SHTE EFD Induction

HardLine Hybrid horizontal hardening machine

SHTE, Norrköping
October 9th 2019
Vincent Roth

SUMMARY

- Short company introduction
- Basics of induction hardening
- Main processes in induction hardening
- Horizontal hardening machine, parts and processes
- Hybrid technology
- Summary

EFD INDUCTION AT A GLANCE

PUTTING THE SMARTER HEAT TO SMARTER USE

HISTORY—Has been developing induction heating solutions for more than 65 years

WORLDWIDE—Present across Asia, Europe and the Americas. Global Sales of €130 M in 2018

MARKET LEADER—More than 20,000 installations in 80+ countries - 1,100 employees in 22 countries

GREEN TECHNOLOGY—No gas. No flames. No noticeable increase in ambient temperature

APPLICATIONS KNOWLEDGE—Unrivalled knowledge of diverse applications

TRUSTED PARTNER—Solutions used by many of world's top companies, from ABB to ZF

THE COMPANY
EFD Induction Freiburg/Germany

SOME KEY INFORMATION:

- 1950: Founding of FDF (Fritz Düsseldorf Freiburg)
- 1996: Merging of FDF and ELVA Induksjon, Norway to create EFD Induction

- Employees: 150
- Turnover 2018: 24,7 Mio. (acc. to IFRS)

- Production site for induction hardening machines
- Sales site for induction power systems
- Technology center for hardening tests
- Service center: 17 employees

Our service center acts as coordinator for providing services throughout Europe.

THE COMPANY
EFD Induction Västerås/Sweden

SOME KEY INFORMATION:

- 14 employees
- Sales engineering and service
- Coil design
- Coil shop

ACTIVITY AREAS:

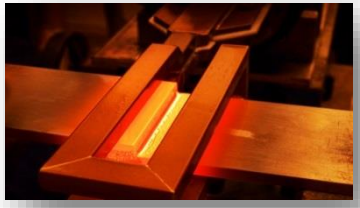
- Induction Power Sources
- Service After Sales

THE APPLICATIONS

VIRTUALLY ANY INDUSTRIAL APPLICATION THAT REQUIRES HEAT

Hardening

Tempering



Brazing

Bonding

Welding and normalizing

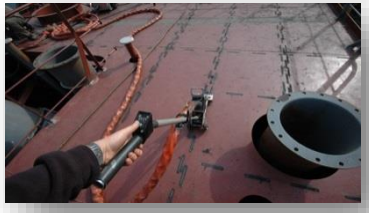
Shrink fitting

Pre-heating

Post-heating

Forging

Melting



Straightening

…and countless more

Visit our website:

https://www.efd-induction.com/

BASICS

INDUCTION HARDENING

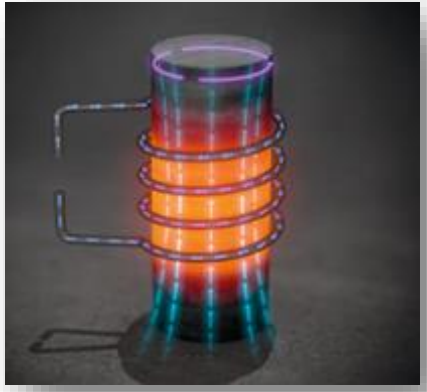
GENERAL

- **PRINCIPLE**
- **FREQUENCY VS SHD**

BASICS

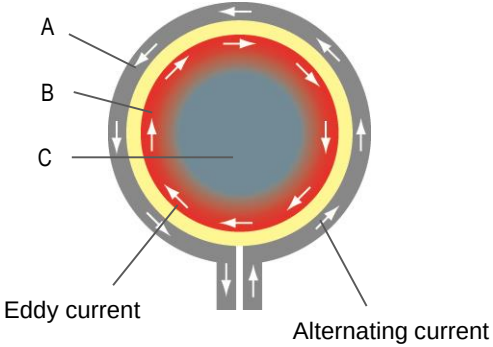
WHAT CAN WE HEAT ?

- Takes power from the mains.
- Converts it into frequencies suitable for specific applications.
- Uses the power to create controllable heat in **any electrically conductive material.**



NO-CONTACT HEATING

- **Heat is produced** where—and only where—these eddy currents flow.
- Heat is generated **directly in the workpiece**.
- At no time does the coil **touch** the workpiece.



FLAME-FREE

- Power is applied to the workpiece by an **induction coil.**
- An alternating current flowing through a coil (A) generates a **magnetic field** (B).
- Placing a workpiece (C) within the field induces **eddy currents** in the piece.

FASTER. BETTER. CHEAPER

- Induction heating is **fast**, precise, clean, energy efficient, **controllable** and **repeatable**.
- Can be used for practically **any** industrial heating **application**.

BASICS

SHD depends on frequency

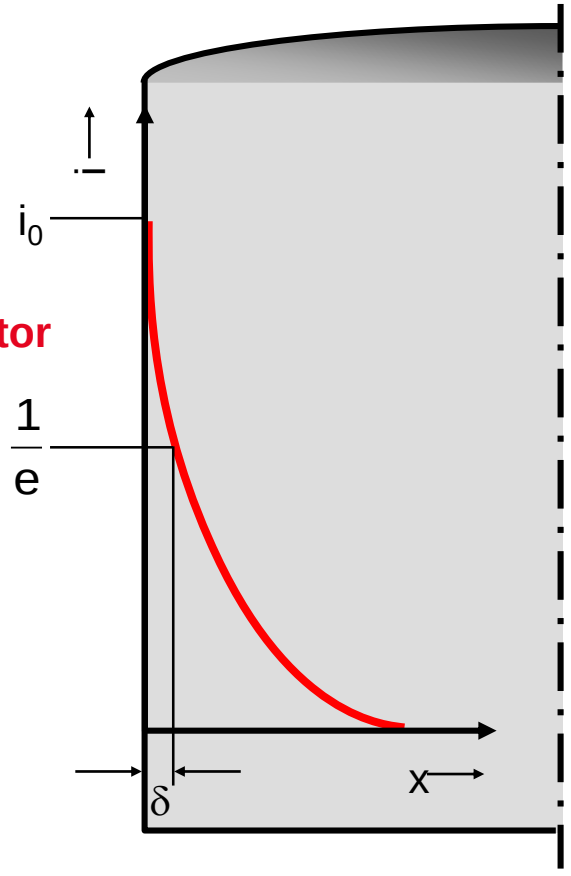
$$\Rightarrow i_x = i_0 \cdot e^{-x \cdot 2\pi \sqrt{\frac{\mu_r \cdot f}{\rho \cdot 10^7}}} = i_0 \cdot e^{-\frac{x}{\delta}}$$

