

NGO electrical steel solutions

for advanced traction motors and sustainable e-mobility

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thyssenkrupp Steel Europe

engineering.tomorrow.together.



thyssenkrupp

Electrical steel powercore[®] by thyssenkrupp Steel Europe

NON GRAIN-ORIENTED ELECTRICAL STEEL



GRAIN-ORIENTED ELECTRICAL STEEL



EU aims at reducing carbon emissions by 55% in 2030, climate-neutrality by 2050

Electrical steel is the base material for essential components needed for the energy and mobility transition

ENERGY GENERATION



up to
53 tons
NGOES
per wind
plant

EU 2030
42.5% from
renewables

Non grain-oriented electrical steel for
GENERATORS

ENERGY DISTRIBUTION



up to
75 tons
GOES
per
transformer

EU 2030
42.5% from
renewables

Grain-oriented electrical steel for
TRANSFORMERS

ENERGY UTILIZATION



up to
80 kg
NGOES
per BEV

EU 2030
30,000,000
EVs

Non grain-oriented electrical steel for
ELECTRIC MOTORS



High performance electrical steel with optimal properties for:



Household



Automotive



Industry



Energy

- For highest demands on energy efficiency
- Homogeneous mechanical properties
- High magnetic polarization, low magnetization losses
- Thicknesses from 0.20 mm to 1.00 mm
- Low-, medium- and high-silicon grades

powercore® A-grades
Fully-finished standard grades

powercore® K-grades
Semi-finished standard grades

powercore® AP-grades
Fully-finished, higher permeability grades

powercore® PP-grades
Semi-finished, higher permeability grades

powercore® traction
Grades for e-mobility and high frequencies

Insulating varnish systems
for all applications

Pole and transformer lamination
with guaranteed properties



powercore® traction NGO: specially designed for e-mobility

powercore® traction is our contribution to **HIGHER ENERGY EFFICIENCY** and **SUSTAINABLE MOBILITY** on rail and road:

- Customized solutions for challenging e-mobility applications
- Complete portfolio in order to meet highest customer requirements
- Thinnest material from 0.20 mm upwards
- Maximum homogeneity of mechanical and magnetic properties – high yield strength, high polarization, low losses
- Large variety of coating and connecting solutions
- Available as narrow strip up to a width of 500 mm and as wide strip up to 1,250 mm



thyssenkrupp Steel is partner to the automotive industry with a long-standing expertise in **STEEL LIGHTWEIGHT DESIGN** and has a leading position in the European NGO market. We support our customers with the optimum materials for the **ELECTRIFIED POWERTRAIN.**



Demands on advanced traction motors and electrical steels

Demands on traction motors

High efficiency

High speeds

High torque



Efficiency



Sustainability



Performance



Properties of the electrical steel

Slit strip

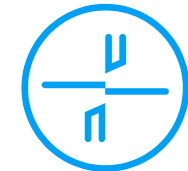


Low core losses

High strength

High magnetic polarization

Punching



Stacking



Performance loss due to material damage conditioned by **punching** and/or **stacking** method

Processing of electrical steel



Our newcomer: powercore[®] traction NGO 025-125Y420

Properties

Max. core loss
at 400Hz / 1.0T

12.5 W/kg

Min. Polarization
at 5000 [A/m]

