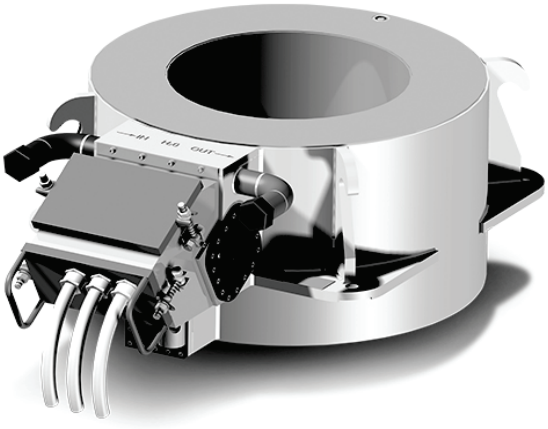
ELECTROTHERM®

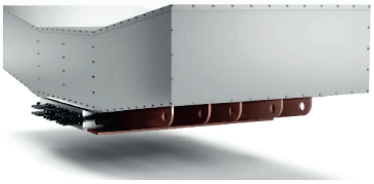
ergolines INNOVATION PARTNER

Electrotherm, the most preferred steel plant maker up to 1 MTPA globally, is now the business partner of Ergolines (Italy), who is manufacturer and market leader of Electromagnetic Stirrers (EMS) for CCM and EAF, non-radioactive automatic mould level controller and powder thickness measurement and control system.



Caster Electromagnetic Stirrer

MFM - Gaussmeter



EAF-EMS Stirrer

Powder Thickness Control

Mould Level Control

PRODUCT RANGE

- Mould Electromagnetic Stirrer (M-EMS)
- Strand & Final Electromagnetic Stirrer (S-EMS & F-EMS)
- Tundish Stirrer
- LF & EAF Stirrer
- Inductive Mould Level Detector (ILD)
- Ultrasonic Mould Level Detector (ULD)
- Optical Powder Profile Detector (OPD)
- Powder Thickness Measurement and Control System (PTC)
- Automatic Mould Powder Feeder (MPF) and Instrumented Powder Diffuser (IPD)
- Vibrational & Optical Slag Detectors (VSD & OSD)
- Mould Oscillation Checker (OPI)

ET®

Engineering & Technologies

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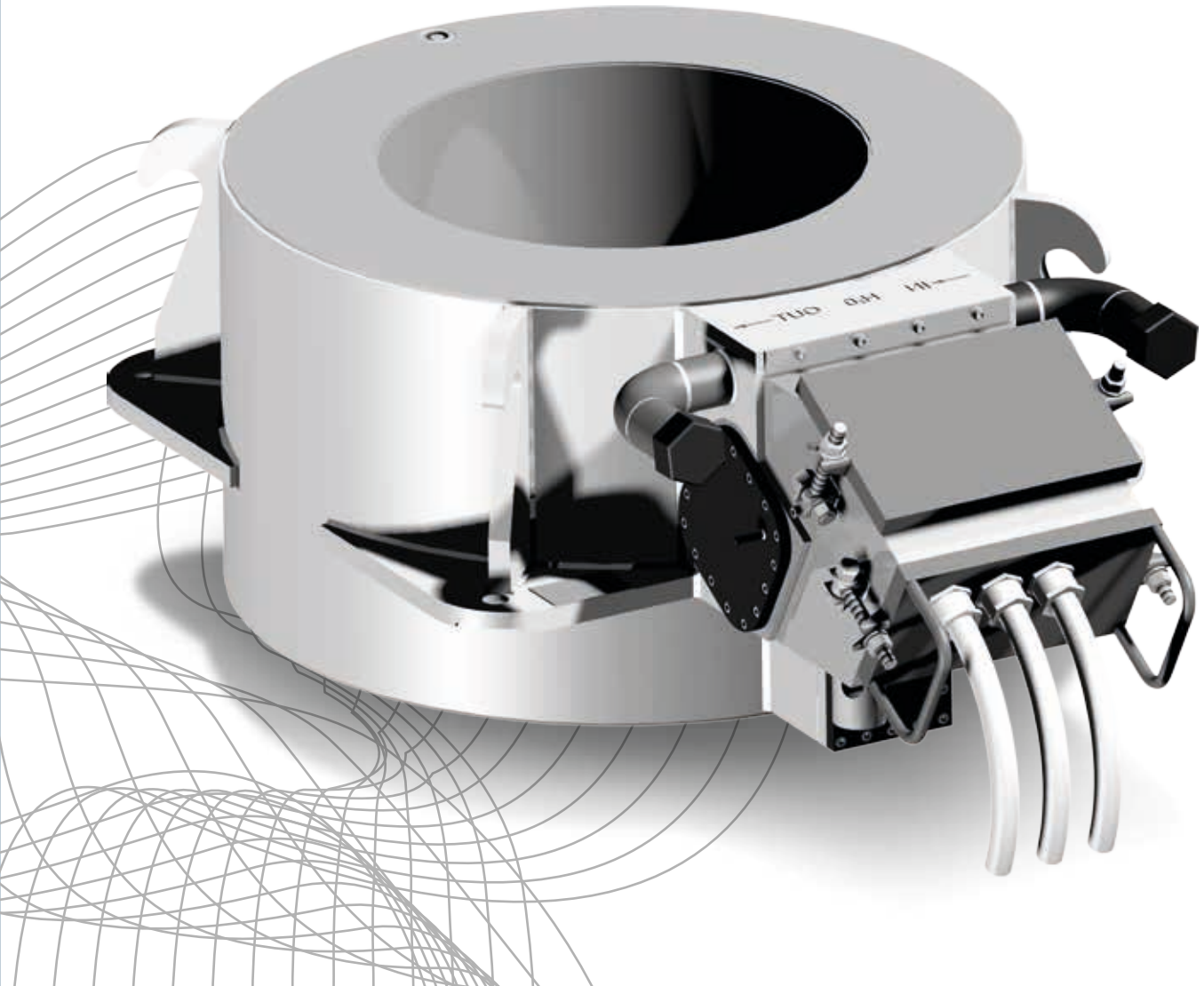
EMS – ELECTROMAGNETIC STIRRER.

Electromagnetic stirrers are used in continuous casting to improve product quality and increase contuous casting machine productivity. According to the position along the casting line and effects requested on the cast product, EMS are classified as:

- M-EMS (Mould Electromagnetic Stirrers)
- S-EMS (Strand Electromagnetic Stirrers)
- F-EMS (Final Electromagnetic Stirrers)

Rotational electromagnetic stirrers are equivalent to an asynchronous motor stator generally supplied by a three-phase, or sometimes two-phase, frequency converter. A rotating magnetic field is thus generated, which impose a main swirl flow and important longitudinal secondary flows to the molten steel.



BENEFITS

The benefits obtained using one or more EMS in combination are summarized in the table.

EMS type & combination	M-EMS	M+F-EMS	M+S+F-EMS	M+S-EMS	S-EMS	S+F-EMS
Pinhole & blowhole	+ + +	+ + +	+ + +	+ + +	—	—
Surface & subsurface cracks	+ + +	+ + +	+ + +	+ + +	—	—
Break-out reduction	+ + +	+ + +	+ + +	+ + +	+*	+*
Solidification structure & internal crack	+ +	+ +	+ + +	+ + +	+ +	+ +
Centerline segregation, center porosity	+ +	+ + +	+ + +	+ +	+ +	+ +
V segregation	—	+ + +	+ +	+	+**	++

* With S-EMS in high position.

** With S-EMS in low position.

ERGOLINES TECHNOLOGY

Ergolines is very close to the customer during the stirrer design stage. Every stirrer is a customized product developed in accordance with specific customer's needs and requests. Thanks to this approach, Ergolines can guarantee:

- a lower power consumption (kW/ton produced) with same metallurgical benefits
- a complete integration of new electromagnetic stirrers in the existing casting machines
- a longer lifetime

The stirrer design is based on computer-aided design and 3-dimensional magneto-hydrodynamic simulation, aiming at achieving highest electric and fluid-dynamic efficiencies and ensuring an optimal windings cooling.

To define the stirrer position into the mould and/or along the CCM. Ergolines has developed some software programs which calculate steel cooling and solidification along the CCM to establish the right position of electromagnetic stirrers.

Regarding the stirrer cooling, this is designed to operate with low pressure water. The internal water circuit is designed to guarantee a well-balanced cooling for an optimal heat distribution, thus preventing areas with an excessive heat accumulation. The cooling is designed to have the lowest temperature difference into the stirrer to avoid dilatations. The cooling water flows from bottom to top to avoid the rubbing of any residual micro-particles with the coils and guarantee a longer stirrer lifespan.

SERVICE ACTIVITIES

Ergolines provides a complete stirrer reconditioning, replacing damaged or worn parts for stirrers of any brand and type and -according to the customer- also improves stirrers performances modifying their actual design.

In its workshop, Ergolines also provides an on-site check-up for stirrers to evaluate their operation or complete integrated tests for stirrers, frequency unit converters and power transformers.

TYPICAL ERGOLINES EMS SYSTEM DESCRIPTION

M-EMS: EXTERNAL-TYPE

mould electromagnetic stirrers (M-EMS) are installed around the mould body. Cooling is accomplished by a closed-loop, de-mineralized water circulation system. The coil manufacturing technology is "wet-insulation" type. High, reliable and long-lasting insulation properties are given by a special insulation technique with an overlapped double kapton-ribbon winding, and by a special proprietary resin treatment based on VPI (Vacuum-Pressure-Impregnation) technology, which ensures a longer coil lifespan.

M-EMS: INTERNAL-TYPE

installed inside the mould body is cooled by primary cooling water circuit or through a dedicated cooling water system like the external type M-EMS.

M-EMS can be also provided in the "dry insulation type", meaning that the copper conductor is a hollow tube with the cooling water flowing inside.

S-EMS AND F-EMS

strand and final electromagnetic stirrer, used for higher quality demands usually for bigger section sizes, are installed along the strand in a position depending on the continuous casting machines characteristics, working parameters and the expected metallurgical effects. Cooling, manufacturing technology, insulation properties and materials are similar for the M-EMS, except particular precautions to be taken for the components exposed to heat radiation, that include either the use of heat resistant materials/components or special water-cooled equipment.

POWER TRANSFORMER AND FULL-DIGITAL FREQUENCY UNIT CONVERTER

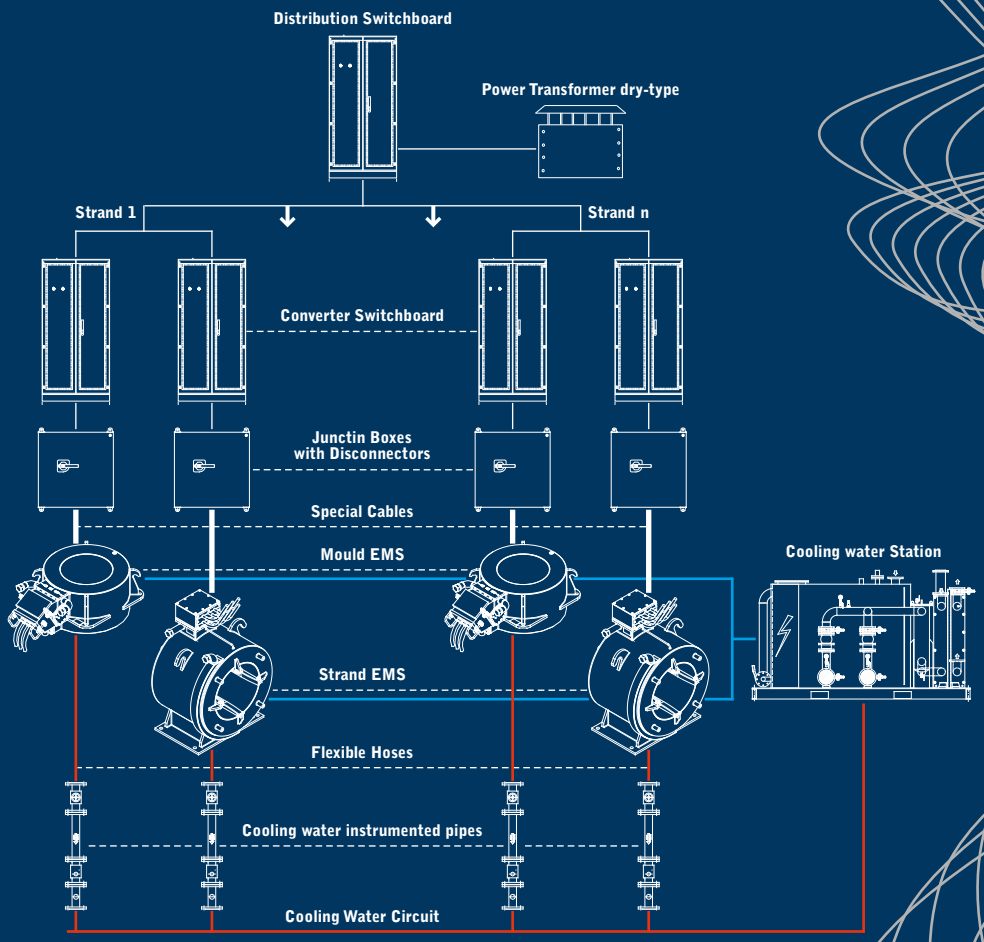
are provided to guarantee the power supply and manage electrical parameters (current, voltage and frequency). The Frequency Converter is specifically designed for operation at the low frequencies involved with EMS equipment.

COOLING WATER SYSTEM (DE-MINERALIZED WATER)

equipped with 2 pumps, one bag filter, one heat exchanger, one stainless steel water tank and all necessary automation components and sensors for safe operations, -including a water conductivity meter- is designed depending on number of strands and stirrers design. The system is locally controlled by a dedicated PLC switchboard with all commands, alarm signals and auxiliary devices. One system is intended to cool the EMSs of all strands, in parallel.

Power cables, junction boxes, stainless steel flexible hoses, cooling water instrumentations pipes are included in the supplies and are chosen according to steel plant characteristics and customer requirements.

Ergolines provides services for EMS system installation check-up, commissioning and personnel training.



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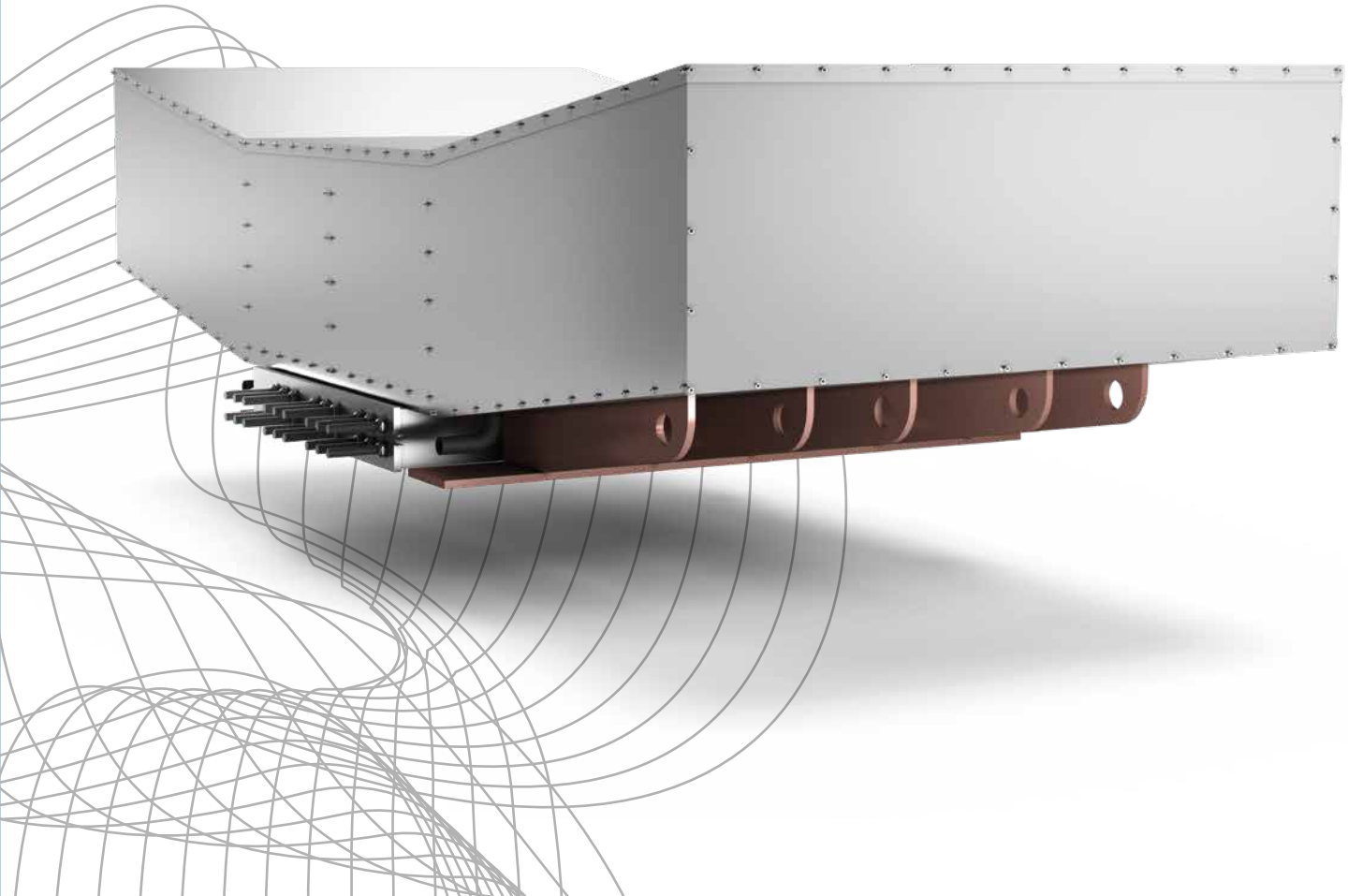
EAF EMS – ELECTROMAGNETIC STIRRER FOR ELECTRIC ARC FURNACE

Electromagnetic stirring in EAF was developed 70 years ago for the secondary reefing phase of the EAF. Nowadays electromagnetic stirring is the perfect tool for increasing the kinetics in the EAF and it is a proven and reliable technology with inexpensive operation able to reduce the EAF operation cost, by saving time, energy and materials.



WHY EAF STIRRING IN MODERN FAST EAF

Following problems can be caused by very short tap-to-tap time:

- unmolten scrap, especially in EBT area
- high FeO level in slag
- high oxygen level in steel
- temperature and chemistry stratification across the bath
- low free opening ratio of tap hole
- scrap cave-in and electrode breakage
- cold boil.

EAF STIRRING BENEFITS

EAF Electromagnetic stirring affects the following areas of steel making:

SCRAP MELTING

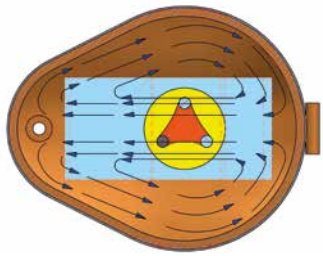
Even melting of scrap in the furnace, reduced cave-ins, less electrode breakage occurrence, large scrap pieces and bundles easily melted thanks to a convective heat distribution, less need for scrap stratification in scrap bucket, no unmolten scrap in EBT or at slag door.

ARC STABILITY, ELECTRODES

Quicker stable arc in each bucket, higher average power, decreased electrode consumption.

SLAG CHEMISTRY

Electromagnetic stirring reduces the oxidation of Fe and Mn under the oxygen lance and improves the reduction of the slag. Lower and more consistent temperature of slag improves slag foaming → less FeO and MnO in slag, improved yield.

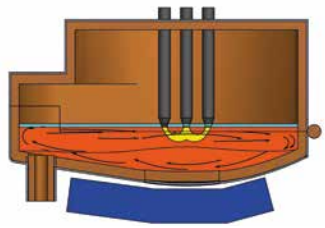


OXYGEN IN STEEL

Electromagnetic stirring drastically reduces super-saturation of oxygen in steel → consistent oxygen level from heat to heat, reduced consumption of de-oxidants in the ladle.

DE-CARBURIZATION

Electromagnetic stirring drastically improves de-carburization rate in steel de-carburization, by a factor of 2 → lower oxygen consumption to get the same de-carburization, consistent de-carburization to low C-levels.



BATH HOMOGENIZATION

The steel bath is completely homogenized; temperature, oxygen and chemistry sampling are representative, no super-heated or partially melted slag.

REFRACTORY

EAF-EMS does not require any special refractories. No super-heated slag or bath improve refractory wear; lower FeO content makes slag less chemically aggressive; total refractory consumption is lower; tap-hole life is improved.

ENERGY CONSUMPTION

Efficient heat distribution from the arcs to the bath lowers energy losses, increases productivity, further reducing energy consumption.

TAPPING

- Hot EBT area → improved free opening of tap-hole by 100%
- vortex suppression → less slag carry over
- less steel temperature variations, longer tap-hole life.

