovative solutions and R&D projects on Grain-Oriented (GO) and Non-Grain-Oriented (NGO) electrical steel grades. We aim to enable the use of new and competitive materials and processes facilitating the introduction of eco-compatible and performing technologies, both in materials manufacturing and in the application for increasingly efficient electric machines. We strive to support clients throughout the entire lifecycle of products, industrial plants and major infrastructure using our know-how in the field of materials and position ourselves as a key player in the technological transfer from research up to the best innovative solutions for the industry, creating value and competitiveness on the global market.

Programmes

14

Recent GO & NGO product innovation programmes

Leadership

50

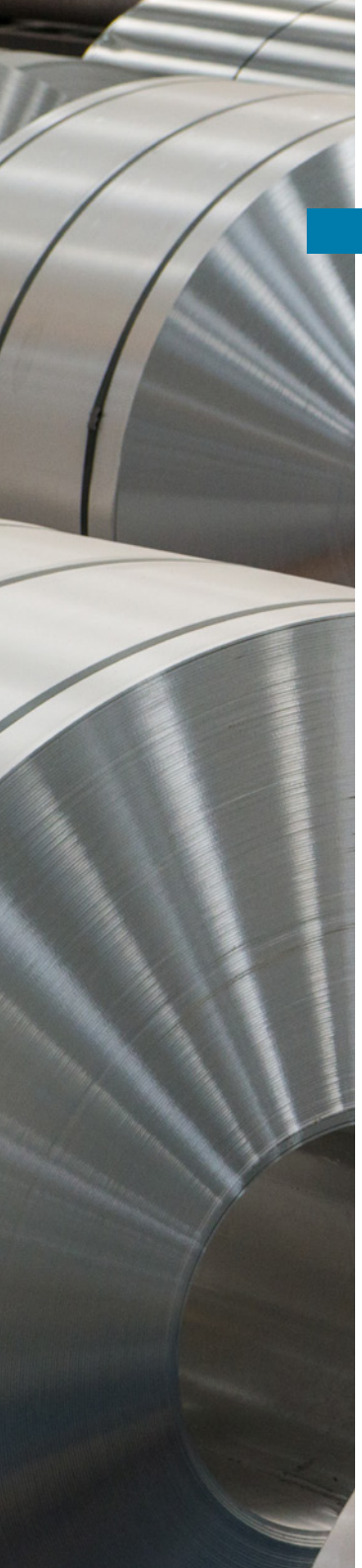
Years of technological leadership

Services

- Metallurgical mathematical modelling & microstructure evolution
- Process simulation & special testing
- Development of new materials and processes
- Industrial cycles testing

Background

Focusing on electrical steels and their industrial production technologies, RINA is engaged in the product / process development of both GO and NGO grades. Activities in this field began in 1968 and were mainly addressed to carrying out research projects for RINA's own shareholders: the Finsider Terni plant. Following privatisation, we started to cooperate with leading electrical steel producers and end-users worldwide. Based on our strong metallurgical background, we can develop new products and processes tailored to final functional requirements and client plant layouts. We can assist clients throughout the entire product development cycle, from metallurgical design to the application engineering phase.



New products & product development

- New NGO high-alloy steel grades (Si + Al > 4%)
- NGO high-permeability grades (85000 >1.75 T)
- New NGO products for high-frequency applications
- NGO semi-finished electrical steel grade development
- Anti-ageing products without solid-state decarburisation (NGO)
- New coating development for GO and NGO grades
- GO extra-low core loss products (laser scribed, low thickness, etc.)
- New fabrication cycles based on innovative casting technologies (strip casting, thin slab processes, etc.) tailored to client industrial layouts for GO and NGO products
- Optimisation of hot / cold rolling schedules to improve steel texture for GO and NGO products
- Optimisation of hot / cold rolling process control to fulfil higher requirements concerning shape and flatness tolerances (GO and NGO)
- Solid-state decarburisation process development (GO and NGO)
- Solid-state nitriding process development for increasing grain growth inhibition for GO grades
- Optimisation of final High-Temperature Coil Annealing (HTCA) in view of HGO magnetic quality improvement and glass film
- Laser scribing technology

Competences and facilities

- Deep knowledge of complex relationships between functional properties and product microstructure
- Strong competence in process metallurgy of Fe-Si alloys along the entire industrial production route (through process)
- Labs equipped to simulate the entire production cycle, from steelmaking to coating deposition and curing
- Pilot plants for scaling-up from laboratory to industrial plants
- High-tech metallurgical characterisation facilities (SEM, TEM, EBSDP-OIM, X-ray, ODF, GDOES, ESCA, magnetic characterisation)
- Metallurgical mathematical modelling tools to predict microstructure evolution along the production route
- FEM models for the study of product behaviour during use and for the design of electric machine optimisation
- Strong 'plant team' of skilled personnel able to design and monitor industrial trials as well as develop process control strategies
- Innovative technologies for GO and NGO production tailored to client plant layouts
- Technical proprietary know-how and patent portfolio

