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ESSIAL

Application method for demonstrators & electrical machines

Préscillia DUPONT & Maxime PLOYARD

Summary

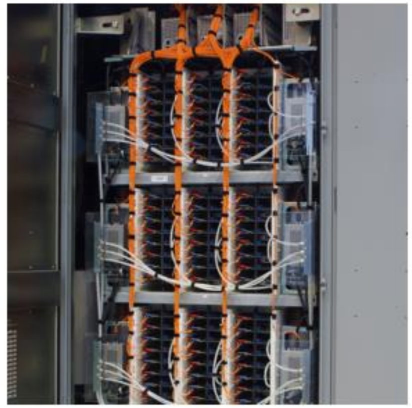
- **Context:**
  - Presentation of JEUMONT Electric
  - General context
  - Technical context
- **Upstream research results:**
  - On Non-Grain Oriented Electrical Steels (NGOES)
  - On Grain Oriented Electrical Steels (GOES)
- **Demonstrators:**
  - Simple Ring Cores
  - Teethed Ring Cores
  - Segment Scale Models
- **Prototypes**
- **Conclusion**

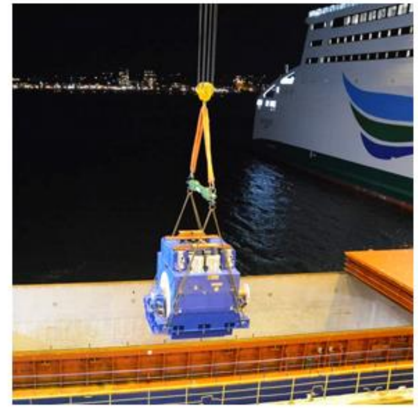
Context: Presentation of jeumont electric groupe altawest

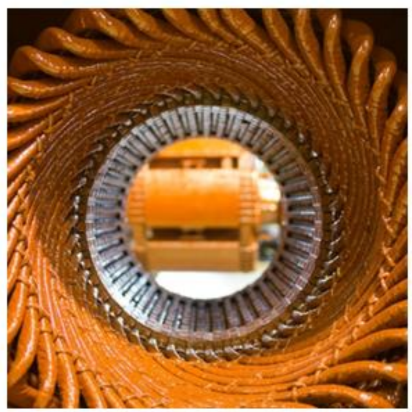
Jeumont Electric is a **key player in the power conversion and power generation markets**. Its state-of-the-art solutions **integrate motors and generators together with variable frequency drives and controls.**

Jeumont Electric **services ensures an increased and safe equipment availability** throughout their life cycle.

Jeumont Electric **acts globally on all markets** (industrial processes, energy, water, marine, etc.) where its expertise allows to **optimize customer processes whilst accelerating ecological and digital transformation.**







Context: Presentation of jeumont electric groupe altawest

Our power conversion solutions

Synchronous Motors
5 to 40MW / 4 to 20 poles

JEMSY *(Salient poles rotor)*

Induction Motors
0,2 to 25MW / 2 to 22 poles

JEMAC *(squirrel cage)*
JEMAB *(slip ring)*

Special applications
Navy, Marine, and Nuclear

Permanent Magnets, Synchronous, and Induction motors

Electrical Power

Pump, Fan, Compressor, Mill, Thruster, winder, etc.

Synchronous Turbomotors
0,2 to 60MW / 2 poles

JISMEV *(Cylindrical rotor)*

DC Motors
0,2 to 25MW / 6 to 20 poles

Context: Presentation of

Our power generation solutions

Engine / Turbine Generators

3 to 70MVA / 4 to 14 poles

JEGSY *(Salient poles rotor)*

Gas / Steam Turbine Turbogenerators

10 to 100MVA / 2 poles

JISALT *(Cylindrical rotor)*

Hydraulic Turbine Generators

4 to 350MVA / 4 to 100 poles



Turbine, Engine

Electrical Power

Excitation Systems / Voltage regulators

Static excitation cabinet

Hydralta, Globalta, Sarn

Context: JEUMONT Electric in ESSIAL

jeumont electric groupe altawest

END-USER

JEUMONT Electric is one of the end-users of the technologies developed in the ESSIAL project

PROTOTYPE MANUFACTURER

JEUMONT Electric is in charge of the manufacturing of 2 rotating electrical machine prototypes

RESEARCH ACTOR

JEUMONT Electric is also involved in upstream research steps of the project

General technical context

Stator production
JEUMONT Electric ©

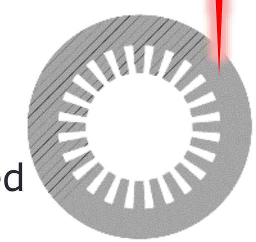
Conductors

Magnetic circuit
(stator stacking)