SAFETY, RELIABILITY

100 % free opening of EBT tap hole, reduced frequency of scrap cave-ins and electrode breakage, reduced frequency of cold boils in furnace, less sampling required, no scrap in slag door, representative samples, easy operation from the furnace automation system, minor need for maintenance.

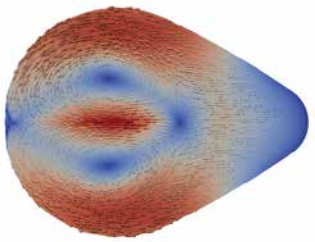
PRODUCTIVITY

Factors discussed above increase productivity by more than 5 %, improved free opening of stir plug in ladle at ladle furnace and less chance for missing connection at caster.

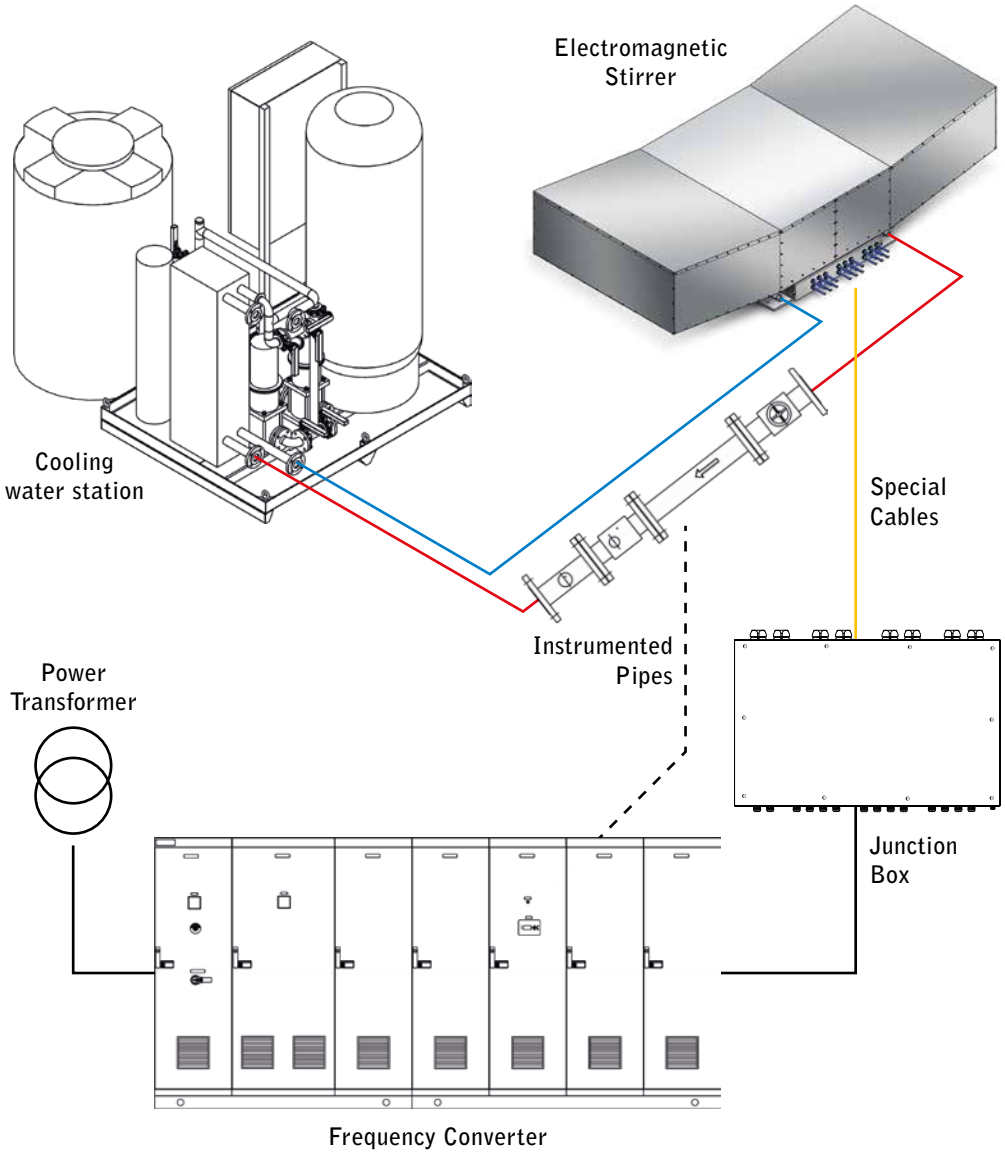
EAF STIRRER INSTALLATION AND DESIGN

The stirrer is placed under the EAF furnace on the rocker. A non-magnetic window in stainless steel is needed at the furnace bottom; normal refractory lining can be used.

EAF stirrers are designed and optimized for each furnace by means of electromagnetic and fluid-dynamic simulations.



TYPICAL ERGOLINES EAF STIRRER SYSTEM



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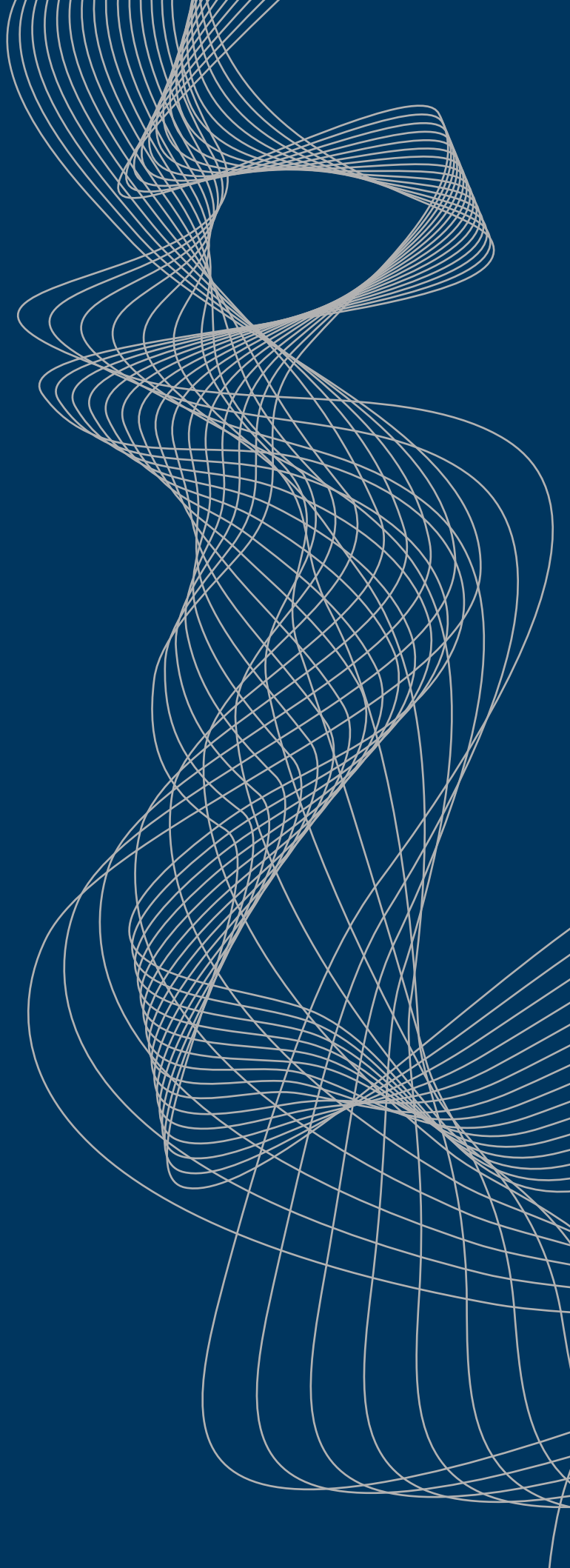

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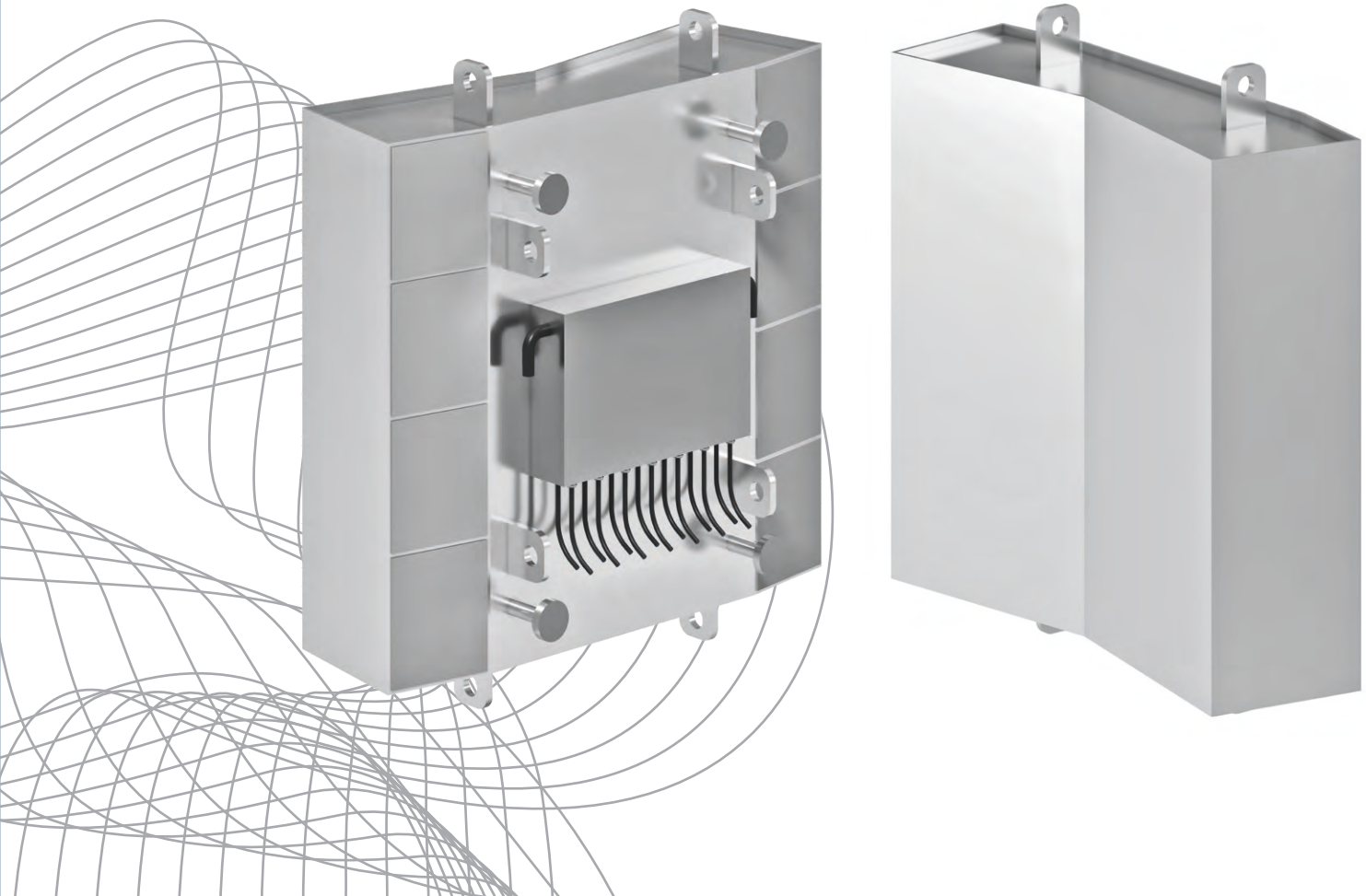
LF-EMS – LADLE ELECTROMAGNETIC STIRRER

LF electromagnetic stirring is a contactless and reliable technology to improve the process in LF furnace.

LF stirrer action is focused on the bath heating, homogenization, on the alloy addition and melting and the inclusion removal.

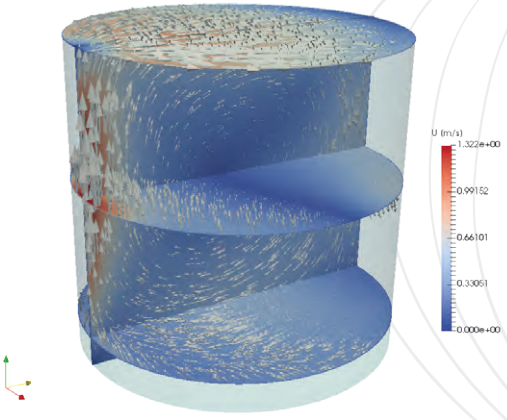
LF stirring is also a save technology, no modification on refractory are needed.



LADLE STIRRING BENEFITS

- RAPID HOMOGENIZATION OF THE MELT
  - both chemical and thermal
- REPRODUCIBLE STIRRING
- LOWER CARBON PICK-UP
- LOWER TOTAL OXYGEN CONTENT
  - Reduced Al consumption
- EFFICIENT REMOVAL OF INCLUSIONS
- OPTIMIZED CONDITION FOR ARC HEATING
  - High heating rate and arc stabilization
- STIRRING WITHOUT BRAKING THE SLAG COVER
  - Low reoxidation
  - Low N and H pick-up
- NO BREAK THROUGH RISK

STIRRER DESIGN AND INSTALLATION



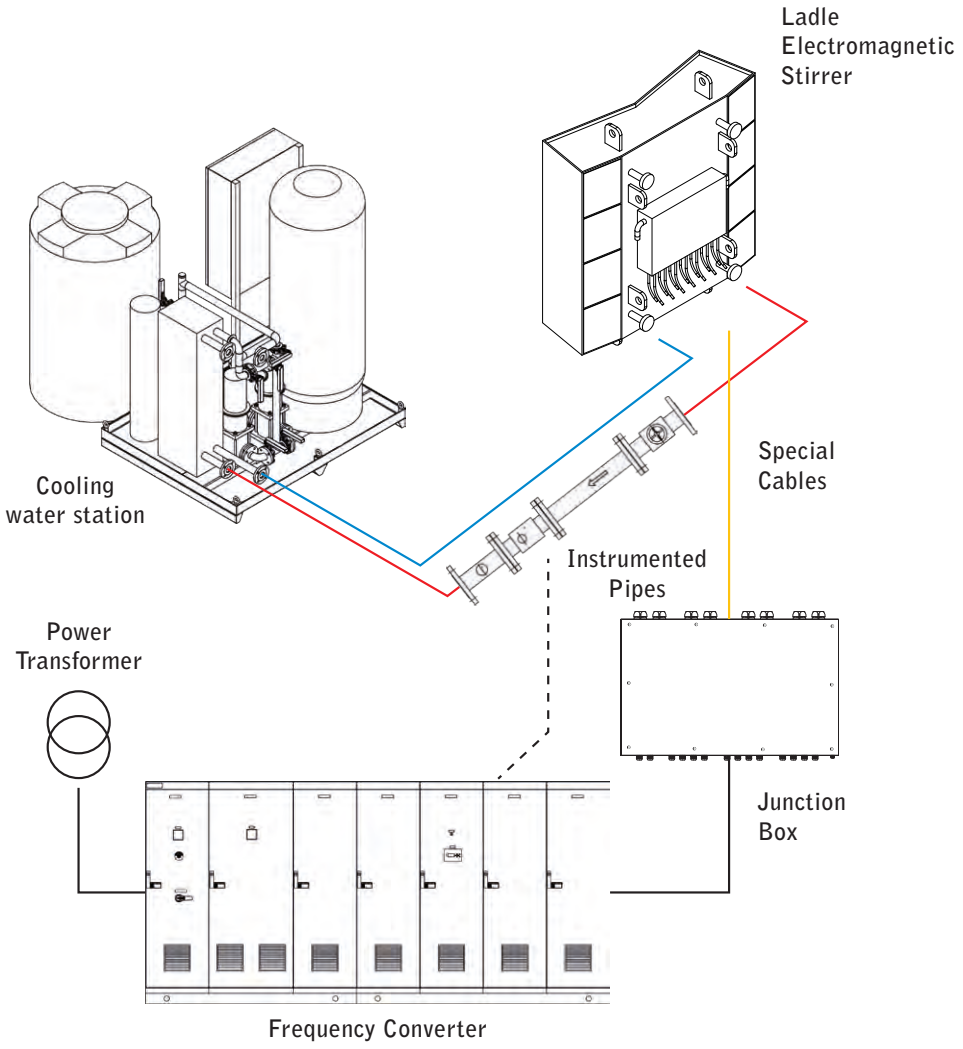
Ladle stirrers are designed and optimized for each plant by means of electromagnetic and fluid-dynamic simulations. Thanks to these sophisticated techniques also customized design are available.

LADLE STIRRER FEATURES

STIRRER MAIN FEATURES

- Dry type stirrer (cooling water flowing inside hollow copper conductors)
- Removable stirrer covers to facilitate the maintenance operations
- Stirrer power control to open a slag free area to alloy addition
- Alternating stirring function available
- Deslagging function if the stirrer tilt with the ladle.

TYPICAL ERGOLINES LADLE STIRRER SYSTEM



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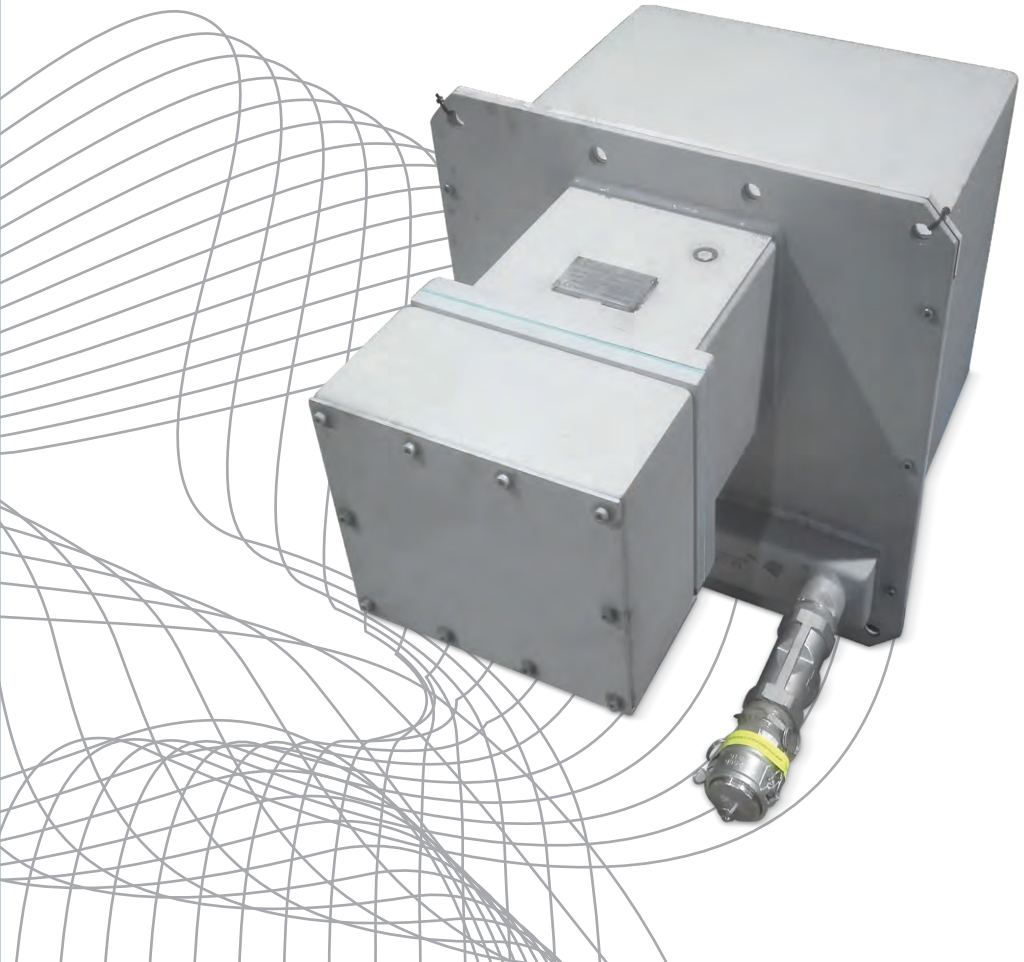
MS EMS – MOULD SLAB ELECTROMAGNETIC STIRRER

In conventional and thick slab casting it is very important to assure stable flow conditions, an optimum meniscus velocity and control of the flow from the submerged nozzle in order to reduce the entrapment of non-metallic inclusion and gas bubbles.

Meniscus velocity control allow the enhancement of the surface and sub surface quality; SEN flow control, meaning the suppression of downward flows, allow to improve the internal quality.

