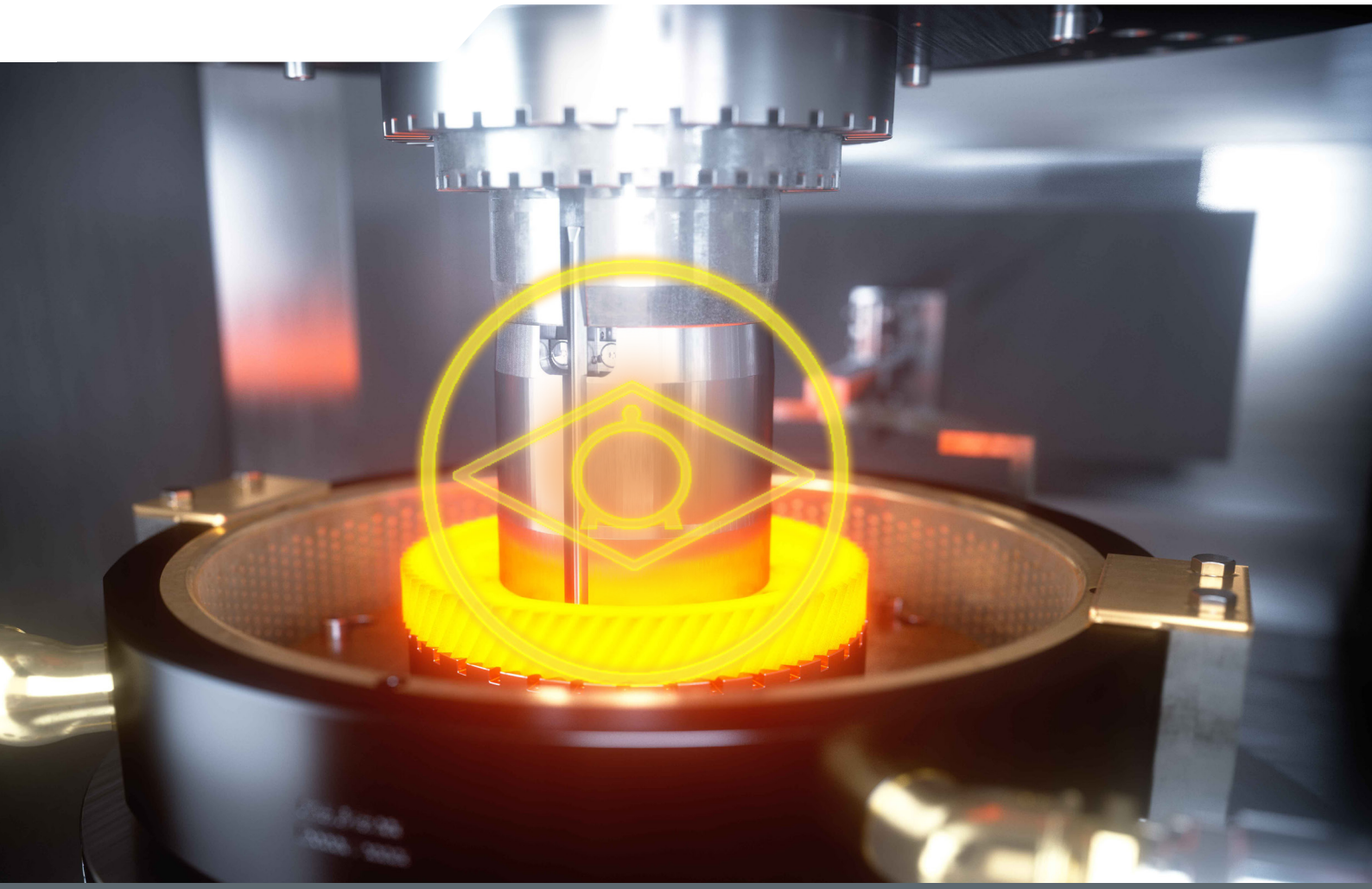
EMA
induction
technology

Fundamentals of Induction Heating

Customer Information



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Preface

This leaflet should provide all of those that have none or little experience with induction heating and annealingsystems, with an easy access to the topic and provide useful information about the most important points.

After an overview of the EMA range of services, you will be given an introduction in material science of steels and the heat treatment. Then we shall deal with the topic “Induction”. After that, you will be provided with a description of the most important points of the specific production of EMA systems (hall logistics, auxiliary and operating materials, safety on the system and environmental protection as well as material testing). And finally, there is information on personnel requirement, qualifications and training.

About us

EMA Indutec is a specialist and full-range supplier of induction heating and hardening systems, frequency converters and services.
For 80 years, our company has been a guarantee for innovation, strength and cooperation.
From a former small repair business in Hirschhorn im Neckartal near to Heidelberg, Germany over the past decades, it has developed to an internationally successful mechanical engineering company with around 130 employees worldwide and two production sites in Germany and China..

Since the beginning of 2024, we have been a proud part of the American ParkOhio Group.

At our current company headquarters in Meckesheim near Heidelberg, we stand for the development of pioneering inductive heat treatment processes and process optimizations.

Being a full-service provider, EMA Indutec produces machines and special systems for hardening, annealing and tempering as well as frequency converters for different applications such as heating, melting, forging and for channel-type furnaces.
The range of services is rounded-off by auxiliary components such as recooling systems, measuring and control systems, washing systems as well as loading and unloading facilities.

For the assembly and maintenance of the systems world wide, at EMA Indutec you will be in good hands with the well equipped service department.

Overview of EMA Range of Services

Induction Heating and Annealing Systems

- About 80 years of experience in inductive heat treatment
- More than 10,000 induction systems permanently in use world wide
- Development and production from a single source
- Economical and highly-reliable systems
- Low energy consumption
- Precise and reproducible hardening results
- High throughput
- Precisely matched heating zones
- Very low-warpage heat treatment processes
- Extremely low-scale hardening zones by heat treatment using inert gas
- Simple integration into production lines
- Reduction of production costs per item
- User-friendly adjustment, retrofitting and maintenance
- FEM simulation
- Applications
  - » Surface hardening
  - » Annealing and tempering
  - » Hardening and calibration
  - » Hardening under inert gas
  - » Shrinkage
  - » Fixture hardening
- Other system parts
  - » IGBT converter
  - » Recooling systems for the cooling water
  - » Recooling system for the quenchant
  - » Measuring and control systems
  - » Loading and unloading systems (optional)
  - » Washing systems for workpieces (optional)
  - » Extraction facilities (optional)

IGBT converter[1] with digital inverter control, type TIV[2]

- Power range from one Kilowatt up to several megawatts
- Frequencies from one Hz to 400 kHz
- Work areas from 0.5 up to 1.2-fold of the nominal frequency
- Easy integration into different production systems
- All common control interfaces available
- Quick and easy operation
- High energy frequency and high efficiency level
- Precise and reproducible hardening energy dosing
- Quick replacement of old and third-party devices
- Customer-specific solutions and special systems
- Low service and maintenance costs
- Wide range of accessories
- Applications (see page 7)

After Sales Service

- Global service with hotline
- High-performance and competent service centre
- Preventive maintenance service
- Smart remote-control solutions
- Efficient spare parts concepts
- Customer-specific system retrofit
- Inductor development, construction and repair service
- Remote assistance
- Training for operators, maintenance personnel and induction experts – also on-location

1) IGBT = Insulated-gate bipolar transistor
= Bipolar transistor with insulated gate electrode

2) TIV = Transistor inverter voltage

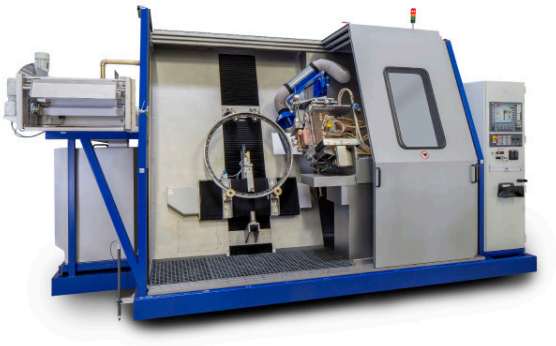
EMA products – Induction heating systems (examples)

Tucana

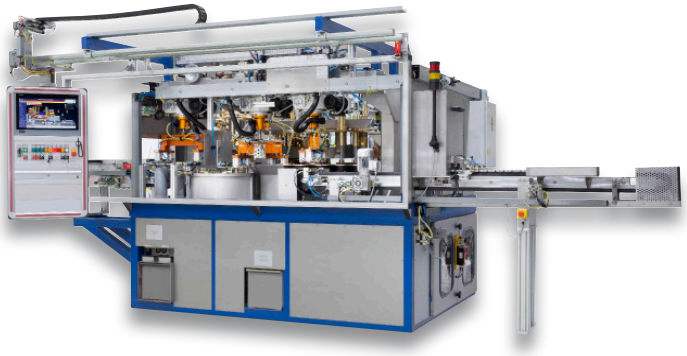
Taurus

Lupus

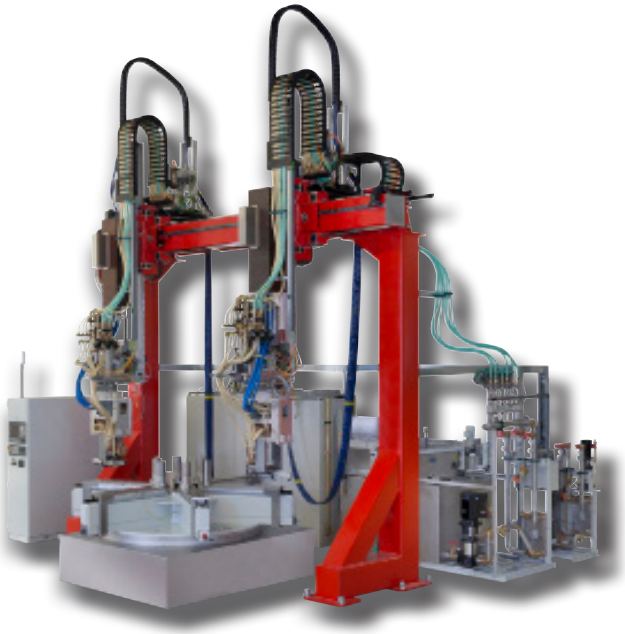
Vela



Libra – inclined



Aquila



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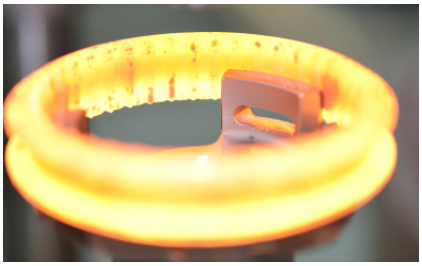
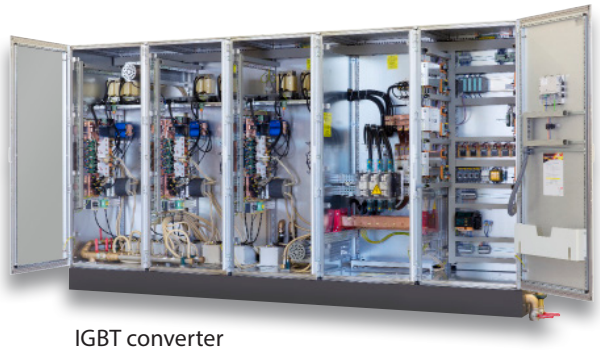
EMA products – Applications for the EMA converter