$$\Rightarrow \frac{1}{e} \approx 0{,}37$$

$$\Rightarrow \delta \approx 503 \cdot \sqrt{\frac{\rho}{\mu_r \cdot f}}$$

Material properties

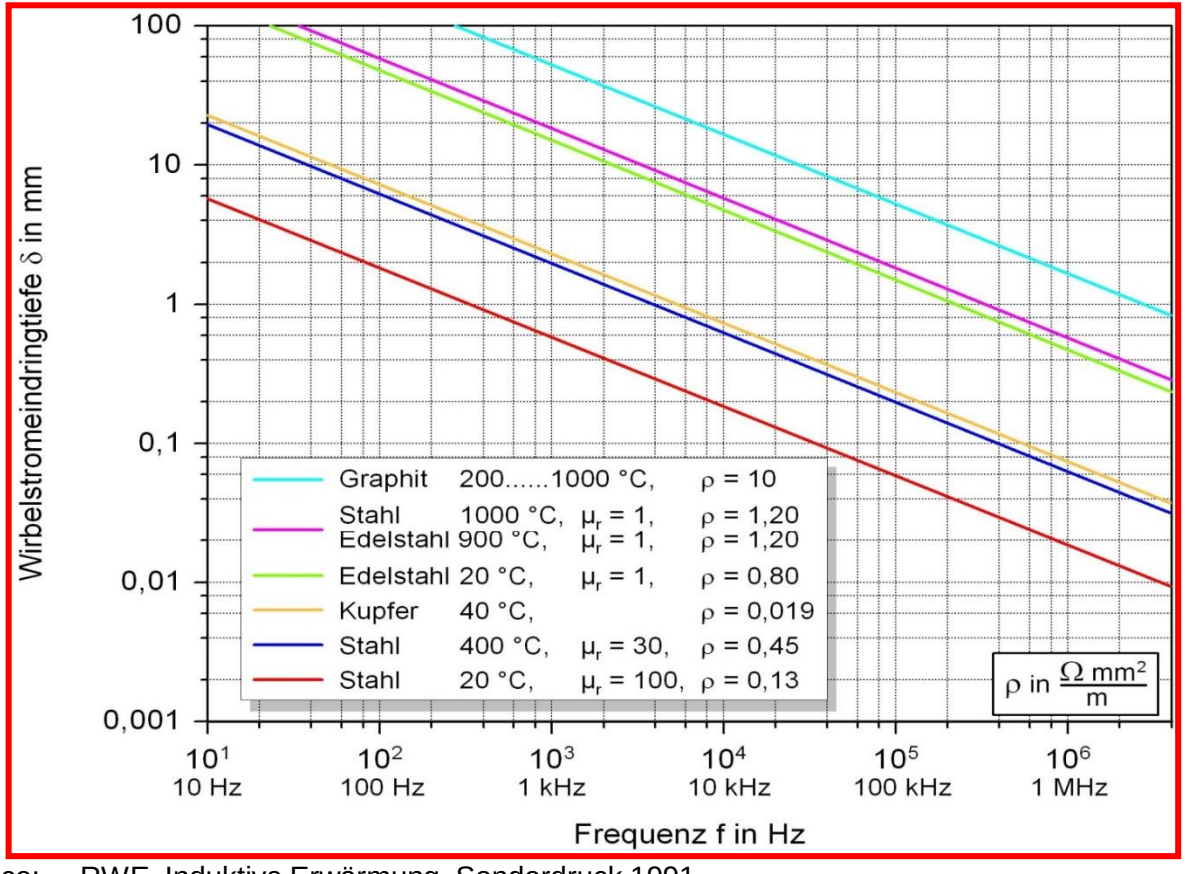
Frequency of the generator



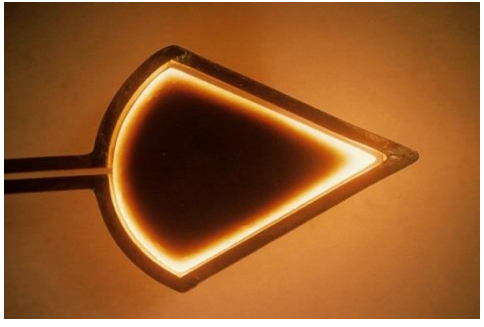
i_0	[A]	=	Current on surface
i_x	[A]	=	Current at depth x
δ	[mm]	=	Electrical penetration depth
ρ	[Ω·mm²/m]	=	Specific electrical resistance of the heated material
μ_r	[1]	=	Magnetic permeability of the heated material
f	[1/s]	=	Frequency of coil current

BASICS

SHD depends on frequency

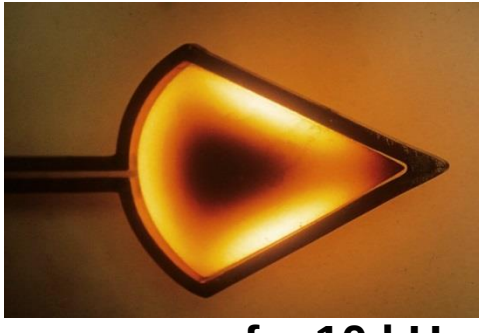


Source: RWE, Induktive Erwärmung. Sonderdruck 1991



f = 700 kHz

Graphite plate



f = 10 kHz

MAIN PROCESSES

INDUCTION HARDENING

GENERAL

- SINGLE SHOT
- SCANNING

SPECIAL PROCESSES (EXAMPLES)