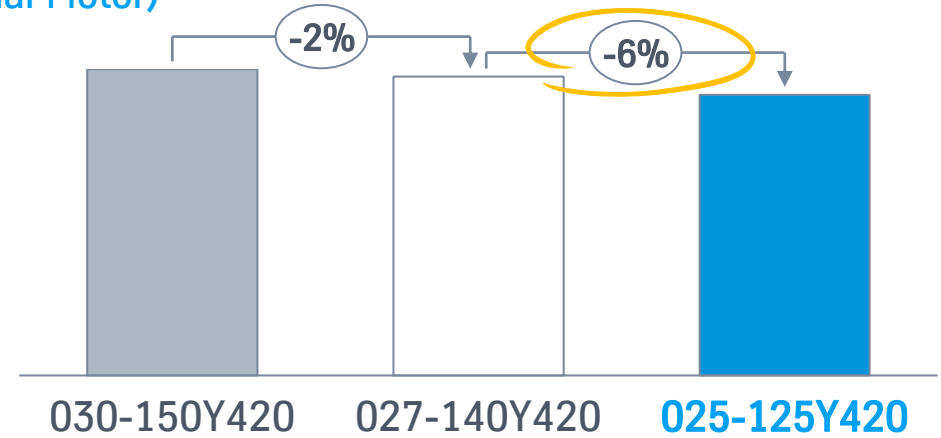
1.61 T

Min. $R_{p0.2}$
Rolling direction

420 MPa

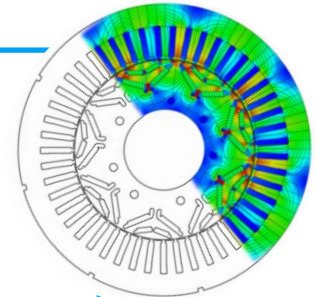
- Least possible power loss and high strength – ideal for high-efficient high-speed drives
- Top grade for e-mobility in high-volume series production – Run-up on new production lines starting from 2025
- Maximum efficiency in the electric motor in combination with our adhesive insulating systems
- Maximum sustainability: available as CO₂-reduced steel

WLTP – driving cycle - Motor losses (Virtual Motor)



Technical data of the PMSM motor KAT4

Max. power P_{max} : 150 kW
Max. speed n_{max} : 17.000 1/min
Winding technology: hair pins

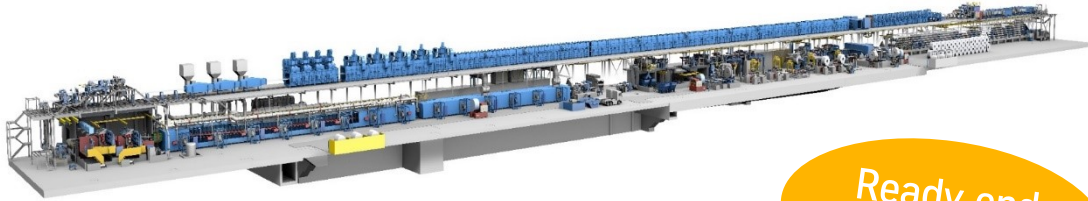


Makes it possible to drive the extra mile: significant increase of efficiency possible



Next generation technology for new e-mobility by thyssenkrupp Steel

UPGRADE OF PRODUCTION LINES



Ready end
of 2024

NEW DOUBLE REVERSING MILL

- Tightest tolerances in geometric properties
- Basis for new NGO products in extremely thin dimensions

NEW ANNEALING AND INSULATING LINE

- High homogeneity of mechanical and magnetic properties
- New NGO grades with better properties
- Capacity increase