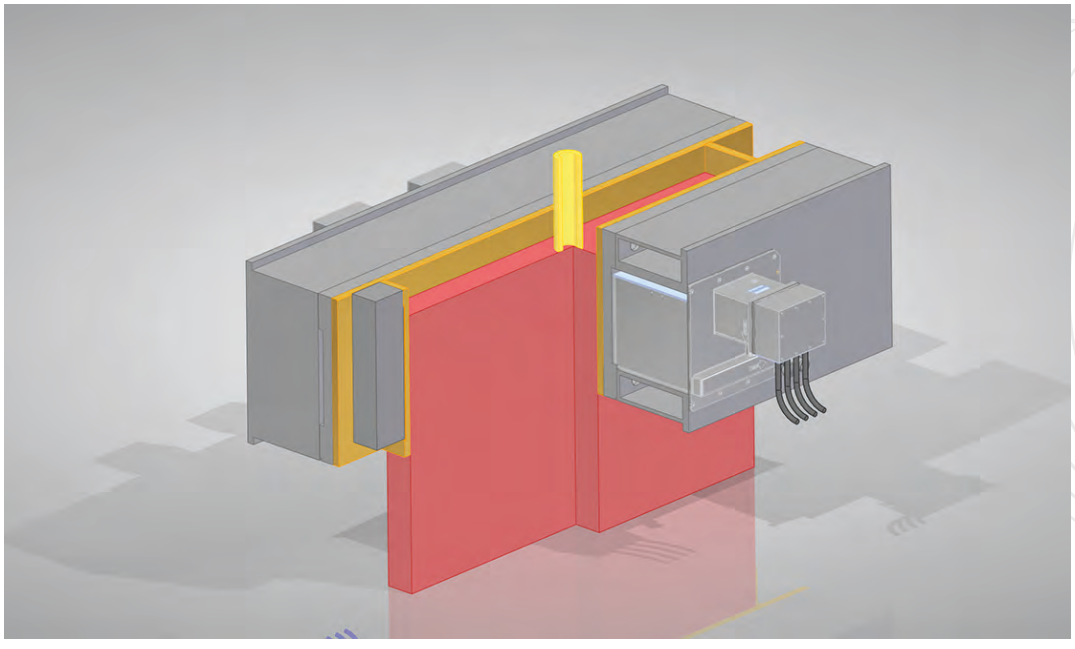
MS-EMS are designed to modify and control the flow pattern inside the mould to reach the maximum quality enhancements in the steel quality.



MOULD STIRRING BENEFITS

- **INTERNAL QUALITY**
  - Reduction of non-metallic inclusion
  - Reduction of gas bubbles inclusion
- **SURFACE AND SUB-SURFACE QUALITY**
  - Meniscus stabilization
  - Constant velocity on meniscus (both left and right side)
    No metallic inclusion in the solidified shell
  - Temperature homogenization – higher temperature on meniscus
    Longitudinal cracks prevention

STIRRER INSTALLATION



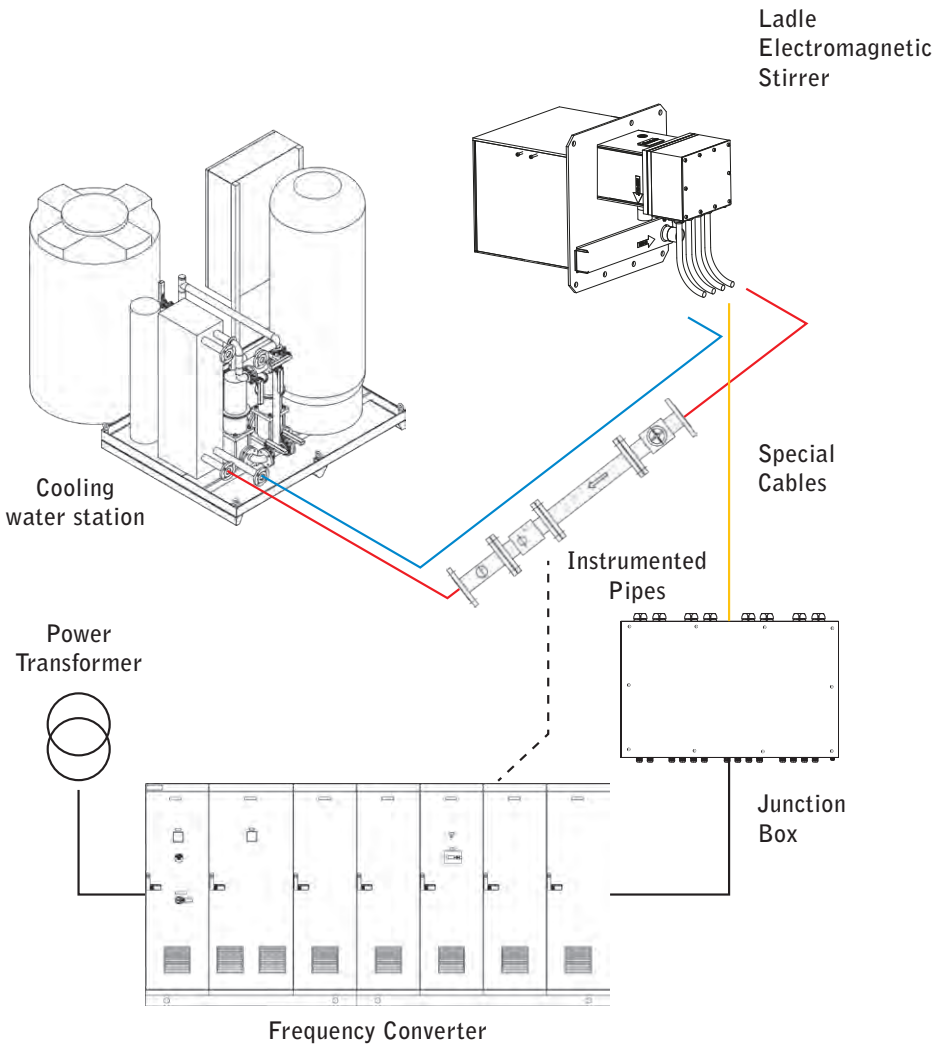
STIRRER DESIGN AND FEATURES

Slab strand stirrers are designed and optimized for each caster by means of electromagnetic and fluid-dynamic simulations. Thanks to these sophisticated techniques also customized design are available.

STIRRER MAIN FEATURES

- Wet and dry type stirrer (cooling water flowing inside hollow copper conductors) available
- Flow accelerating and braking functions
- Alternating stirring function available
- Custom shape for any kind of mould and installation.

TYPICAL ERGOLINES MOULD SLAB STIRRER SYSTEM



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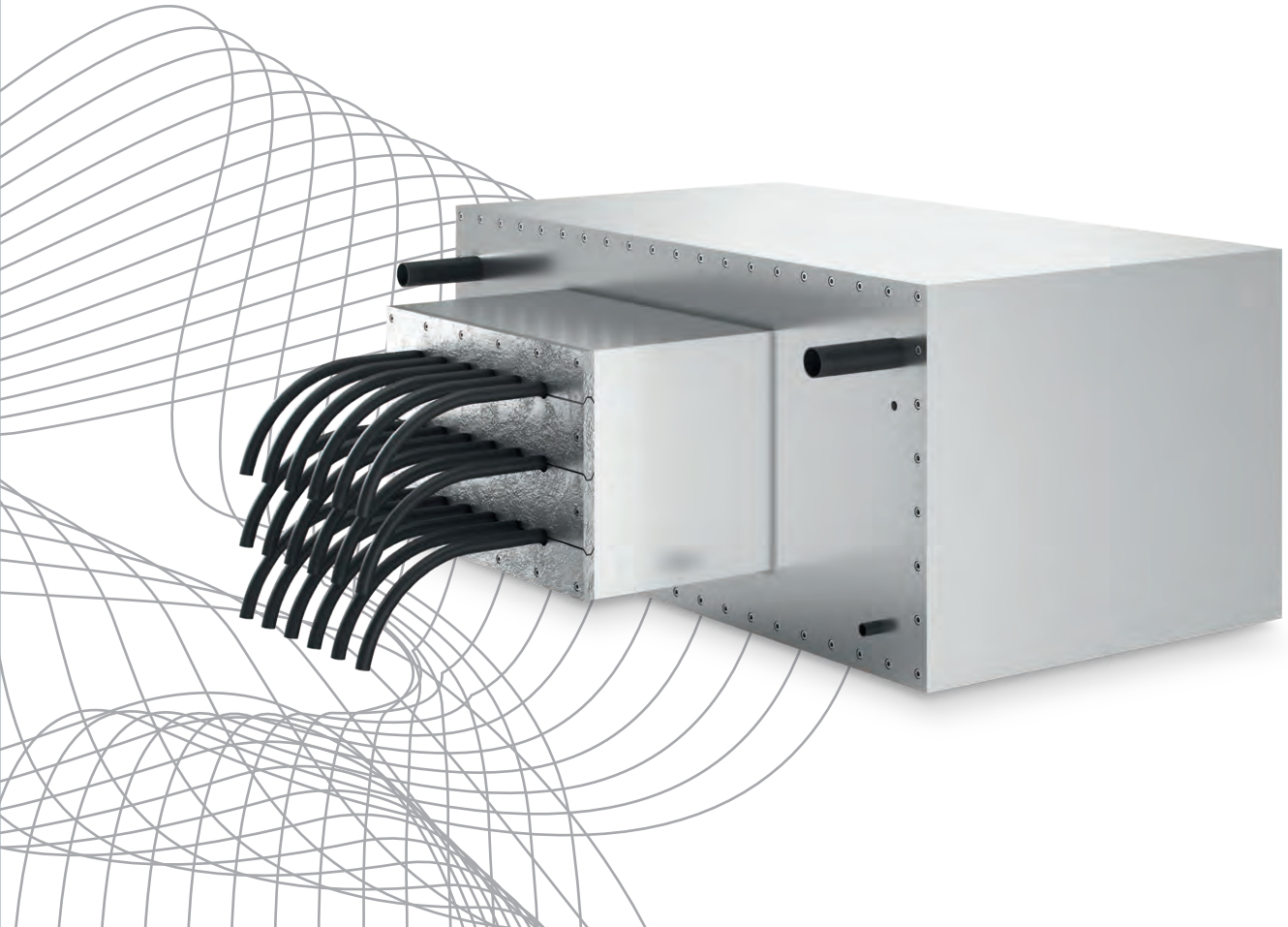
SS EMS – SLAB STRAND ELECTROMAGNETIC STIRRER

Slab strand electromagnetic stirrers are mainly used for ferritic stainless steels and silicon steels.

In ferritic stainless steel casting, strand stirrers refine the solidification structure and prevent surface defects after rolling as ridging and roping.

In silicon steel casting for electrical steel sheets production, the strand stirrer enlarge the equiaxial area and refine the grain dimension; as a consequence the steel sheets have more isotropic magnetic properties.

Strand stirrer can be used also in medium and high carbon casting to enhance the central soundness.



STRAND STIRRING BENEFITS

FERRITIC STAINLESS STEELS

› equiaxial zone area increase

› "ridging" and "roping" defects reduction.

SILICON STEELS (ELECTRICAL APPLICATION)

› equiaxial zone area increase

› grain dimension reduction.

MARTENSITIC AND DUPLEX STAINLESS STEELS

› equiaxial zone area increase

› reduction of central segregation and porosity (installed in low position).

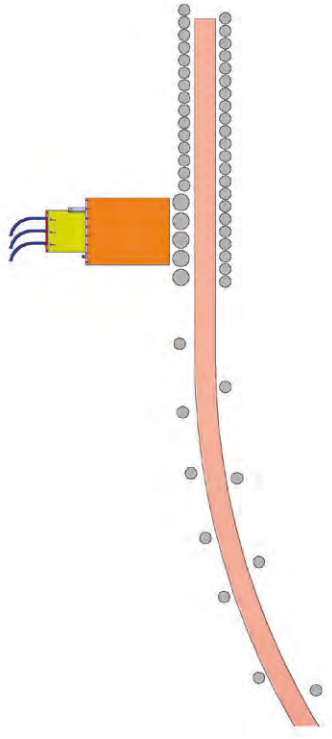
CARBON STEELS (MID/HI C)

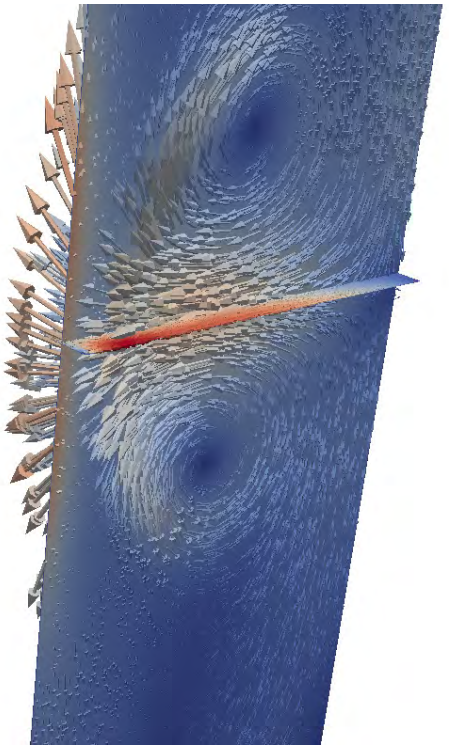
› equiaxial zone extension increase

› reduction of central segregation and porosity (installed in low position)

› reduction of internal cracks.

STIRRER INSTALLATION

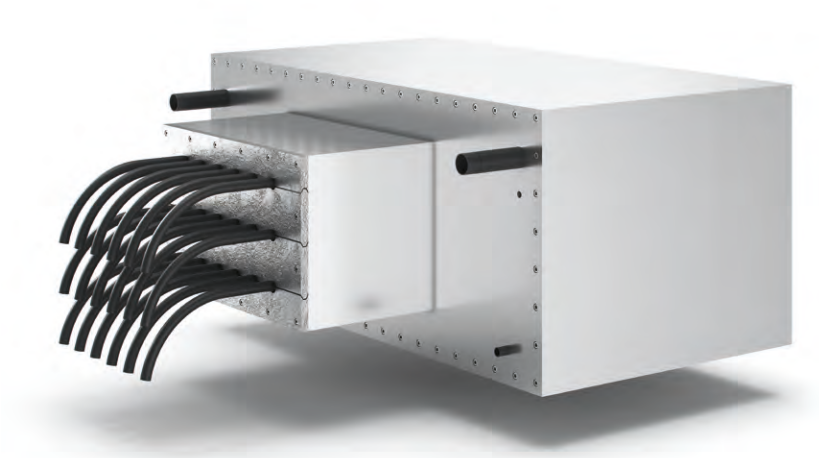




The stirrer is usually installed in the lower part of the bending zone, at about 3-4 m from the meniscus. The travelling magnetic field generates 2 big recirculating zone as represented in the figure above (CFD simulation).

STIRRER DESIGN AND FEATURES

Slab strand stirrers are designed and optimized for each caster by means of electromagnetic and fluid-dynamic simulations. Thanks to these sophisticated techniques also customized design are available. In the figure below a standard solution (on the left) and custom stirrer that can be inserted in the rolls support (on the right) are shown.



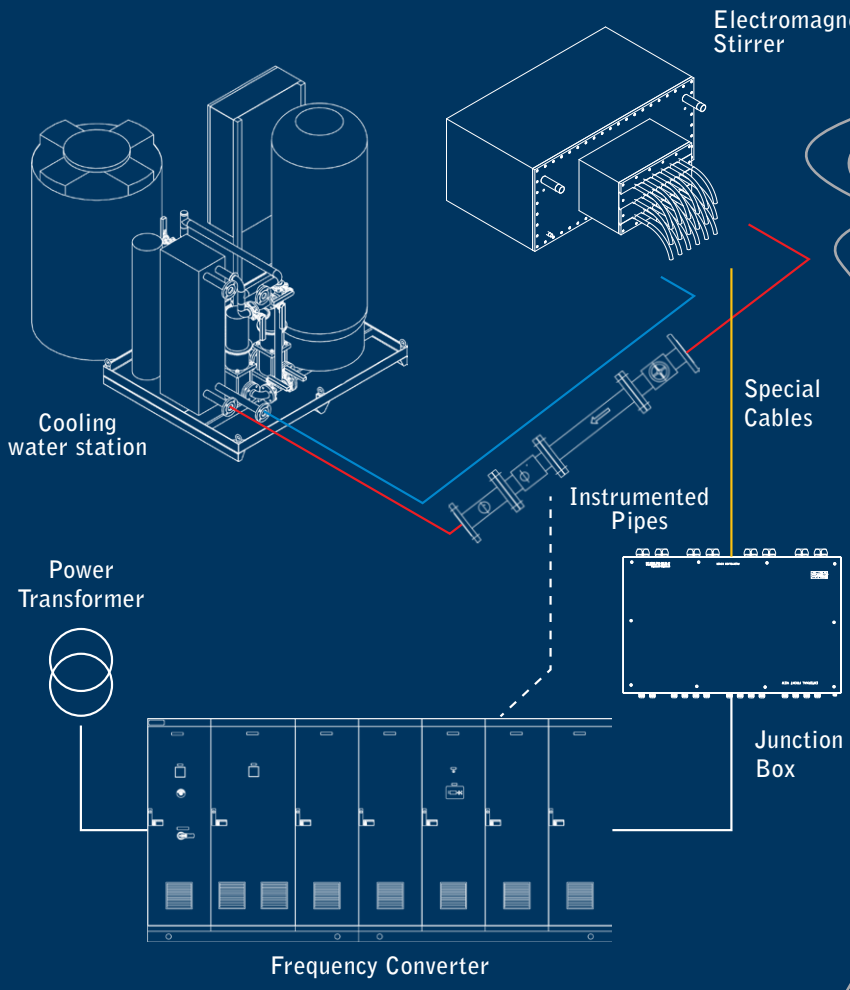
Standard Stirrer

Custom Stirrer

STIRRER MAIN FEATURES

- Dry type stirrer (cooling water flowing inside hollow copper conductors)
- External case cooled by a secondary water circuit
- The stirrer case is composed of two parts screwed together to facilitate the maintenance operations
- Alternating stirring function available
- Custom shape for installation behind rolls without segment modification.

TYPICAL ERGOLINES SLAB STRAND STIRRER SYSTEM



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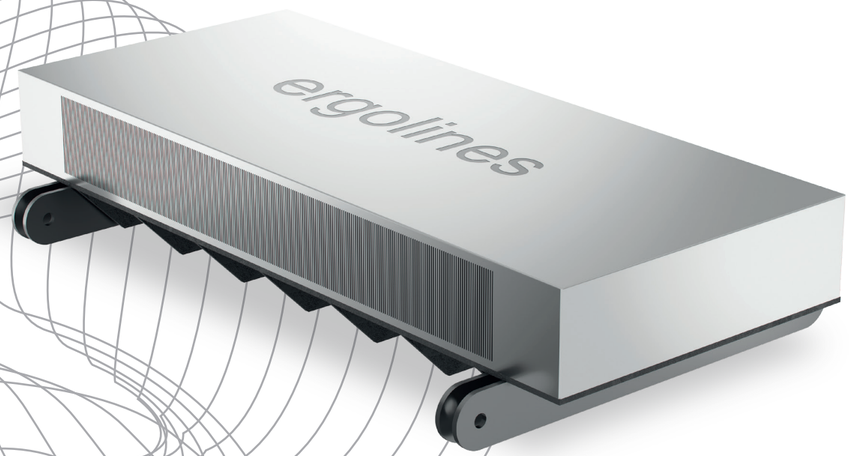
ERG-AL3 – ELECTROMAGNETIC STIRRER FOR ALUMINUM FURNACES

ergolines produces a wide range of stirrer for non-ferrous alloys, mainly for the production of aluminum and copper alloys. Efficient stirring of the aluminum melting furnaces is one of the key factors enabling to speed up the kinetics of the chemical reactions and improve both heat and mass transfer.

ERG-AL 3 is the cost-effective solution to increase productivity, optimize charge and furnace yield and reduce maintenance costs.



ERG-AL3

Ergolines is market leader in stirring technology, providing standard and customized EMSs for steel and non-ferrous alloy industries. Our customer oriented approach enables extreme design flexibility and personalized engineering, making ergolines the ideal partner to guarantee high value and fast return on investment.

Our worldwide projects and references in the supply, installation and commissioning of EMS systems for continuous casters, arc furnaces and melting/alloying furnaces witnesses the quality of the ergolines effort to deliver reliable and innovative solutions to optimize production processes and increase products quality.

BENEFITS

ERG-AL3 EMS family for aluminum furnaces sized up to 200 tons, based on 3 phase, air or water cooled coils, is the cost-effective solution to:

- Optimize charge and furnace yield
- Optimize alloying
- Increase productivity
- Extend lining life
- Reduce dross formation
- Reduce gas inclusion into the alloy
- Reduce fuel consumption and emissions of the furnace burners
- Reduce maintenance cost
- Reduce manual labor and usage of fork lifts

ERG-AL3 EMS SYSTEM CONFIGURATION

- EMS Unit (standard or custom design, air or water cooled)
- Power System (Inverter, transformer, special cables and junction boxes)
- Cooling system (air or water)
- Design improved to fulfil customer expectations in term of performance, power consumption and installation requirements
- Turn-key solutions for EMS systems including EMS, power supply and cooling systems, moving and lifting devices.