- PROTECTIVE ATMOSPHERE
- HARDENING OF TEETH

MAIN PROCESSES

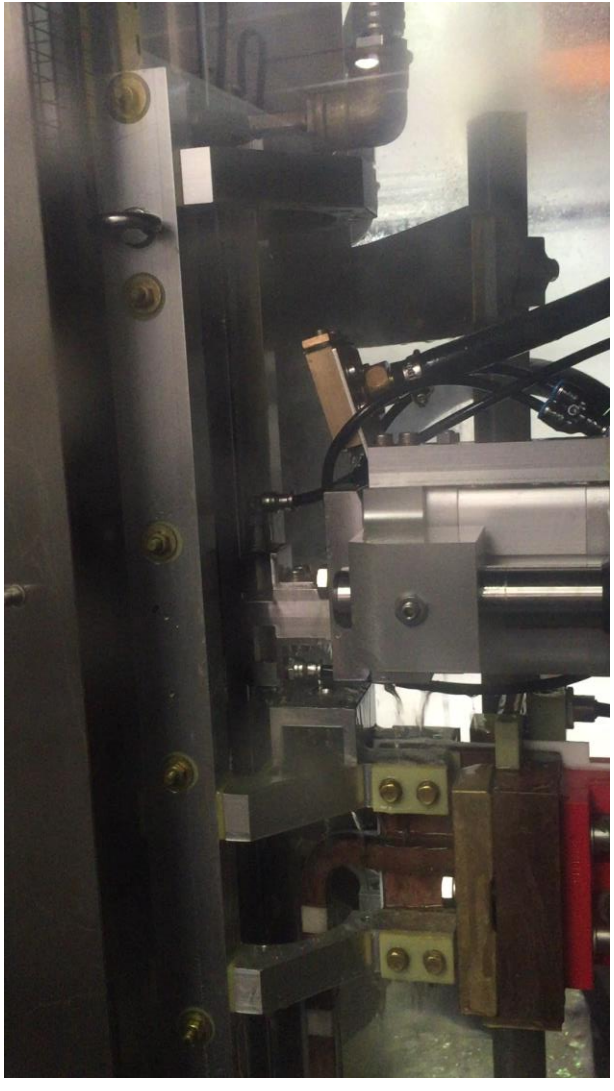
INDUCTION HARDENING SINGLE SHOT

BASICS

- Coil fully adapted to the part geometry
- Coil doesn’t move during the heating cycle
- Complex part geometry are feasible

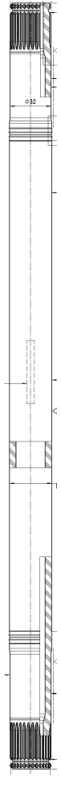
PRO / CON

- Short cycle time
- High power level needed for heating and quenching
- Reduces part checking time
- Coil specific to the workpiece



EFD® INDUCTION

EXAMPLE PART: DRIVE SHAFT



HARDENED IN VERTICAL POSITION

MAIN PROCESSES

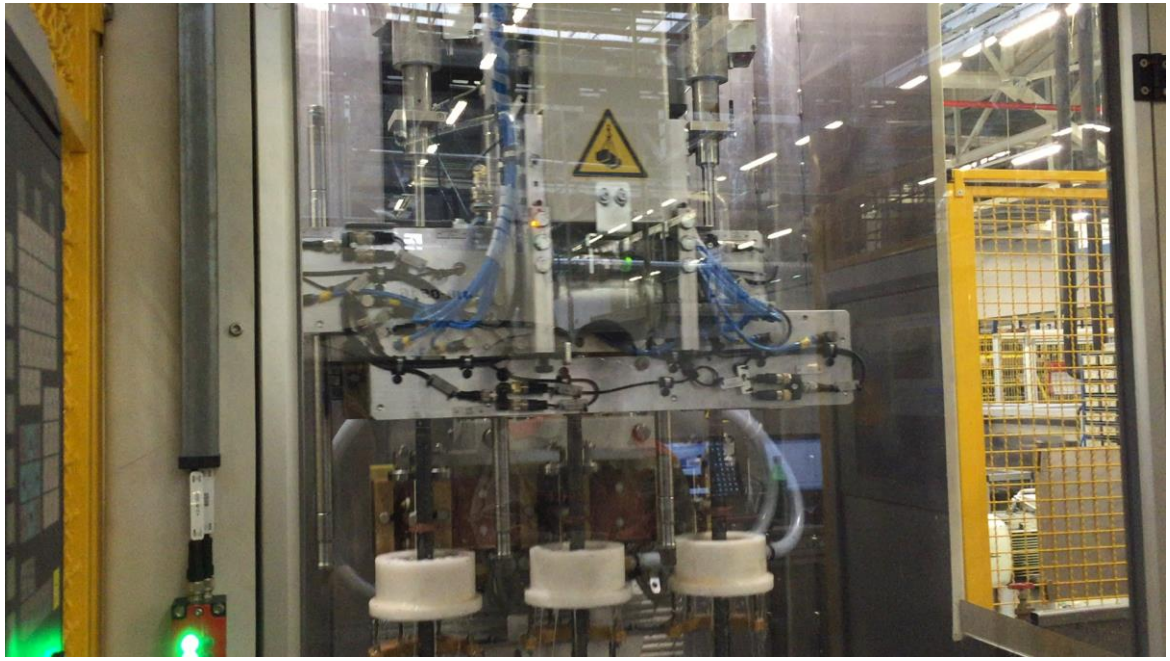
INDUCTION HARDENING
SCANNING

BASICS

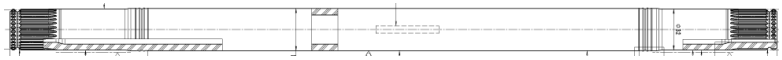
- Coil partially adapted to the part geom.
- Coil and quenchers moves together during the heating cycle

PRO / CON

- Long cycle time, multi-spindle solutions
- Low power needed for heating and quenching
- High part checking time
- Coil can be used for other workpiece as long as diameter remains similar