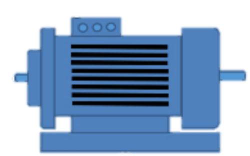
Soft ferromagnetic materials

Iron losses

MAIN GOAL:
Find surface laser treatments adapted to rotating electrical machines

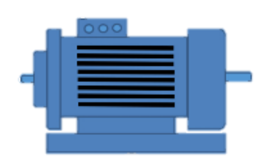


Machine **A**
Non-laser treated



$\eta_A < \eta_B$

Machine **B**
Laser treated



To the main goal through steps

MAIN GOAL:
Find surface laser treatments adapted to rotating electrical machines

UPSTREAM RESEARCH

- Tests on samples
- Modeling

1

DEMONSTRATORS

- Proof of concept
- Intermediary steps between samples and prototypes

2

PROTOTYPES

- Validation of the ESSIAL technology

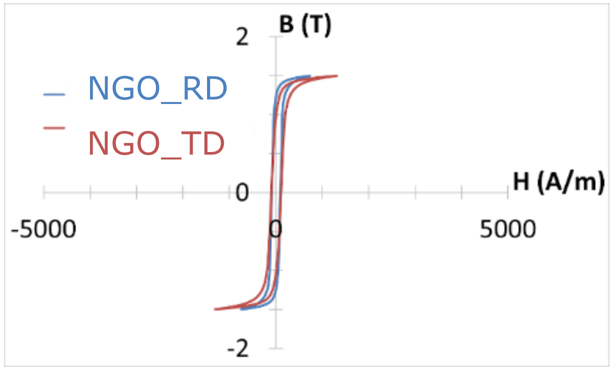
3

APPLICATION ORIENTED

1.1. Upstream research results: NGOES

Soft ferromagnetic materials

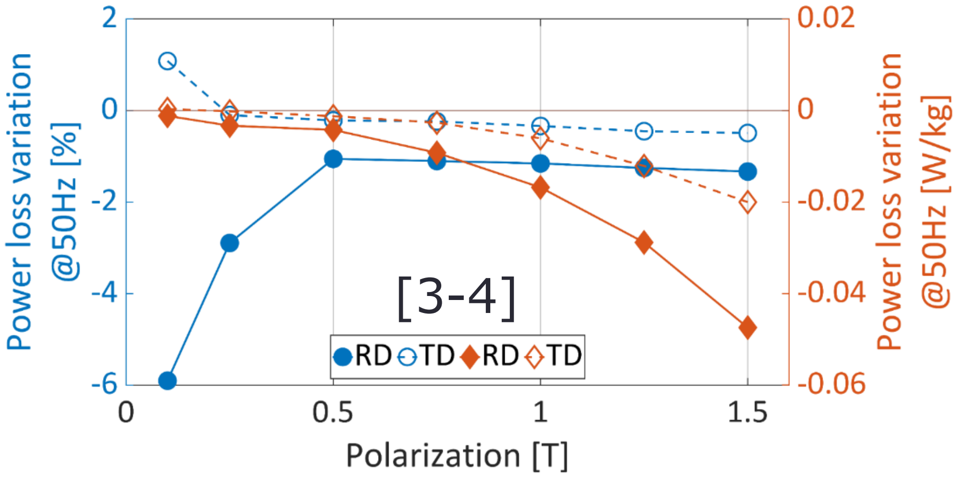
Non-**G**rain **O**riented **E**lectrical **S**teels **NGOES**



→ Limited literature on laser treated NGOES [1-2]

GOAL n°1:
Improve the performances of NGOES along one direction (1D) (i.e. under alternating fields)

RD: Rolling Direction; TD: Transverse Direction

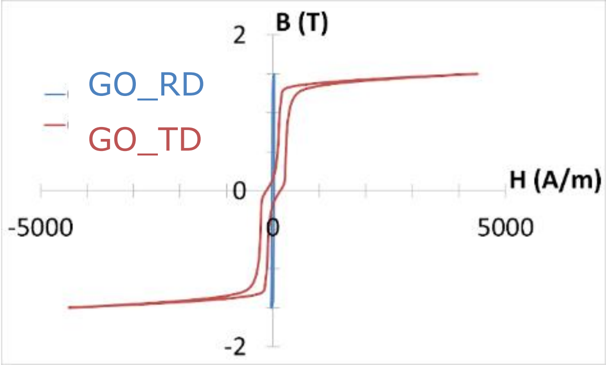


- Numerous trials NGOES
- Impact on losses:
  - Small in %
  - Comparable to GOES in W/kg

1.2. Upstream research results: GOES

Soft ferromagnetic materials

Grain **O**riented **E**lectrical **S**teels **GOES**



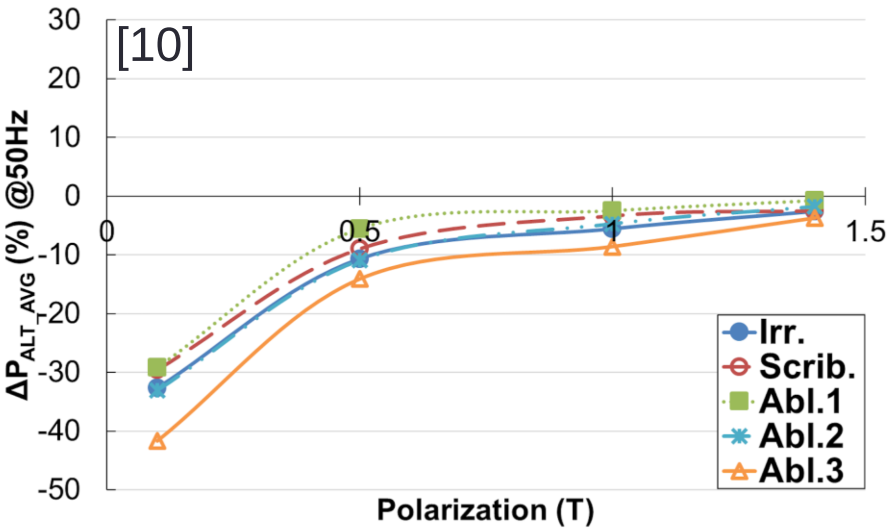
GOAL n°2:
Improve the performances of GOES under non-classical excitation field configurations (2D or 1D but not along RD)