ADVANTAGES OF EMS

- Low maintenance required, no production stops
- Continuous stirring action of the whole bath of molten aluminium; stirring direction reversibility facilitates dross skimming and counteracts dead corners
- To be installed underneath or integrated in the furnace, allowing stirring also when the furnace tilts
- Stirrer parameters can be tuned to achieve fluid dynamic performance able to guarantee:
  - Temperature homogenisation
  - Heat transfer increase
  - Improved alloying

ALUMINUM EMS MAIN TECHNICAL CHARACTERISTICS

Technical data	ERG AL3AE-1600 ERG-AL3EE-1600	ERG-AL3AE-3000 ERG-AL3IE-3000	ERG-AL3IE-3200	ERG-AL3IE-3800	ERG-AL3IE-5500
Furnace Size	Up to 15 ton	15 ÷ 30 ton	30 ÷ 60 ton	60 ÷ 120 ton	100 ÷ 200 ton
Nonmagnetic window size (LxW [mm])	1800x1000	3200x1500	3400x1100	4000x1700	5800x2200
Max distance from window [mm]	20	20	20	20	20
Cooling system	Air/Water				Water
Dimensions (LxWxH [mm])	1600x900x450	3000x1300x485	3200x820x640	3800x1500x1000	5500x2000x1100
Operating frequency range [Hz]	0.5 ÷ 2	0.5 ÷ 1	0.5 ÷ 1	0.5 ÷ 1	0.5 ÷ 1
Reversible Stirring direction	√	√	√	√	√

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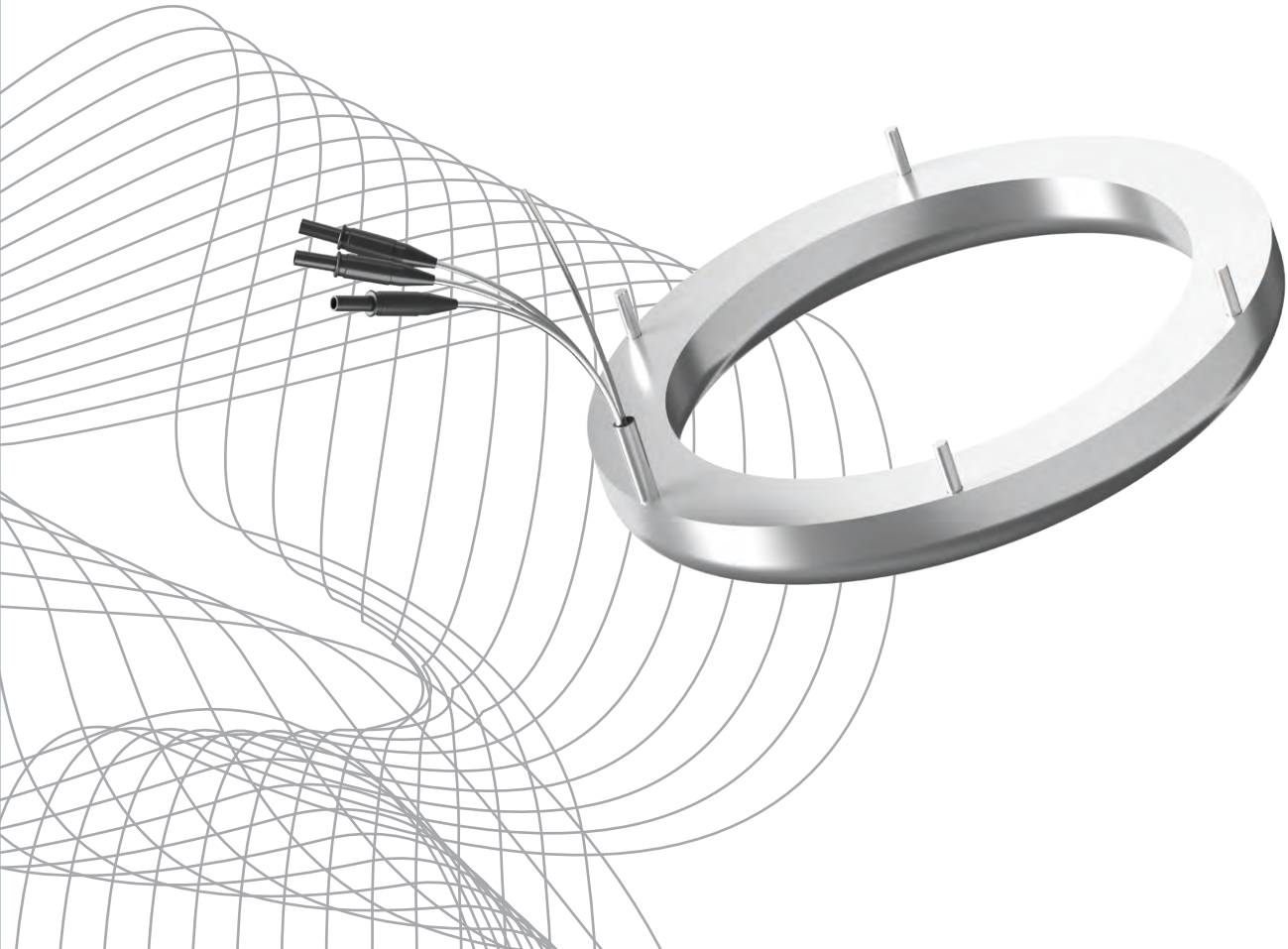
HT-EMS – ELECTROMAGNETIC STIRRER FOR DIRECT CHILL ALUMINUM CASTING

Direct chill (DC) casting is the most commonly used technology in the production of semi-finished products of aluminum alloys for plastic deformation process. After casting, a homogenization process is needed to enhance the material plasticity before the billet extrusion.

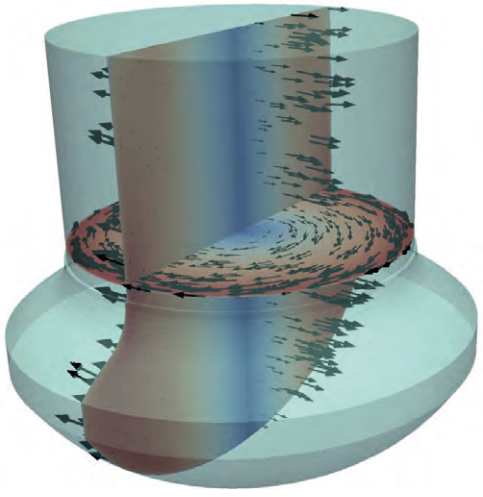
DC casting with HT-EMS technology application aims at the production of semi-finished products with fine globular structure to be extruded without intermediate thermal treatments.



STIRRING BENEFITS

- ENHANCED SURFACE QUALITY AND LOWER SUB-SURFACE SEGREGATIONS
- BILLET GLOBULAR STRUCTURE
- GRAIN REFINEMENT
- CHEMICAL HOMOGENIZATION
- ENHANCED HOT WORKABILITY
- NO HOMOGENIZATION NEEDED BEFORE THE EXTRUSION PROCESS
- REDUCED STRAIN HARDENING DURING EXTRUSION AND FORGING
- SAME MECHANICAL PROPERTIES OF EXTRUDED AND FORGED COMPONENTS EVEN WITHOUT HOMOGENIZATION
- POSSIBLE CASTING SPEED INCREASE THEREFORE PRODUCTIVITY

STIRRER DESIGN AND FEATURES



Ergolines electromagnetic stirrers are designed and optimized for each caster by means of electromagnetic and fluid-dynamic simulations. Thanks to these sophisticated techniques also customized design are available. HT-EMSs are rotative type stirrers. In the figure below the flow motion induced in the molten aluminum is reported.

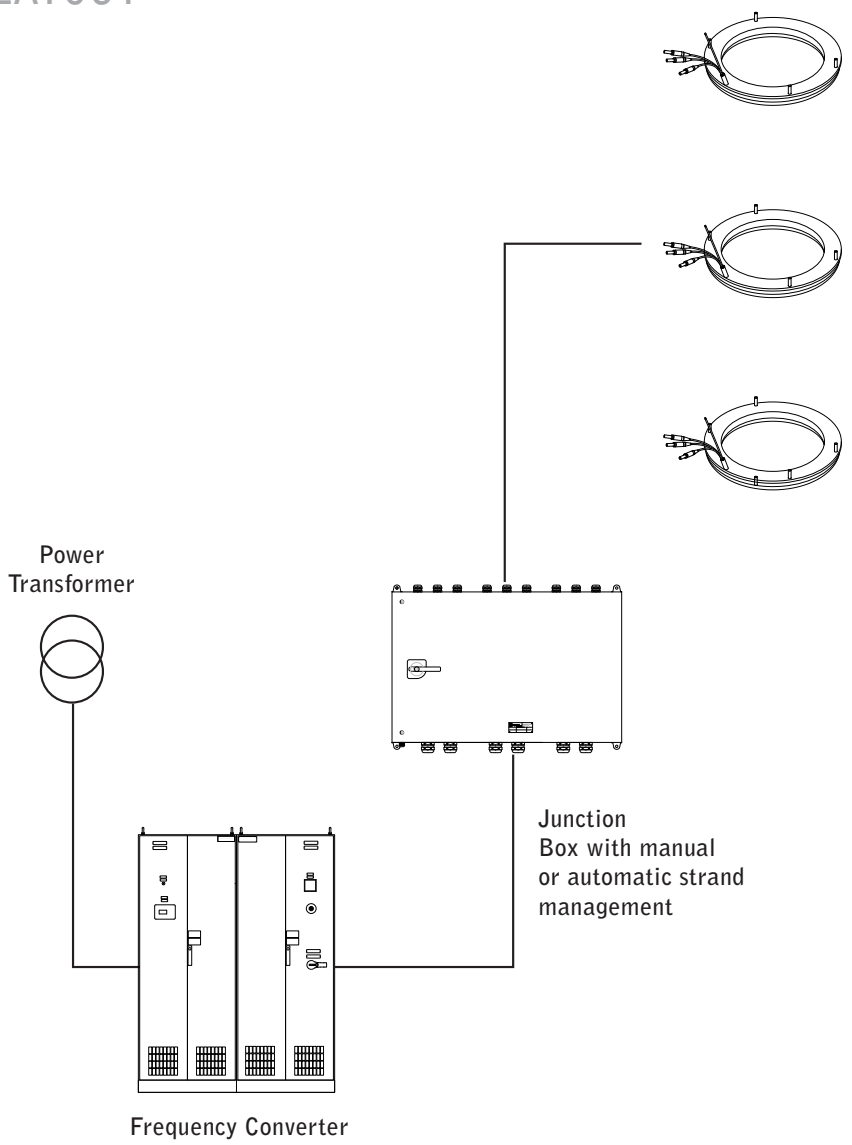
STIRRER MAIN FEATURES

- Available for every casting size and up to 72 strands or more;
- Easy installation, minor modification needed in existing casting machines;
- No cooling needs;
- Windings temperature monitoring system;
- No maintenance needed.

STIRRER INSTALLATION

Stirrers are usually installed in the refractory in order to be effective both on the first solidification zone and the center of the casted billet. Minor modification are needed for the installation in existing casters.

TYPICAL ERGOLINES STIRRER SYSTEM LAYOUT



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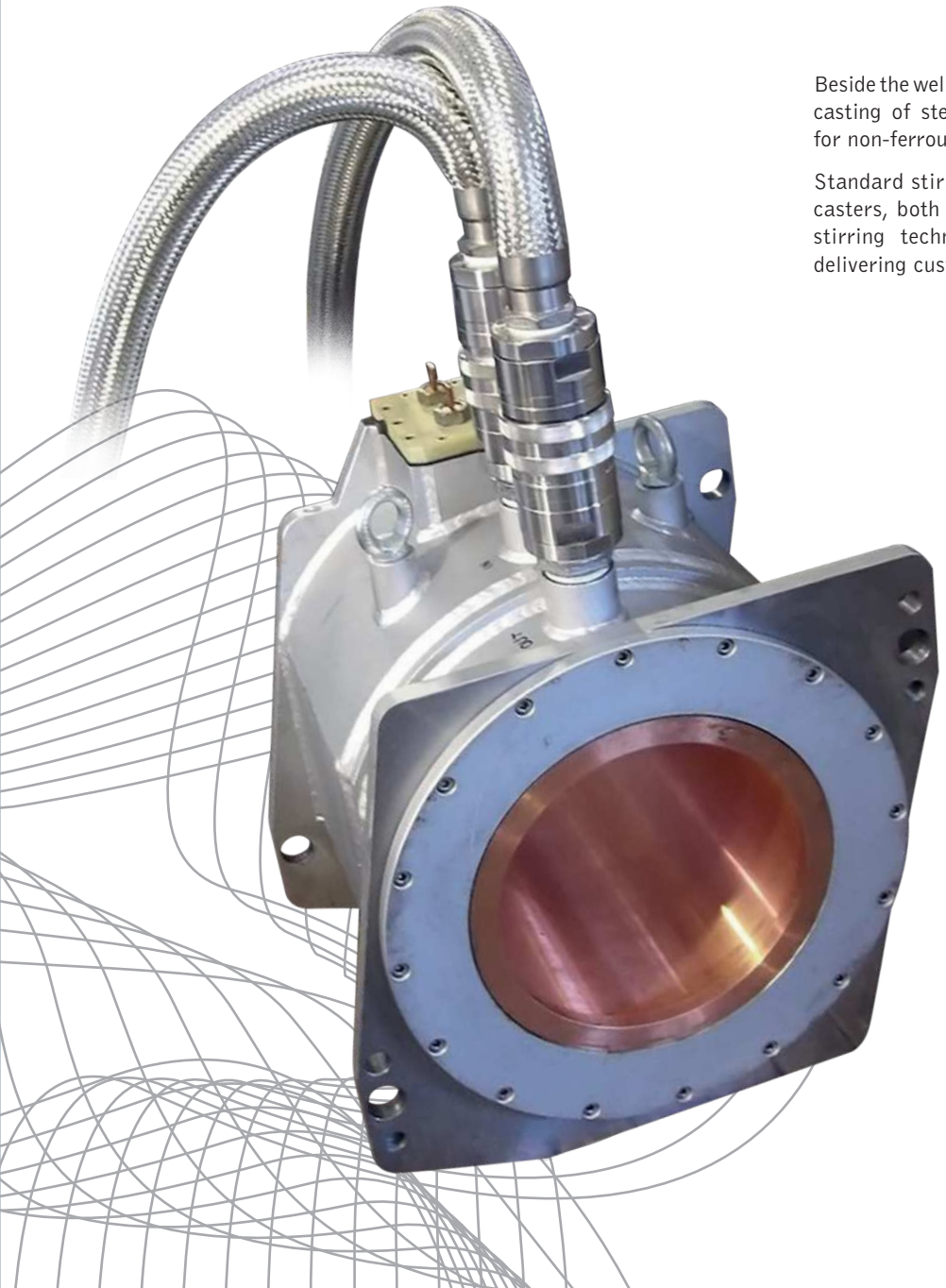
EMS – ELECTROMAGNETIC STIRRER FOR COPPER ALLOYS CASTING



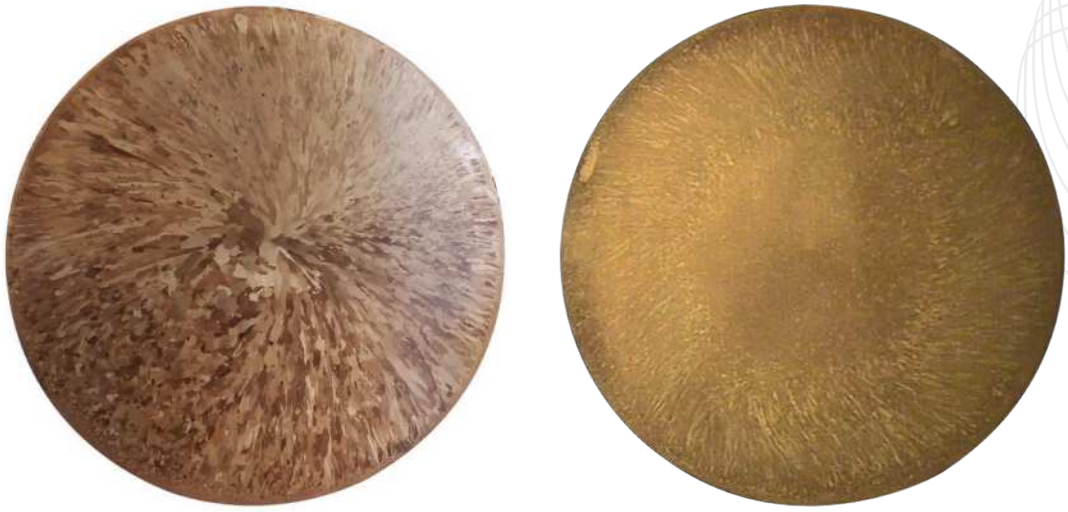
Beside the well-proven range of electromagnetic stirrers for continuous casting of steel products, ergolines offers a wide range of stirrers for non-ferrous alloys, such as aluminum, brass and copper alloys.

Standard stirrers are available for continuous and semi-continuous casters, both horizontal and vertical; moreover ergolines provides stirring technology also in case of non-standard applications, delivering customer-tailored solutions.

OVERVIEW

OVERVIEW ON STIRRER METALLURGICAL BENEFITS

- Improved surface and sub-surface quality
- Sub-surface segregation reduction
- Improved solidification structures (wider equiaxial and globular areas)
- Grain refinement
- Uniform distribution of alloying elements and particles
- Central segregation and porosity reduction
- Central cracks reduction



Macros of specimens obtained without and with electromagnetic stirrer.

STIRRER DESIGN

ergolines stirrers are designed and optimized for each caster by means of electromagnetic and fluid-dynamic simulations. Thanks to these sophisticated techniques also customized designs are available.

APPLICATION

APPLICATION IN HORIZONTAL CONTINUOUS & VERTICAL CONTINUOUS AND SEMI-CONTINUOUS CASTING MACHINES

In horizontal continuous casting machines, the stirrers are usually installed inside the mould body and they are cooled by the mould water circuit.

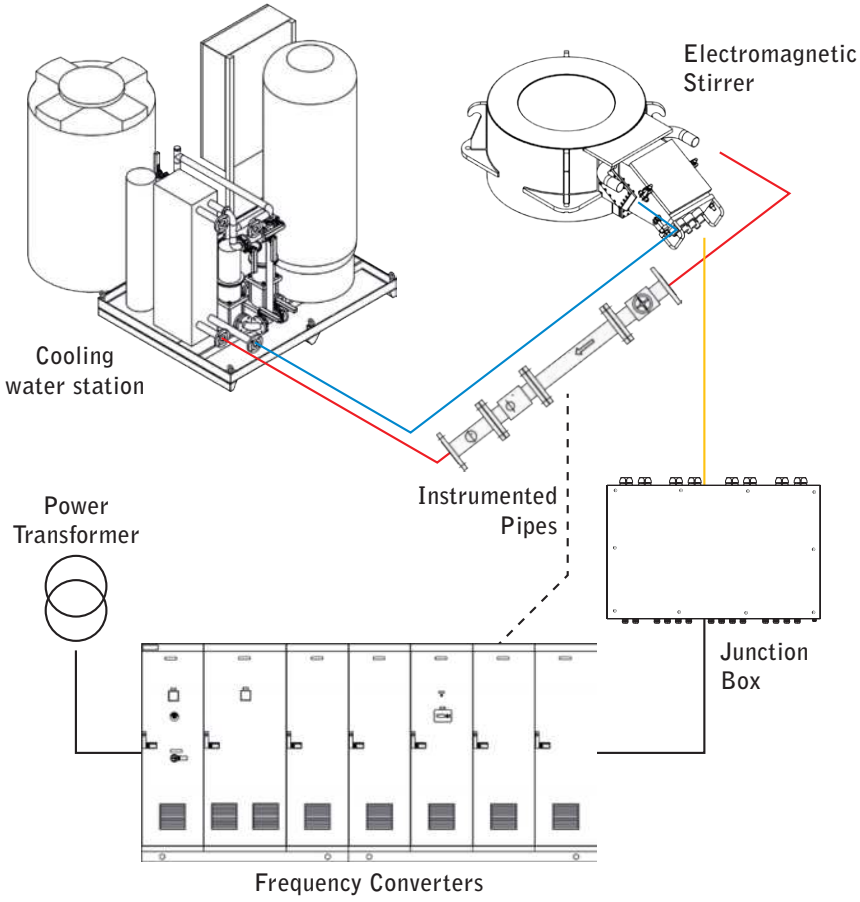
Depending on the available spaces and the casting machine layout, it is also possible to install the stirrer installation outside of the mould. In this case, a dedicated cooling water circuit has to be envisaged.

Mould for horizontal continuous casting of brass equipped with an electromagnetic stirrer

In vertical continuous and semi-continuous casting machines, the stirrers are usually installed outside of the mould body, nevertheless internal stirrer solutions are also available depending on the available space inside the mould body.

In addition to the electromagnetic stirrer, ergolines can supply not only the engineering of the mould, designed to integrate the stirrer but also turnkey solutions that includes the mould body, the electromagnetic stirrer and the power supply system.