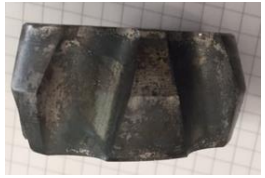
EXAMPLE PART: DRIVE SHAFT

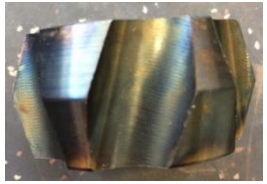


HARDENED IN VERTICAL POSITION

MAIN PROCESSES

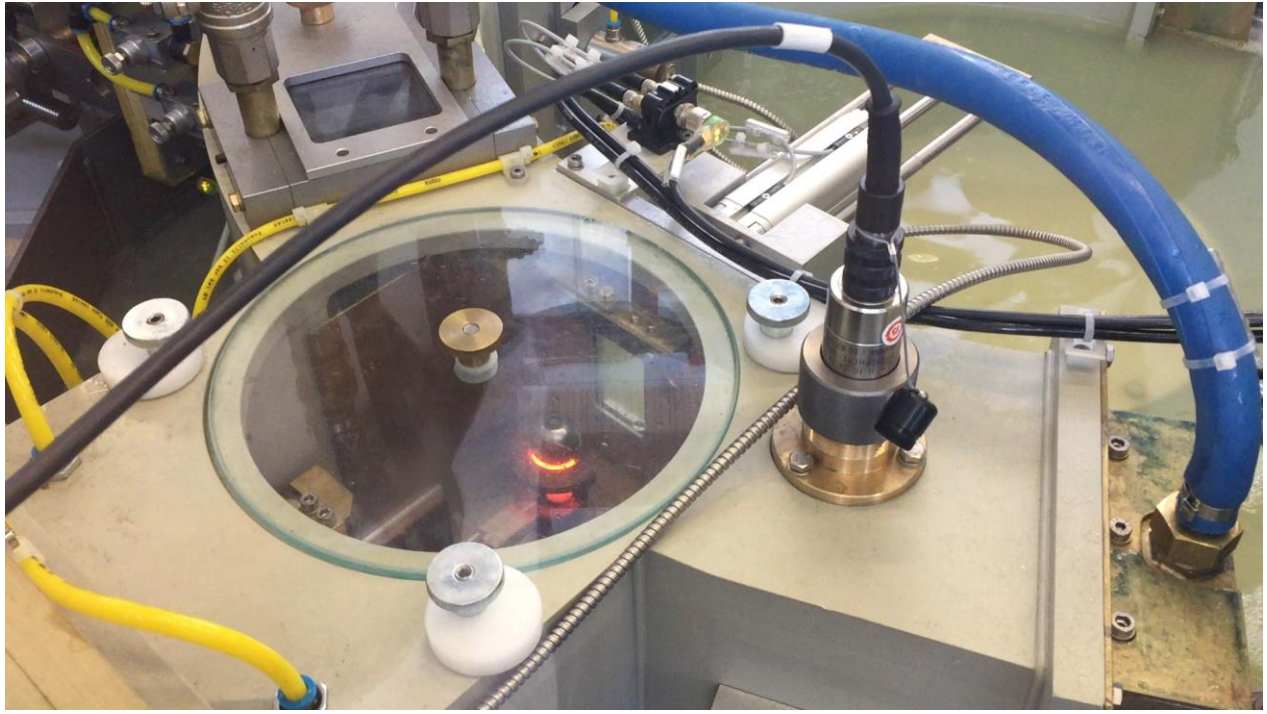
INDUCTION HARDENING
PROTECTIVE ATMOSPHERE





BASICS

- Reduce the oxygen content in the hardening surrounding to reduce or eliminate scale building

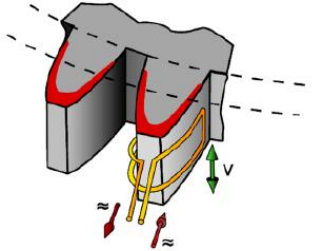


PRO / CON

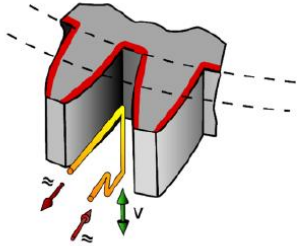
- Increase the cycle time depending on the implemented solution
- Enable to save further machining steps

MAIN PROCESSES

HARDENING OF TEETH

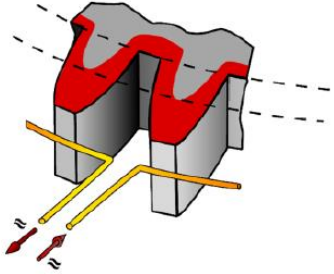


m ≥ 3,5 mm

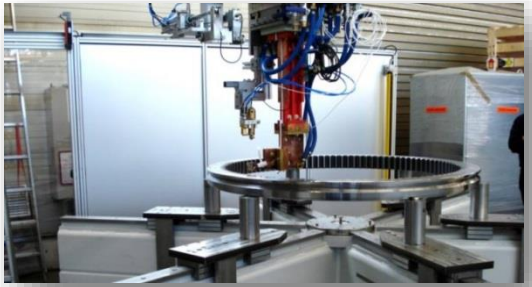


m ≥ 2,5 mm (HF)

m ≥ 6,0 mm (MF)