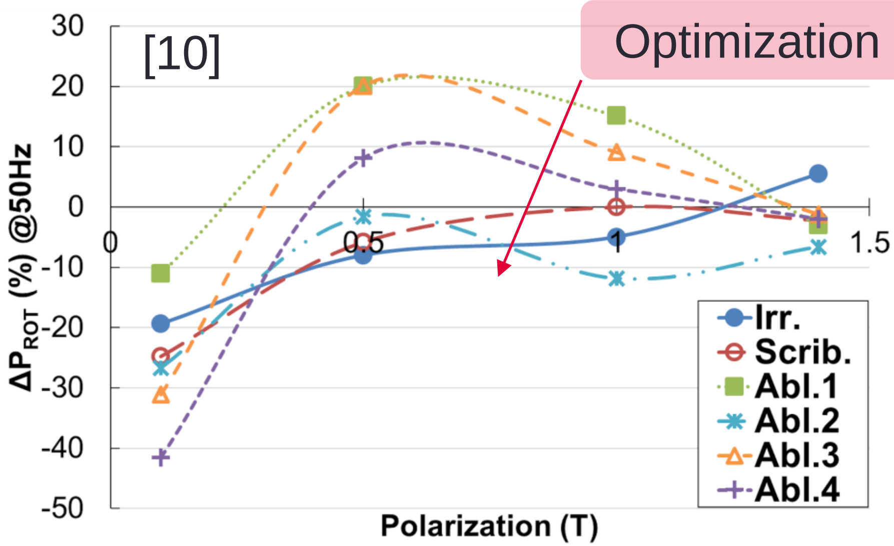
RD: Rolling Direction; TD: Transverse Direction

Literature on laser treatment (GOES):

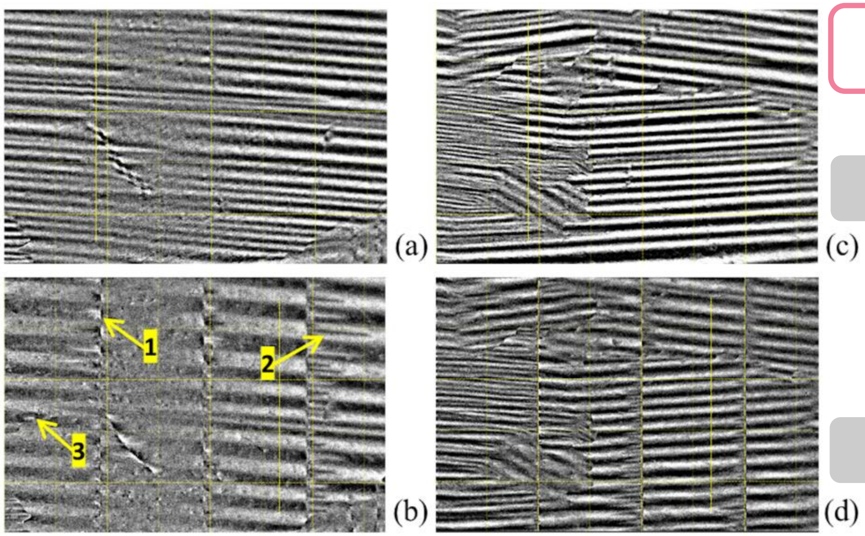
- Plentiful for improvements along RD:
  - Classical treatments [5-7]
  - New ablation treatments [8]
- Poor for impacts under non-classical excitation fields [9]

1.2. Upstream research results: GOES





Irradiation



[10]