TYPICAL ERGOLINES STIRRER SYSTEM



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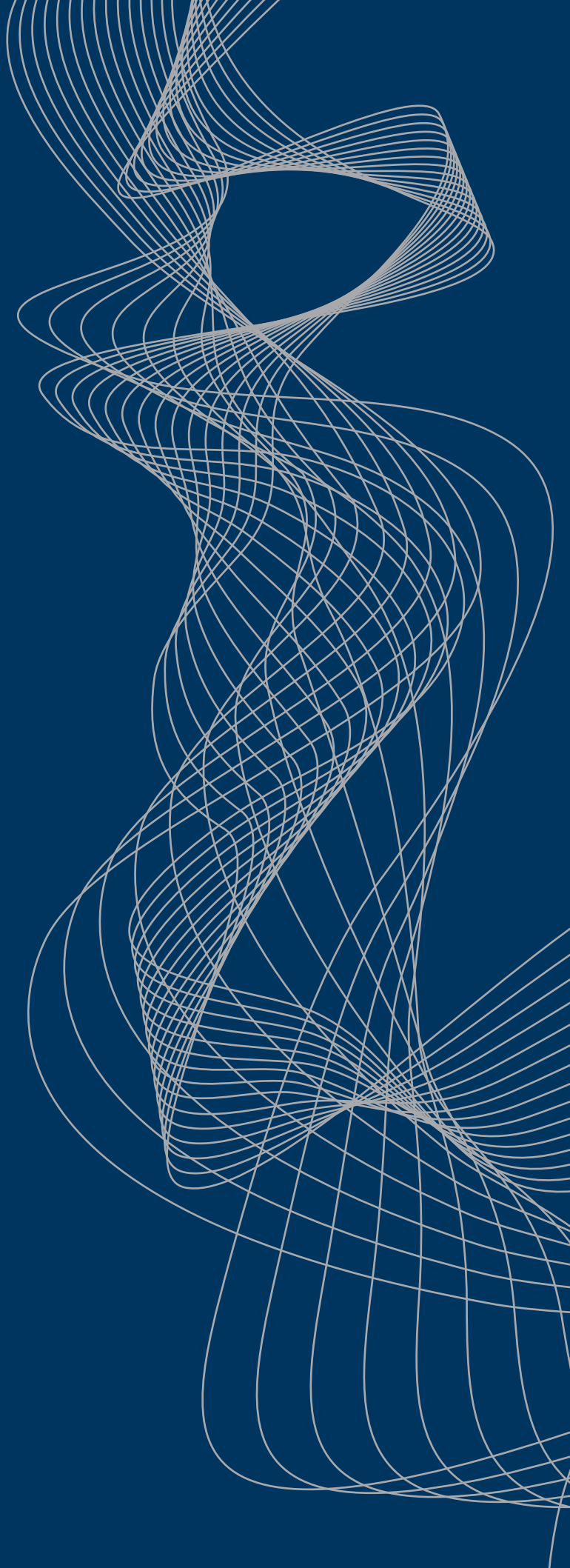

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MFM – INSTRUMENT FOR MEASURING THE ELECTROMAGNETIC FIELD PRODUCED BY STIRRERS.

Thanks to the in-depth know-how it has acquired in the manufacturing of electromagnetic stirrers, Ergolines has developed an extremely sturdy instrument that enables complete testing of any type and brand of stirrer, even when installed on board the casting machine.

The instrument is intended for applications in production, quality control and for servicing personnel and enables periodic control of the performance of electromagnetic stirrers, thus guaranteeing maintenance and also an improvement in the effects of electromagnetic stirrers for various steel grades.

MFM (Magnetic Field Meter) can measure the magnetic field on 3 axes in every single position inside the crystallizer (Mould EMS) vor inside the stirrer in Strand EMS and Final EMS.

INSTRUMENT MAIN FEATURES

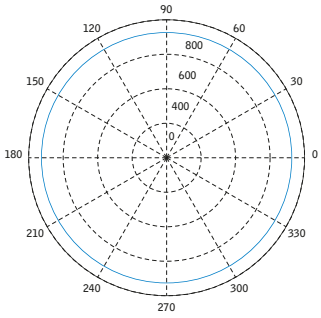
The pocket terminal guides the operator through the measurements and enables quick assessment of all parameters that are typically required for the various plant technical personnel:

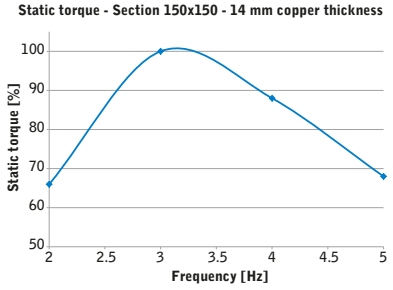
PRODUCTION PERSONNEL, METALLURGISTS, QUALITY CONTROL

- magnetic field B (Gauss)
- field frequency
- field geometry
- static torque produced in the mould
- position of the stirrer with respect to the various steel grades and casting modes (open stream or submerged casting).

MAINTENANCE AND ASSEMBLY PERSONNEL

- assessment of field symmetry to check the proper operation of the stirrer and the supply system
- assessment of the presence of harmonics to check the stirrer supply system
- alignment of the stirrer with the mould or with the strand
- indications of operating conditions which could require preventive maintenance on the stirrers.





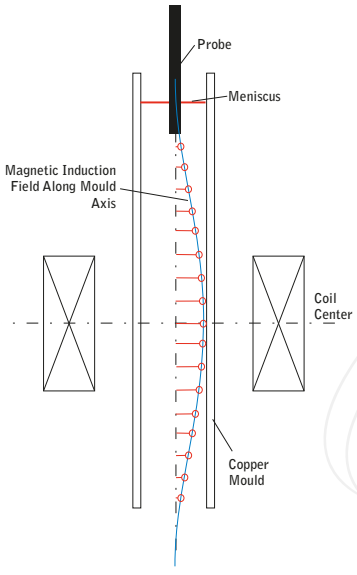
The pocket terminal has an internal memory where all the measurements can be saved in a statistical database.

HOW IT WORKS

The probe is inserted into the stirrer (in the workshop or on the line) or into the mould, making it possible to measure magnetic induction along the stirrer axis.

The probe handle is fitted with three buttons allowing access to all the functions of the pocket terminal, namely:

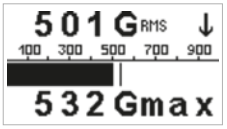
- magnetic field
- frequency
- field symmetry graph
- presence of harmonics
- magnetic field rotation direction.

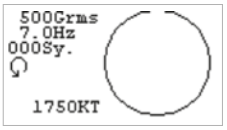


SYSTEM COMPONENTS

The system is made up of the following components:

- handheld probe
- Connection cable to the pocket terminal
- Pocket terminal
- Hermetic, shock resistant and dustproof transportation case
- Software for graphics display and storage in PC





TECHNICAL DATA

Maximum measurable field	2000 Gauss
Accuracy	± 2%
Measurement frequency range	0.6 ÷ 60 Hz
Dimensions	1250x240x60 mm
Weight	2.7 Kg
Degree of protection	IP54
Operating / storage temperature	0 ÷ 50 °C / -20 ÷ 60 °C

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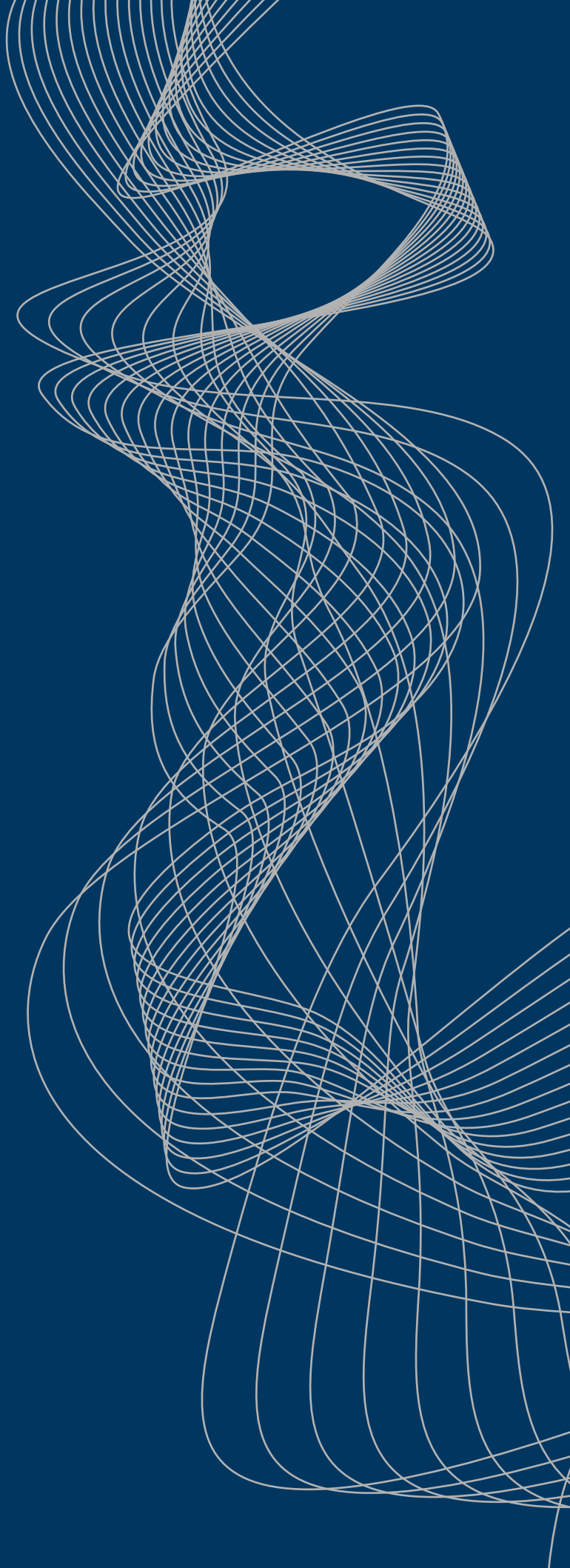

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IRM – INSTRUMENT FOR MEASURING THE INSULATION RESISTANCE OF THE ELECTROMAGNETIC STIRRERS.

Thanks to the know how acquired during years of testing, ergolines has developed a portable and extremely sturdy instrument that enables to measure the insulation resistance of any type and brand of stirrer.

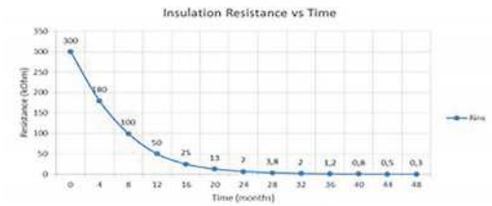
The instrument is a useful tool for maintenance technicians and quality control staff because it permits to monitor the insulation performance curve of the EMS windings.

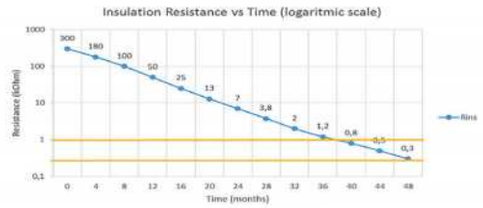
MAIN FEATURES

IRM allows to schedule a preventive maintenance of the stirrer when reaching the first insulation threshold value, namely it starts getting damaged.

An early intervention permits to have the EMS perfectly working before the insulation resistance decreases down to the second threshold, requiring the total revamping.

The preventive maintenance scheduling that can be implemented using this instrument helps avoiding any risks to be forced to cast without the stirrers necessarily requested for quality steel.





	Insulation resistance (Rins) (*)	Description	Activities
	Rins > 1000 Ω (*)	EMS in good conditions	Monthly measurements of Rins
First threshold value	300 <= Ω Rins <= 1000 (*)	EMS with low Rins	Weekly measurements of Rins
Second threshold value	Rins < 300 (*)	EMS requires coils revamping	Stirrer needs maintenance

(*) Warning and fault thresholds are illustrative and Ergolines will specify them for each type of EMS.

HOW IT WORKS

IRM is able to measure low insulation resistance values, typical of all stirrers' application (wet or dry).

Its resolution of 0.1 kΩ (in the range 0.2 – 100 kΩ) allows to be fully aware of the stirrer conditions.

The use is very simple and the insulation can be measured in different ways, directly at the terminal box on the stirrer, or at the in-field Junction Box.

It can also be used to measure the insulation resistance while the system is in operation.

Plant technical/maintenance personnel will be able to:

› verify the proper operation of the stirrer and the supply system;

› have indications on when to proceed with a preventive maintenance.

After start up, the instrument continuously measures the insulation resistance displaying its value on the monitor.

INSTALLATION

The instrument has four connections (2 cables to be connected to 2 different phases of the stirrer and 2 cables to be connected to ground). It can be used in the workshop or on the line.

The instrument is equipped also with an analog indication of the insulation resistance value (4-20 mA) and a digital output for alarm (alarms threshold can be set from panel).

SYSTEM COMPONENTS

The instrument is made up of the following parts:

- instrument in its IP54 shock resistant and dustproof transportation case;
- four connection cables with crocodile clamps;
- battery charger;
- user's manual.

TECHNICAL DATA

Resistance measurement range	0.2 kΩ to 1 MΩ
Frequency measurement range	From DC up to 60 Hz
Dimensions	270x175x247 mm
Weight	5.1 Kg
Degree of protection	IP54
Operating / storage temperature	0 ÷ 50 °C / -20 ÷ 60 °C

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MTM/BPS – MOULD THERMAL MONITORING AND BREAKOUT PREVENTION SYSTEM.

The mould is the most important section of the caster, where liquid steel forms a first solid skin. Incorrect growth of the shell can cause sticking, which in turn can result in breakage of the solid shell (breakout). This results in system downtime and expensive repair operations.

The MPS/BPS system performs real-time monitoring and analysis of the temperature map of the mould walls, by means of a matrix of high-accuracy type-K thermocouples.

Thanks to sophisticated algorithms, the MTM/BPS system enables identification of sticking in the mould, thus reducing the probability of a breakout.

Thermal monitoring also makes it possible to:

- Check that the mould has been designed properly (proper conicity)
- Monitor the proper operation of the lubricating powders
- Signal any process problems or uneven cooling in the mould.

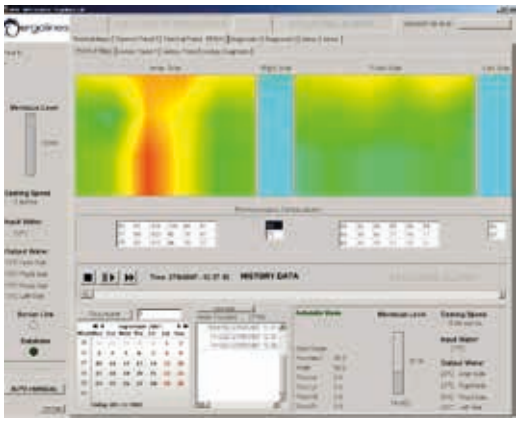
INSTRUMENT MAIN FEATURES

The advantages of the MTM/BPS are set forth below:

- the system can be updated with new recognition algorithms at any time during operation
- there is a built-in historic database of recorded data, on which it is always possible to perform new analyses, statistical data processing, simulations of operating conditions, final post-process summaries, etc.
- It is possible to accurately fine-tune the system and improve its efficiency thanks to offline adjustment of recognition parameters/thresholds, by using the data stored from events (for example, sticking and breakouts). The events can be recreated with different settings of the recognition algorithms
- The third row of thermocouples provides further thermal data to better recognise the dynamic temperature curves that lead to stickers and reject false alarms
- All data is stored for post-processing analyses and to improve the analysis algorithms.

HOW IT WORKS

When sticking occurs, the liquid steel is closer to the mould, generating a sudden increase in the temperature of the wall itself. The temperature of the mould is monitored constantly by two or more rows of thermocouples. The temperature detected by each thermocouple is then analysed mathematically in real-time, and when sticking is recognised, an alarm is triggered which is sent to the PLC of the strand. The PLC initiates a casting speed slowing procedure which allows restoration of the solid shell, preventing sticking and resulting breakouts.



SYSTEM COMPONENTS

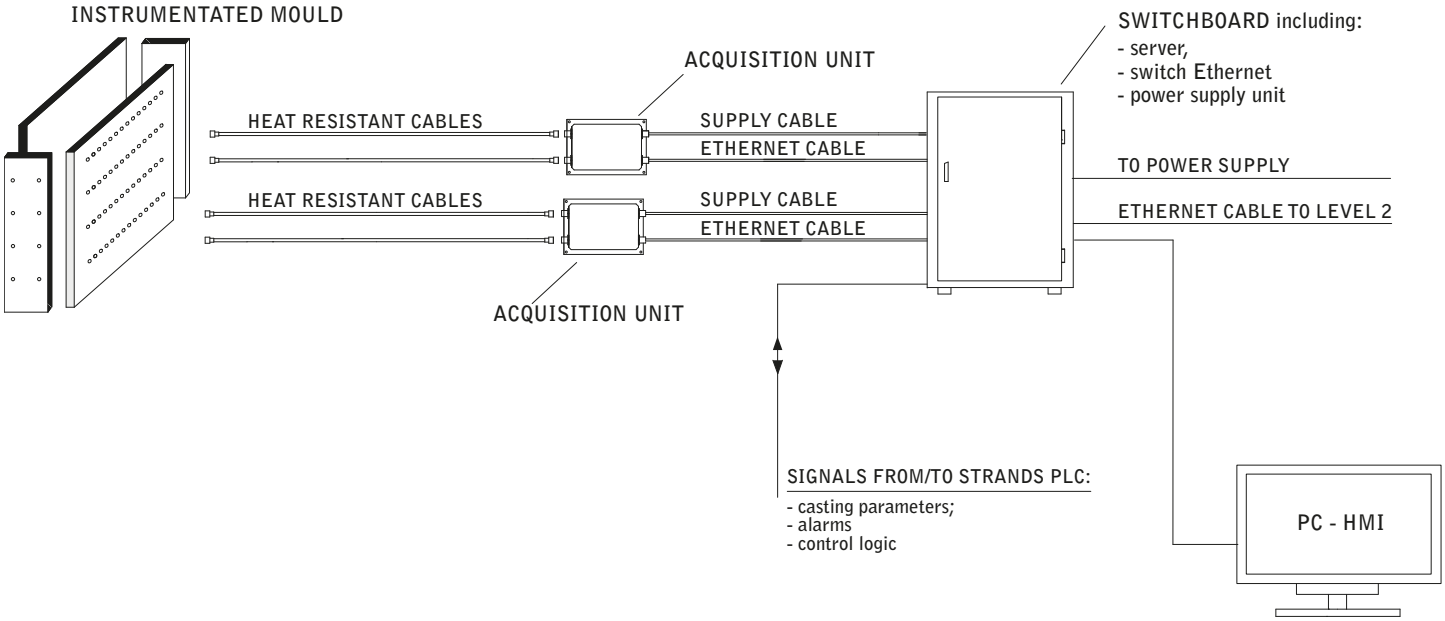
The system is made up of the following components:

- thermocouples installed on the mould
- compensating cables
- connectors
- data acquisition unit /junction box
- central unit
- I/O unit
- ethernet switch
- monitoring unit
- database
- PLC.

INSTALLATION

The MTM/BPS system is designed for installation on plate moulds, and therefore in bloom or slab casters. Installation involves working the copper plates to allow insertion of the thermocouples which are fastened to the back plates.

A special installation is also available for billet moulds, thus allowing thermal monitoring of the crystalliser in order to optimise the design and obtain the best metallurgical results by studying the evenness of cooling in the mould.