UPGRADE OF NGO PORTFOLIO

020-120Y420 under development

Max. core loss
at 400Hz / 1.0T

12.0 W/kg

Min. $R_{p0.2}$
Rolling direction

420 MPa

Target:
SOP from
2025

NEW TOP GRADE UNDER DEVELOPMENT

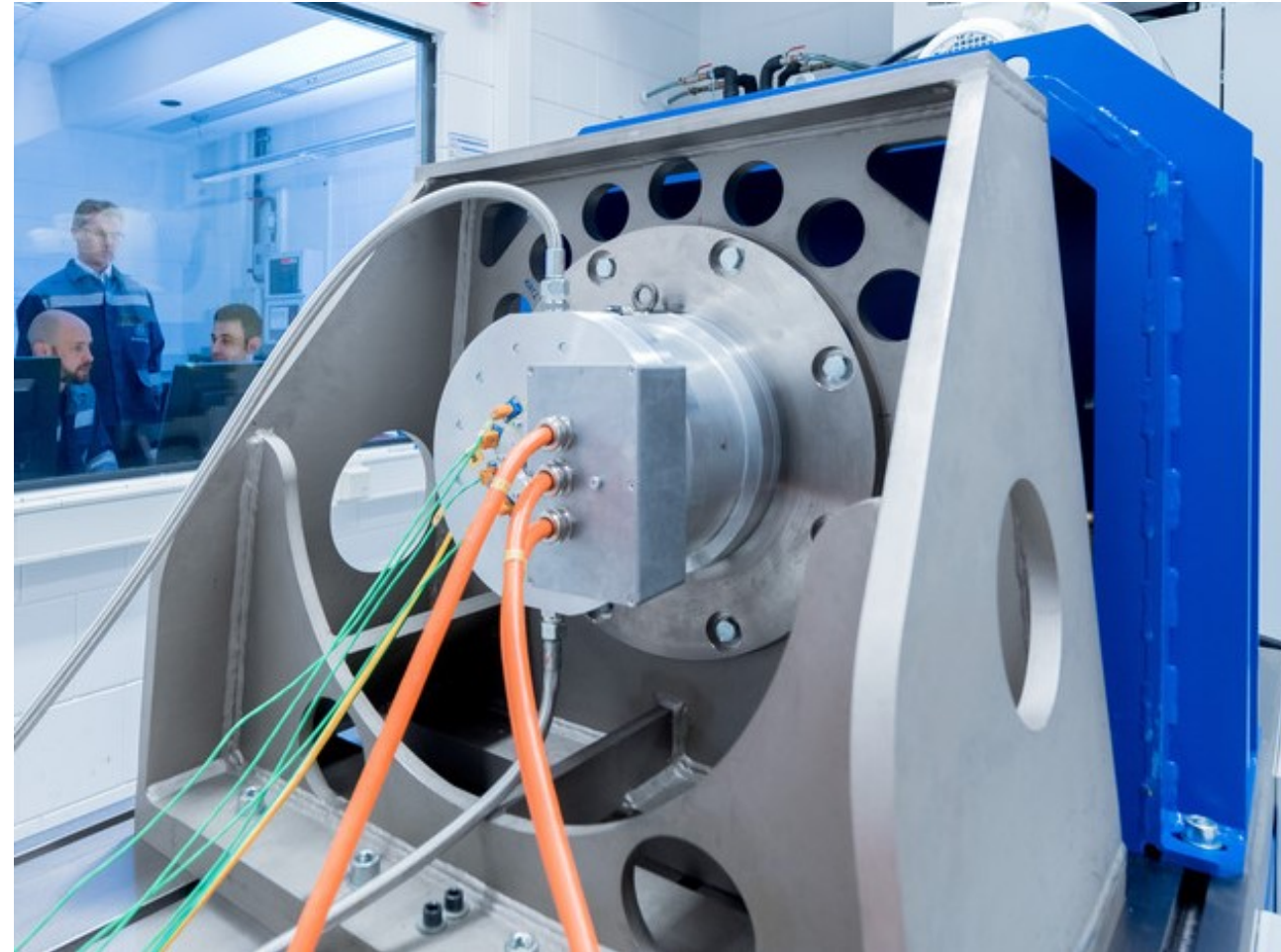
- Promising magnetic and mechanical properties achieved in the final product development stage
- Ideal for **ULTRA-EFFICIENT** high-speed drives
- Production start scheduled from beginning of 2025



thyssenkrupp Steel qualifies products with experimental engines in its own motor test bench

Design of test motors and test bench measurements in the tk Competence Center E-Mobility in Bochum

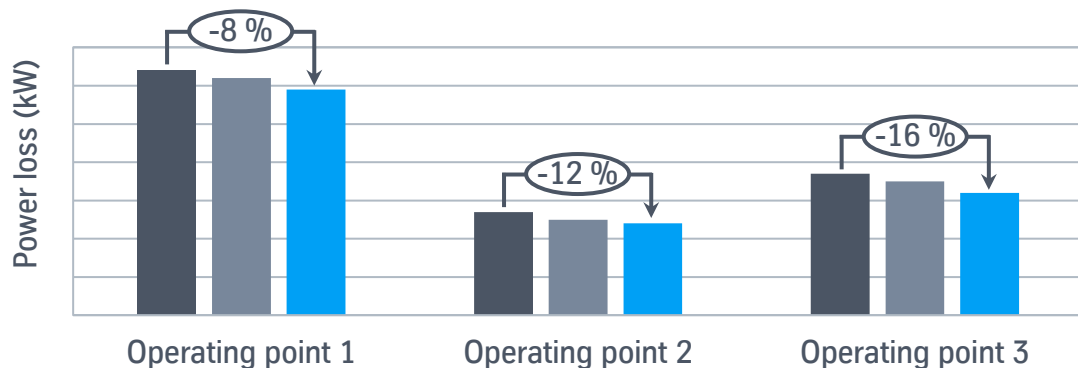
- Different packaging methods with significant effects on motor efficiency: Quantitative comparison using the example of a permanent-magnet excited synchronous machine
- Design and construction of motor prototypes with common requirement spectrum of automotive traction engines
- Use of a single electrical steel grade; identical rotor stack construction for all machines; stack construction of the stator in three variants by means of
 - Interlocking
 - Welding
 - Bonding