Ablation

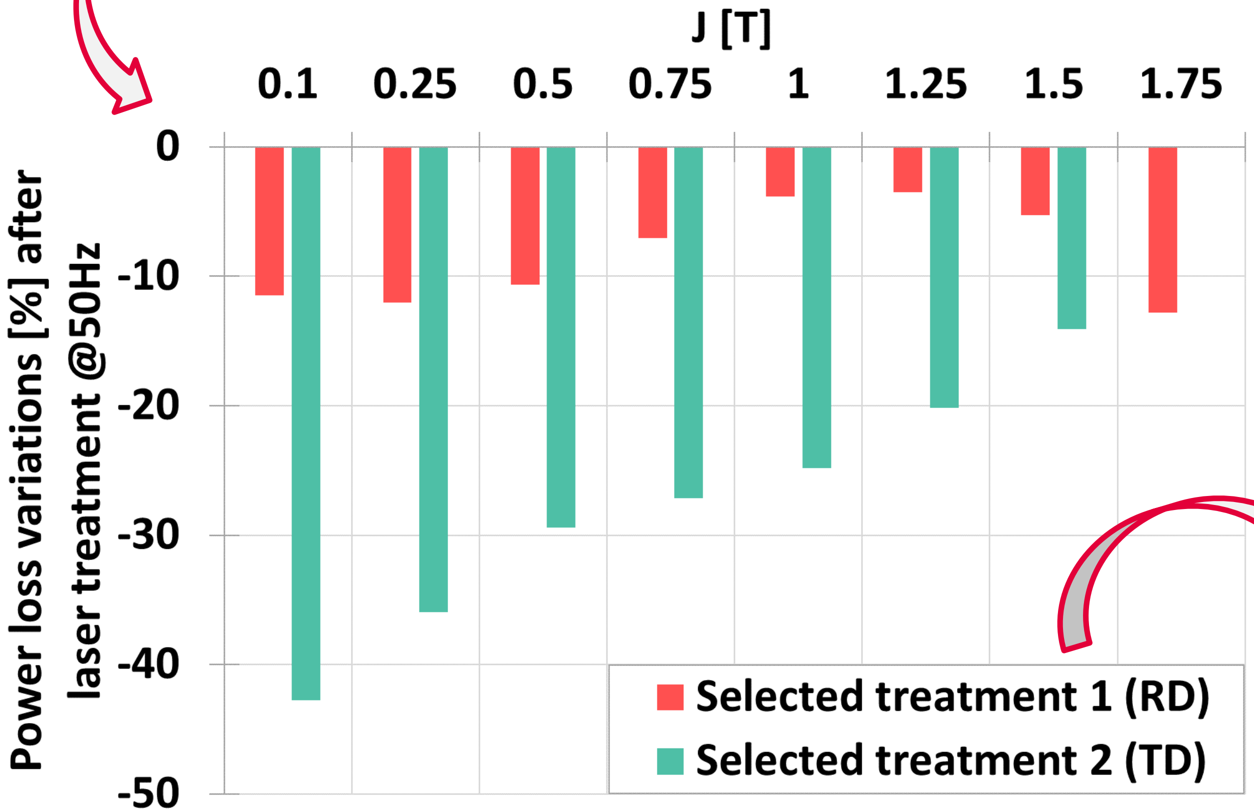
BEFORE

AFTER

MOIF: Magneto-Optical Indicator Film Technic

1.2. Upstream research results: GOES

Additional optimization and upscaling steps led to further improvements of power loss reduction rates



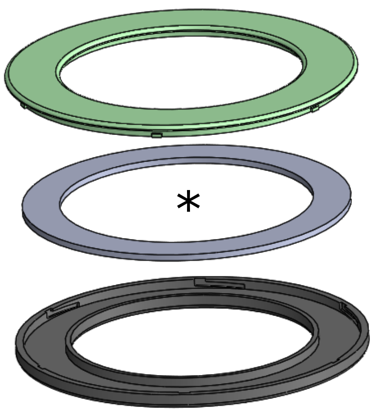
Correspond to **selected** treatments applied on demonstrators in different zones

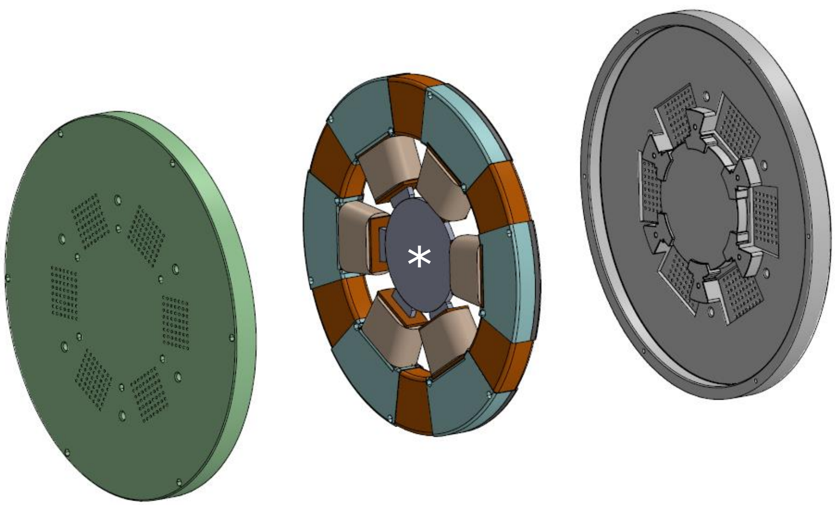
RD: Rolling Direction; TD: Transverse Direction

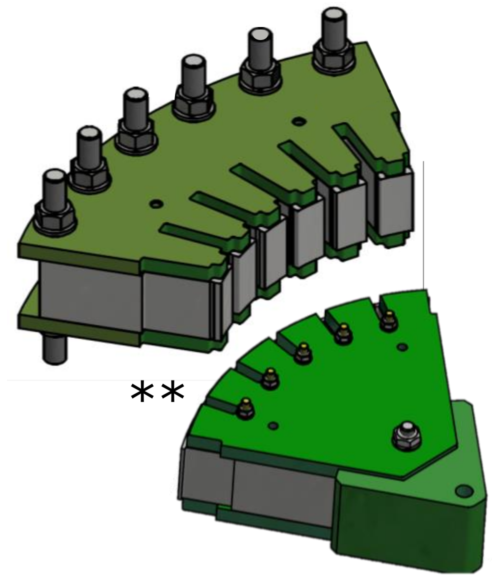
2. Demonstrators (scale models)

3 TYPES

SIMPLE RING CORES	TEETHED RING CORES	SEGMENT SCALE MODELS







→ All designs based on rotating electrical machine prototypes (geometry, excepted working conditions, etc.)