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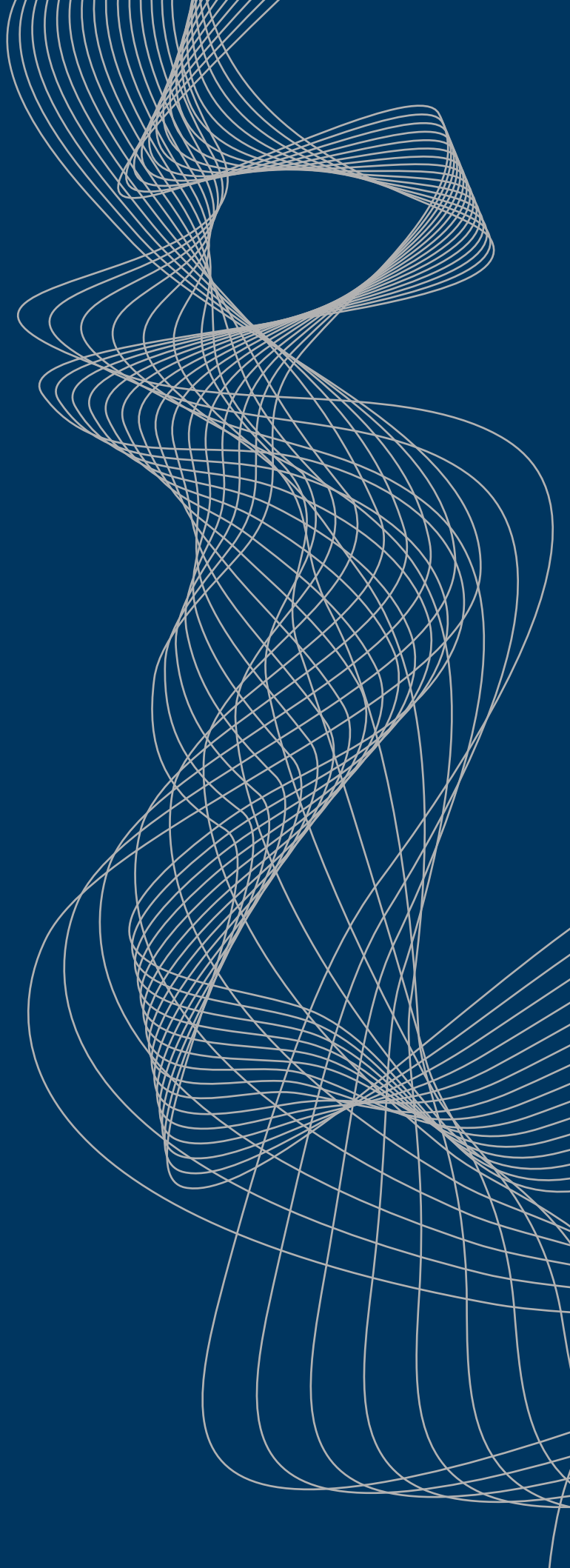

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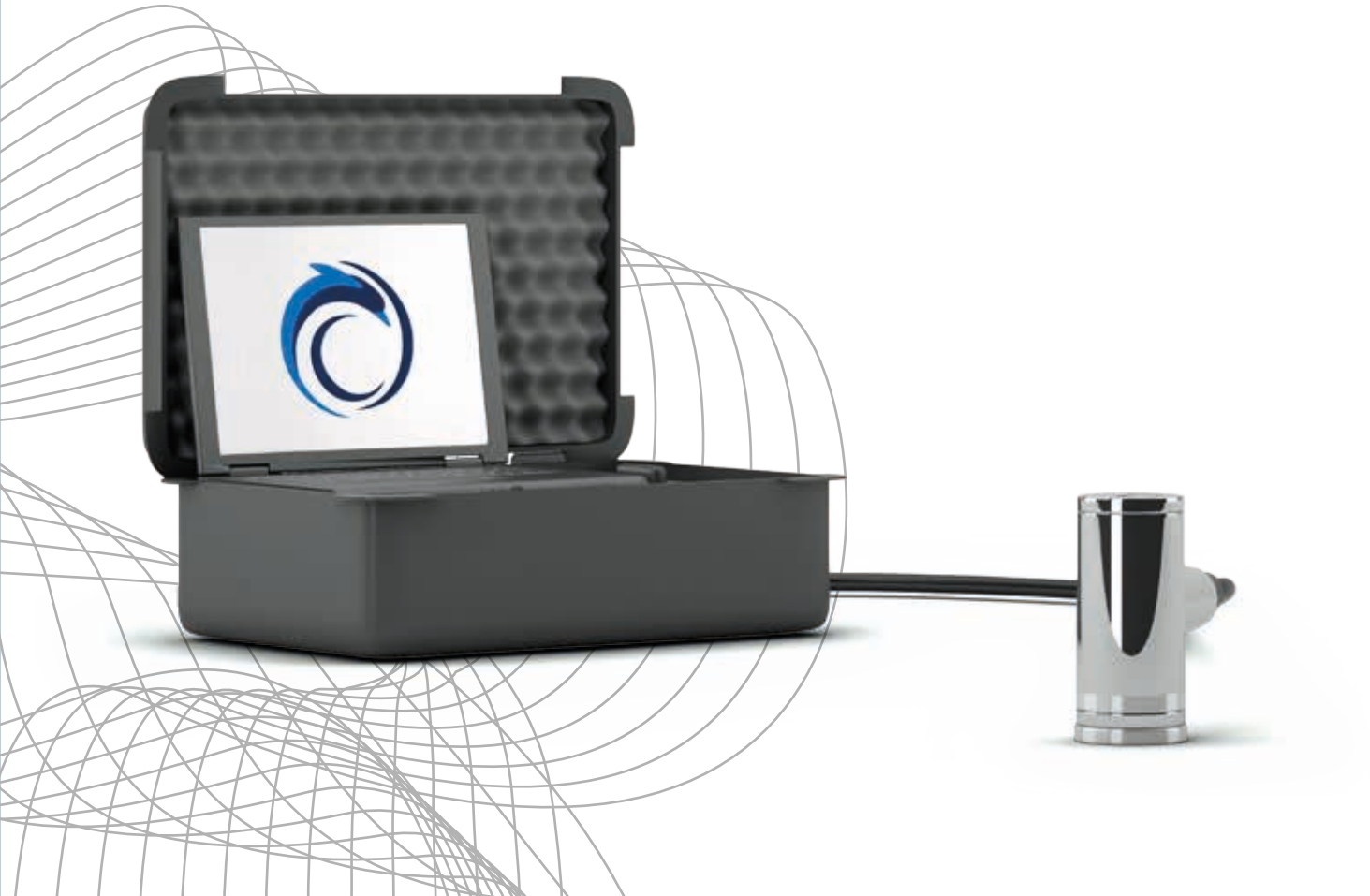
OPI – OSCILLATION CHECKER INSTRUMENT FOR BILLET, BLOOM AND SLAB CASTERS.

OPI measures and reconstructs the trajectory of the mould on three orthogonal axes, by means of 3D accelerometers fixed to the oscillation table structure.

Accurate measuring of the spatial trajectory of the mould is of great help in anticipating situations where the oscillation table requires maintenance. It is also useful for monitoring and preventing abnormal caster behaviour and analysing this unusual behaviour in order to obtain the best quality in the cast product.



INSTRUMENT MAIN FEATURES

This system can be used to compare the actual oscillation of the table with the set value. In combination with the casting speed data, **OPI can also estimate the strip time**.

MAIN ADVANTAGES

- you can assess the stability of the mechanical components of the oscillation table
- allows you to perform preventive maintenance
- you can prevent any sticking situations.

VARIABLES MEASURED AND RECORDED

- speed on the vertical axis
- displacements on the z axis
- transversal displacements on the x and y axes
- expected oscillation curves and measurements can be compared.

SYSTEM COMPONENTS

OPI is available in the 1 accelerometer, typically used in billet casters, and 2- or 4-accelerometer versions, which are used in bloom and slab casters. All versions can be supplied as permanent and mobile installations.

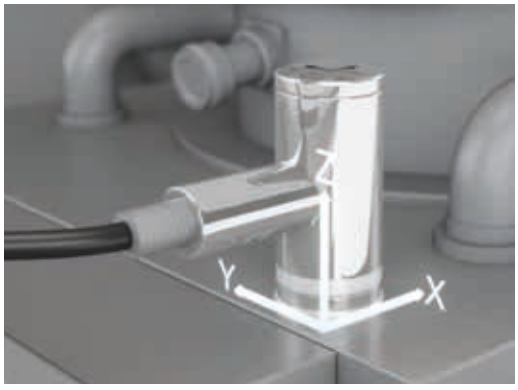
Permanent installation envisages the supply of:

- OPI sensors
- connecting cables with dynamic laying
- field junction box with acquisition electronics (SPUe)
- panel containing the PC processing unit and the interface with the PLC of the line
- PC-HMI.

HOW IT WORKS

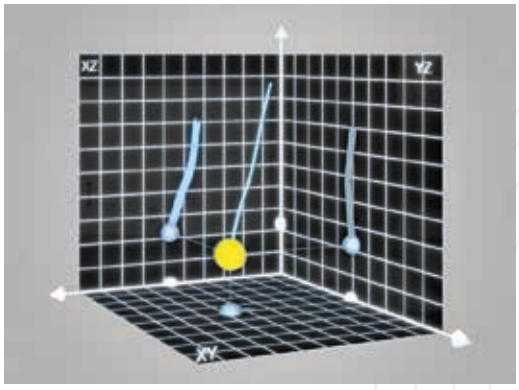
STEP 01

The OPI sensor detects the mould movements on the three axes, X-Y-Z, analyses the planar movements (2D diagram X-Y, X-Z and Y-Z) and reconstructs the complete spatial 3D trajectory of the mould.



STEP 02

All the data acquired is processed through a Fourier analysis in order to determine the oscillation frequency; this enables the user to reliably diagnose the system composed of oscillation table and mould assembly.



INSTALLATION

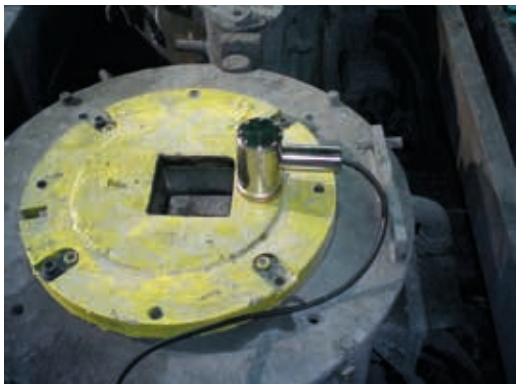
Installation can be permanent or mobile. In the mobile version both the sensor and the laptop are contained in a special instrument transportation case equipped with USB port and an Ethernet connection for data transfer. The data is displayed in real-time on the PC-HMI screen and saved for later analyses.

PERMANENT INSTALLATION

All strands are permanently equipped with an OPI sensor to constantly monitor mould oscillations during casting.

MOBILE INSTALLATION

The OPI system is supplied as a portable instrument, equipped with a transportation case, for strand by strand periodic control of the oscillation unit.



TECHNICAL DATA

Frequency range	1 ÷ 10 Hz (60-600 strokes/min)
Oscillation amplitude range	± 10 mm
Operating temperature	0 ÷ 80 °C
Degree of protection	IP 67
Dimensions	ϕ=80 mm, h=150 mm
Weight of sensor	2.5 Kg

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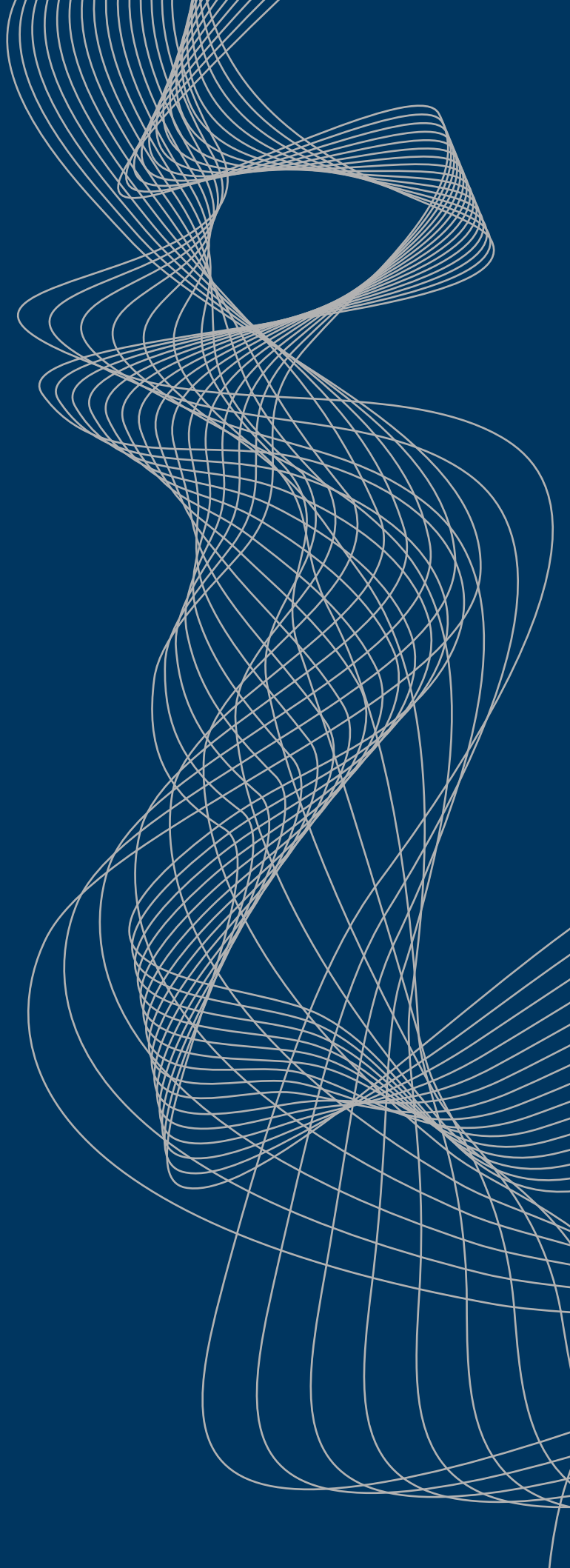

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VSD – VIBRATIONAL SLAG CARRYOVER DETECTOR.

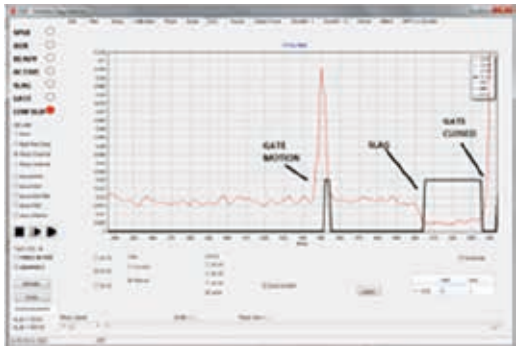
The VSD is an automatic vibration-based monitoring system to detect slag carryover from the ladle to the tundish.

One of the reasons for poor quality steel in cast products is excessive slag in the tundish. High quality standards impose restrictive constraints on production, which often require costly reconditioning operations.

INSTRUMENT MAIN FEATURES

This device allows the following:

- to improve steel quality
- to increase the productivity, optimising the slag/steel ratio
- to optimise ladle productivity
- to reduce wear of the refractory and slide gate refractory plate.



HOW IT WORKS

VSD is an indirect device which exploits the variations in the flow of steel in the shroud, when the said flow starts to become turbulent in the presence of slag. Vibration variation can be easily monitored, by analysing the behaviour of the manipulator arm in the final stage of casting.

SYSTEM COMPONENTS

The system is made up of the following components:

- sensor with 3D accelerometer
- 10 m shielded cable
- junction box
- central processing unit
- operator panel.

All components are installed far away from sensitive casting areas, thus ensuring a long device life.

INSTALLATION

VSD is installed directly on the manipulator with a dedicated support and is designed based on the characteristics of the existing arm. Ergolines offers a manipulator arm optimised with the installed instruments as an alternative. The sensor is equipped with a cooling circuit which makes it suitable for use even under particularly high temperature conditions.

TECHNICAL DATA

Operating temperature	0 ÷ 80 °C
Degree of protection	IP 67
Overall dimensions	l=300 mm, h=150 mm
Sensor weight	5 Kg

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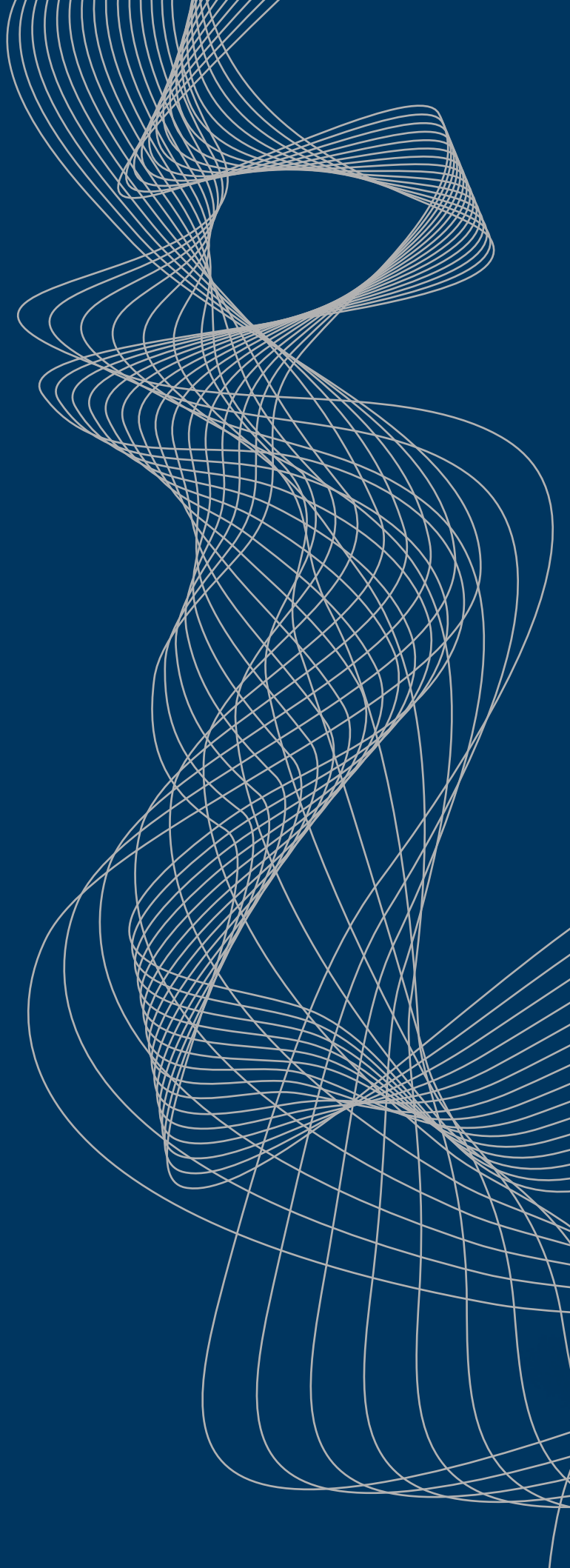

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ILD – MOULD LEVEL MEASURING AND CONTROL SYSTEMS FOR BILLETS AND BLOOMS.

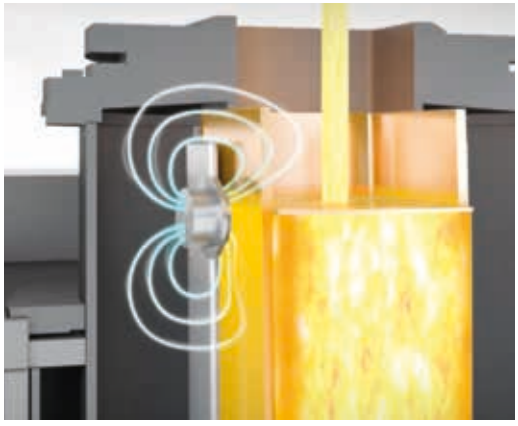
The use of electromagnetic sensors to measure the level of steel in continuous casting is common practice throughout the world. The ILD sensor is an inductive sensor used to control the level in billet and bloom casts.

HOW IT WORKS

The operating principle of the ILD sensor is based on eddy currents.

STEP 01

An alternating magnetic field is generated by the sensor towards the external wall of the crystalliser, generating eddy currents in the copper. In turn, these eddy currents generate a response electromagnetic field from the copper wall, which is detected by the sensor.



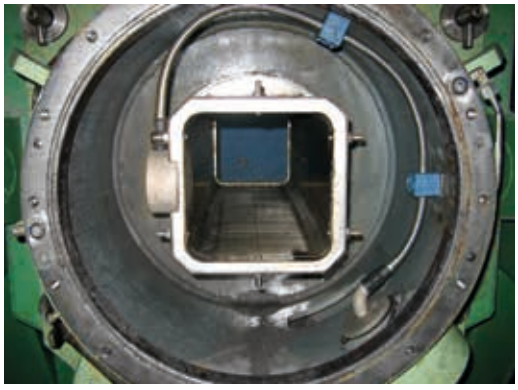
STEP 02

The eddy current induced depends on the resistivity of the copper, which in turn depends on the temperature curve generated by the level of liquid steel. The signal measured by the sensor is then processed to allow reading of the actual level of the steel.

The sensor 2x80-07 is also available for management of the automatic start function of the castings. It is made up of 2 transducers, an upper one for measuring and a lower one to detect the steel level at the start of casting and to manage the automatic start function.