Different stacking technology with significant impact on motor efficiency

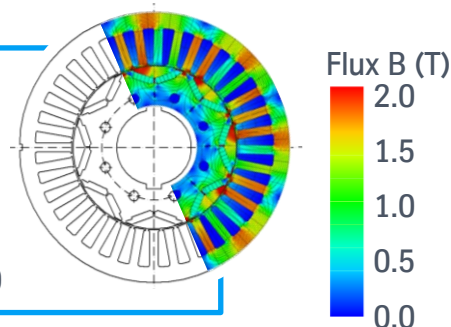
Comparison between interlocking, welding and self-bonding

- **Test bench** - Through self-bonding in the specific case study, a significant reduction in power loss was achieved

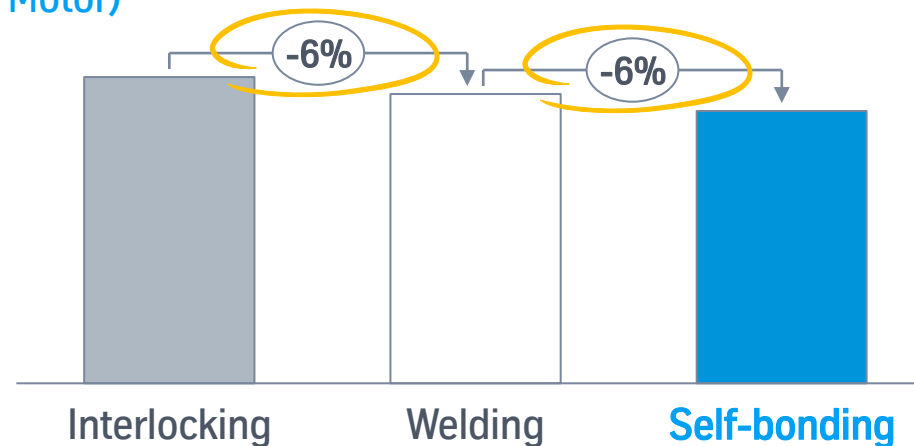


Technical data of the PMSM motor KAT2

Nominal power P_N :	50 kW
Max. power P_{max} :	100 kW
Max. speed n_{max} :	12,000 1/min
Electric strip grade:	030-160Y420



WLTP – driving cycle - Motor losses (Real Motor)



Significant efficiency advantages, further potential expected



NO damage to laminations

In the concrete case study: Reduction of power loss in WLTP driving cycle through self-bonding by up to 12 % proven



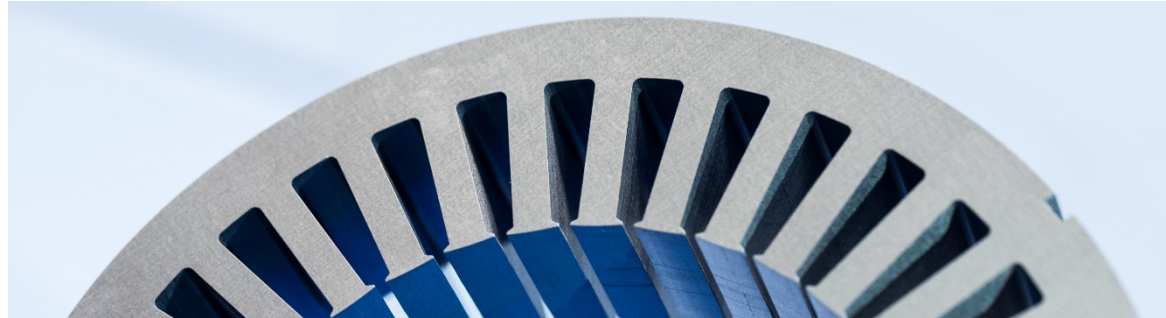
stabosol® is our self-bonding solution for highest thermal demands

stabosol®

- Highly reactive insulating/adhesive system
- No damage to the laminations

Allows
Advanced
motor design

stabosol® shows high
thermal stability !