→ All laser treatments selected based on results obtained on samples

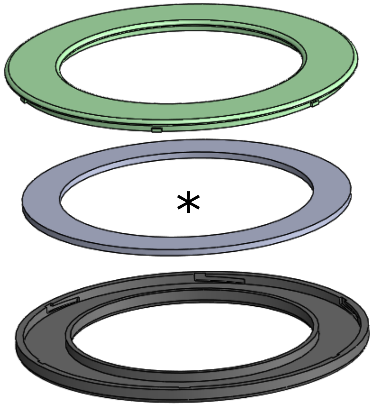
* 3D model from PFT_INNOVALTECH

** 3D model from JEUMONT Electric

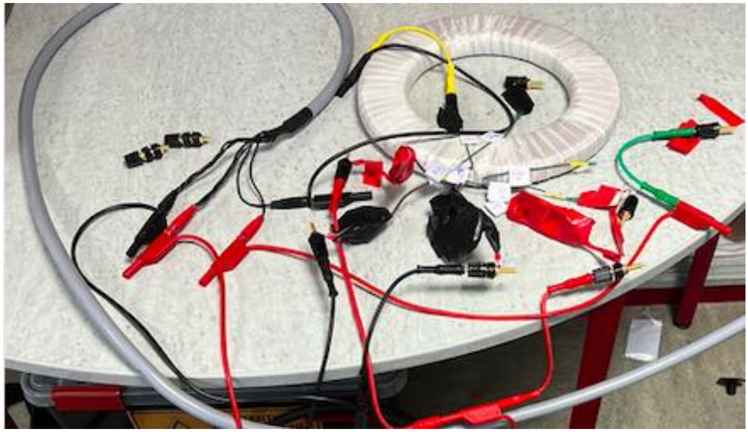
2.1. Demonstrators (SIMPLE RING CORES)

SIMPLE RING CORES

Goal: Quantify the impact of laser treatments (LT) on orthoradial structures



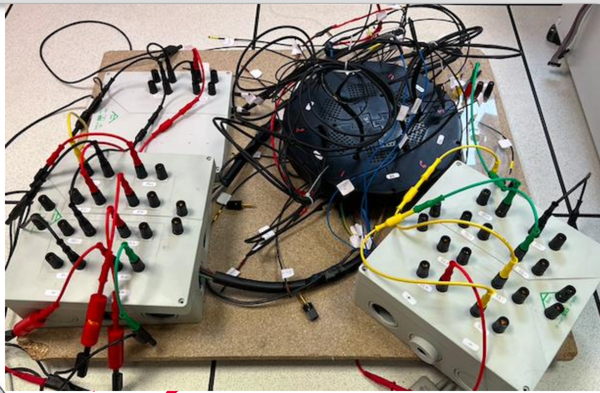
- 3 demonstrators:
  - 1 without LT (REF)
  - 2 with LT compared with REF
- Expected loss reduction rates:
  - 0% - 5% for LT1
  - 5% - 10% for LT2
- Test (on going):
  - Single Ph. Config.
  - Wide range of B/f couples



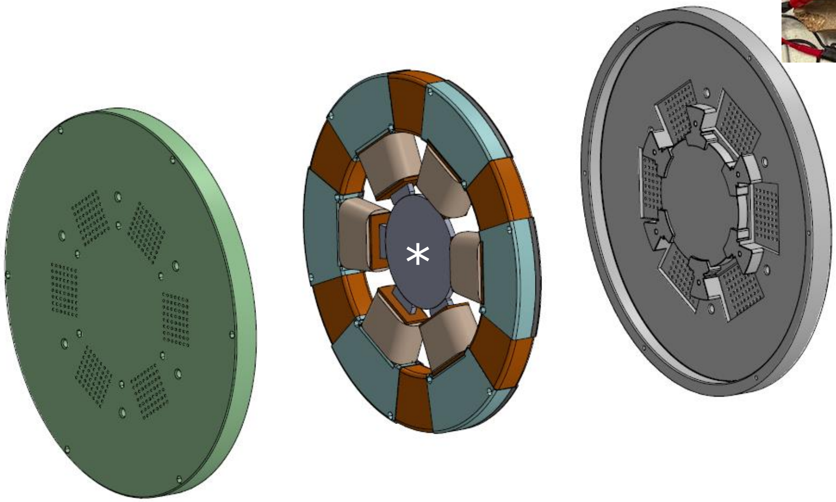
* 3D model from PFT_INNOVALTECH

2.2. Demonstrators (TEETHED RING CORES)

TEETHED RING CORES



- 2 demonstrators:
  - 1 without LT (REF)
  - 1 with LT compared with REF
- Expected loss reduction rates: 5% - 15%
- Tests (on going):
  - Single Ph config.
  - Wide range of B/f couples
- Tests (on going):
  - Three Ph config.
  - 50Hz
  - Wide range of B



Goal: Quantify the impact of laser treatments (LT) on a teethed structure

Preliminary measurement results (mono/50Hz)

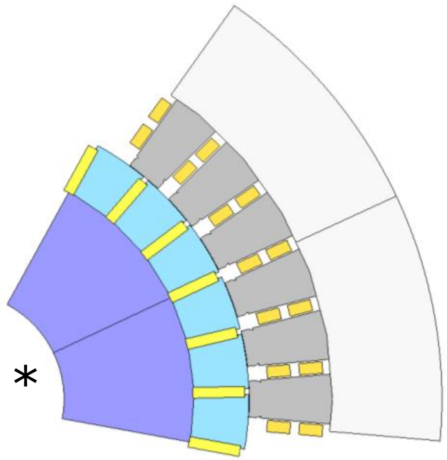
J [T]	ΔP [%]
0.1	-5.9
0.5	-7.3
1	-5.5
1.5	-3.8
1.75	-3.1