Rolling & annealing

Electrical steels have demanding requirements concerning geometrical tolerances and surface quality and, at the same time, microstructure and texture evolution need to be carefully controlled throughout the process. More advanced automation and process control models of hot & cold rolling and annealing, able to integrate their conventional functions with dynamic metallurgical models, are adopted to allow a very refined online control of process and product properties. RINA's automation, process controls and metallurgical models are fully in line with these requirements, with particular experience of:

- Offline simulation of hot rolling and annealing processes in different plant configurations and auto-adaptive online models for rolling mills and annealing temperature pre-setting
- Metallurgical modelling to predict microstructure / texture evolution during hot or cold rolling and annealing processes
- Second phase precipitation modelling for grain growth process control
- Primary and secondary recrystallisation modelling for optimisation of GO / NGO production
- Final (HGO) annealing models for optimisation of magnetic properties and glass film quality

Coating and surface treatments

The requirements for interlaminar electric insulation of electrical steels demand for the development of special coatings both for GO and NGO grades. Surface tensioning in coatings are developed specifically for GO grades to reduce core losses and improve the magnetostriction behaviour of the products, and a special surface treatment is used to refine the domain structure (core loss reduction). In this framework RINA offers the following capabilities:

- Coating chemical composition formulation
- Coating deposition and curing
- Coating qualification (thickness, resistivity, tensioning, etc.)
- Laser scribing optimisation to reduce core losses and improve magnetostriction

Steel **manufacturing**

More than four decades of R&D projects and activities on liquid steel preparation cleanliness and refinement have allowed RINA to become a global reference research centre for steel preparation technologies. We have developed specific skills to manage the stringent requirements of electrical steels in terms of chemical composition ranges and inclusions content, with capabilities including:

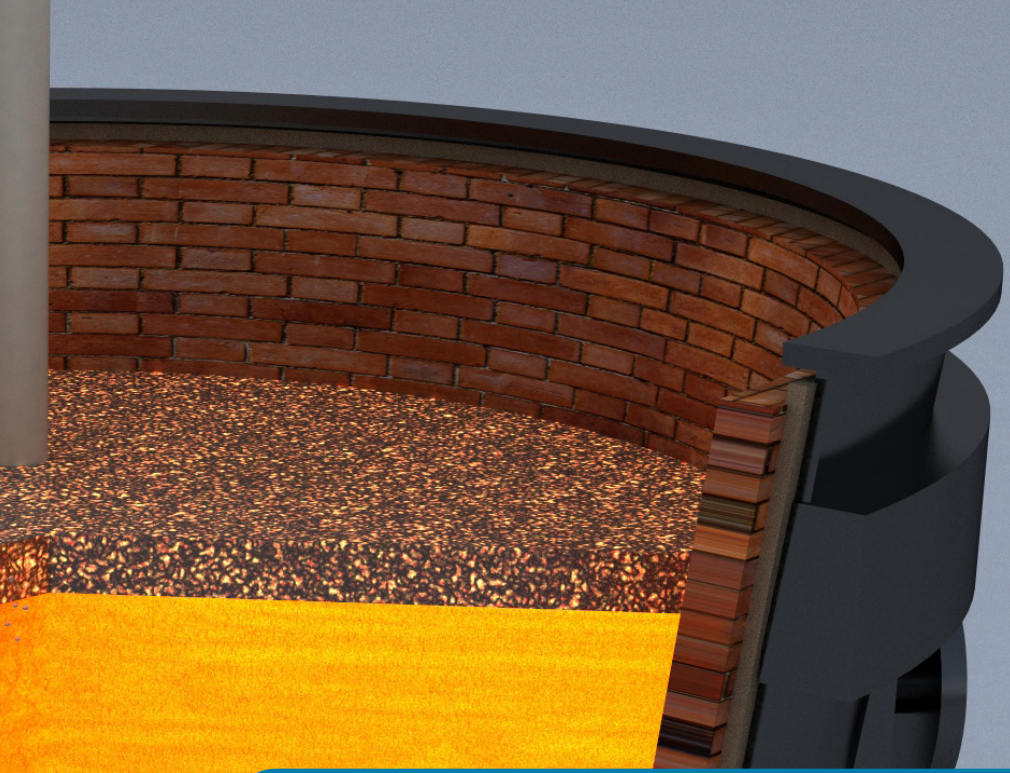
Electric arc furnace | Metallic charge selection | Thermodynamic study on steel-slag-refractory interaction | Management of steel chemistry to be achieved inside EAF.