m ≥ 2,0 mm



Horizontal scanning hardening machine

Parts and processes

GENERAL

- MACHINE PRINCIPLE
- PART EXAMPLES
- HYBRID TECHNOLOGY

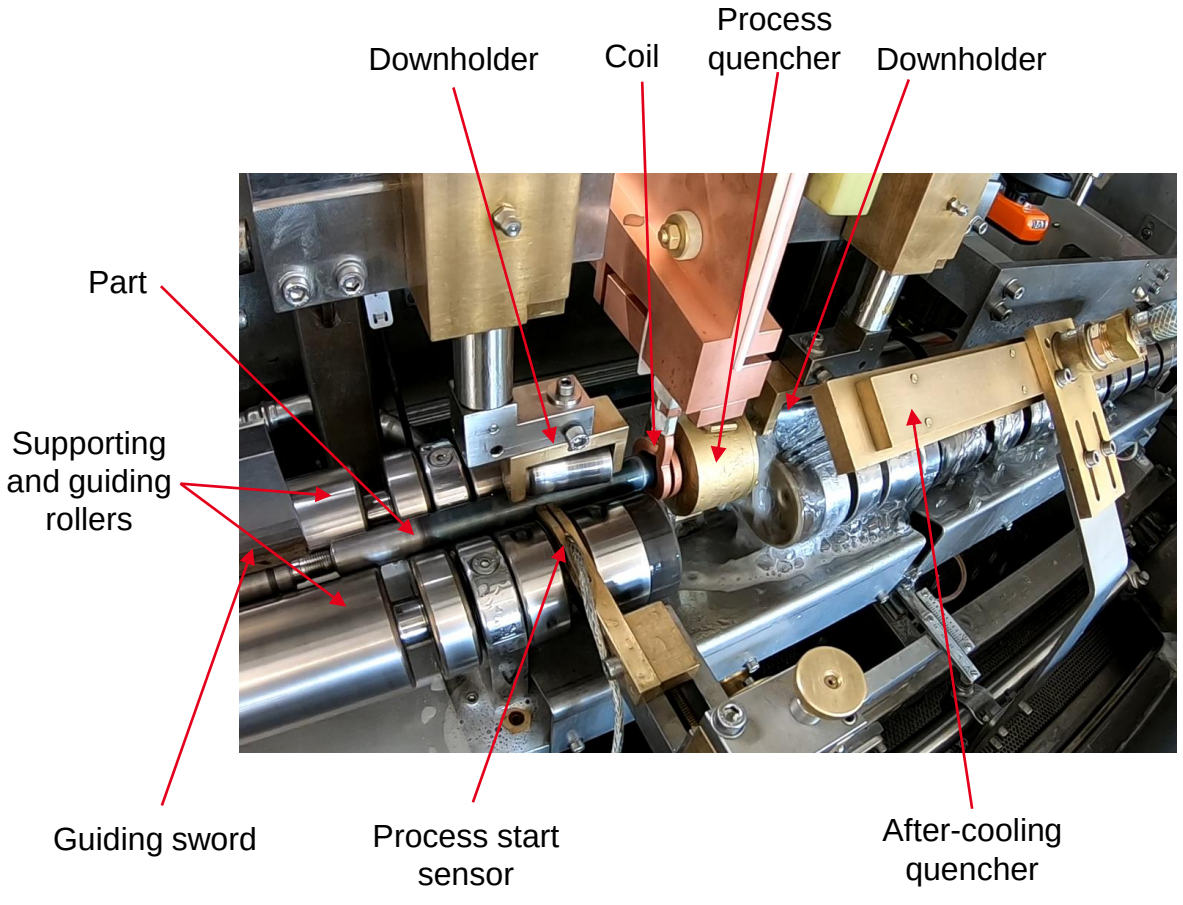
Horizontal scanning hardening machine

Parts and processes

BASICS

- Parts must have a cylindrical shape with a major common diameter
- Parts are supported and guided on a rotating roller pair
- Parts are maintained on rollers using downholders before and after the coil / quencher
- Hardening process: scanning

BEST MACHINE CONCEPT FOR PART DISTORSION (RUNOUT)

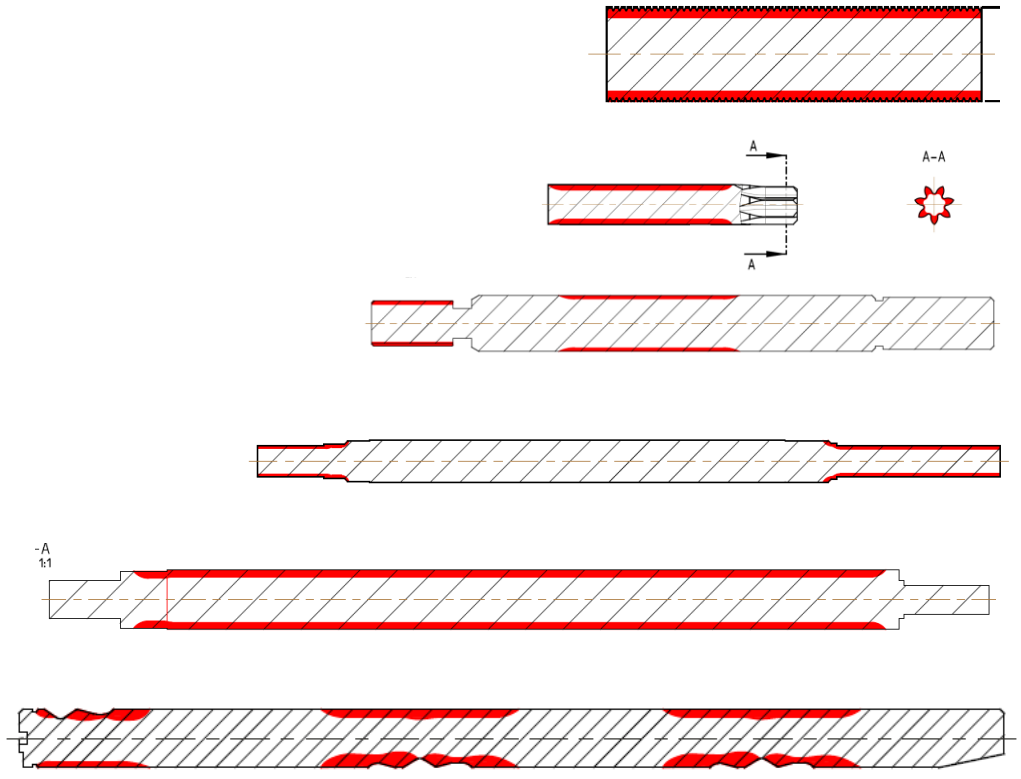


Horizontal scanning hardening machine

Parts and processes

PART EXAMPLES

- Parts must have a cylindrical shape with a major common diameter
- Center of gravity must be located close to the center of the major common diameter
- Various SHD and hardening pattern are achievable depending on the combination of material, converter power / frequency and scanning speed.
- Part dimensions: length up to 8 m for special machine, Ø up to approx 200 mm



Horizontal scanning hardening machine

Parts and processes

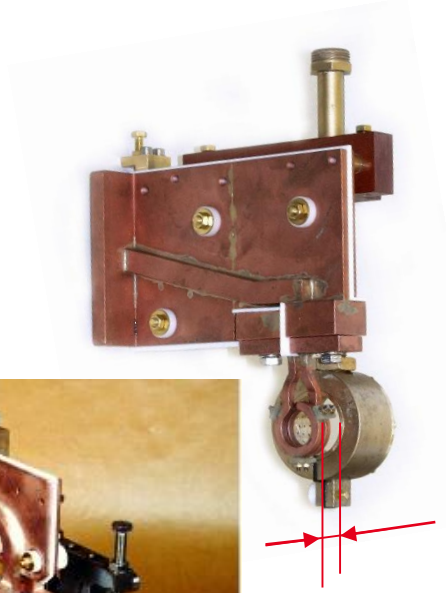
Depending on the required hardening pattern, various coil and shower executions are used

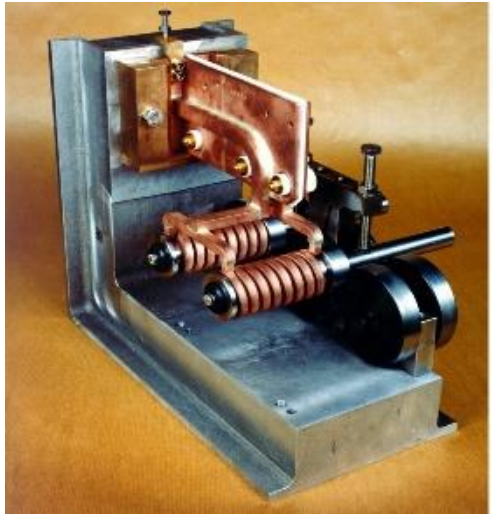
Influence of the coil execution:

- The more windings there are, the better the efficiency is. But this has as a consequence to increase the size of the heating area which might reduce the accuracy.