INSTALLATION

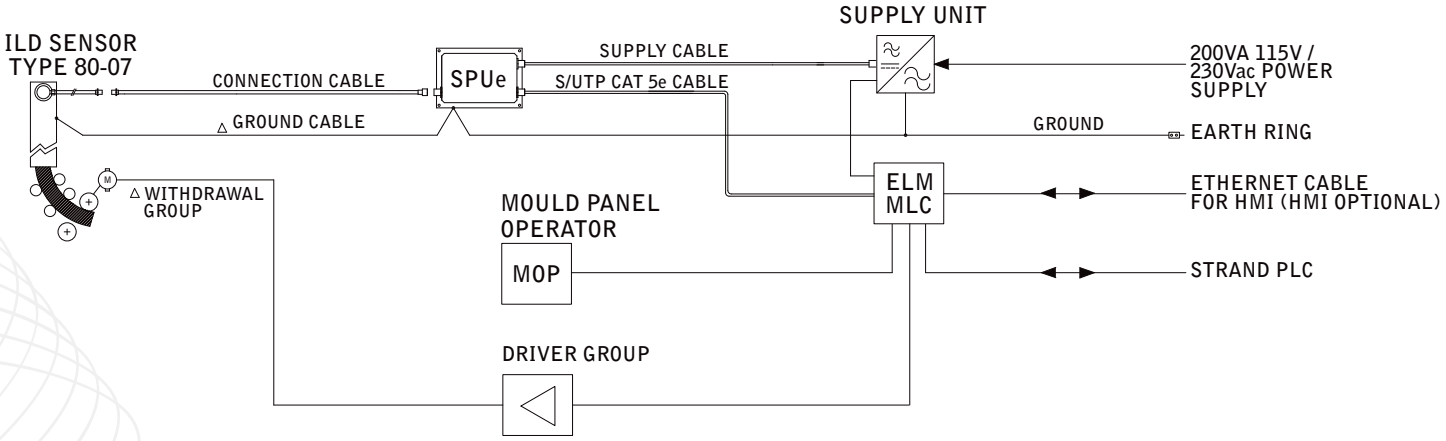
The sensor is installed inside the mould body, on the conveyer, which should be appropriately machined to house the transducer.



SYSTEM COMPONENTS

The system is made up of the following components:

- ILD sensor (model 80-07)
- Flexible cable, 5 or 10 m
- Signal processing unit, which pre-processes the level signal
- Ergolines logic unit for Mould Level Control
- PC unit for data acquisition and analysis, data recording and graph viewing
- Operator panel (on request).



TECHNICAL DATA

Operating frequency	< 200 Hz
Reading range	80 or 160 mm
Accuracy	± 4mm
Response time	50 msec
Also works with mould Stirrer	YES
Measurement only system available	

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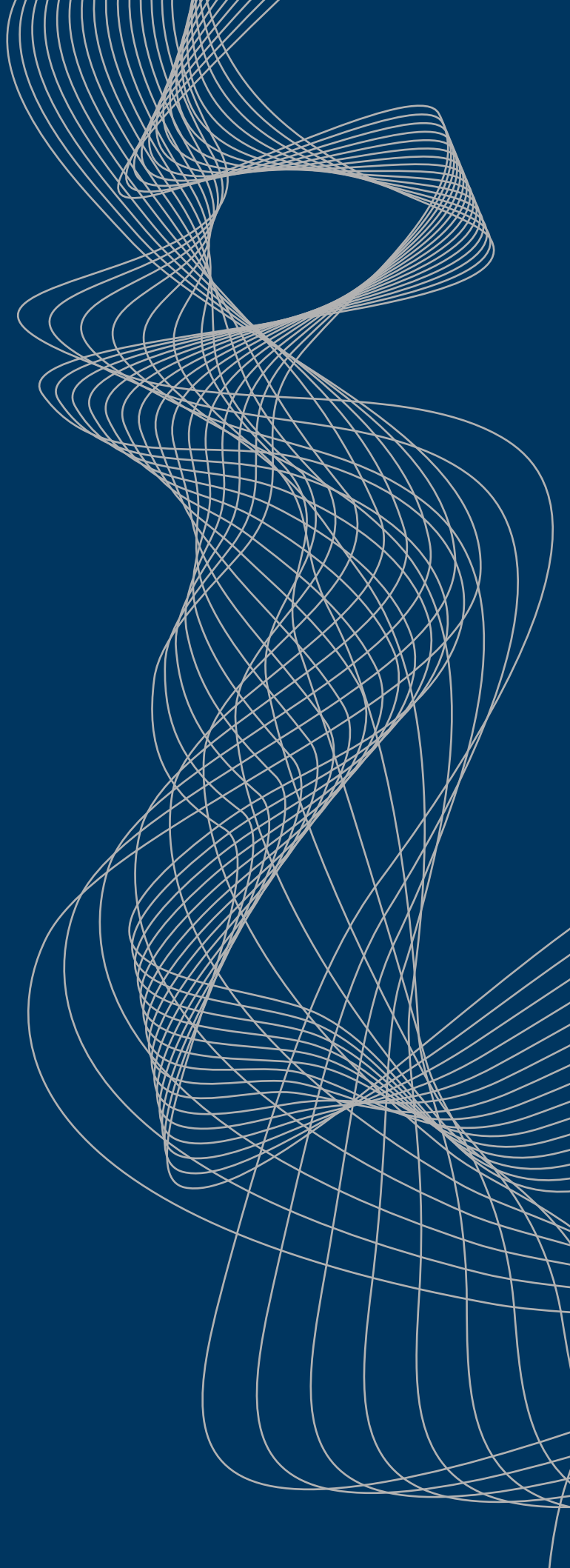

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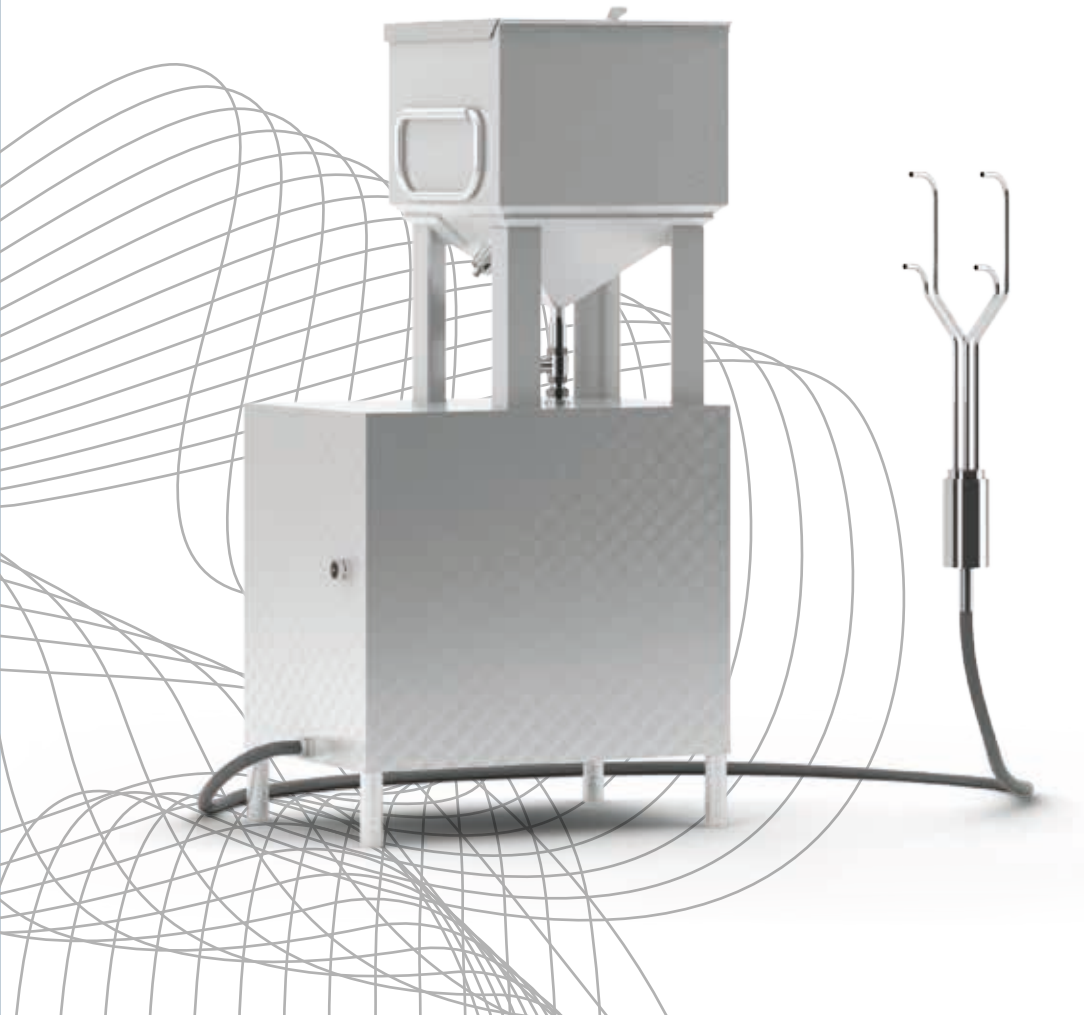
MPF – AUTOMATIC POWDER FEEDING SYSTEM.

MPF is a device developed for continuous casting with protected pouring, where it is necessary to automate the powder feeding on the liquid pool into the mould.

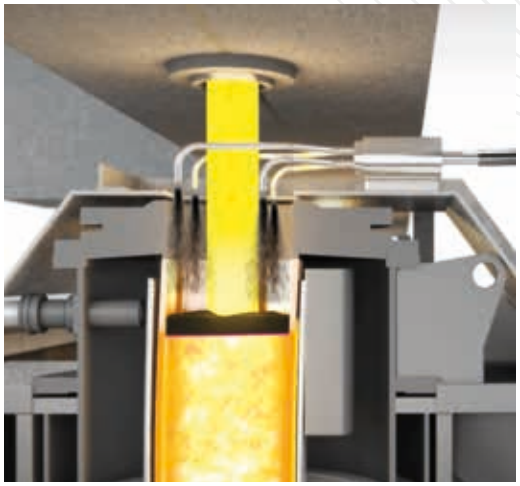
Automatic powder feeding is a priority to ensure the stability of the steel level and quality. The MPF system provides the required amount of powder during casting, ensuring even distribution thanks to calibrated and continual doses at regular time intervals.



HOW IT WORKS

MPF dispenses calibrated powder doses. The powder flow rate can be adjusted by changing the number of doses per minute. The number of doses is set by the operator or can be automatically adjusted in combination with the powder control system PTC developed by Ergolines.

Conveyance is achieved with an intermittent gas stream (argon or nitrogen); this enables extremely accurate distribution and reduces gas consumption compared to continuous-flow systems. The amount of powder in the single doses is set a priori in view of the casting format and the required powder flow rate per hour. The distribution on the bath is made even and uniform thanks to multi-area distributors specifically developed for the different casting formats.



INSTRUMENT MAIN FEATURES

The automatic powder feeder system - MPF is built to work with any section and format (billets, blooms and slabs) and allows fine adjustment of the powder flow rate and attainment of even distribution on the casting bath.

The device was developed to be integrated with the PTC powder thickness measuring and control technology developed by Ergolines.

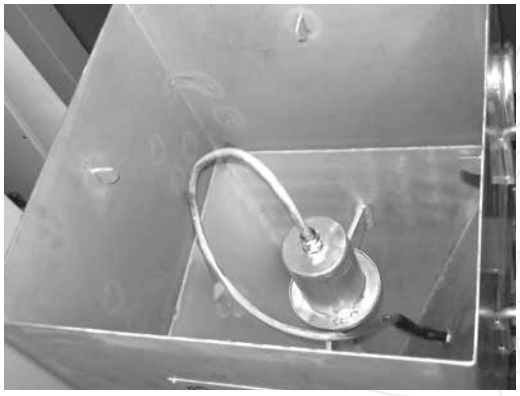
BENEFITS OFFERED

- reduces the meniscus instability
- reduces level fluctuations
- an operator need not be present to check and feed the powder into the mould
- reduces the risks for the operator and increases safety
- gives the possibility of setting the powder thickness in the mould before and after casting
- improves productivity and the quality of the steel, reducing breakout risk
- ensures optimum lubrication, regular feeding and appropriate powder distribution.

INSTALLATION

Each casting line is equipped with an independent powder distribution module which can be added to a shared unit or to separate units, according to the installation requirements of the Client. The conveyance technology adopted allows the use of long conveyance pipes, making it easy to prepare the hopper layout on the casting floor.

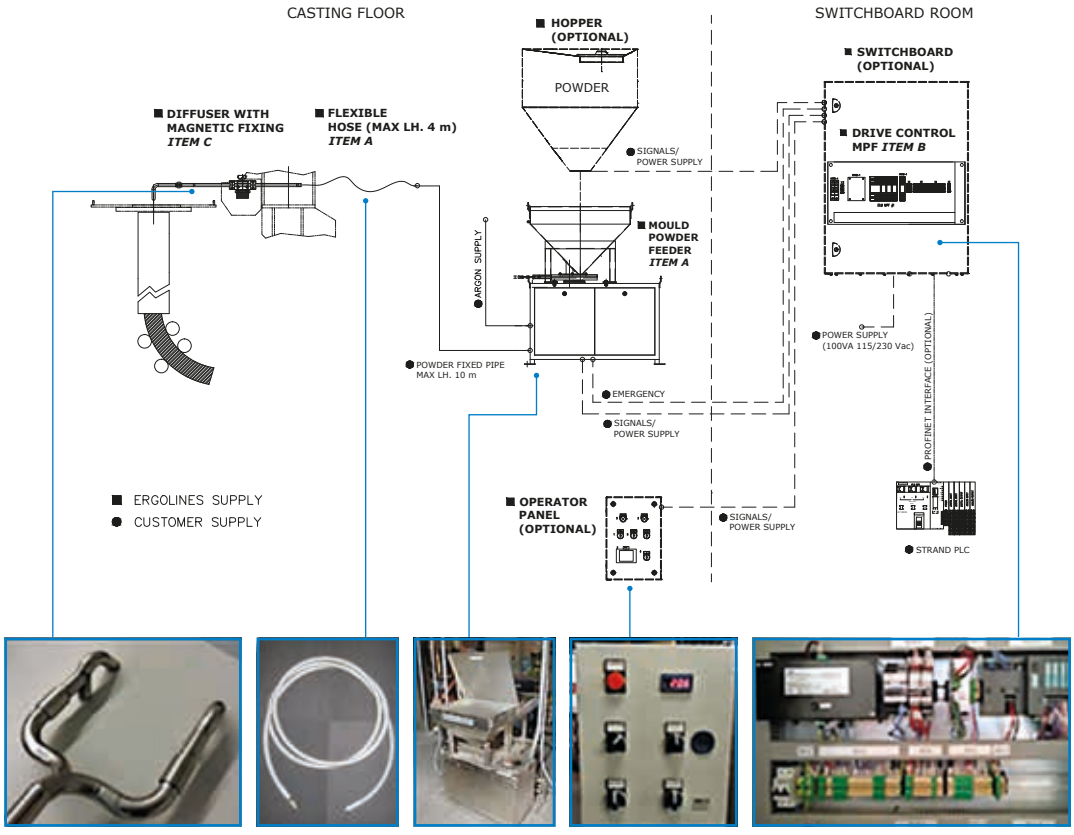
The system is designed to store an amount of powder based on consumption, to ensure that there is enough for a complete casting cycle. Additional large storage tanks connected directly to the distribution units can also be installed where required by the Client.



SYSTEM COMPONENTS

The system is made up of the following components:

- electrical panel with control unit
- feeder system complete with regulating valves, electronic devices and powder tank
- multi-area powder distributor for billets, blooms or slabs
- heat-resistant flexible pipes with quick connectors
- operator panel
- additional tank (optional).



TECHNICAL DATA

Uses	Billets, Blooms or slabs
Powder type	Granular 0.1 – 1 mm
Control parameters	Powder feeder frequency
Working pressure	4– 20 bar
Power supply voltage	24 V DC
Weight without tank	100 KG
Installation	Casting floor or tundish car

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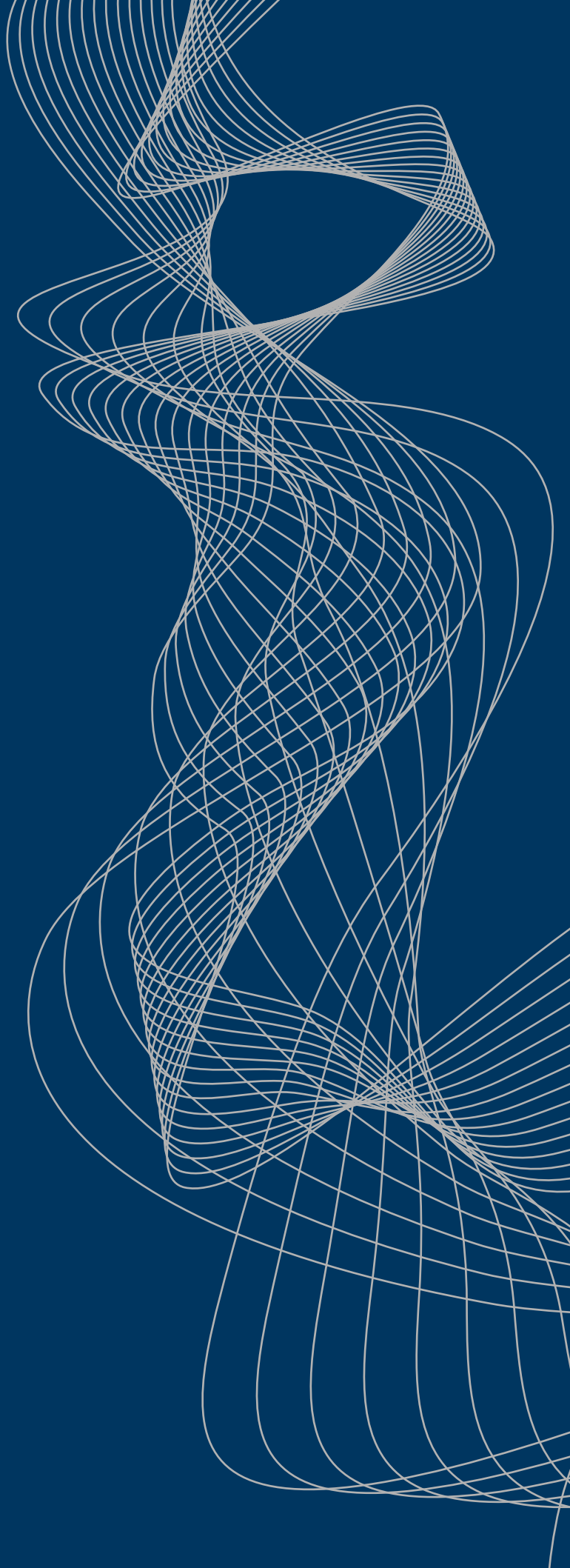

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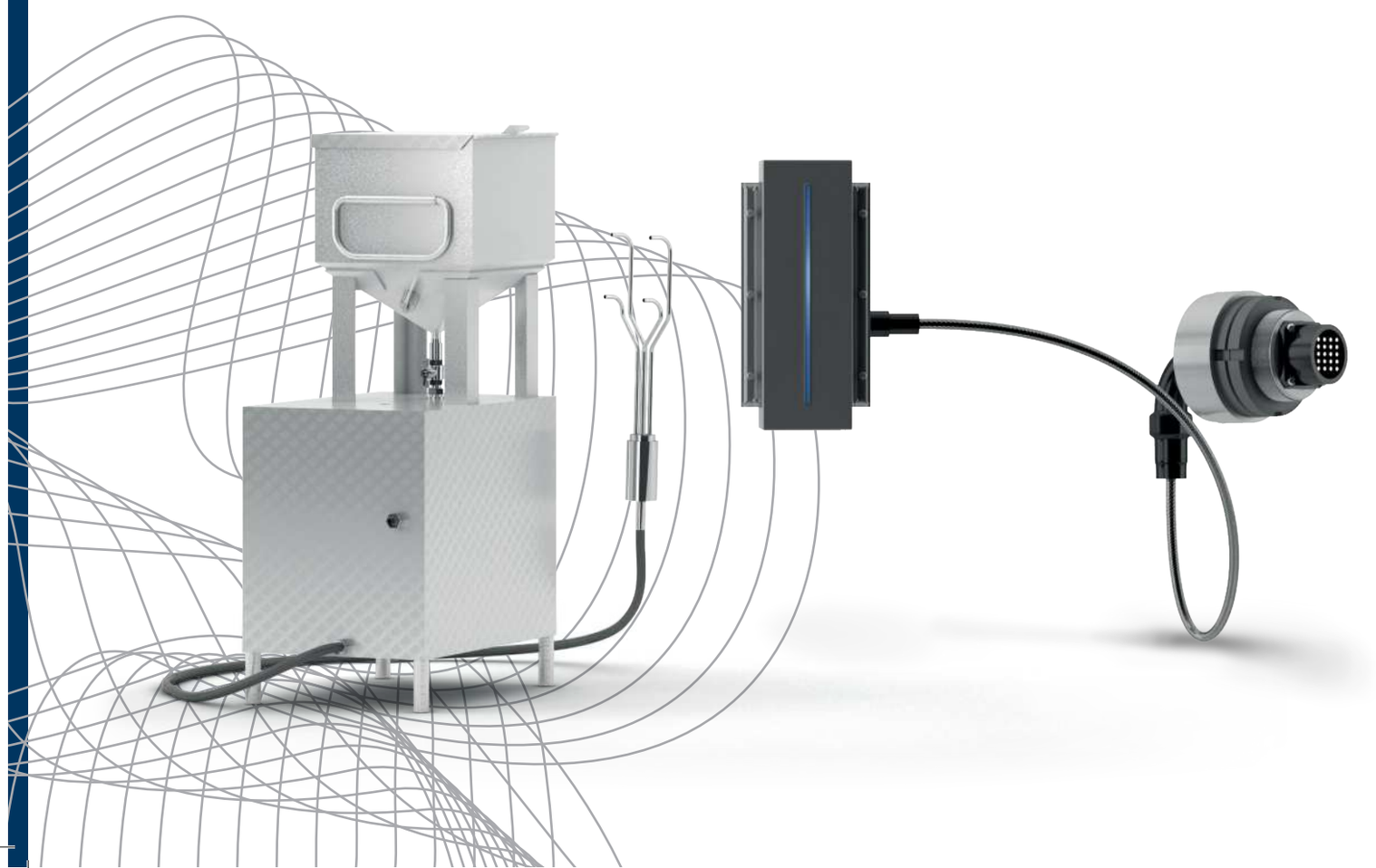
ULD – ULTRASONIC LEVEL DETECTOR.