LD converter | Development of online static models for LO converters | Stirring efficiency supersonic lance optimisation.

Liquid steel refining | Refining treatments for thermodynamic & kinetic modelling in terms of killing and alloying sequences, steel-slag interaction, refractory chemical consumption | Slag design and management | Inclusion design, removal improvement, and chemical modification | Mathematical and physical fluid-dynamics modelling to measure vacuum treatment efficiency, enhance inclusion removal and manage thermal stratifications inside ladles | Description of thermodynamics & kinetics of chemical reactions and gas removal from steel during vacuum treatments | Design of stirring methods and devices.

Casting | RINA can boast competences on all topics related to steel solidification (tundish and mould steel fluid-dynamics, shell lubrication, casting powder and liquid steel interaction, solidification metallurgy and defect analysis). New casting technologies such as 'thin slab' and 'strip' casting offer new opportunities for microstructure and second phase precipitation control; both factors are of major importance for the production of both GO and NGO electrical steels.

Examples of RINA casting competences | Thermo-mechanical analysis and optimisation of mould shape and assembly in relation to shell features | Mathematical and physical fluid-dynamics modelling including electromagnetic effects and thermal exchange during solidification along the strand | Design of nozzle shape and refractories | Microstructural analysis of solidification patterns and definition of mechanisms of defect formation as a function of the process parameters | Design and testing of casting powders | Development, setup, and online tuning of specific sensors.

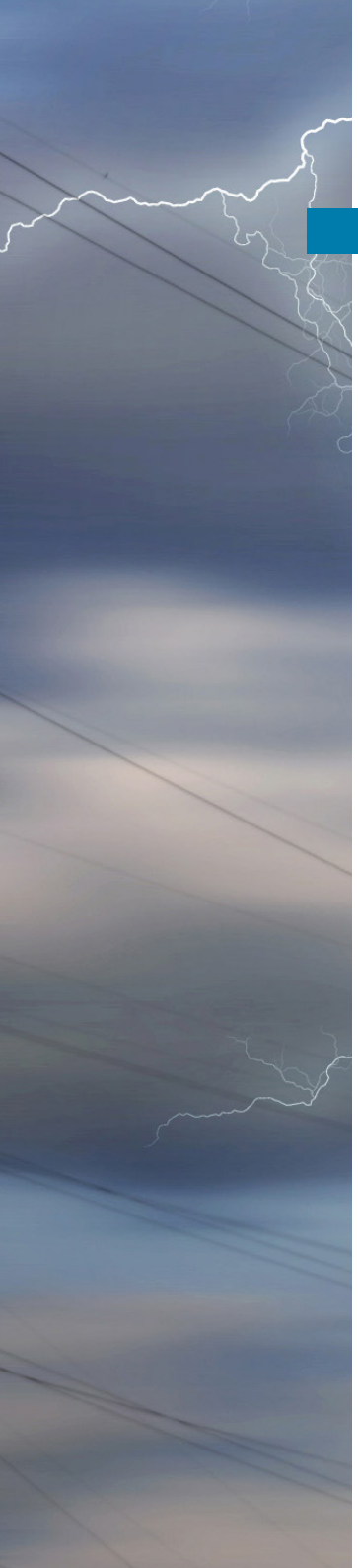


Case study

Disstec project N.G.A: 709740 | 18 months | BFI (Leader), RINA, CRM, MPI, MEFOs
The project covered dissemination of the knowledge gained and technological solutions introduced in relevant European supported (RFCS) projects on secondary metallurgy based on modelling tools, lab tests, onsite support & analysis, and describes the most relevant findings achieved so far after EU projects focused on steel manufacturing operations involving modelling (physical and numerical), lab activities and plant tests aimed at improving steel quality (cleanliness) and productivity during metallurgical operations.