Hardening, annealing, tempering

- Examples, see pages 16 to 17

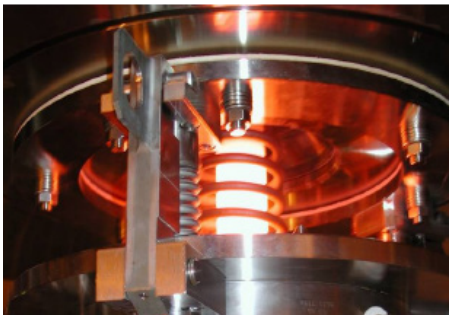




IGBT converter

Heating

- Shrinkage
- Glass heating
- Coating and drying
- Straps, cable and wires

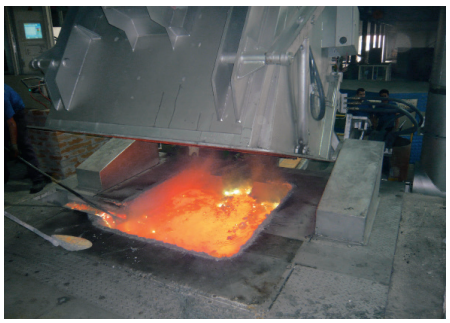


Melting

- Crucible furnaces
- Laboratory furnaces
- Vacuum furnaces

Channel-type furnaces

- Copper and copper alloys
- Aluminium and aluminium alloys
- Steels



Forging and moulding

- Blocks and rods
- Pipes and pipe ends
- Rails

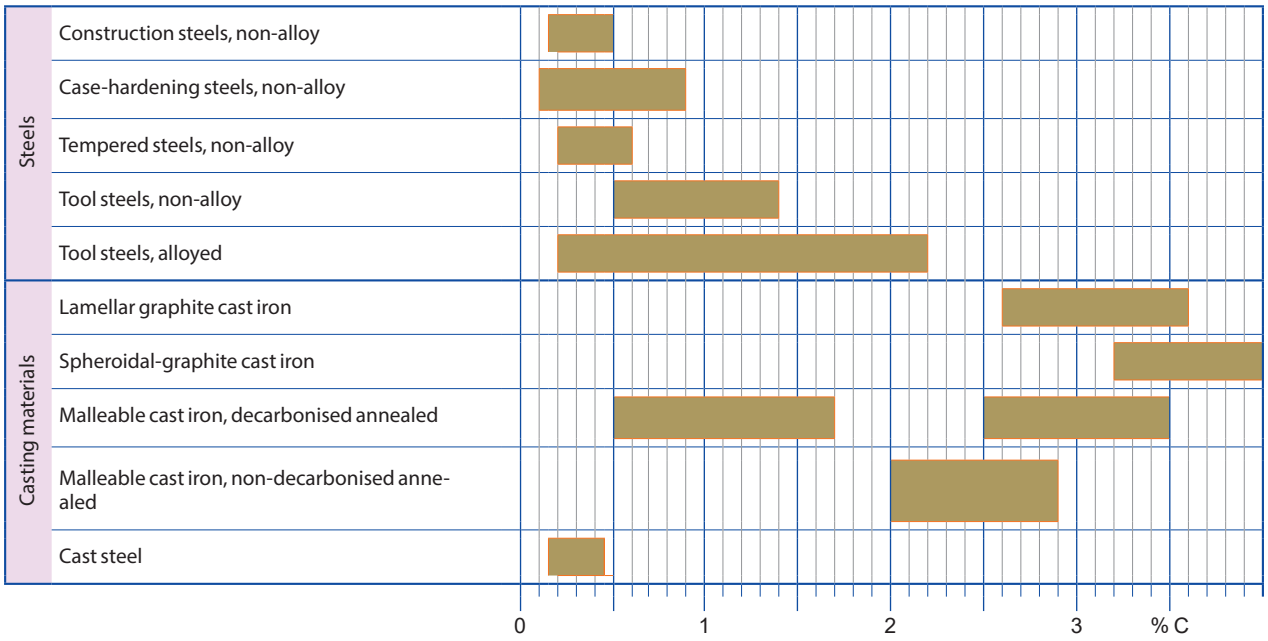
billetXpress

Carbon Content of Steels

Together with the other alloy elements, the carbon content of the steels and the cast iron material influences the structure. The structure is decisive for the mechanical properties (e.g. toughness, brittleness, hardness, tensile strength or wear resistance) and for the production-related properties (e.g. formability, machinability, weldability or hardenability).

Designation System for Steels

In Europe, the designation of the steels is defined standardised by the standard SN EN 10027. Part 1 specifies the structure of the abbreviations, part 2 the structure of the material numbers. The abbreviations are either orientated according to the intended purpose and the properties or according to the chemical composition of the steels.



Structure Types of Ferrous Alloys

Carbon is the most important alloy element of iron and steels. Almost all ferrous alloys used technically contain carbon. A relatively small amount of carbon content is already enough to change the structure and properties of the iron significantly. Carbon may exist in ferrous alloys in different forms: dissolved in solid solution or precipitated in the form of elementary carbon (graphite) or in the form from carbides (= Cementite = Fe_3C).

If one examines the structure of iron cooling slowly, one notes that it contains different structure types depending on the C-content:

Technically pure iron forms a structure that is called Ferrite. It is malleable, easy to form and magnetizable.

Iron with 0.1 % to 2.06 % carbon is called steel.

Steel does not contain the carbon in a pure form, but as iron carbide (Fe_3C). This structure content is called cementite. It is hard and brittle.

With a low C-content in steel of less than 0.8 % the cementite is precipitated in the form of thin strips (strip cementite) that is drawn through by individual ferrite grains. Due to its mother-of-pearl-type appearance, this structure is called Perlite. In steel with 0.8 % carbon, all ferrite grains are streaked with strip cementite.

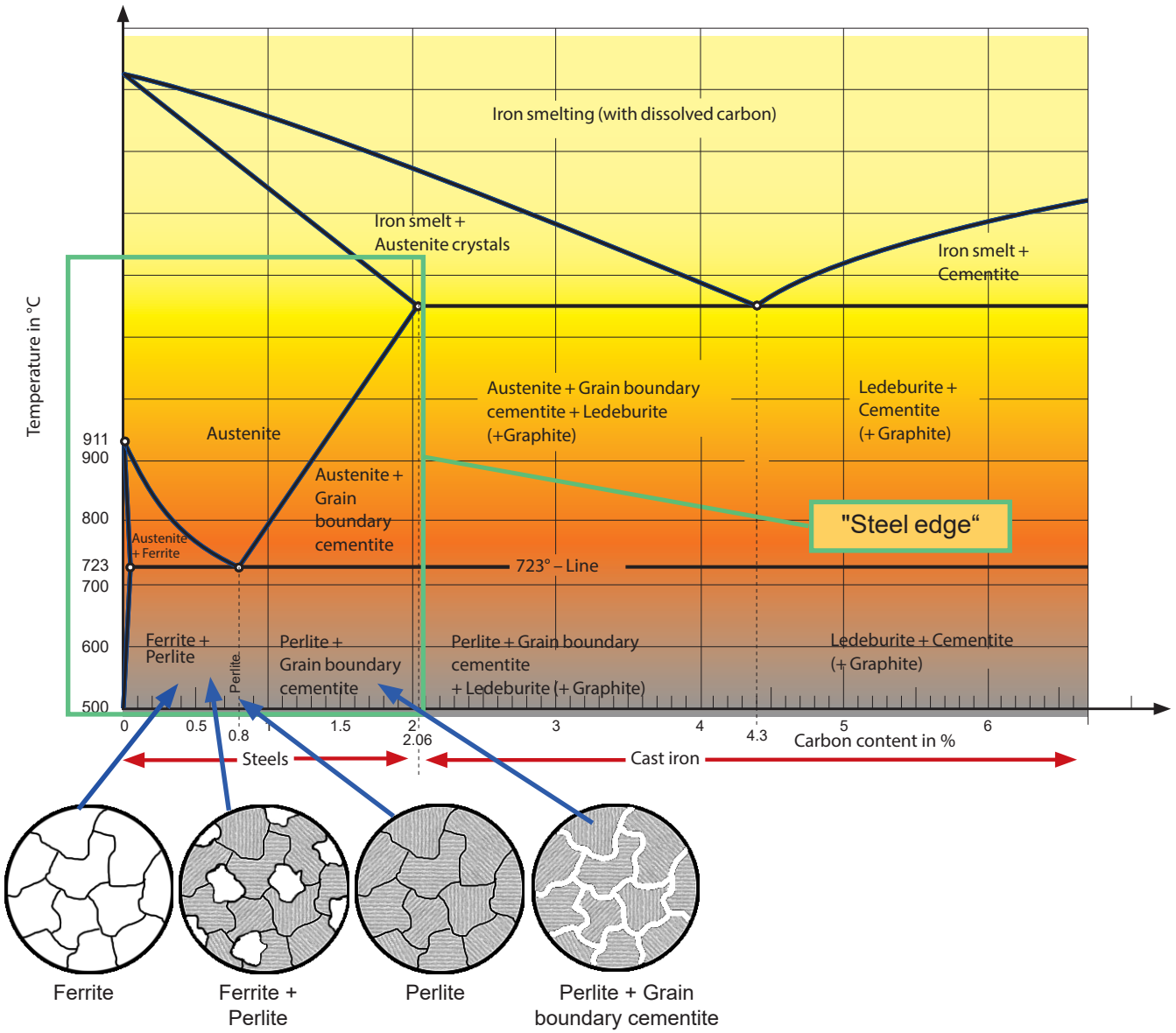
Steels with less than 0.8 % carbon have a structure that contains ferrite and perlite grains. One designates this as ferrite-perlite structure.

Steels with more than 0.8 % carbon contain as much carbon that in addition to strip cementite in the perlite grains, cementite is also deposited on the grain boundary (Grain boundary cementite). The higher the cementite content, the harder but more brittle the steel.