* 3D model from PFT_INNOVALTECH

2.3. Demonstrators (SEGMENT SCALE MODELS)

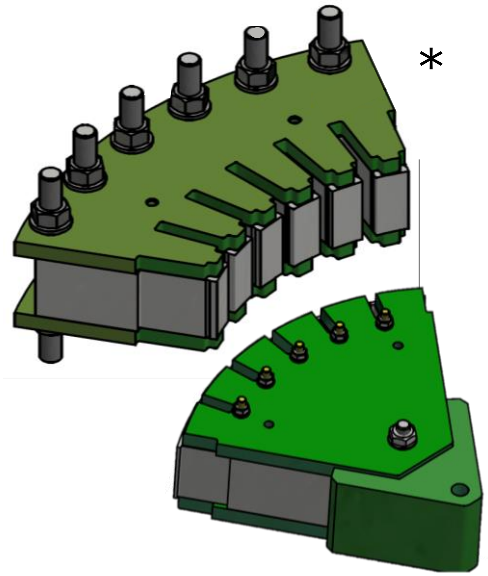
Goal: Quantify the impact of laser treatments (LT) on a segment structure (≈1/6 of the prototype)

SEGMENT SCALE MODELS



- 1 pole pair

- 2 demonstrators:
  - 1 without LT (REF)
  - 1 with LT (**stator/rotor**)
- To be tested: Three Ph. config. / 50Hz / Wide range of B / Different rotor positions
- Manufacturing still on going:
  - Stator/Rotor LT ✓
  - Stator/Rotor stacking ✓
  - Winding ✗
  - Retention system ✗

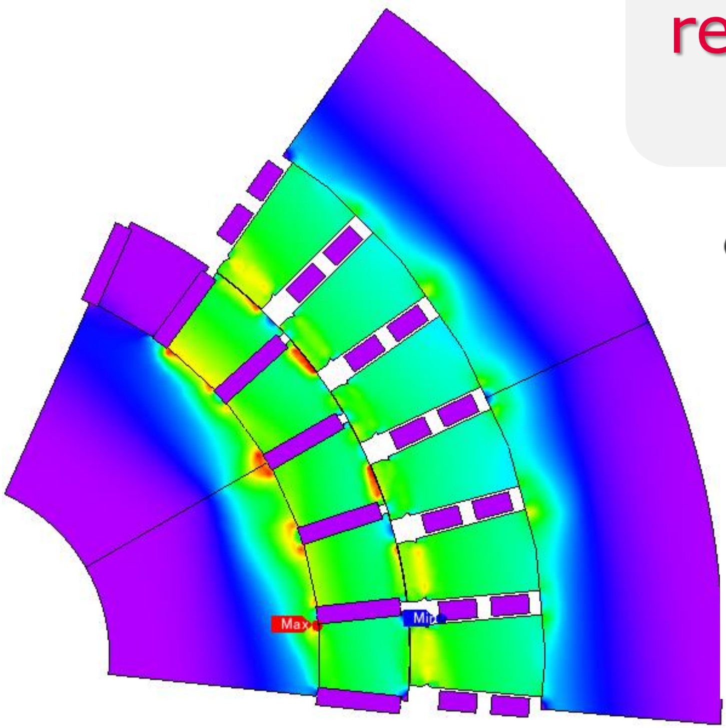


* 2D and 3D models from JEUMONT Electric

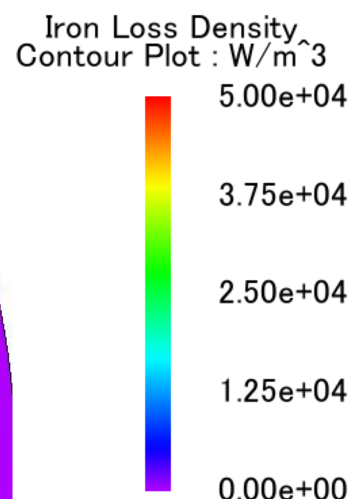
2.3. Demonstrators (SEGMENT SCALE MODEL)

