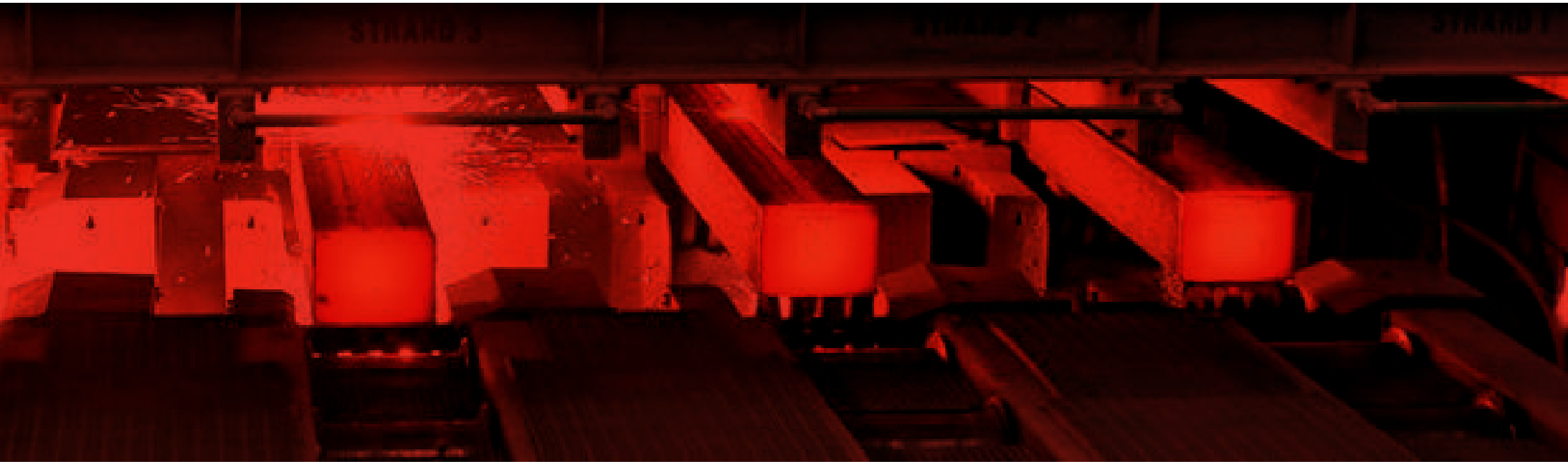
Innovative isotropic steel solutions for high performance gears



massiver LEICHTBAU

ZF TECH. DAY
24/10/2019

Summary

2018 Main figures

"**Sidenor**, a market leader in the European special steel long product industry, has the aim of being at the forefront of process and product **innovation**"

Annual Sales (Tonnes)

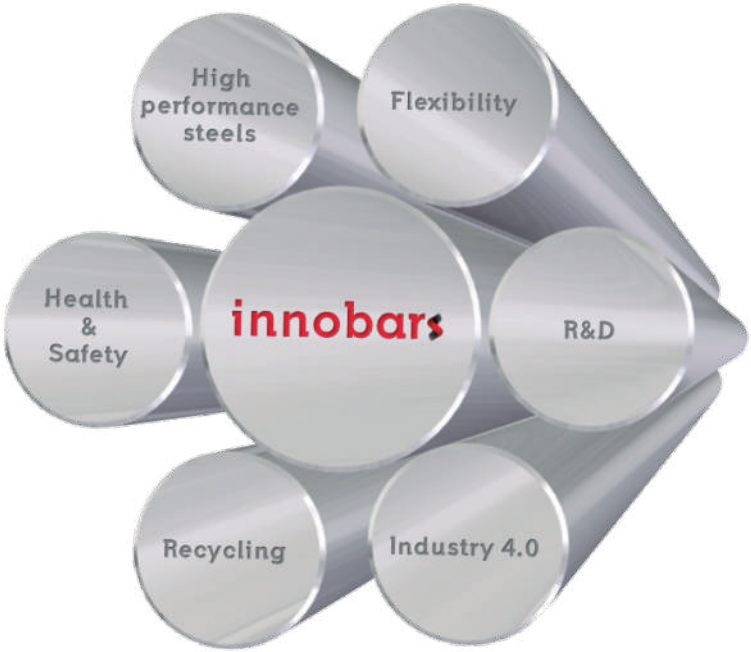
809,000

Revenues (mill€)

898

Employees

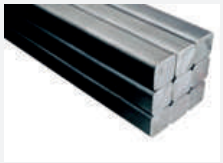
2,324



Product portfolio and main applications

Products

SEMIS
- CC Billets
- CC Rounds
- Blooms
- Ingots



HOT ROLLED BARS
- Rounds
- RCS
- Flats

WIRE ROD
- Coils

FORGED BARS
- Rounds
- RCS
- Flats

BRIGHT BARS
- Drawn
- Turned
- Ground

DRAWN WIRE

Automotive Applications

- Crankshafts
- Gears
- Common-rail
- Leaf springs
- Bearings
- Shafts
- CVJ's
- Steering racks
- Steering pinions
- Shock absorbers
- Fasteners
- ...