- The distance between the coil and the shower has an impact on the heat treatment as it influences the delay between heating and quenching (higher time for temperature drop by increased distance). The orientation of the shower's holes have as well the same impact.

- The distance between the coil and the workpieces influences the efficiency. The smaller this distance is, the better the efficiency will be. Heat treated part tolerances and machine tolerances must be considered.



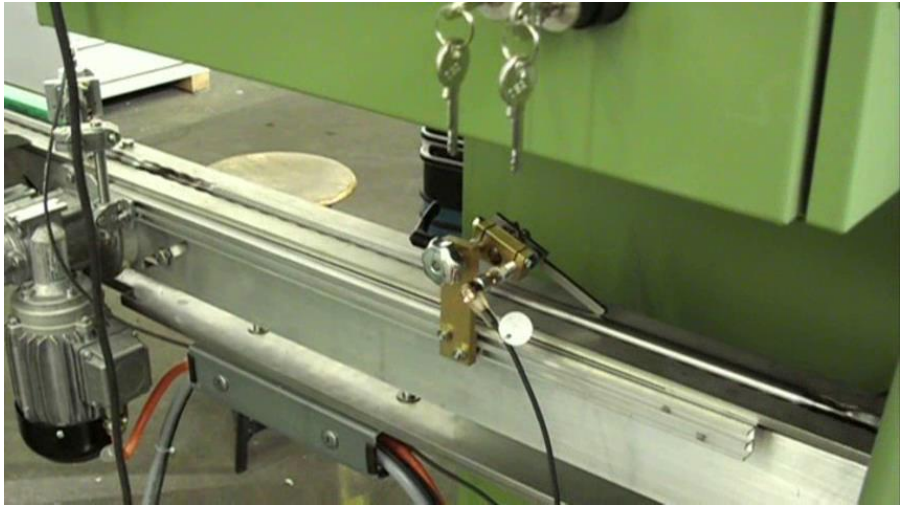


Horizontal scanning hardening machine

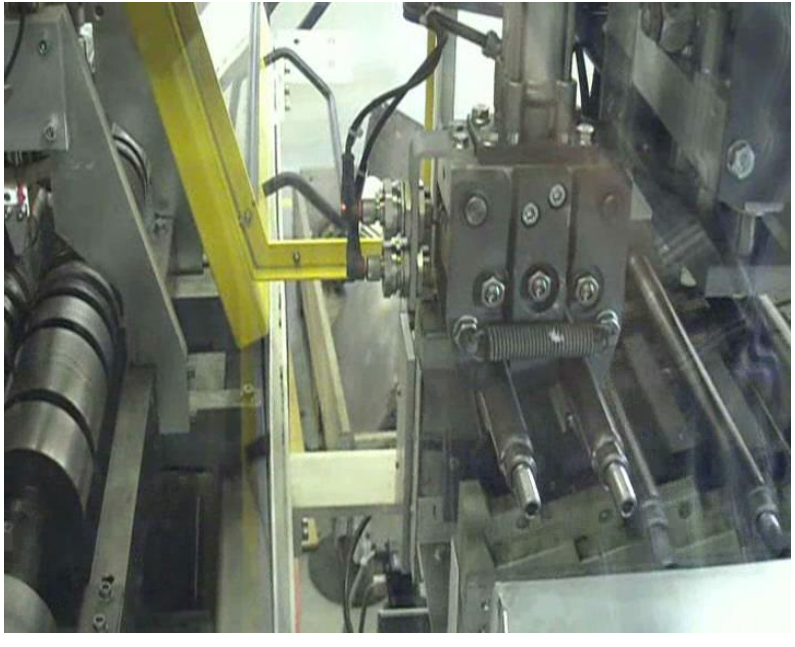
Parts and processes

PART MOVING TECHNOLGIES DEPENDING ON REQUIRED HARDENING PATTERN

MACHINE WITH CONTINUOUS DRIVING SYSTEM



MACHINE WITH PUSHER DRIVING SYSTEM



Horizontal scanning hardening machine

Parts and processes

CONTINUOUS DRIVING SYSTEM

- Very short cycle time are achievable (< 2 seconds)
- The machine has to work continuously (no stop of the driving system allowed)
- The part geometry has to fit some specific requirement (shape for process start sensor). If not available, either move to HP solution or develop a special HC solution.

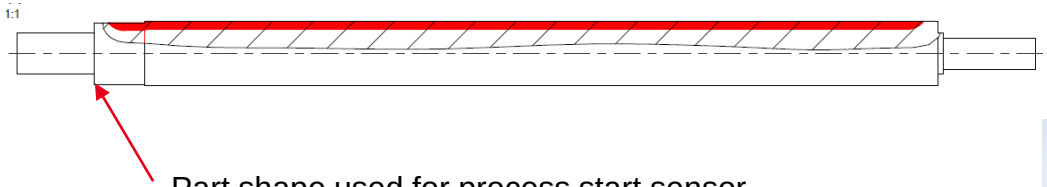
PUSHER DRIVING SYSTEM

- The requirement to have a specific shape for the process start sensor is not relevant
- It is possible to stop the workpiece at a defined position to realize complex hardening patterns

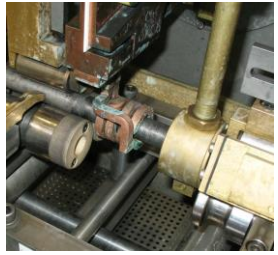
Horizontal scanning hardening machine

Parts and processes

CONTINUOUS DRIVING SYSTEM



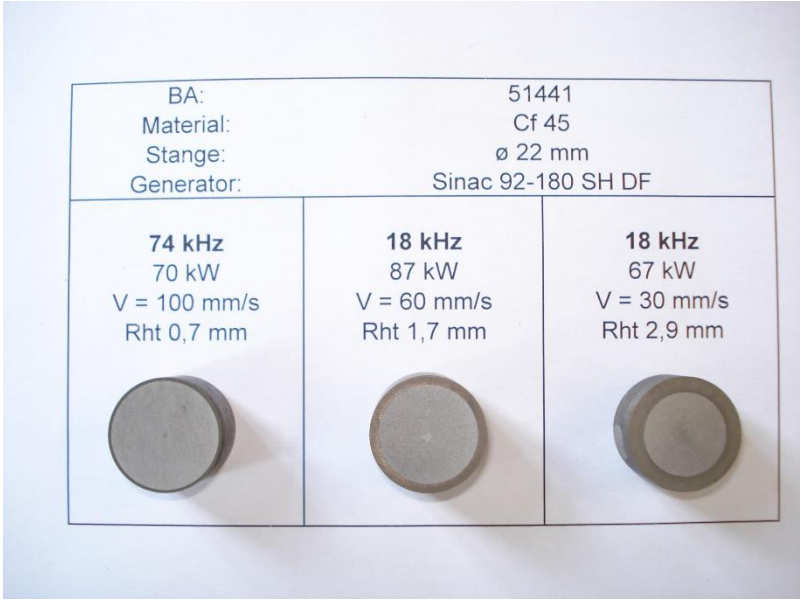
Part shape used for process start sensor