SEGMENT SCALE MODELS

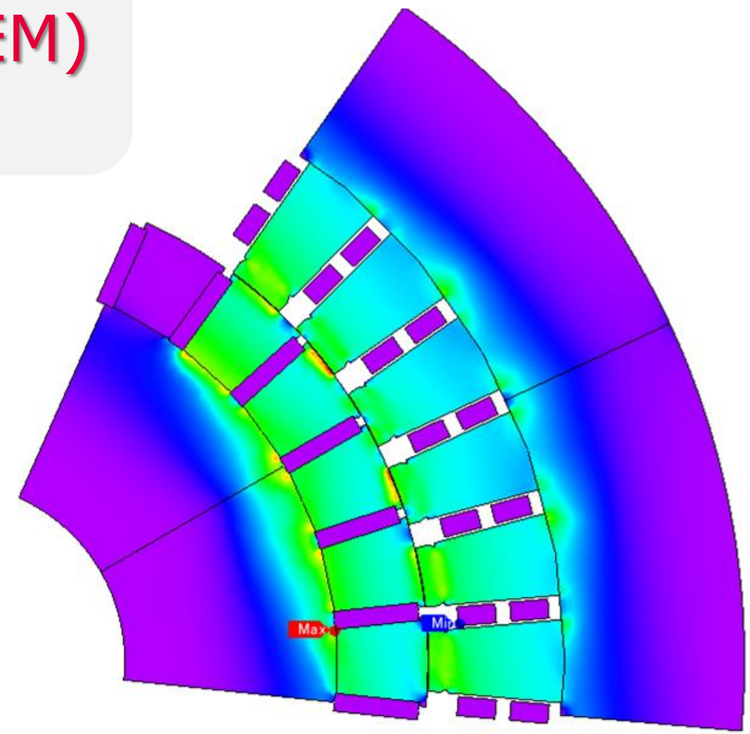
NO LASER TREATMENT



Estimated loss reduction (FEM) ≅ -17%



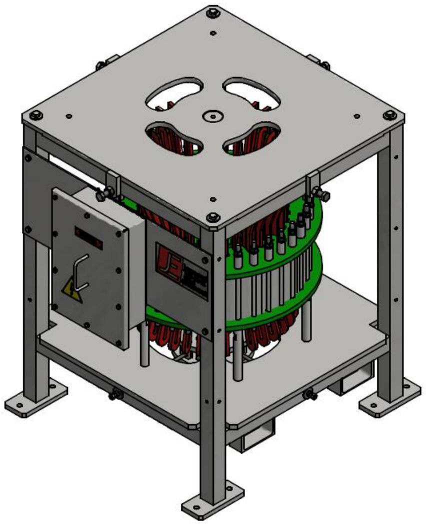
WITH LASER TREATMENT



3. Prototypes (Concept)

Reminder: JEUMONT Electric → design and manufacturing of full-scale prototypes

- 2 prototypes with and without Laser Treatment (LT)
- Specific design to integrate GO steel (segmentation of magnetic circuit)



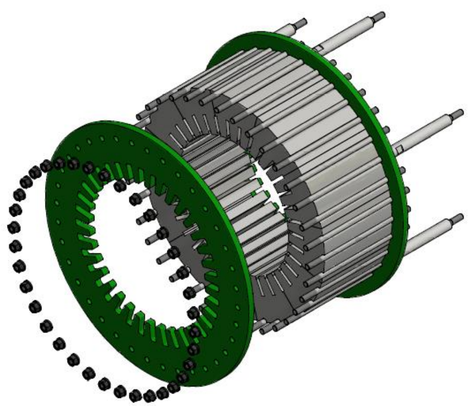
Stator segment

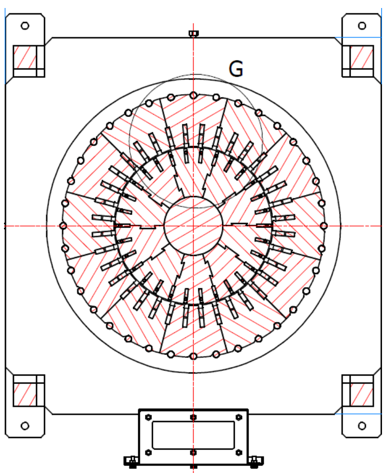
Rotor segment

3. Prototypes (Design overview)

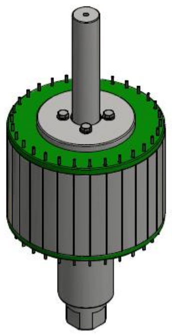
- Design based on 4 pole - 355 mm frame size Induction Motor (IM)
- Prototypes dedicated to Iron Loss (IL) estimation
  - Static rotor
  - Avoid mechanical losses
  - Rotor without cage
  - Generate iron loss on rotor stack
  - Ensure reliable IL measurements

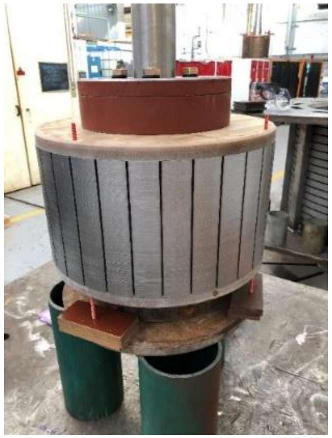
STATOR





ROTOR



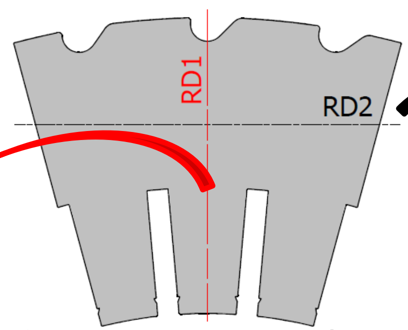


3. Prototypes (Design specificities)

[11]

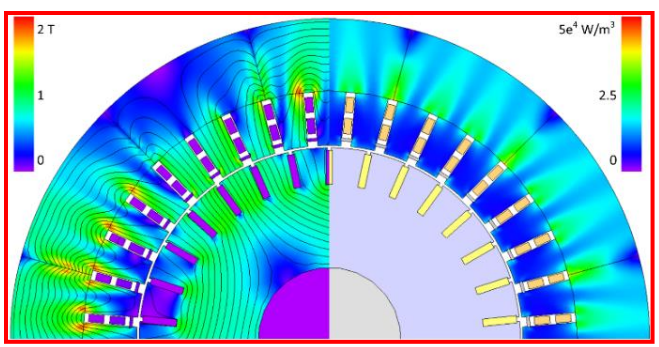
- Use GOES instead of NOES is justified (even without LT)
- Use GOES gives a degree of freedom for RD's position
  → Two directions (**RD1** & **RD2**) are investigated