Iron-Carbon State Diagram

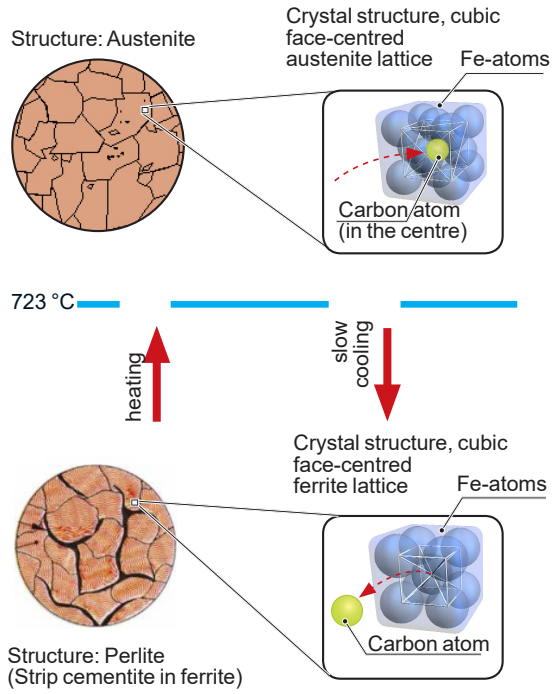
When heating iron materials above 723 °C, other types occur in addition to the structure types specified. An overview as to which structure type occurs at a certain temperature and a certain C-content is given in the iron-carbon state diagram. When exceeding of falling below the structure limit line, the structure is converted.

Structure type	Structure properties
Ferrite	max. 0.02 % carbon, malleable, tough, easily formable, low strength, magnetic, not resistant to corrosion
Perlite	mixture of 88 % ferrite and 12 % cementite (dark strips) with 0.83 % carbon, high strength
Cementite = Fe_3C = Iron carbide	from 4.3 % carbon content, hard, brittle, not formable
Austenite	at 1,147 °C, can dissolve up to 2.06 % of carbon; austenitic steel is stable at room temperature if sufficient alloy elements (Cr, Ni, Mn) are contained, very tough, well formable, heat resistant, non-magnetic, corrosion-resistant



Heat Treatment

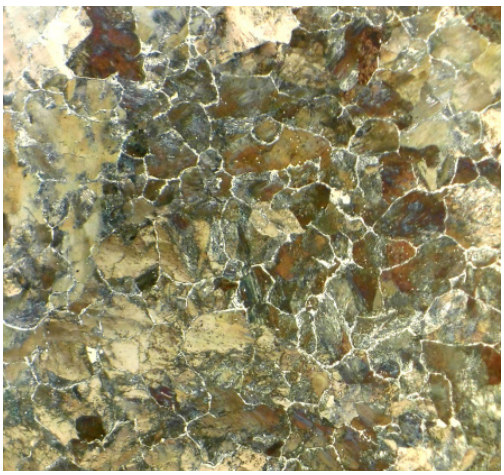
Using heat treatment, the properties of steels and cast-iron materials can be changed in the desired manner.
In particular, the hardness, strength, workability and durability of materials can be improved. The cause for these improvements is in the modification of the material structure.



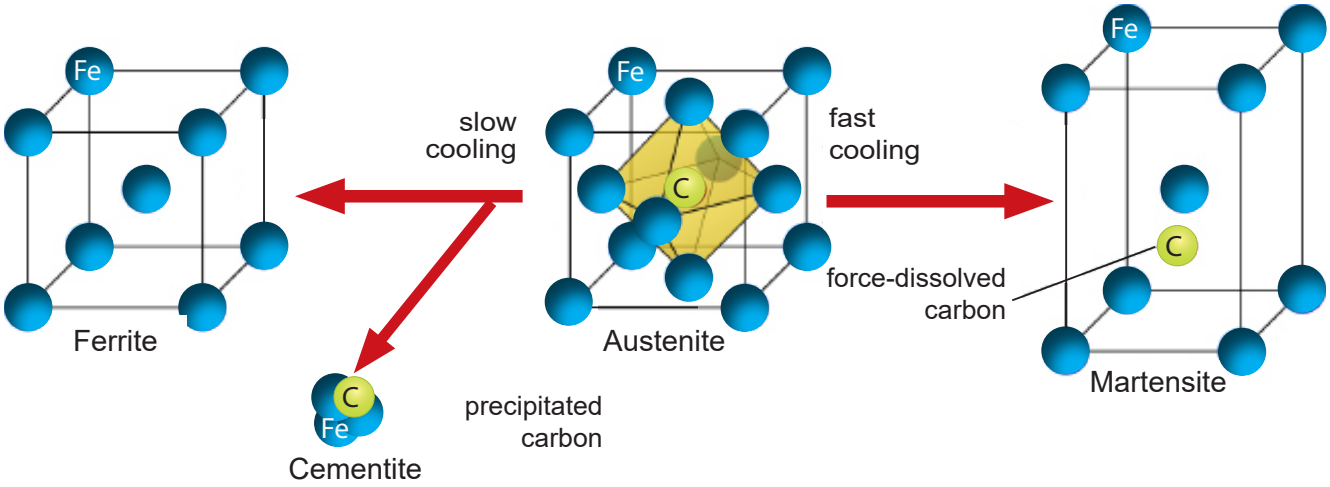
Lattice and structure changes of a steel with 0.8 % carbon at 723 °C

Structure of the Steels when Heating

Steels are heat treated in order to improve certain properties. In doing so, diverse procedures take place in the material. If the steel is heated to more than 723°C, its structure converts. The reason for this are changes to the crystal lattice. The cubic, face-centred austenite lattice is created from the cubic, body centred perlite lattice. A carbon atom is added in the middle of the cube becoming free and a solid solution is created. Austenite is tough, easy to form and non-magnetizable.
When cooling slowly, the procedures described run in the reverse order.



Grinding pattern for perlite (Strip cementite in ferrite)



Change in structure when cooling

Heat Treatment Types

Heat treatment is when changes to the structure and properties remain caused by heat treatment.

The most important methods are:
Annealing, hardening, tempering, nitriding (is not described here) and the hardening of the boundary zone.

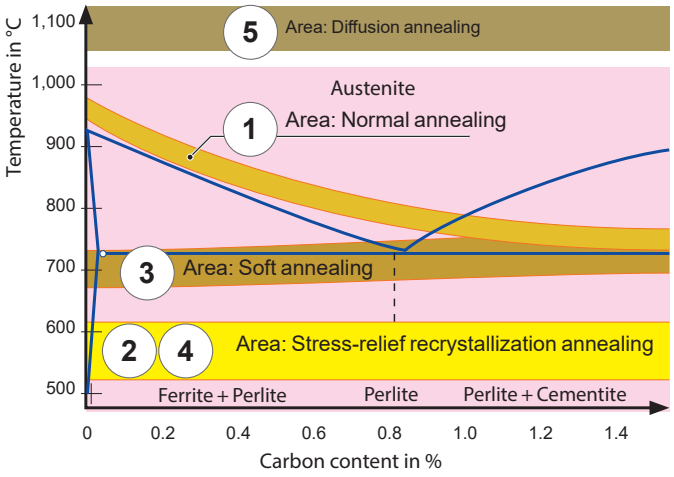
Annealing is the heat treatment of a workpiece at a determined temperature when considering a certain holding period and subsequent slow cooling.

One differentiates between the following annealing methods:

Normal annealing (1) is predominantly carried out after previous hot working of components. By normal annealing, the adjustment of a fine-grain perlite settings should be achieved. This allows coarse grained and uneven structures to be transferred to new homogeneous and fine structured ones. One anneals at 750 °C to 950 °C depending on the carbon content.

Stress-relief annealing (2) serves to remove residual stress in the workpiece as a result of cold forming, structure transformation, thermalloading or machining. The stress-relief annealing is usually carried out between 550 °C and 650 °C with sufficiently long holding periods and subsequent very slow cooling. Basic changes in the structure and the mechanical properties do not take place.

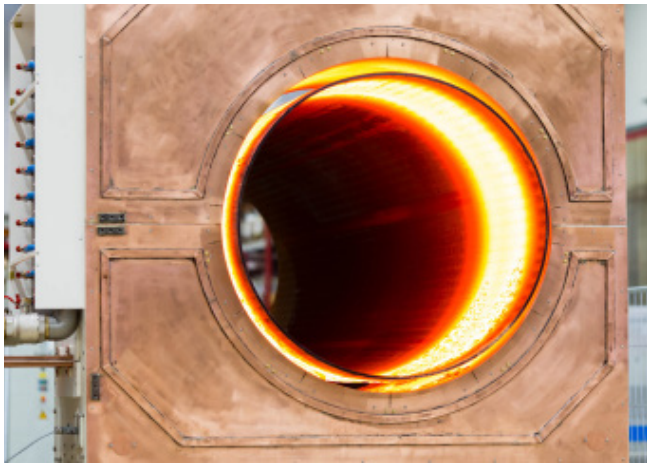
Soft annealing (3) is when one anneals at a temperature of 680 °C to 750 °C and then allows to cool slowly in order to achieve a state as malleable as possible. In doing so, granular perlite should result, with a malleable structure, which gives the optimum workability in non-cutting and cutting processes.



Annealing temperatures of non-alloy steels, drawn in the iron-carbon state diagram

Recrystallization annealing
(4) is used if a structure that has been distorted by cold forming should be transformed back to the undistorted structure state.

Diffusion annealing (5) is a long annealing at 1,050 °C to 1,250 °C. When casting large cast-iron pieces, it is used to reduce the concentration differences occurring.



Inductive pipe annealing system

Hardening

Hardening is a heat treatment that makes steels hard and wear resistant. In particular, tools and components subject to wear are hardened. The hardening comprises several work processes. First the tool is heated to the hardening temperature and, where applicable, kept at this temperature. Then it is quenched, thus, immersed in water or oil. This makes the steel very hard, but also brittle and liable to fracture. For this purpose, the workpiece is then tempered, this means heated to the tempering temperature. Generally, it is the goal of a tempering treatment to increase the forming properties of hardened components as well as reducing the risk of fractures. Then the workpiece is left to cool at air temperature.