Vital steel manufacturing strategies for magnetic steel production & quality

- Physical modelling techniques: water modelling with conductivity measurement to assess mixing conditions
- Numerical modelling of steel manufacturing practices: gas stirring operations described by Computational Fluid Dynamics (CFD)
- Steel cleanliness required in quality steels (e.g. magnetic): as-cast not affected by non-metallic inclusions



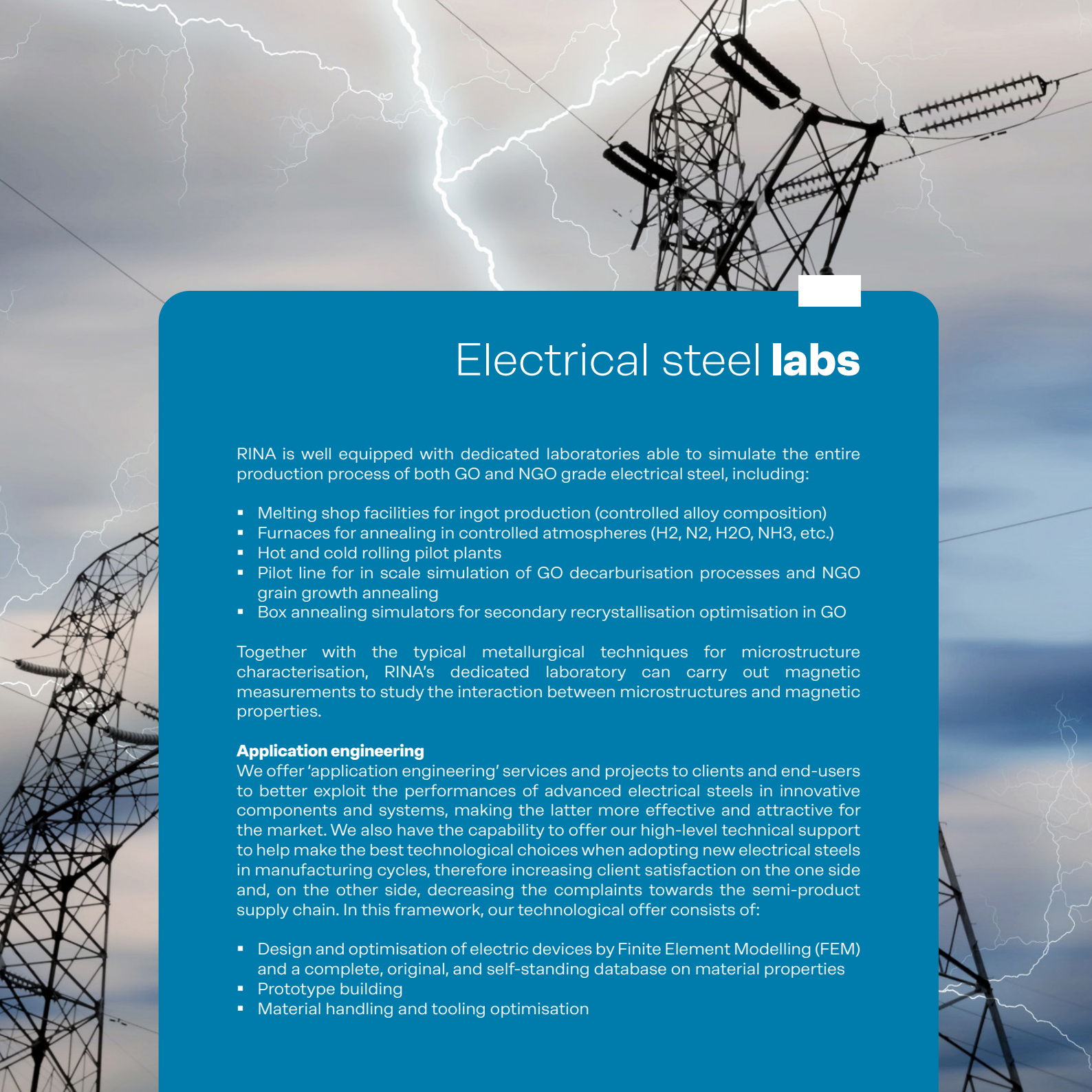
Offer for
electrical steel manufacturers

RINA provides technological services for electrical steel manufacturers (or prospective manufacturers) including for the development of the production technologies. We can conduct investigations to identify the optimal industrial layout (greenfield) and the necessary modifications to existing plants (brownfield).

We can define specifications for plant engineers - including local suppliers - for new plants and give assistance to the manufacturer, when necessary, in bidding, evaluating proposals and during the commissioning of plants for both hot and cold rolling areas. Personnel training in the operation of the technology required for basic metallurgy, processing and operation is a particular point of strength.

Technology implementation is required along all production lines (through process), defining operational practices to carry out industrial trials and to assist the steel manufacturer in upgrading the physical and magnetic yield of production to a clear and viable industrial target level.

RINA can train staff and provide specification to the steel manufacturer for the implementation of a quality control laboratory and to set up material testing and a qualification laboratory for GO electrical steel. We can also provide ancillary production technology design, such as laser scribing, for top GO grade products and design research and development facilities to simulate decarburisation and nitriding (pilot lines) to support the future steel manufacturer in research and development.