+33% of losses compared to the same machine made of NOES

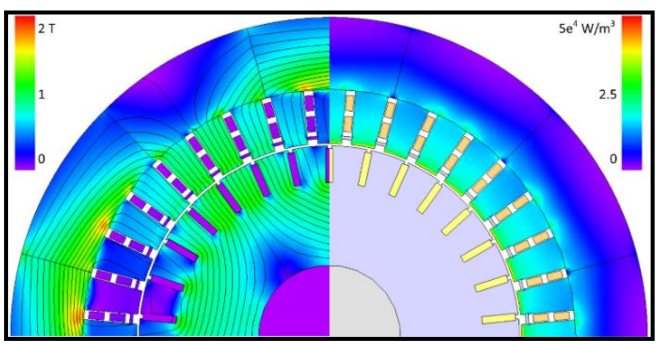


-21% of losses compared to the same machine made of NOES

RD1 → RD on middle of tooth

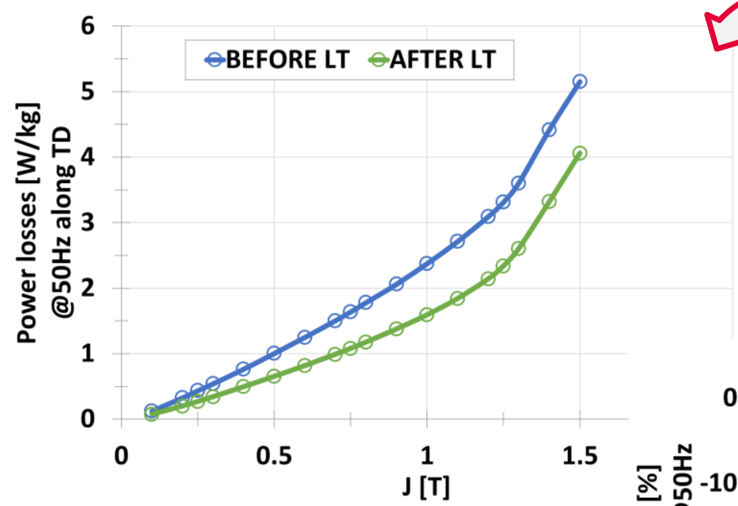


RD2 → RD along yoke direction

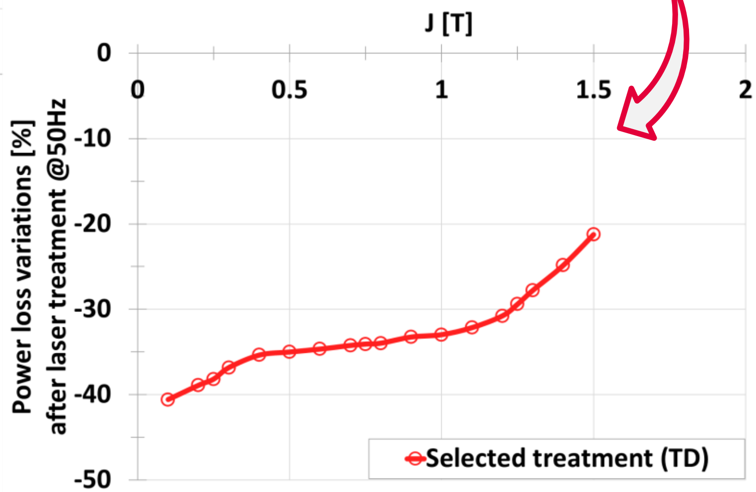


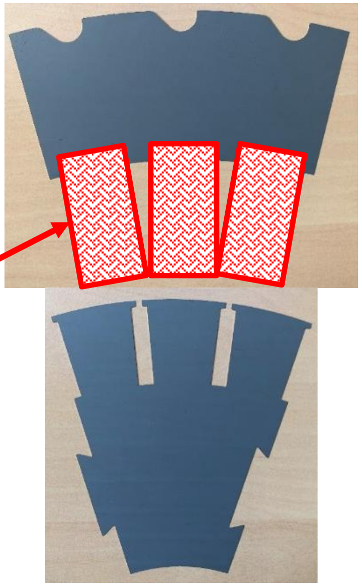
3. Prototypes (Design specificities)

Only stator teeth are laser treated → Compromise between optimized reduction rates and laser treatment time



Laser treatment area





3. Prototypes (Expected loss reduction rates)

Manufacturing of prototypes is still ongoing
→ FE calculations for expected reduction rates estimations

⇩ Comparison between: ⇩

- GOES and NGOES
- GOES with and without LT

Frequency [Hz]	Voltage [V]	Stator Iron Loss variations [%] GOES vs NGOES	Stator Iron Loss variations [%] LT GOES vs GOES
50	690	-14.0	-15.0
50	552	-10.8	-16.6
50	300	+1.7	-19.6
60	828	-13.2	-14.4

More than 14% reduction rate for each tested configuration!
(GOES Vs LT GOES)

Results should be confirmed by experiments

Conclusion

- Upstream studies led to promising laser treatments adapted to rotating electrical machines

- Lab. scale prototypes are under tests, first results are promising and will be enriched with further analyses

- Segment scale models and Industrial scale prototypes are being assembled and will be tested as soon as possible

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Thank you for your attention!