Internal procedures when hardening (see also lower graphic on page 10):

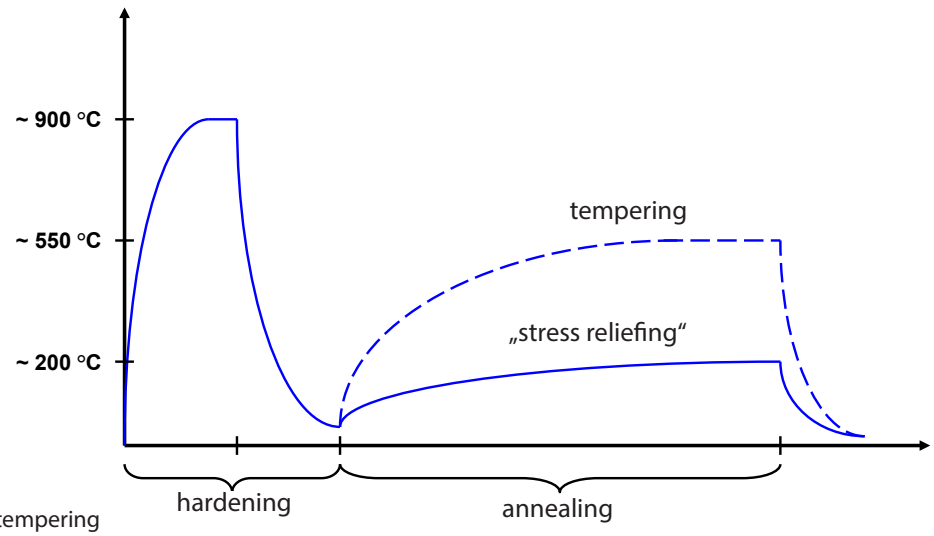
When heating, the cubic, body centred ferrite lattice is transformed into the cubic, face-centred austenite lattice. The space in the crystal lattice becoming free is occupied by a carbon atom. If the austenitic steel is cooled rapidly (quenched), the cubic, face-centred austenite lattice folds rapidly into the cubic, body centred ferrite lattice. The carbon atom in the centre does not have any time to escape from the lattice. Now a carbon atom and an additional iron atom are in the lattice centre. This strongly distorts the crystal lattice. A needle-like structure is created that is called martensite. Martensite is very hard but brittle, and is only created when a carbon content of at least 0.2 % is contained in the steel. With certain high-alloy steels, the cooling in open air already leads to the formation of martensite.

Tempering

Components that are exposed to higher and more sudden loads require high strength and stronger toughness at the same time. One achieves these properties by annealing the tempered steels suitable for this purpose, with a heat treatment from hardening and then annealing to the temperatures between 500 °C and 700 °C. The annealing temperatures are significantly higher than annealing after the hardening. Non-alloy and alloyed steels are used for tempering. Unalloyed tempered steels contain 0.2 % to 0.6 % carbon, alloyed tempered steels contain additionally small contents of chrome, molybdenum, nickel and manganese.

Internal procedures when tempering:

After quenching, needle-shaped martensite is present. When annealing to 400 °C, a part of this degrades into finely-distributed ferrite and cementite needles that are precipitated in the remaining martensite. The martensite degradation continues with increasing annealing temperature. It degrades completely into ferrite and cementite needles when annealing to 550 °C. At 700 °C, the cementite needles finally roll to cementite grains.

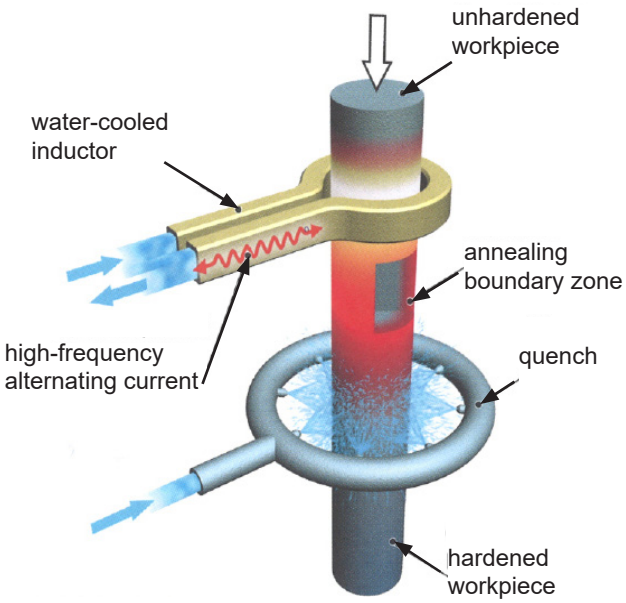


Comparison hardening, annealing and tempering

Heat Treatment

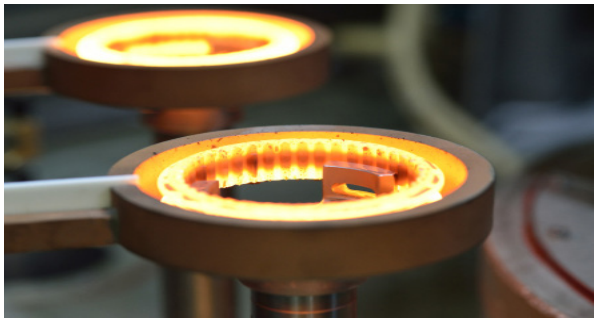
Surface Hardening

Surface hardening of a workpiece is used when the workpiece requires a hard and wear-resistant surface zone, but needs a high-strength and tough core.
This is necessary for workpieces whose surfaces are exposed to wear and have to withstand the impact and alternating mechanical loading such as, e.g. shafts, bolts, gear wheels or chutes.
With surface hardening, a thin outer layer of the workpiece from temperable steel is heated quickly by a strong heat supply and hardened by quenching immediately. Martensite is generated as a result. The deeper areas of the workpiece are not heated enough in the short heating time and remain unhardened. The surface hardening heating is carried out using different methods:



Induction hardening

With Induction hardening using EMA systems, the heat is generated by eddy currents in the surface layer of the workpiece. The eddy currents are produced by the field of an induction coil in to which a high-frequency alternating current flows. The penetration depth can be set by the variable frequency of the current. Rotary-symmetrical components are particularly suitable for induction hardening.



Laser hardening from approx. 0.3 % carbon content is used for the surface hardening of smaller areas such as, e.g. the bearing pin of a shaft.

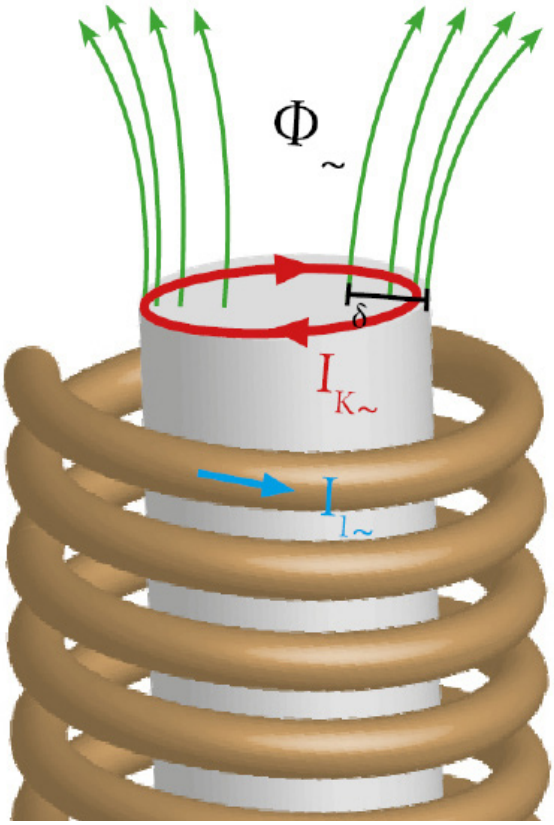
With flame hardening, the surface layer is heated with a strong burner flame and then quenched with a water sprinkler.

With case-hardening, the surface layer of a low-carbon steel is enriched with carbon (carburised) and then hardened. As a result, one obtains a workpiece with hardened carbon-intensive surface layer and a low-carbon unhardened and tough workpiece core.

For carburizing, steels with 0.1 % to 0.2 % carbon content are used that are not really hardenable.
The workpieces are annealed in resources emitting carbon at 880 °C to 980 °C for several hours. In doing so, carbon diffuses into the surface layer that, as a result becomes hardenable.
Resources used are solid substances (coke / charcoal granulate), fluid substances (highly toxic cyanogen molten salt) or gases (mixtures of CO and H_2).
Due to the subsequent hardening and annealing, the carburised workpiece is then provided with the desired application properties. Only the surface layer is hardened, the workpiece remains unhardened and tough.

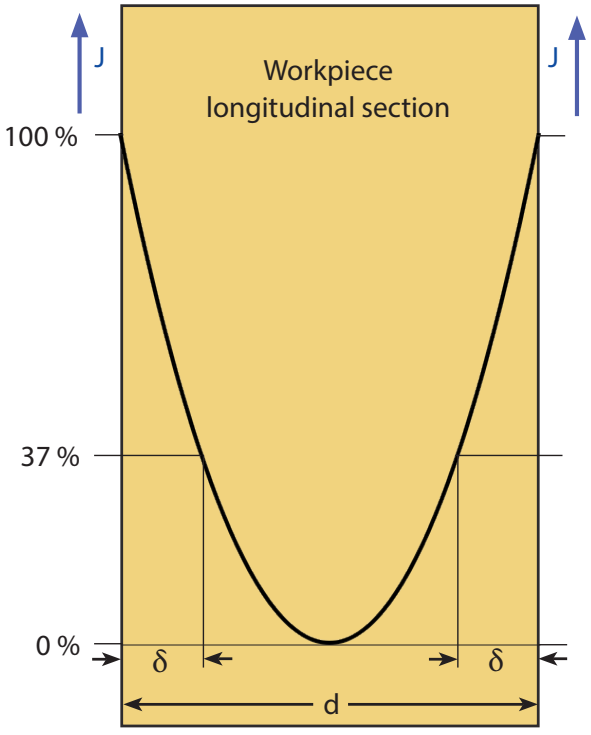
Electromagnetic Induction

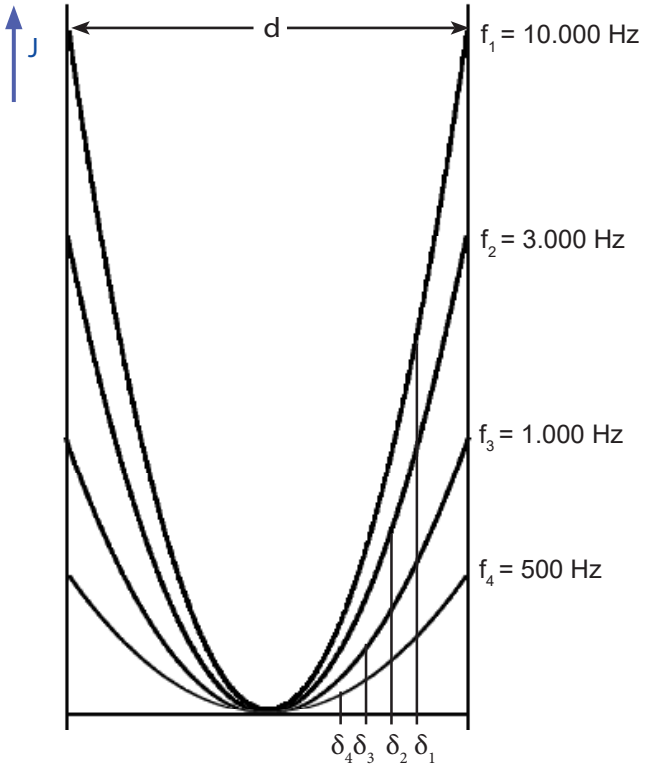
If one moves an electric conductor through a quiescent magnetic field so that the conductor cuts the field lines, an electric voltage is induced in the conductor. Or: If the magnetic field around the conductor changes, an electric voltage is also induced in the conductor. Thus, induction is created as a result of a magnetic field that is generated by a coil.
A coil made from copper (inductor) is located around the workpiece through which cooling water runs at high pressure. If an alternating voltage is applied to the inductor, a current $I_{1\sim}$ flows thus creating a magnetic alternating field $\Phi_{\sim}$. This induces a ring-shaped eddy current $I_{K\sim}$ in the conductive workpiece and the workpiece is heated with a sufficiently high intensity. The current always flows on the outer circumference of a workpiece. The degree of the heating can be influenced via the current intensity in the coil and via the duration of the power supply.