- Suitable for automotive applications with short cycle times
- Optimal preservation of original material properties
- Energetically advantageous (short time, low temperature)
- High thermal stability increases stack stability & new design

Electrical steel from thyssenkrupp Steel with stabosol® for maximum thermal stability and energy-efficient traction motors



thyssenkrupp Steel Europe takes responsibility and has set itself clear targets

Our goal by the year 2030¹

>30 %

Reduction in CO₂ emissions
(-6 m metric tons)

Our goal by 2045 at the latest

-100 %

CO₂ emissions
(-20 m metric tons)



1. -30% CO₂ emissions in 2030 refers to Scope 1 and Scope 2 emissions (reference year 2018)



tkH₂Steel With hydrogen toward carbon-neutral steel



Supported by:
 Federal Ministry for Economic Affairs and Climate Action
 on the basis of a decision by the German Bundestag

Funded by:
 Ministry of Economic Affairs, Industry, Climate Action and Energy of the State of North Rhine-Westphalia




2019
 Trialling H₂ use in the blast furnace

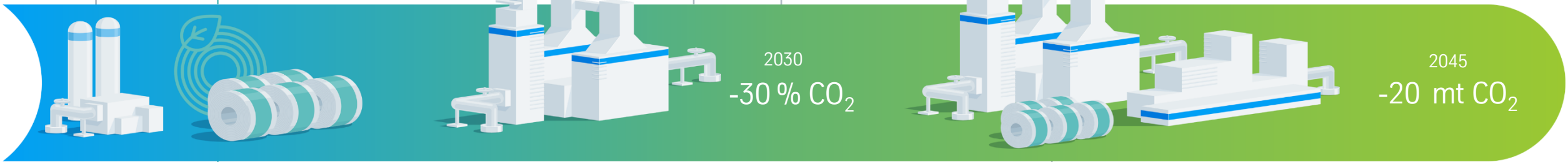
since 2021
 bluemint® Steel

from 2027
 First DR plant with melting units (SAF)
 Removal of the first coal-based blast furnace

up to 2029
 Hydrogen ramp-up of the first DR plant to 100%

up to 2030
 Removal of the second coal-based blast furnace replacement by DR-based technology

before 2045
 Complete implementation of the transformation
 Carbon-neutral steel production without coal-based blast furnaces incl. decarbonization of the downstream systems



Available quantities of bluemint® Steel per year

2022-2026 ~ 50-500 kt/a 2027 onward ~ 3 mt/a 2030 onward ~ 5 mt/a 2045 onward ~ 11 mt/a

Avoidance of residual CO₂ emissions, e.g. through Carbon2Chem® (CCU)



Advantage of our transformation strategy

Offering of all grades, no cutbacks on new production pathway

Portfolio

Green high-quality flat steel for all application sectors with full product and grade portfolio

Quality

Continued highest qualities in terms of formability and strengths, surfaces and electromagnetic properties

Process reliability

All production processes ex-steel mill remain in place. Established quality concepts do not have to be changed, stability in approval processes



Our solution kit for maximum environmental benefit and traction motor performance

PRODUCTION

USE

RECYCLING

BATTERY
ELECTRIC
VEHICLE
(BEV)²



bluemint[®]
recycled



powercore[®]
traction NGO
025-125Y420



stabosol[®]
- self-bonding
varnish

=

MAXIMUM
CO₂ SAVING
FOR TRACTION
MOTORS



Together we can shape sustainable energy generation and mobility for today and tomorrow

No energy and mobility transition without steel. Our electrical steel powercore[®] is the base material for e-mobility and the generation of green energy for example for wind and hydro power.

- 1 thyssenkrupp Steel Europe is **FULL-RANGE** and **TOP-GRADE** supplier for non grain-oriented and grain-oriented electrical steel
- 2 We are **INVESTING** in product quality and increased capacity. **NEW NGO PRODUCTION LINE** (CR & ACL) ready by end of 2024
- 3 **NEW 025-125Y420** already available and **020-120Y420** planned for 2025 to meet increasing motor efficiency requirements, further **GRADE & BONDING** advancements in progress
- 4 We have a clear transformation pathway to **REDUCE CO₂-emissions**. With **bluemint[®]** we support our customers already **TODAY** to reach individual carbon dioxide emission targets



HOW CAN WE HELP YOU?

CWEME 2024

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David Pieronek beleuchtet die Anforderungen von besonders energieeffizienten Antriebsmotoren in Elektrofahrzeugen (und stellt effiziente und nachhaltige Produktlösungen vor).

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thyssenkrupp



Thank you for your attention

powercore[®] and powercore[®] traction are brands of thyssenkrupp Steel Europe AG and stand for NGO electrical steel with the highest requirements for energy efficiency of electric motors and generators. We supply industry, manufacturers of household appliances, energy producers and the automotive industry with high quality branded materials worldwide and work in close cooperation with our partners.

powercore[®] and powercore[®] traction are our contribution to higher energy efficiency, to sustainable mobility on railroad track and road and to the generation of renewable energy.

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