Electrical steel **labs**

RINA is well equipped with dedicated laboratories able to simulate the entire production process of both GO and NGO grade electrical steel, including:

- Melting shop facilities for ingot production (controlled alloy composition)
- Furnaces for annealing in controlled atmospheres (H2, N2, H2O, NH3, etc.)
- Hot and cold rolling pilot plants
- Pilot line for in scale simulation of GO decarburisation processes and NGO grain growth annealing
- Box annealing simulators for secondary recrystallisation optimisation in GO

Together with the typical metallurgical techniques for microstructure characterisation, RINA's dedicated laboratory can carry out magnetic measurements to study the interaction between microstructures and magnetic properties.

Application engineering

We offer 'application engineering' services and projects to clients and end-users to better exploit the performances of advanced electrical steels in innovative components and systems, making the latter more effective and attractive for the market. We also have the capability to offer our high-level technical support to help make the best technological choices when adopting new electrical steels in manufacturing cycles, therefore increasing client satisfaction on the one side and, on the other side, decreasing the complaints towards the semi-product supply chain. In this framework, our technological offer consists of:

- Design and optimisation of electric devices by Finite Element Modelling (FEM) and a complete, original, and self-standing database on material properties
- Prototype building
- Material handling and tooling optimisation

Selected **patents**

WO2015170271 Fortunati | Process for the production of NGO electrical steel strips with a high degree of cold reduction.

WO2013051042 Fortunati, Cicalé, Abbruzzese | Oriented magnetic sheet with a high level of cold reduction.

WO2011063934 Fortunati, Abbruzzese | Process to manufacture GO electrical steel strips and GO electrical steel produced thereof.

WO2011114227 Cicalé, Abbruzzese | GO steel strips with high magnetic characteristics, and the manufacturing process thereof.

WO2010057913 Fortunati, Abbruzzese, Cicalé | Process for the production of GO magnetic sheets from thin slabs.

WO2009153244 Abbruzzese, Cicalé, Fortunati | Process and plant for producing in situ ammonia-based mixtures with controlled nitriding power.

WO2008129490 Abbruzzese, Cicalé, Fortunati | Process for the production of a GO magnetic strip.

WO0250315 Fortunati, Cicalé, Abbruzzese | Process for the production of GO electrical steel strips.

WO0250318 Cicalé, Fortunati, Abbruzzese | Process for the production of GO electrical steel.

WO0250314 Fortunati, Cicalé, Rocchi, Abbruzzese | Process for the production of GO electrical steel strips.

Selected **patents**

WO0212572 Fortunati, Cicalé, Rocchi, Abbruzzese | Process for the control of inhibitor distribution in the production of GO electrical steel strips.

WO0073517 Ban Gabor | Process for the improvement of the magnetic characteristics in GO electrical silicon steel sheets by laser treatment.

WO9946413 Fortunati, Cicalé, Abbruzzese | Process for the production of GO electrical steel strips.

WO9841659 Cicalé, Fortunati, Abbruzzese | Process for inhibition control in the production of GO electrical sheets.

WO9828451 Fortunati, Cicalé, Abbruzzese | Process for the production of GO silicon steel sheets.

WO9828452 Cicalé, Fortunati, Abbruzzese | Process for the production of GO electrical steel sheets with high magnetic characteristics.

WO9828453 Fortunati, Cicalé, Abbruzzese, Matera | Process for the treatment of GO silicon steel.

WO9810104 Fortunati, Cicalé, Abbruzzese | Process for the production of GO electrical steel strips from thin slabs.

WO9808987 Fortunati, Cicalé, Abbruzzese | Production process for highly magnetic GO electrical steel strips from thin slabs.

(EP0434641) Barisoni | Process for the production of semi processed NGO electrical steel.

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DISCOVER
our web page

RINA consists of the parent company RINA S.p.A., the holding which controls the main sub-holdings RINA Services S.p.A., RINA Consulting S.p.A. and RINA Prime Value Services S.p.A. In order to ensure compliance with the applicable recognition, authorization, notification and accreditation rules, including those relevant to the management of impartiality, RINA has adopted a governance and organizational model. According to this model, the sub-holdings are subject to direction and co-ordination by the holding in the finance, administration, strategic, organizational, managerial and business continuity fields, while technical and operational decisions remain under the exclusive responsibility of the sub-holdings and their controlled companies. The strict separation of duties in the governing bodies and the impartiality risk assessment, which identifies and manages the impartiality and conflict of interest threats coming from the company relations, ensure compliance with the applicable impartiality rules.

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