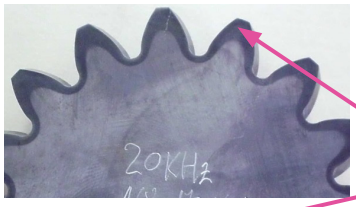
Penetration Depth (Skin Effect)

The skin effect is an effect of electric conductors being flown through by high-frequency alternating current. Through this, the current density J on the inside of the conductor is lower than in the outer areas.
The cause for the skin effect is that the alternating fields penetrating into the conductor due to the high conductivity of the material are damped to a large extentbefore reaching the inside of the conductor. The eddy current induced is reduced exponential to the centre. The current penetration depth or skin-depth δ is the distance from the surface where the current density is reduced to 37 % of its maximum value. The induced current in the centre is always zero. The penetration depth δ can be calculated from the following parameters: workpiece-specific parameters such as specific electric resistance and permeability figure (measure for magnetic strength) as well as the variable frequency of the power supply.



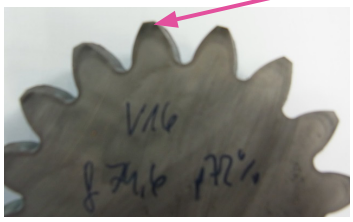


The penetration depth of the induction depends particularly on the frequency of the alternating voltage: The higher the frequency of the current, the smaller the penetration depth and therefore also the hardening depth. Practically-orientated reference values of the correct frequency for the penetration depth required can be determined using tables.



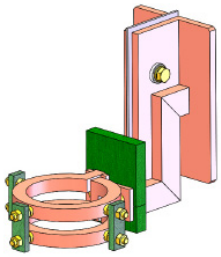
Frequency: 20 kHz
Output: 170 kW

Martensite

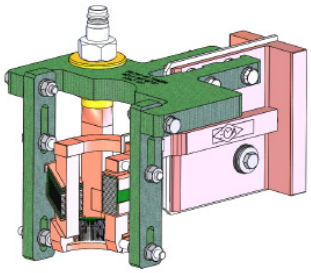


Frequency: 70 kHz
Output: 145 kW

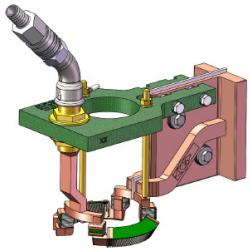
EMA inductors (examples)



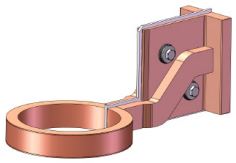
for joint hubs



for joint housings



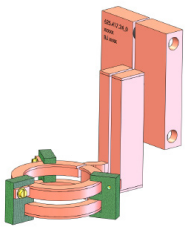
for wheel bearing flanges



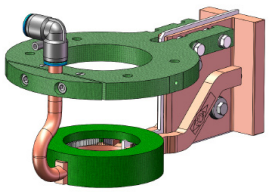
for sliding collars

Benefits of Induction Heating:

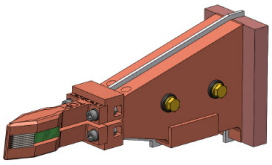
- direct heat generation in the workpiece,
- no transmission loss,
- energy saving,
- highest production rates,
- precise control,
- no emissions,
- high power densities,
- high process temperatures,
- high heating up speeds.



for individual cams



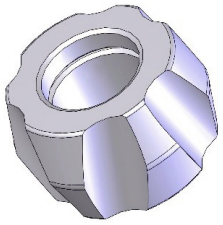
for cam shafts



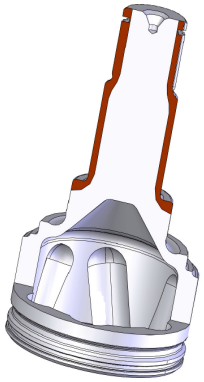
for individual sprocket hardening

Induction Hardening with EMA Systems (examples)

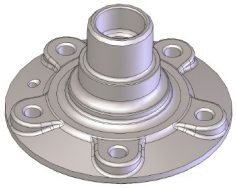
Joint hubs can be hardened and tempered to running tracks and inner gears fully automatically in very short cycle times. The joint hubs can also be processed in a housing using inert gas. In this manner, the sintering of the component surface is reduced significantly. The unit can also be retrofitted to existing systems at any time. EMA Indutec offers concepts for hardening and annealing one to three joint hubs at the same time, adapted to the customer´s requirements.
On a three track annealing system, up to three different components can be processed at the same time. This guarantees the highest flexibility with the best possible output and floor space.



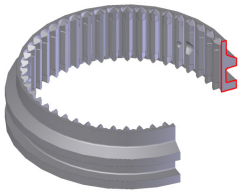
Together, the joint housing and the joint hub form the basic module for a constant velocity joint. As with the joint hub, short cycle times and high productivity are in demand. Here the joint housing can also be processed with the EMA Indutec annealing system using inert gas. A benefit that pays-off as reworking of the bell is made much easier as a result. For the processing of joint housings, EMA Indutec offers a matured concept for hardening or the hardening with annealing. The systems are adopted to the processing tasks and can carry out the different processes reproducibly. The compact systems can be optimally integrated into the existing production line. The systems are equipped with a washing box and a component drier that ensure for the best results and quicker further processing.



The systems for hardening and annealing wheel bearing components are characterised by the high flexibility and outstanding output. Thus, in one system there is a possibility to inductively harden wheel bearing flanges and outer races and also to inductively anneal in a special procedure. Thanks to the modular design of the system, they will optimally satisfy the high demands on the cycle time. For reducing the cycle time, components may also be pre-heated, for example. The fully-automated systems are equipped with a buffer and the possibility to discharge test parts.

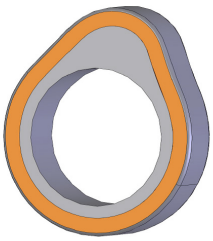


Sliding sleeves can be heated inductively and calibrated in an inert gas atmosphere. The tolerances of the components on the calibrated surfaces is less than 0.05 mm. Frequently reworking of the sliding sleeves is omitted due to this procedure. A further great benefit is that also complex gearing geometries can be processed on the sliding sleeves using the special procedures of EMA Indutec. Protruding as well as missing gears and different tip diameters can be processed in the inductive calibration facility of type *Vela* without any problem. Buffer accumulator and automation connection as well as process know-how round up the range.
A universal testing machine is available in the competence centre in Meckesheim, Germany for the purpose of process development or prototype components.

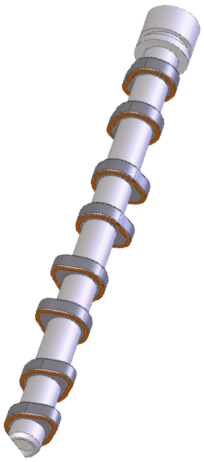


Induction Hardening with EMA Systems (examples

With assembled camshafts, the individual cams are fixed in the desired position on a precision tube. The individual cams are heat treated separately before assembly. In order to satisfy the large quantities and high quality requirements, EMA Indutec has developed a system for series production with particularly low cycle times and optimum accessibility for maintenance and service.
The system of type Aquila can be optimally integrated into existing production lines thanks to the integrated automation. Process monitoring and robust mechanical components ensure for the high quality of the inductively processed workpieces. The Aquila still has the option to process different cam geometries such as sleeve cams from the sector for cylinder deactivation or pump lobes.



The classical production process for cam shafts is casting and subsequent mechanical machining. The bearing surfaces and the cams are inductively heat treated after the pre-machining. EMA Indutec offers a special process for hardening the camshafts. The cams are aligned rotary using the CNC axis and the inductor is positioned accordingly before the component is heated by induction. This guarantees a homogeneous hardening pattern over the entire cam. The machine of type Lupus can be operated as stand-alone solution as well as integration in a production line. All components of the system are combined on a base frame.
This results in quick commissioning and easy installation of the system. The EMA converter with digital control guarantees an economical machining and process monitoring at the highest level.



XXL components are hardened inductively, in particular at locations with high mechanical load such as gear teeth or running tracks with ball bearings and roller bearings. The applications are generally based on special customer requests. Thus, the quantities are rather small and the main focus is placed on the flexibility and efficiency of the system. Systems of type Libra have been designed for just these requirements. Due to a very stiff processing portal, different workpiece dimensions can also be processed.
In order to simplify the definition of the workpiece when setting up, EMA Indutec has developed a user friendly parameter input mask for the control. Only the dimensions of the workpiece and the tools are defined here. The machining program is created by the control itself which omits the programming work.
The high flexibility and the high efficiency level of the EMA converter is an ideal supplement for the machine. The systems can be configured for the number of inductors. The greatest benefit: when hardening the teeth, two teeth can be processed at the same time which halves the processing time.

Installation Location, Foundation and Required Space

The installation of the system is carried out in the production line intended by the customer. With the selection of the installation location, ensure that the intended area is dry and free from frost.

The installation, function test and commissioning of the system supplied must be carried out assisted by EMA specialist personnel.

Particular foundations are generally not necessary for the installation of the heating system. However, the operating company is obliged to check the load bearing capacity of the floor at the installation site for its static load according to the system weight and the information provided by EMA Indutec.

The free area at the work place must be dimensioned in such a manner that the employees are able to move freely during their activities. This means that a minimum free area of movement of 1.5 m² must be available for each employee. The area of movement must not be less than one meter at any position.

The floor must not be uneven, have any holes, tripping points or inclines. It must be weight-bearing, stepping safe and non-slip.

Ambient conditions

The ambient conditions for operating the system have been dimensioned to European conditions.
All possible external influences occurring such as dirt, dust, heat, cold, etc. must be reduced to the minimum by the customer. This will assist the trouble-free operation of the system.
The ambient temperature must never fall below sub-zero temperatures during operation as well as during downtimes as there is otherwise a risk of the cooling circuit freezing.
This could lead to the destruction of the system.

Temperatures during operation:	maximum permissible temperature:	+45 °C
	minimum permissible temperature:	+10 °C
	maximum relative humidity:	80 %

These ambient temperatures must be observed under all circumstances and should not deviate from the media temperature substantially as you would have to expect condensation.
This may lead to the destruction of system parts and in extreme cases, to personal injury.