Cycle time approx. 4 seconds

Part length approx. 400 mm

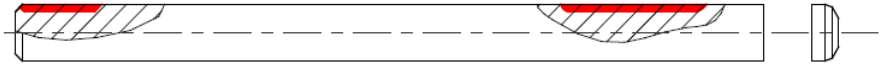
Remark: this part could also be hardened with a HP machine

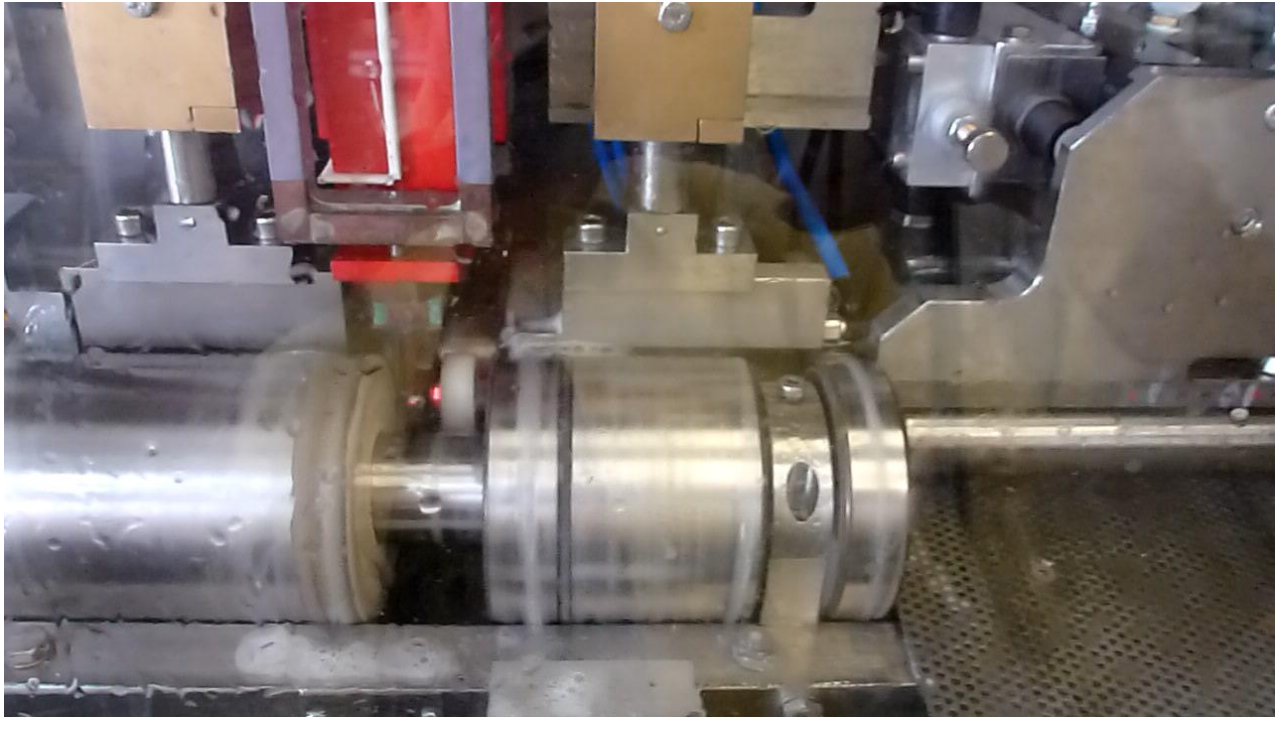


Horizontal scanning hardening machine

Parts and processes

CONTINUOUS DRIVING SYSTEM

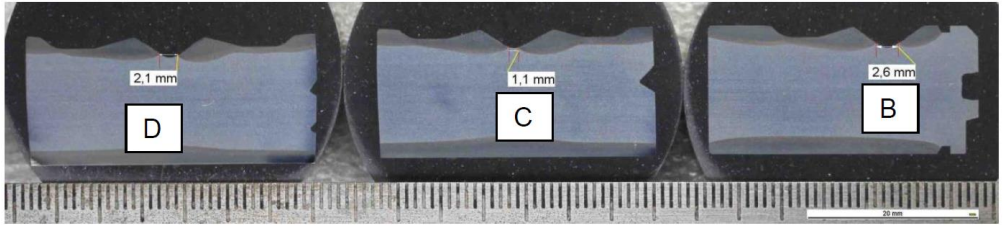




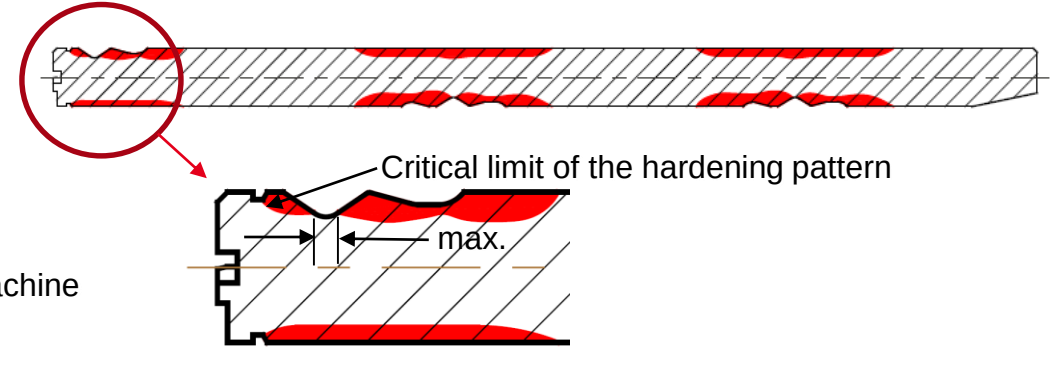
Horizontal scanning hardening machine

Parts and processes

PUSHER DRIVING SYSTEM



Part diameter:	15 mm
Part length:	260 mm
Cycle time:	14 seconds (with dual lane machine)
Hardening depth:	Variable, up to 2 mm.
Scanning speed:	15 mm/s
Power:	40 kW
Frequency:	160 kHz