Non-Automotive Applications

OIL & GAS

WIND POWER

RAILWAY

OFF HIGHWAY EQUIPMENT

Research from the steelmaking to the final product

"The mission of **Sidenor R&D** is to create, develop, transfer and protect Sidenor technology in order to **reach innovative solutions in the production and use of steel** materials and components"

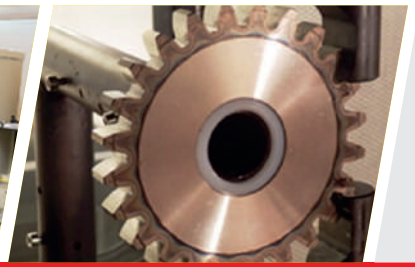
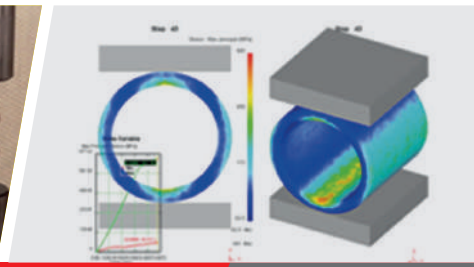
Development of higher performance steels

Cost optimization at the value chain

Characterization of second phase particles

FEM simulations



Research from the steelmaking to the final product

- To reduce the elevated machining costs, S is commonly added to the steel, forming MnS inclusions

- These MnS, which are softer than the steel matrix and act as voids, have the following beneficial effects on the machinability:

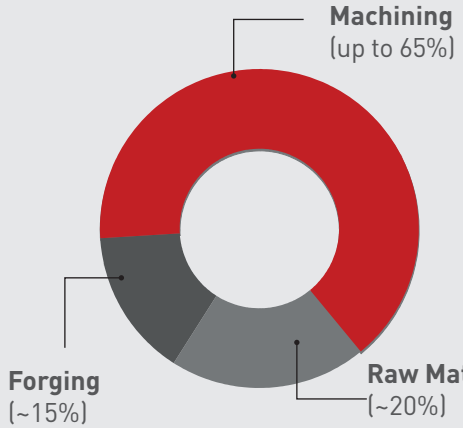
Lower power consumption

Shorter chips

Longer tool life

- After the steel rolling, MnS are found as elongated inclusions

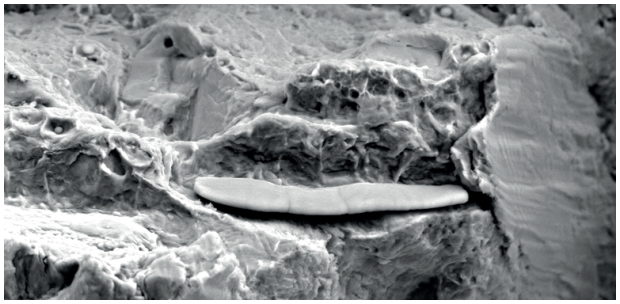
Example of the production costs distribution for a gear shaft[1]



[1] N. Anmark et al. "The effect of different non-metallic inclusions on the machinability of steels". Materials. Vol. 8, 751-783. 2015

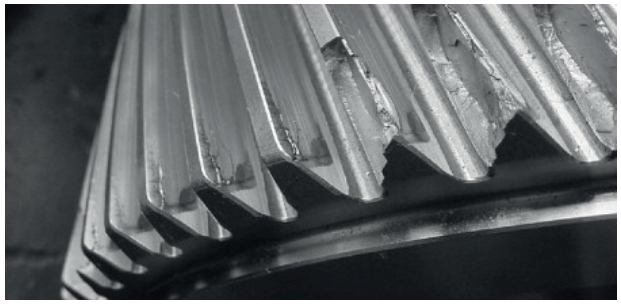
Reasons to reduce the S content

Isotropy deterioration



The elongated shape of MnS deteriorates the steel isotropy, negatively affecting the transversal properties

Component failure



The isotropy worsening is especially adverse for parts loaded in different directions with regard to the steel fibre, i.e. gears

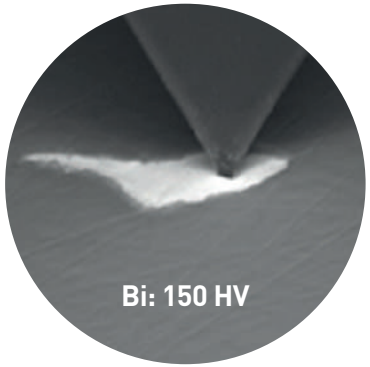
Looking for the equilibrium

To improve the component performance, which will allow its downsizing, the steel isotropy must be enhanced. This improvement is achieved through the S content reduction. However, this S diminution leads to notably higher production costs.