Energy and Supply Connections

The assembly or installation is to setup the system components and the transmission lines such as, e.g. mounting of the water supply and drain lines or the electric cables to the marked connecting elements. In all cases, the assembly must be carried out by or under the supervision of EMA specialist personnel. The connections may only be carried out when depressurised or at zero potential, using the respective approved material and when observing the applicable safety standards.

Cooling Water and Quench Connections

If the system is in position and the individual components (induction heating system, heat exchanger for water and quenchant, converter, where applicable gravity filter, exhaust air purification, robots, material supply, etc.) are aligned to each other, the cooling water and quench connections are routed. Connection of the network water is established by the end customer. All information on the cooling water and quench connections (e.g. minimum and maximum water temperatures, quantities and pressures, tank volumes) can be found in the following plans supplied: Arrangement drawings / layout, water plan, pneumatic diagram, operating instructions of the heat exchanger, the converter and the system as well as, where applicable, inert gas plan.

EMA cooling system:	Water pressure at the inlet:	minimum 4.0 bar, maximum 8.0 bar
	Differential pressure:	minimum 4.0 bar
	Booster pump:	maximum 12.0 bar
	Inlet temperature:	maximum 30 °C

On request, EMA Indutec can also supply suitable chillers. The minimum inlet temperature depends on the ambient temperature and on the present humidity. The minimum inlet temperature must be selected as such that condensation is avoided.

Compressed Air and Inert Gas

After routing the compressed air and, where applicable, the inert gas supply line, the customer must establish the operating pressure on the network side. Water and oil-free compressed air of at least 6 bar is a requirement for operation of the system. A pressure of 3 bar is sufficient for flooding the hardening chamber with inert gas. If workpieces also have to be blown-off, at least 5 bar is required.

Cable Ducts and Control or Power Cable, Online Connection

After the assembly of the cable ducts has been carried out, then the specialist personnel of EMA will carry out the wiring of the system parts between each other in accordance with the cable connecting diagram and terminal or plug diagram.
From the time of starting assembly on the construction site, the customer must provide an online connection on the machine to allow EMA Indutec to access the machine per remote maintenance. This is the only way that quick assistance can be provided.

Power supply

The amount of energy required depends on the mass to be heated, the material type and the time required as well as the efficiency of the energy transfer. Detailed information for this can be obtained in the training courses that take place at EMA Indutec at regular intervals.

Extraction

Smoke, vapours, gases or dust are generated when heating the workpieces. A system for the extraction of the air that may be contaminated must either be provided by the customer, or purchased from EMA Indutec.

Hall Logistics

Transport and storage

Information on transporting within the company can be found in the operating instructions.

If the machine or parts of the machine have to be stored for a certain period, take care that the storage location is protected against moisture and sub-zero temperatures, as well as that the floor is level.

Unloading and bringing in the system is carried out by the customer at their responsibility.
Crane, forklift, lifting gear, etc. must be provided by the customer.

Maintenance, Servicing and Customer Services

Information for this can be found in the operating instructions and in the lubrication and maintenance schedule. Here you will also find a description of the EMA official maintenance seal (regular system maintenance by trained EMA specialist personnel).

Modifications to the system as well as attachments are only permitted on consultation with EMA Indutec. Modifications to the system at your own authority exempt a liability of the manufacturer for property damage and personal injuries caused as a result of this. More information on warranty and liability can be found in the operating instructions.

Availability of Workpieces and Spare Parts

The customer must provide EMA Indutec with a sufficient amount of workpieces within due time.
The amount must be determined depending on the component and the procedure.

The workpieces are required for:

- pre-testing,
- running in the machine at EMA Indutec,
- the preliminary acceptance,
- running in the machine on the construction site and the final approval.

These workpieces must have the same condition as the parts that the customer will be running on the machine later on (clean, free from oil and grease, without chips, geometry and material according to drawing guidelines, etc.).

The customer must stock spare parts for the machine or system if they want to ensure for high availability. The customer shall be provided with the spare parts list with the supplied documentation.

Collection Trays

The customer ensures for one or several collection trays to collect any leakages.
On request, EMA Indutec can also supply suitable collection trays.

Hall Logistics

System Safety

For the time between delivery of the system or machine and start of assembly by EMA Indutec, the customer is responsible for the safety of the system parts.
The customer must protect the system or machine against soiling, theft and damage.

Assembly and Approval of the System

As long as these services are a component of the agreement, the customer shall provide the following free of charge for the duration of the assembly, commissioning, approval and production assistance:

- the energy and media required such as power, water and compressed air in a sufficient amount and required quality,
- rooms for storage of assembly materials and tools that can be locked,
- project management, changing, washing and recreation rooms,
- telephone and internet connections,
- scaffolding, platforms and ladders,
- cranes and forklifts.

The customer should be prepared to connect the machine or system to the required supply media (power, cooling water, compressed air, inert gas, etc.) within 2 to 3 days so that the assembly and commissioning on the construction site is not disturbed.

In doing so, the following delivery limits apply:

- electric energy: the supply terminals in the machines control cabinet or converter,
- cooling water: on the intended transition points, first shut-off on-site,
- compressed air: maintenance station on the machine /converter, first shut-off on-site,
- data connection: service laptop (if included in the scope of supply) or connecting point in the machine control cabinet or converter,
- interface signals to upstream or downstream machines or systems: connecting point in the machine control cabinet or the converter.

A final approval or at least a hand-over ready for operation takes place directly after running in the machine or system by the customer.
Important: A system without a hand-over ready for operation or final approval must not be operated by the customer.

During commissioning of the system, EMA Indutec shall make the settings so that the hardness pattern and the hardness depth is within the tolerance window of the hardness guideline. A further optimisation e.g., to the tolerance average as well as to determine the limit value or limit value observation (e.g. for amount of energy, frequency, quenchant, etc.) are extensive and should therefore be carried out by the customer.
The dimensional accuracy of heat treated components may change for physical reasons.
For this reason, EMA Indutec cannot assume any guaranties with regard to the dimensional accuracy and the tolerances of heat treated components.

Cooling Water and Quenchant

Cooling Water Specifications

The cooling water specification is valid for the cooling of converters and induction heating systems of EMA Indutec. For the treatment of the necessary cooling water, we recommend consulting a specialist company if you do not dispose of your own specialists.

Non-observance of this specification can lead to the shortest corrosion times, destruction of hoses and massive coolant output reducing deposits which can lead to significant faults and downtimes. EMA Indutec uses selected materials in their systems that have been accrued through many years of operating experience. This ensures that the cause of rust or lime deposits in the rarest cases should be sought in the materials used.

The limit values for the cooling water contents specified form a system together. For this reason, all values must be maintained. Deviations can be compensated by effective and perceivable measures.
For maintaining the prescribed limit values, different measures may be necessary depending on the system. The properties of the cooling water must be checked at regular intervals. With regard to theconditioning and monitoring of the cooling water, EMA Indutec recommends cooperating with a specialist company for water treatment. When determining the limit values, one orientates on the recommendations of VDI 3803 for heat exchanger circulation water.

In order to reduce microbiological germination, the system must be operated virtually closed.
Contact to the atmosphere may only exist due to the necessary pressure compensation and for venting the system. The regular check of the microbiological loading of the system water must be carried out according to VDI 6022. The system should preferably be topped up with demineralised water.

Quality	Limit values	Remarks
Appearance	transparent when possible, clear without sediment	
Particle size	< 150 µm	Important: Install dirt traps in front of the supply ex-factory!
pH value	7.5 to 8.5	Deviations are possible when using conditioning chemicals. Attention: coordinate with specialist company!
Total salt content	< 250 mg/l	
Electric conductivity	< 30 mS/m	
Total hardness*	1 to 2 mmol/l	= 1 to 2 mol/m^3 = 5.6 to 11.2 °dH
Chloride (Cl^-)	< 50 mg/l	
Sulphate (SO_4^{2-})	< 50 mg/l	
Nitrite (NO_2^-)	< 0.04 mg/l	
$KMnO_4$ consumption	< 100 mg/l	
Metal content (Fe, Mn, Cu, Al)	< 0.2 mg/l	
Bacterial count	< 1,000 ml^{-1}	

Quenchant

The agents of a quenchant are reversibly insoluble at high temperatures and separate from the solution on the hot steel surfaces during the cooling procedure.
Depending on the concentration, an insulating film of different thicknesses is formed which means that the cooling intensity can be controlled within wide limits depending on the concentration. If the parts cool back down to the temperatures of the fluids, the film releases again completely and the hardened workpieces occur with clean surface. The drag-out and therefore the consumption remain low in the process.

By diluting the quenchant, the polymer solution is mixed with clean tap water that is not too hard. In order to achieve an intensive and homogeneous mixing of the concentration with the water, it has been proven to be suitable to either first fill the water in the quenching container and to add the concentration with running circulation, or to add the measured amount of concentrate into the water jet when filling the container.

The following must be observed with regard to the quality requirements of polymer solutions:

- Generally, the stability of the solution is influenced only slightly by the water hardness.
  However, with a new approach the water hardness must only be between 1 and 2 millimole per litre (mmol/l) = approx. 5 °dH to 11 °dH.
- Old residues in the line system must be removed by rinsing thoroughly with water.
  This applies particularly for pipelines, cooler and filter.
- Furthermore, it must be considered that at locations difficult to access there is frequently the accumulation of dirt that may be strongly saturated with micro-organisms. We therefore highly recommend a thorough rinsing with disinfection agent in-between.
- In particular with fluctuating water quality, we recommend a complete analysis of the water before use.
- The dissolving and refilling water must be free from bactericides and fungi.
- In ideal cases, the chloride content should be less than 50 mg/l and better than 30 mg/l.
  If the water should have a higher chloride content, we recommend mixing with demineralised water in order not to have a negative impact on the long-term corrosion protection.
- Sulphates could also influence the corrosion protection. Where applicable, a test should also be carried out here. The limit values as with chloride apply.
- The application concentrations are in the range of approx. 3 % to 6 % for weak and non-alloy steels as well as simply formed parts. With medium and high-alloy steels as well as for difficultly formed workpieces, 12 % to 25 % should be applied.
- The application temperature should maintained between 20 °C and 35 °C and must not exceed 45 °C. With extremely low ambient temperatures, where applicable, the solution should be heated to approx. 20 °C.
- In order to avoid a progressive increased hardening of the polymer solution when refilling, we recommend the use of demineralised water.
- Depending on the concentration, the pH value is between 8.5 and 9.5. It should be check frequently. A pH value must not fall below 8.0 as a sufficient corrosion protection is otherwise no longer given.
- We recommend checking the polymer solution on a daily basis, e.g. by measuring the refractive index with a refractometer according to a specified testing plan.