Remark: this part couldn't be hardened with a HC machine

Horizontal scanning hardening machine

Hybrid Technology

GENERAL

- **INTRODUCTION TO THE HYBRID TECHNOLOGY**
- **TECHNICAL SPECIFICATION OF THE NEW STANDARD MACHINE**

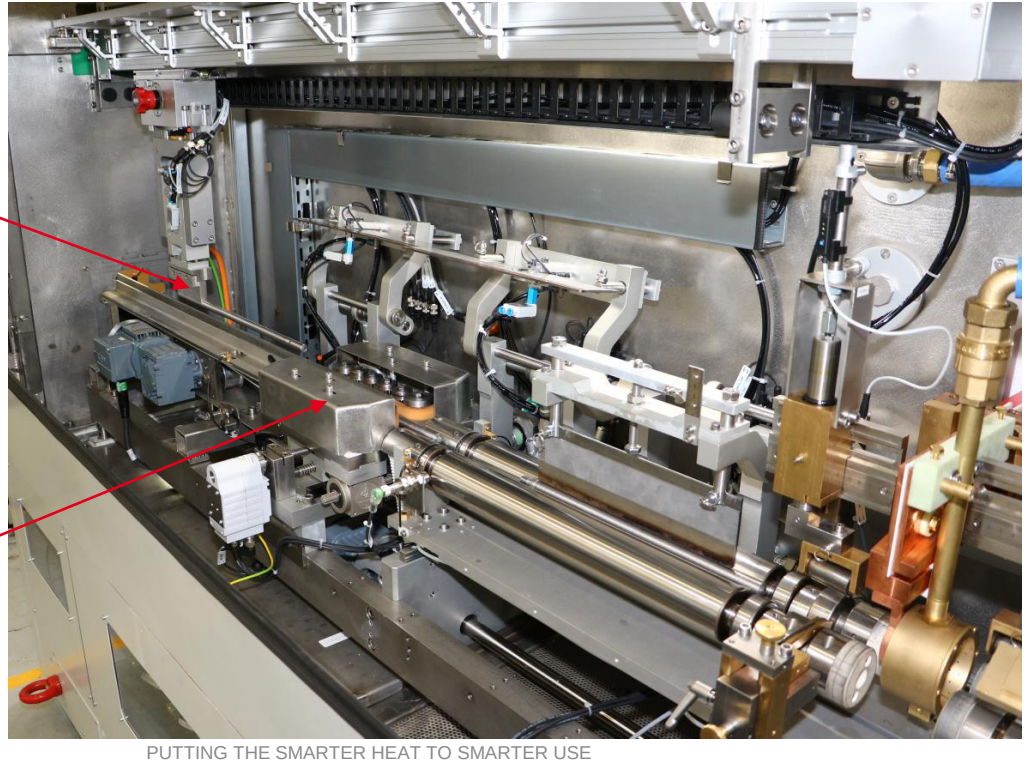
Horizontal scanning hardening machine

Hybrid Technology

HP = horizontal pusher
HC = horizontal continuous
HH = horizontal hybrid (both working modes combined in one machine)

Pusher (NC controlled)

Feeding unit for continuous



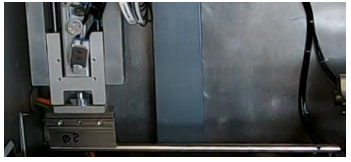
Horizontal scanning hardening machine

Hybrid Technology

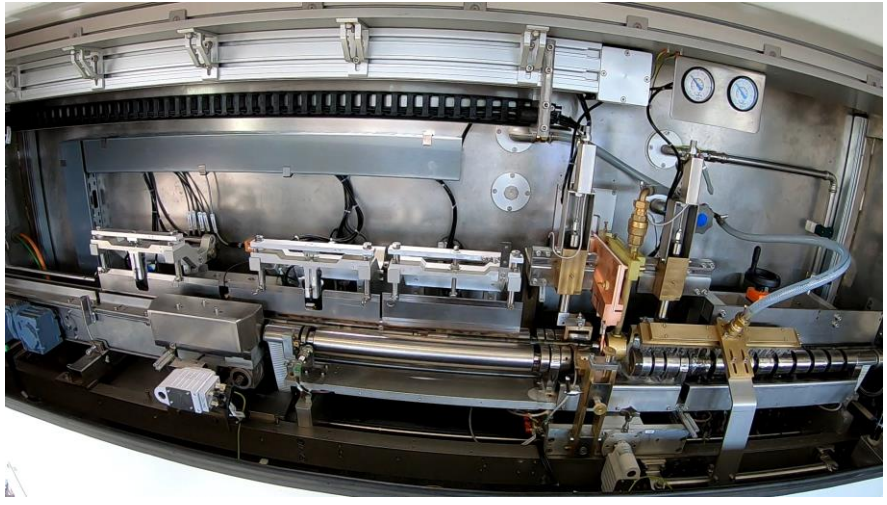
Horizontal scanning hardening machine

Hybrid Technology

Functions			HC	HP	HH
workpiece length	mm	min. / max.	50 / 600	50 / 600	50 / 600
workpiece diameter	mm	min. / max.	5 / 30	5 / 50	5 / 50
workpiece weight	kg	max.	3	9	9
workpiece speed	mm / sec.	min. / max.	1 / 200	1 / 200	1 / 200



CONTINUOUS MODE (HC MACHINE)



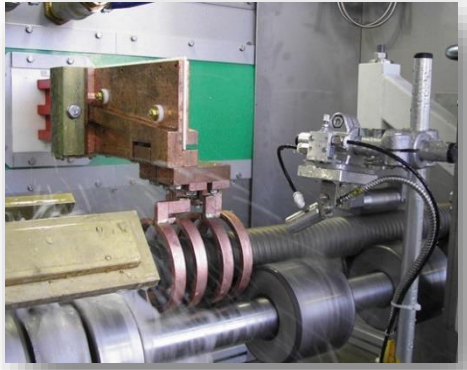
PUSHER MODE (HP MACHINE)

SUMMARY

- The hybrid technology enables to have both machine types combined in one machine!
  - Advantage of the accurate Pusher
  - Advantage of the short cycle time of the continuous drive

- Various automation solutions can be proposed for this kind of machines.

- We are still able to provide some special solution such as a
  - combined hardening and tempering
  - big dimensions



Thank you for your attention,

Any questions?