A compromise machinability-performance is required

An alternative to S

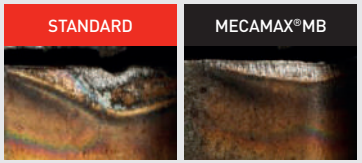
- The **Bi addition** to the steel is the basis of the **MECAMAX®MB** technology



✔ Bi is a **non-toxic element** that presents a **low melting point**. This, together with the **low hardness** of Bi inclusions, leads to the following benefits during the steel machining:

01 | **Easier chip fragmentation**

02 | **Reduction of the tool wear**



03 | **Diminution of the cutting T and forces (power consumption)**

✔ Bi addition allows to reduce the S content without penalizing the steel machinability

✔ MECAMAX®MB technology can be applied to **any steel grade** to be used in **any application**

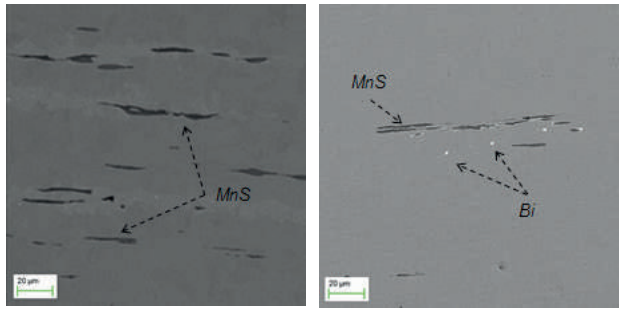
MECAMAX®MB: the perfect equilibrium

- MECAMAX®MB steels, compared to grades with higher S content, lead to:

01

Better steel isotropy

The small and spherical shape of Bi inclusions makes that, contrary to MnS, Bi presence hardly affects the steel isotropy



02

The same or better machinability

- Lower power consumption
- Shorter chips
- Longer tool life

- Reducing the S content and applying MECAMAX®MB technology, an **excellent compromise between isotropy and machinability** is reached

Case study: 20MnCr5

Machinability evaluation

- **Testing procedure**

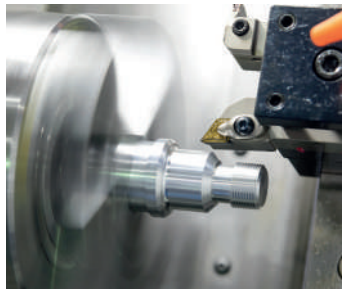
  Dry turning according to ISO 3685-1:1993

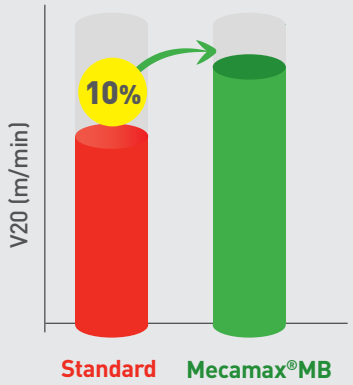
- **Studied steels**

  Subcritical annealing (210 HB)

  Standard: 20MnCr5 (**0.035% S**)

  Mecamax®MB: 20MnCr5 (**0.020% S + Bi**)





- ✔ Mecamax®MB: machinability improvement even with lower S content
- ✔ **V20 value 10% higher** than with standard steel
- Lower power consumption
- Shorter chips
- Longer tool life

Fatigue studies

- **Testing procedure**

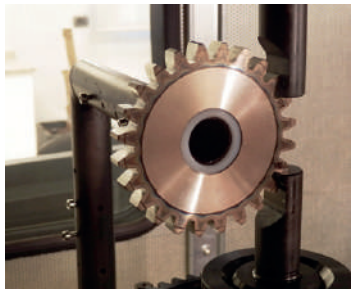
  Tooth bending fatigue tests; 100 Hz

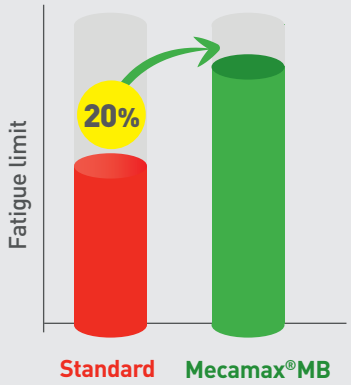
- **Studied steels**

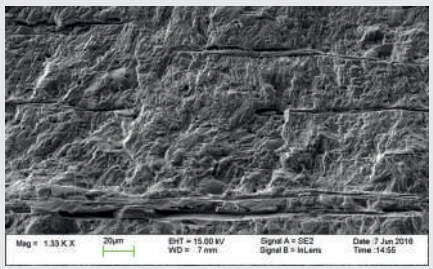
  Carburized gears (layer depth 0.4 mm)