Product Safety

Technical safety instructions for EMA heating systems

This EMA heating system is constructed using state of the art technology and generally accepted technical safety guidelines. Nevertheless, hazards may result for the user or third parties during operation, or damage may occur to the machine or to other objects.

The machine should only be used:

- for its intended use,
- in a completely safe condition,
- when the protective equipment is in a correct state,
- when personal protective equipment is worn,
- when the operating instructions have been carefully read,
- when faults that could impair safety have been immediately rectified.

During operation, induction heating systems are supplied with dangerous electric voltage. The housing and switch cabinets to be opened must therefore be switched to zero potential before commencing service, maintenance, cleaning or repair work, and secured against being switched back on. The state of the electric system must be identified so that no unqualified persons have access to live parts.
It is possible that the emitted electromagnetic fields influence electronic cardiac implants or metal implants. Persons with such implants should not remain in the vicinity during operation of the system.

The processing machine required for the heating procedure comprises moving and rotating parts. In event of unauthorised removal of the necessary covers, incorrect operation or insufficient maintenance, there is a risk of causing severe health damage or material damage. It is essential to wear protective gloves and goggles for certain work.

If protective equipment is opened during or after heating up, you may obtain burns from the parts and workpieces heated by the inductor. In such a case, a cooling phase to room temperature must be observed, or wear suitable protective gloves. In event of insufficient cooling, burns are also possible on live parts (e.g. inductor, intermediate jaws and busbars), or on heated workpieces.

Depending on the local conditions, a sound pressure level higher than 85 dB(A) may occur that may lead to deafness. With such sound levels, the operating personnel are instructed to wear hearing protection.

When processing heavy pieces of metal, safety shoes must be worn.

The coolant is pressurized. Before changing the filter, switch off the pump.

Before working on the maintenance unit of the compressed air, the main line must be closed and the system vented.

The installation of the system is carried out by specialist personnel that have been instructed in an EMC compliant installation. The manufacturer's declaration is available for the supplier parts.

The customer is responsible for safety on the construction site. Personnel appointed on the construction site by EMA Indutec must be provided with a safety instruction by the customer.

Product Safety

There is a risk of injury from fluids escaping under pressure (cooling water, quenchant). System sections and pressure lines to be opened must be depressurized before commencing repair work.

Prescribed maintenance and service work must be carried out according to schedule.
Before starting the servicing, adjusting, repair and maintenance work, the operating personnel must be informed. After finishing the servicing work, check the function of all safety equipment.

There is a risk of intoxication from eating and drinking at the work place. Eating and drinking is therefore forbidden at the work place.
The quenchant and the demineralised water must not be consumed or used for physical cleaning.
The safety data sheet and the directions for using the quenching concentration must be observed.

There is a risk of slipping from the quenchant or oil (e.g. lubricants) in the work area of the system. Walking areas must be secured, e.g. by non-slip flooring covers. Quenchant or oil on the floor must be rectified immediately. Binding agent, collecting vessels and extraction devices must always be ready for use.

Mechanical components with safety-orientated functions must be replaced as soon as the number of their actuations has exceeded the specified limit.

Systems from EMA Indutec have been designed and built in such a manner that all fire risks are avoided that could originate from the machine itself or from gases, fluids, dust, vapours and other substance released from or used by the machine. Due to the heat on the inductor and on the workpiece being processed generated due to the process, when used for its intended purpose, there is no risk of fire in the processing room of the system. As all eventualities, misconduct and fire hazards in the vicinity of the system cannot be foreseen, we recommend that fire fighting measures are taken (fire extinguisher, fire blanket, water hose, etc.). Moreover, we recommend in training the operator about fire prevention and fighting. Despite the use of personal protective equipment, in event of a concatenation of unfortunate procedures, injuries may be caused to the operator or other persons in the area of the system. For this purpose, all persons working on the system must be informed about first aid measures. Moreover, all persons that have sustained injuries must then seek professional medical treatment.

Only personnel with respective training and experience as qualified electrician according to DIN VDE 0105 Part 1 (Operation of Power Installations) may work on electrical equipment. These specialist personnel must be familiar with all safety instructions and measures that are listed in the operating instructions for transporting, installation, operation, maintenance, cleaning and disassembly of the system.
The housing and switch cabinets to be opened must be switched to zero potential before commencing service, maintenance, cleaning or repair work, and secured against being switched back on. The residual voltage must also be checked.

Environment Protection

The operating company must ensure for a responsible disposal and recycling of the waste products. When disposing, ensure for a clear separation.

Consumed quenchant, hydraulic oil, lubricant, cleaning agent residues and materials, sinter waste as well as filter and filter residues must be intermediately stored in a correct manner, and disposed of by an approved waste disposal company.

The relevant regulations for scrapping waste or special waste disposal apply for the disposal of cleaning agents, lubricants and refrigerants, electric components, cables, etc. as well as mechanical components.

The disassembly of the system must be carried out by trained professional personnel with respect to any mechanical or electric hazards. This also applies to the disassembly and reassembly in another room.

The operating company must ensure that in case of being scrapped, that all components of the system are disposed of correctly. The national guidelines must be observed for this purpose.

After draining, the use or removal of cleaning agents, lubricants and refrigerants, the contaminated location must be cleaned. Where applicable, the danger area must be identified accordingly by a sign “Attention, risk of slipping”.

Especially during installation, repair or maintenance work, substances hazardous to water such as lubricating grease and oils, hydraulic oil, emulsions and fluids containing solvents should not burden or escape into the ground or the sewage system. The substance must be stored, transported, collected and disposed of in suitable containers.

Oil and waste containing oil as well as lubricating grease represent a high hazard potential for the environment. This is why their disposal is carried out by specialist companies.

Different metals must be separated and disposed of. The disposal must be carried out by an authorised company.

Devices with this symbol on the packing or on the device must be separated and must not be disposed of in normal domestic waste.

When removing from the annealing system, the workpiece is coated with quenchant due to the quenching process. Recesses or drilled holes on the workpiece may be filled with quenchant. As a result, there is a discharge of quenchant from the machine. Measures for the reduction of the discharge must be discussed especially between the customer and EMA Indutec.

Workpiece Examination

The following work must be carried out in this order when examining workpieces in a metallographic laboratory:

1. Separation with an angle grinder with water cooler, to avoid heating of the sample.

2. Manual pre-grinding of the cut sample with a band saw with water cooling to avoid heating of the sample.

3. Embedding (semi-automatic) in artificial resin with an embedding press for better handling of the samples in steps 4 to 7. A manual embedding without press is also possible. In this case, one has to also consider the hardening time.

4. Grinding and polishing (manually or semi-automatically) in several stages with a grinding and polishing disc with grain becoming even more fine.

5. Etching the sample in order to increase the contrast of the structure constituents for microscopic examinations. Etching agent: nitric acid, picric acid, V2A pickling or copper ammonium chloride. Dilution is carried out using alcohol or glycerine in order to prevent intensive etching.

6. Hardening test in accordance with Vickers or Rockwell
With the hardening test in accordance with Vickers, the tip of a four-sided pyramid made of diamonds is pressed into the sample with a testing force and the diagonals of the pyramid imprint generated is measured.

A hardening test in accordance with Rockwell comprises four work steps: first a test body is pressed into the sample with a testing force and then the dial gauge is set to 0. Then the actual testing force is applied and removed again after a short period. The penetration depth of the test body remaining in the sample is read from a dial gauge directly as Rockwell hardness.

7. Microscopy with an incident light microscope with 50 to 1,000-fold magnification; a PC connection with camera and suitable software permit the precise evaluation.

Important:

On-site, the customer requires a laboratory that they can use to already evaluate components when running in the machine and for the final approval.
The laboratory needs an extraction and a poison cabinet as well as personal protective equipment safety glasses, protective gloves as well as eye rinsing bottle.
All chemicals must be labelled and marked correctly and completely.

Personnel Requirement and their Qualification

For the safe operation of an induction heating systems, employees with different qualifications are required:

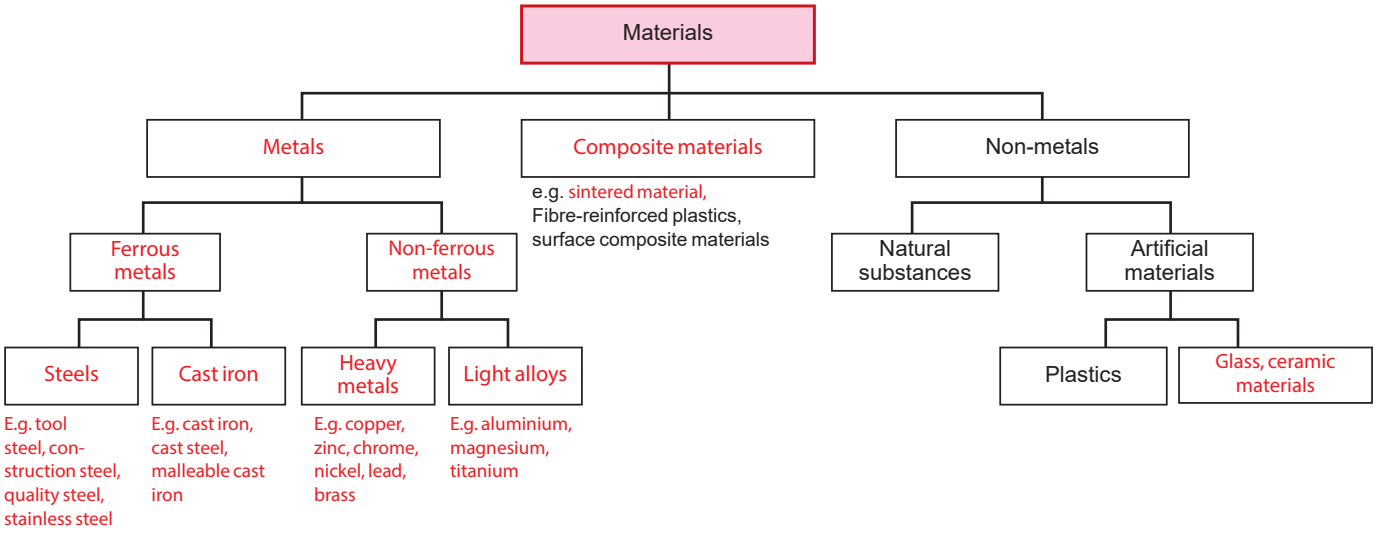
- Several trained operators with experience in metalworking and induction heating as well as knowledge in CNC programming (amount depends on the number of shifts),
- Maintenance and installation persons with respective education and experience as qualified electrician,
- If required, a member of staff trained in inductor construction; complicated inductors should be purchased from EMA Indutec in all cases,
- Material tester or laboratory technician with metallurgical knowledge for the laboratory.