The key impact of mould powders on the quality of cast steel is widely recognized. Specifically, the ability to maintain constant powder thickness and stable meniscus position is essential to cast quality steel. Mould powder thickness can be controlled through closed-loop automated powder feeding. Ergolines' Ultrasonic Level Detector (ULD) is a new sensor dedicated to the real-time measurement of mould powder thickness. Closed-loop powder thickness control is implemented by using the ULD feedback to drive an automated powder feeding machine, leading to improved steel quality and process stability.

The ULD can be used either in combination with a pre-installed radiometric sensor or with Ergolines' OPD.



MAIN FEATURES

The ULD is designed to work with several sections of long products and allows for fine tuning of the mould powder flow rate.

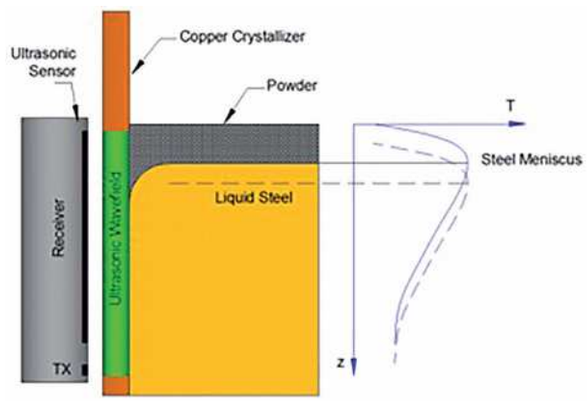
MAIN FEATURES

- keeping powder thickness constant;
- reducing level fluctuations;
- optimizing mould lubrication;
- reducing inclusion entrapment;
- improving homogeneity of the powder thickness and consequently favouring even heat transfer;
- keeping product quality constant;
- reducing need to visually check the powder and manually feed it into the mould.

HOW IT WORKS

Powder thickness is measured by processing the signals measured by two sensors:

- Ergolines' ULD sensor, which detects the meniscus thermal profile and the meniscus position accordingly;
- A radiometric sensor, which measures a mass-weighted average of steel and powder or the Ergolines' OPD, which detects the profile of the powder top.



The ULD measures the mould thermal profile in the meniscus region through a fully contactless approach, based on ultrasound propagation. The steel level is then calculated from the thermal profile by means of a dedicated algorithm.

Ergolines' logic module exploits further signal processing algorithms to determine the instantaneous powder thickness. This value is used as feedback signal to drive the powder feeding machine. By automatically regulating the powder flow rate, the powder thickness is kept constant at the set point.

INSTALLATION

The ULD sensor is installed directly on the water jacket, requiring minimal machining.

ULTRASONIC SENSOR INSTALLATION IN WATER JACKET

SYSTEM COMPONENTS

The system is made up of the following components:

- ULD – Ultrasonic Level Detector;
- Flexible cable (Max LH 10 m);
- Signal processing unit - SPUe;
- Main Switchboard, including electronic components for measurement and closed loop control;
- HMI for data recording, visualisation and management;
- Operator Panel (on request).

TECHNICAL DATA

Sampling frequency	max. 10 Hz
Measurement range	80 mm on vertical axis
Precision	± 2 mm

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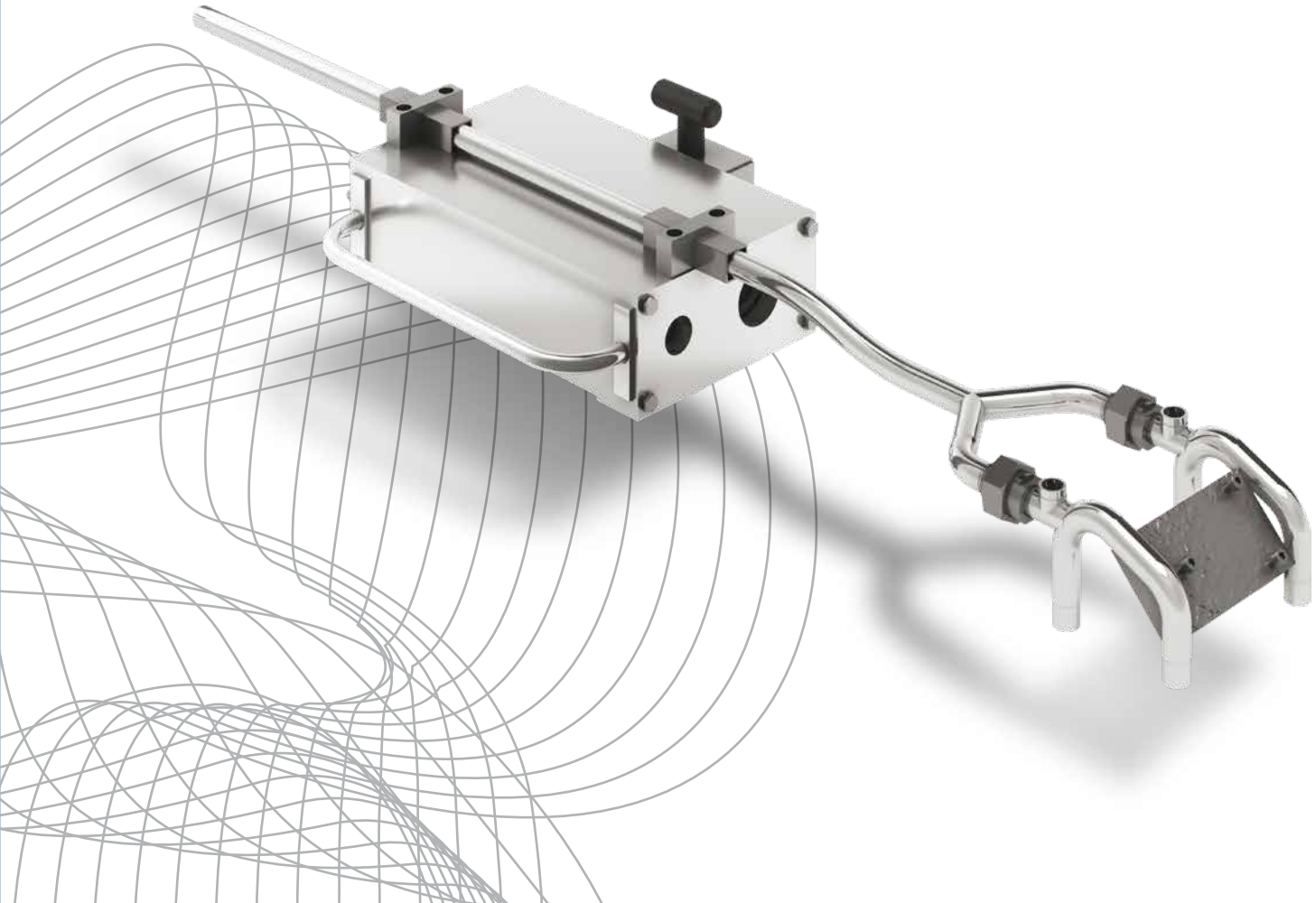
IPD – INSTRUMENTED POWDER DIFFUSER.

The crucial role played by mould lubricating powder in submerged steel casting is widely recognized, being optimal results achieved keeping constant the powder thickness over the steel meniscus.

IPD is a new generation powder diffuser equipped with an optical system (designed for CCM with submerged casting), suitable for measuring the upper profile of the powder in the mould, through laser line triangulation.

It can be used either in combination with radioactive or inductive mould level control system.



MAIN FEATURES

IPD is designed to be used with several sections and formats of billets and blooms and allows fine tuning of the mould powder flow rate.

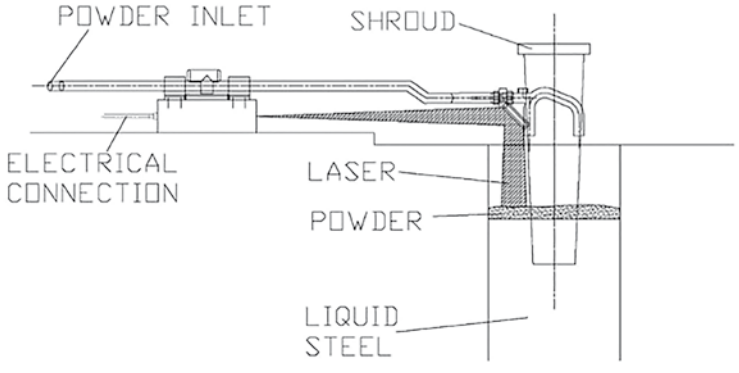
BENEFITS

- keeping powder thickness constant;
- reducing meniscus fluctuations;
- optimizing mould lubrication;
- reducing inclusions' entrapment;
- improving homogeneity of the powder thickness and consequently favouring an even heat transfer,
- keeping product quality constant;
- reducing need to visually check the powder and manually feed it into the mould.

HOW IT WORKS

The final diffuser of mould lubricating powder is equipped with a special laser able to produce a line, highly distinguishable from other light sources, such as steel surface and shroud.

The emitted laser line is focused on the powder surface and its reflection read by a camera, whose signal is processed, providing the real upper powder profile.



The profile measured through the above technology is then combined with either a radioactive sensor level signal or an inductive level signal, to assess the powder thickness.

The choice between the sensor to be coupled with the IPD depends on either available mould level control or customer preference. For bigger sections, the uncertainty of the radioactive sensor signal in distinguishing the material densities due to the long distance between source and detector, forces to prefer inductive sensor coupling.

The advantage arising from coupling measurement system and powder final feeding diffuser in one single tool is evidently easy & handy to use, efficient, compact, as none in the market.

INSTALLATION

The IPD is placed on the mould and anchored through a magnetic fixing device.

SYSTEM COMPONENTS

The system is made up of the following components:

- Mechanical parts: sprinklers, pipe, collars, joining elements and fixing magnetic device
- Optical Focusing System
- Piping and cabling
- OPD – Optical Profile Detector

TECHNICAL DATA

Sampling frequency	max. 10 Hz
Measurement range	200 mm on vertical axis
Precision	± 1mm
Cooling	Air cooling

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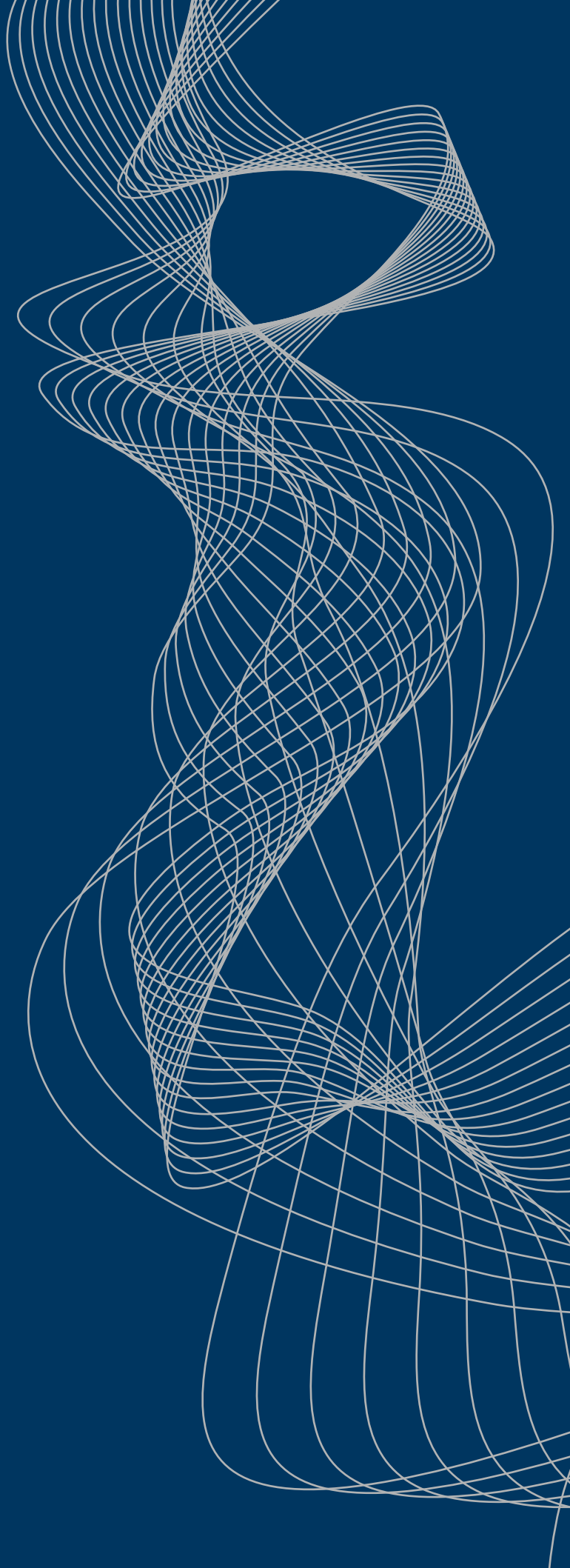

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EMBr – ELECTROMAGNETIC BRAKE FOR SLABS

Most of the defects affecting steel quality in continuous casting process of slabs are associated with fluid flow in the mold. Excessive surface velocity can entrain mold-slag inclusions and cause surface level variations and fluctuations and consequent surface defects formation. Insufficient surface flow leads to meniscus freezing and related surface defects. Deep penetration of the jet entering the mold cavity encourages the capture of subsurface inclusions. Thus, the mold flow pattern must be carefully optimized to find windows of stable casting conditions.

EMBr

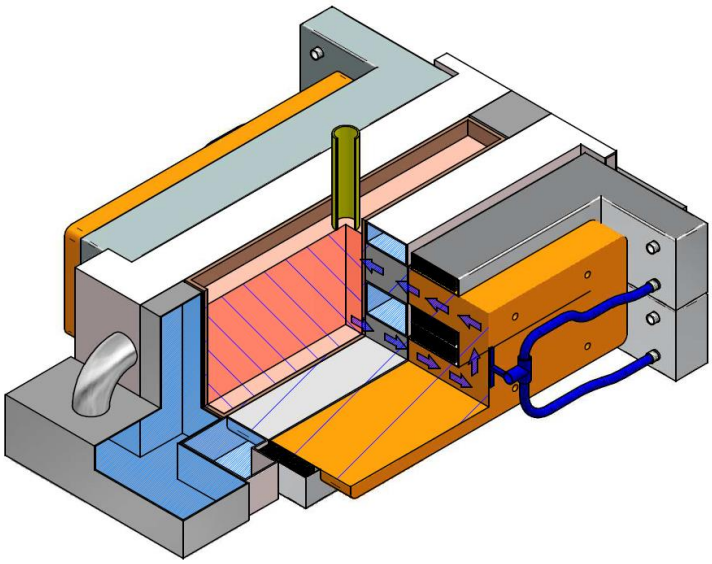
BENEFITS

EMBr (ElectroMagnetic Brake) is an equipment to control the molten steel flow in a mould of continuous casting process using a transverse static magnetic field. The effects of EMBr on the fluid flow phenomena in the mould can be summarized as the substantial reduction of two major circulations of molten steel in the mould. The important advantages obtained by the suppression of such circulations are as follows:

- ➔ reduction of inner or subsurface inclusions
- ➔ elimination of mould powder entrapment
- ➔ reduction of the longitudinal and transverse cracks
- ➔ reduction of static and dynamic waves at the meniscus
- ➔ increase of meniscus temperature
- ➔ elimination of remelting at narrow side

STIRRER INSTALLATION

Electromagnetic braking equipment has been rapidly advanced from the localized imposition of the field (the first generation of electromagnetic braking equipment) to today's design covering the entire width of the strand. This second generation of electromagnetic braking equipment is designed to be less sensitive to the operating conditions and has one or two levels of magnetic fields in the mould.



STIRRER DESIGN AND FEATURES

Ergolines provides second generation EMBr which generates two independent static magnetic fields, the first at meniscus level to control the meniscus metal flow velocity and turbulence while the second field at the bottom of the mold to control the penetration depth of the steel jets. EMBr are designed and optimized for each caster by means of electromagnetic and fluid-dynamic simulations. Thanks to these sophisticated techniques also customized designs are available.

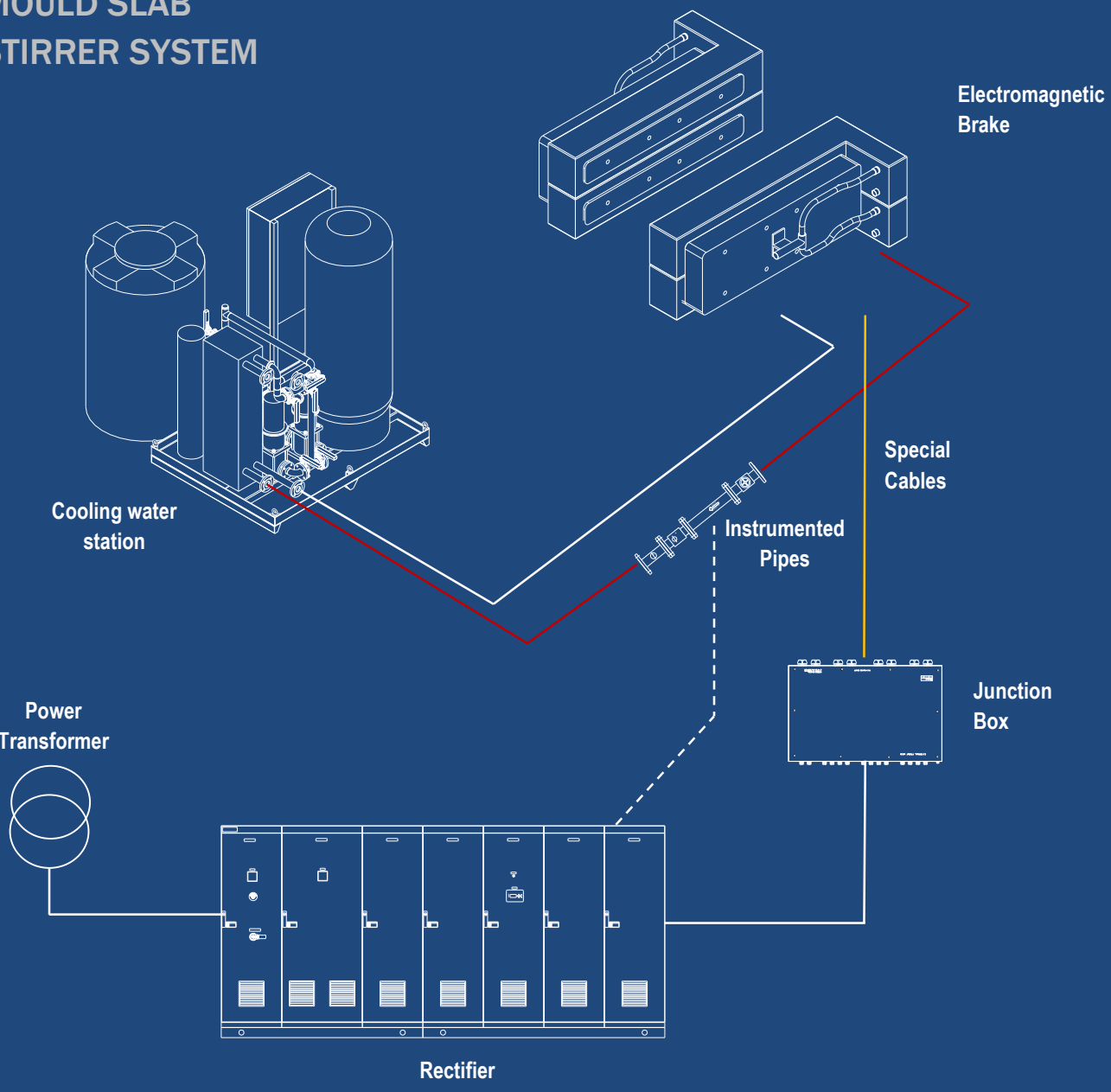
Steel flow inside the slab without EMBr - CFD Simulation

Steel flow inside the slab with EMBr - CFD Simulation

EMBr MAIN FEATURES

- Dry type device (cooling water flowing inside hollow copper conductors);
- Independent regulation of the upper and lower brake;
- Custom shape for any kind of mould and installation.

TYPICAL ERGOLINES MOULD SLAB STIRRER SYSTEM



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