  Standard: 20MnCr5 (0.035% S)

  MECAMAX®MB: 20MnCr5 (0.020% S + Bi)



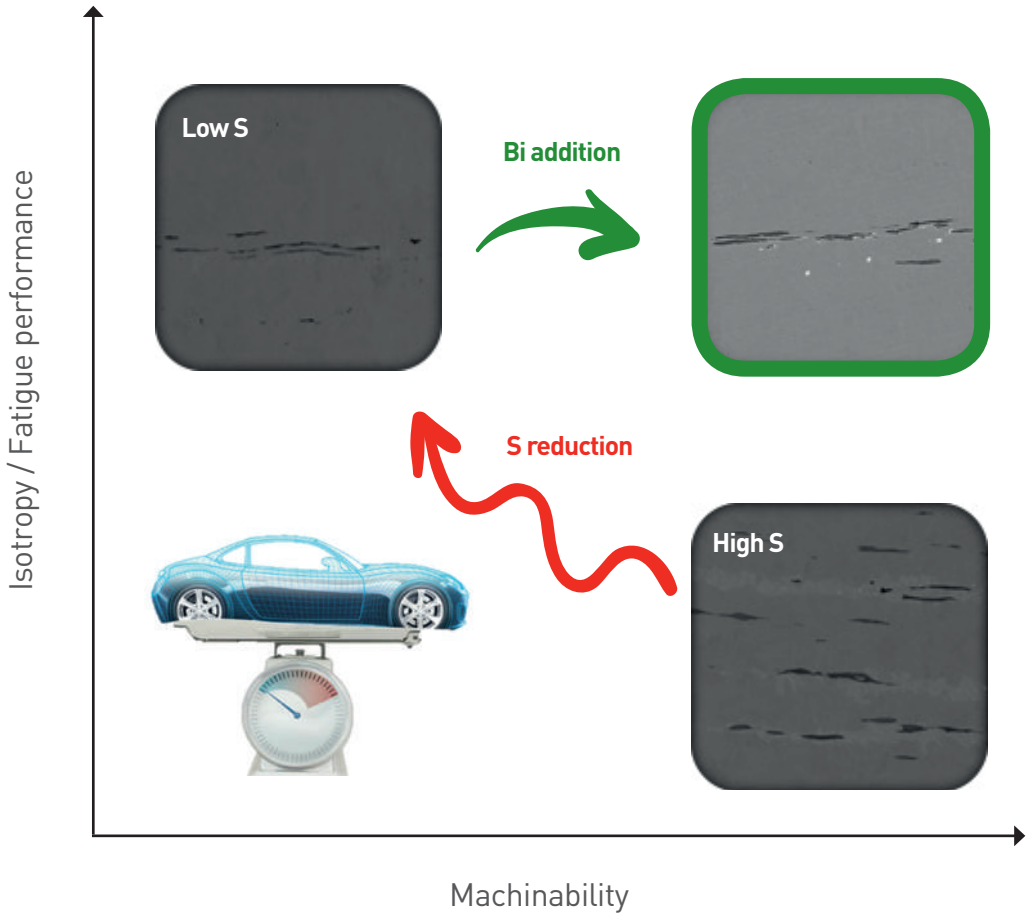




Fractures analysis

Using Mecamax®MB steels, the fatigue limit is increased in **20%. None of the fractures initiated in Bi inclusions**, most of them in MnS

Summary



MECAMAX®MB:

THE BEST COMPROMISE BETWEEN MACHINABILITY AND ISOTROPY!

- Lower power consumption
- Shorter chips
- Longer tool life
- Lower power consumption
- Excellent fatigue performance

Summary

01

The technology **MECAMAX®MB is the best solution** to improve the steel isotropy without increasing the machining costs

02

This technology can be applied to **any steel grade, for any application** (automotive, energy...)

03

The attained **machinability** is **similar or better** to that of steels with higher S content. Besides, the **fatigue limit is increased** in 15-20%, which will allow the **component downsizing**

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Thank you very much

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