Training Courses

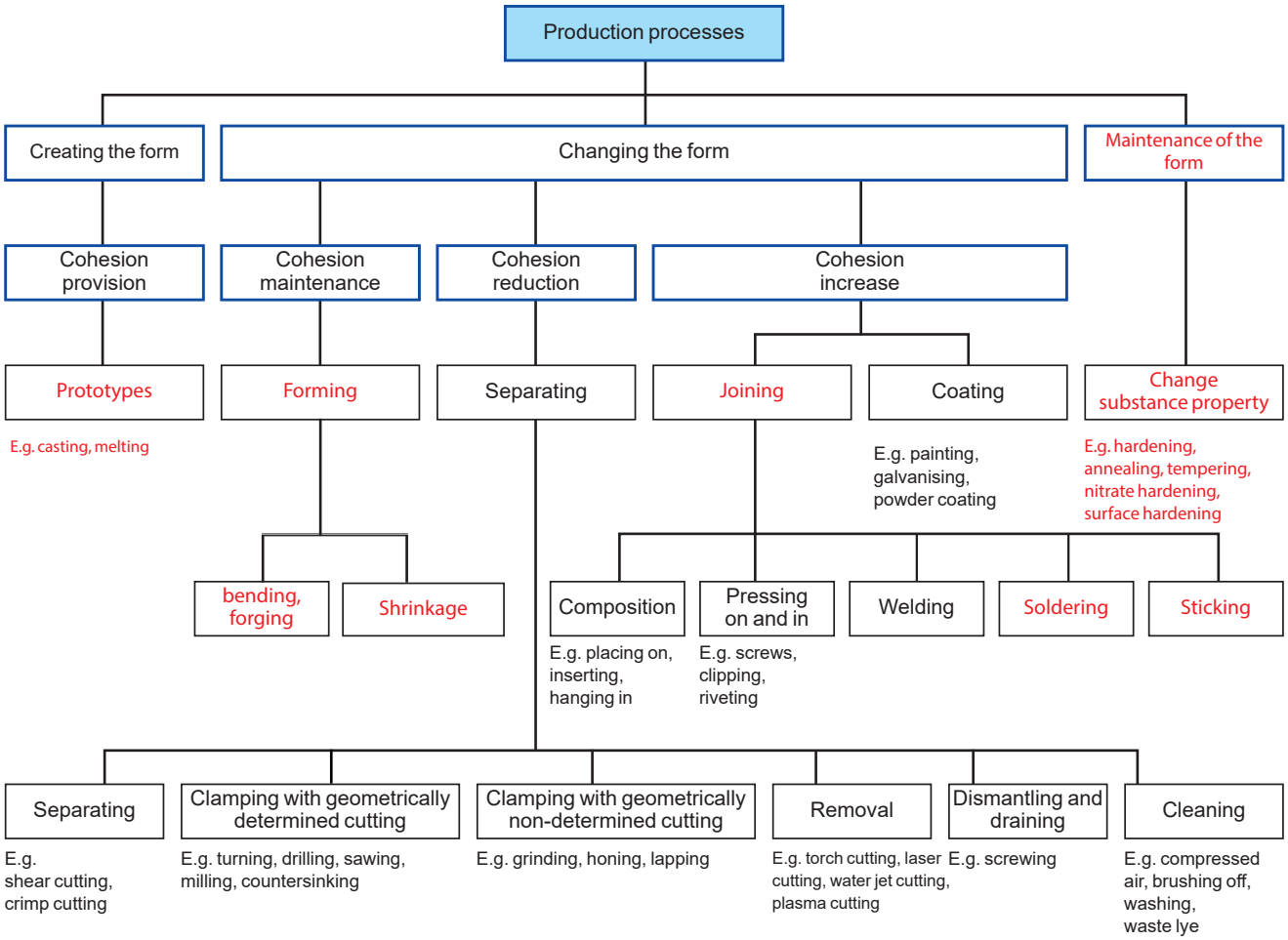
The following customer training courses are offered by EMA Indutec:

- Fundamentals of induction technology,
- Converter technology,
- Fundamentals of inductor manufacturing,
- Training for persons operating,
- Training for persons setting up,
- Training for maintenance and service personnel.

Overview of Materials and Production Processes



Red text: materials that can be treated using EMA Indutec products.



Red text: production processes in which inductive heating is used with EMA systems.

After Sales Service

In order to anticipate the desires of their customers, EMA Indutec hasextended the range of products of their services significantly. Contactless analysis, examinations using a thermal image camera or a machines data analysis via remote service offer the possibility to detect creeping defects and changes to the system in time and to eliminate them in a preventive manner. Moreover, a call service for spare parts and precision tools will be provided.
By proactive maintenance, the service life and operational safety of the EMA range of system products is increased significantly.
In event of machine downtime and for clarifying technical queries, EMA Indutec can be contacted via the service hotline.
If induction heating systems have to be modernised in partial sections or completely, EMA-Retrofit is the right choice. With qualified specialist personnel from all specialist departments, we can take over the revision or modernisation of older induction heating systems.
In addition, EMA Indutec offers a remote service, extremely short response times and the matching training program to allow customers to be able to make the greatest possible use of their systems.

Contact

Contact us if you have any questions or technical problems. Through our telephone consultation and teleservice, you will benefit from the expert knowledge of our qualified specialists when it comes to troubleshooting and fault diagnosis. We will help you to eliminate errors in a targeted manner and as quickly as possible.

Tel.: +49 6226 788 111
Fax: +49 6226 788 112
E-mail: service@ema-indutec.com

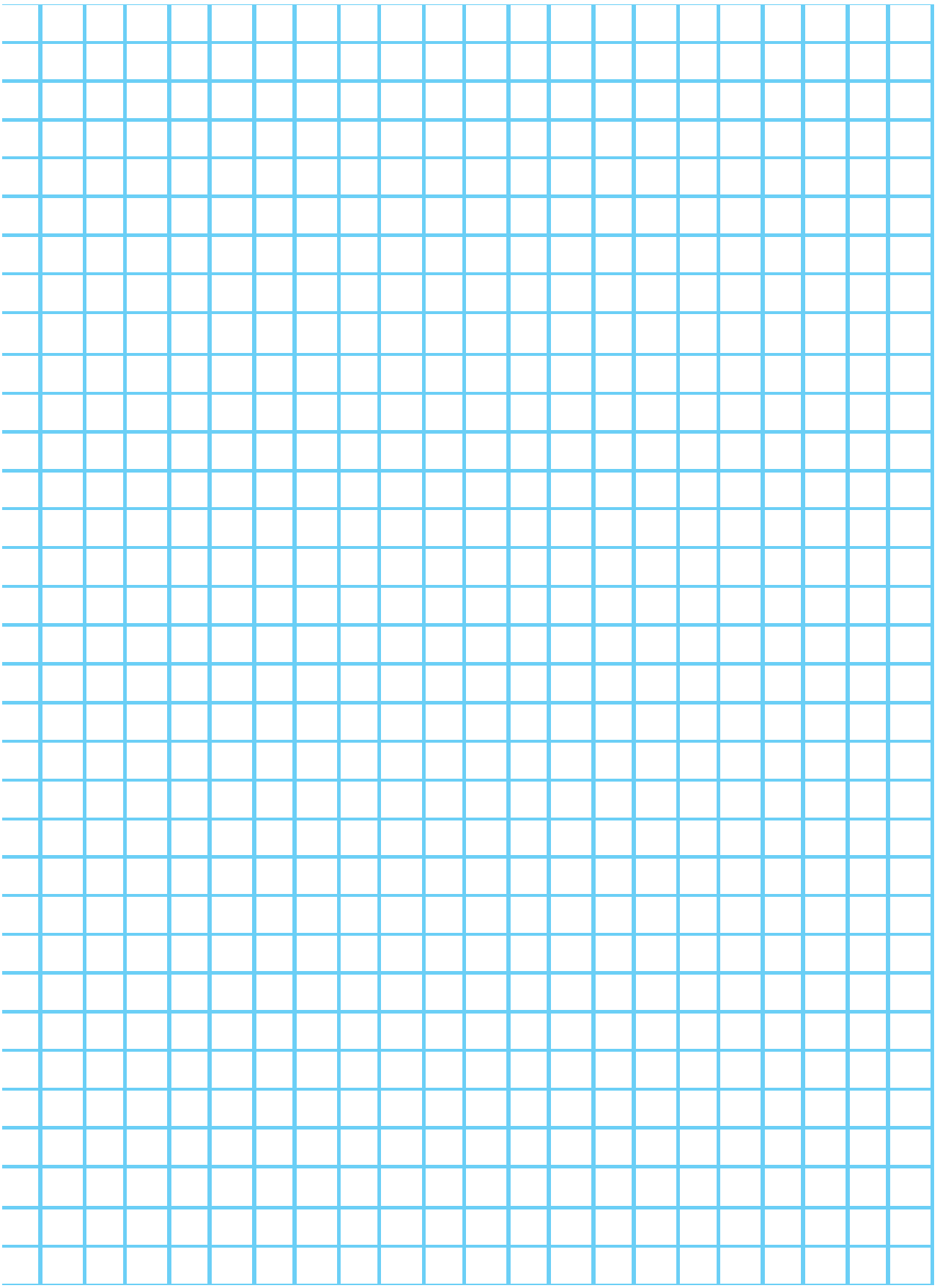
Our service hours:

Monday to Thursday: 8 am to 16 pm
Friday: 8 am to 12 pm

Additional times of standby service:

Monday to Thursday: 16 pm to 20 pm
Friday: 12 pm to 20 pm
Saturday: 8 am to 12 pm

Notes



Ideal Solutions for Heat Treatment

Induction heating and hardening systems

- Economical and highly reliable systems
- Low energy consumption per workpiece
- Accurately reproducible hardening results
- High throughputs
- Heating zones and times can be determined precisely
- Heat treatment processes with low distortion
- Scale-free hardness zones due to heat treatment with protective gas
- Simple to integrate into production lines
- Lower expenses for production parts
- Tailor-made induction systems from a single source
- User-friendly adjustment, retrofitting and maintenance
- Modern engineering supported by FEM simulation
- Areas of application: surface hardening, annealing and tempering, heat shrinking, fixture hardening

IGBT converters

- Digital converter control
- Power range from 10 kW up to several Megawatt
- Frequencies from 5 Hz to 400 kHz
- Heating and melting
- Hardening, annealing and tempering
- Forging and forming
- High energy efficiency
- Easy integration into production lines
- Customized solutions and special systems
- Replacement of old and external devices

After Sales Service

- Qualified and knowledgeable Service Centre
- Service hotline for troubleshooting
- Preventive maintenance
- Smart remote control solutions
- Efficient spare part concepts
- Customized plant-retrofit
- Inductor development, construction and repair service
- Training for operators, maintenance personnel and induction experts (also on site)

Top quality from one source

- More than 80 years of experience in heat treatment
- Over 10,000 induction systems in long-term operation worldwide
- Development and manufacture from a single source
- DIN EN ISO 9001:2015 certified
- Efficient project and quality management from the first question to subsequent service

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