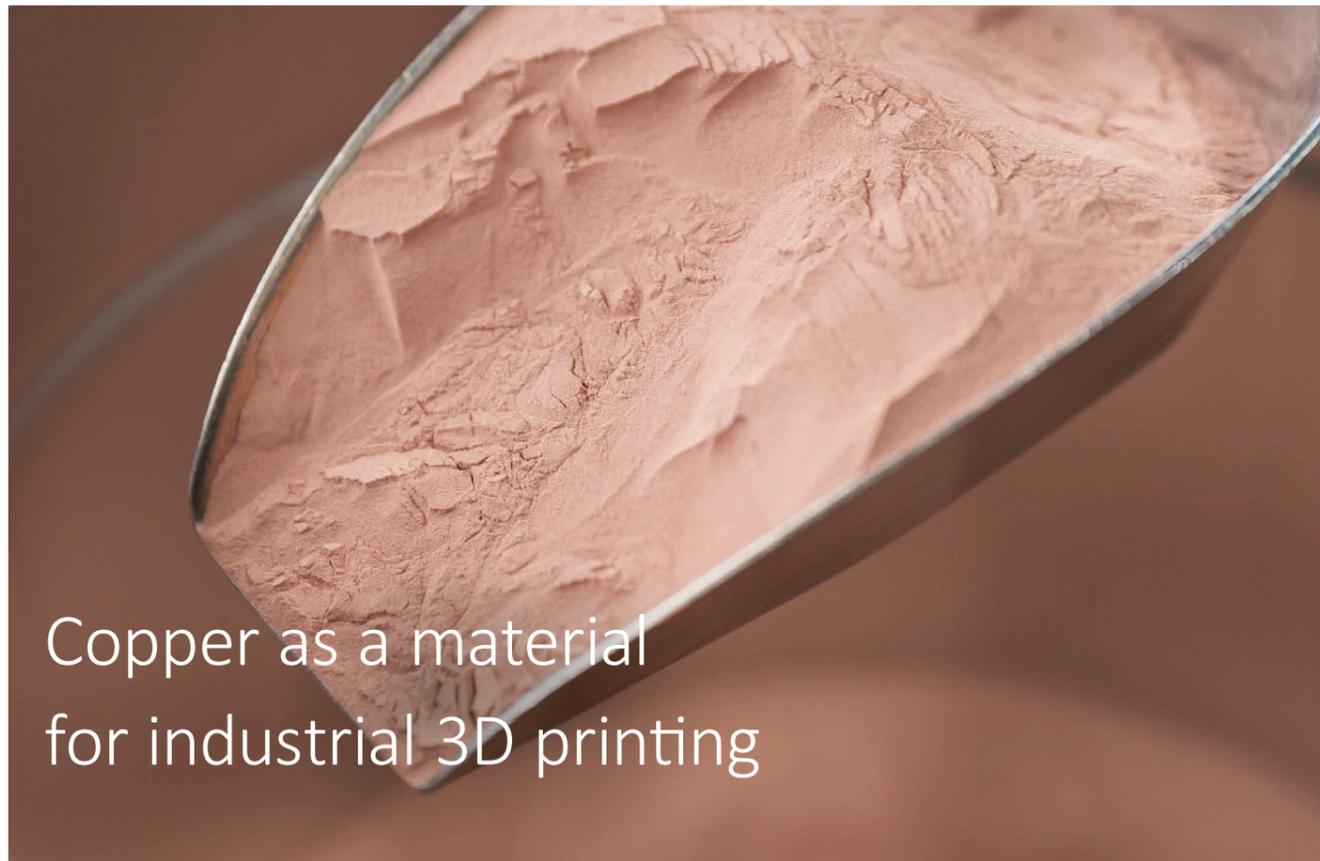


Copper inductors from 3D printing

- Shorter cycle times
- Economical production of customized geometries
- Precision implementation true to your data





Copper as a material for industrial 3D printing

More than 10,000 years ago copper was one of the earliest metals to be worked by humans. In industry today it is still a widely-used metallic material. Thanks to its outstanding electrical conductivity, copper is used in the production of inductors for the partial hardening of components. These are traditionally manually shaped by means of bending and soldering. It is important here to ensure that the inductor fits closely to the workpiece to be hardened.

In 3D printing, copper inductors are produced directly from CAD drawings, without the need for additional tools. The result is highly conductive, durable products that match the specified dimensions exactly – a precision that can scarcely be achieved by conventional methods. Thanks to additive manufacturing even complex, customized geometries can be realized within a few days.

Copper – the challenge for additive manufacturing

PROTIQ manufactures inductors by an additive process using selective laser melting. Since copper reflects a high proportion of the rays of conventional laser melting equipment, it is common to use alloys with a relatively low copper content. Yet the conductivity of such combinations is significantly lower.

In 2011 PROTIQ succeeded in developing a unique process in which highly-conductive copper can be processed additively. This has made us one of the first 3D printing providers to be able to produce copper inductors of the highest industrial quality.

High-conductivity copper for 3D printing

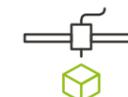
	Pure copper content	Density	Elongation at break	Tensile strength	Electric conductivity
RS-CU	99 %	8,82 g/cm ³	20 ± 5 %	238 ± 15 MPa	up to 50 MS/m
CU	100 %	8,9 g/cm ³	50 ± 10 %	220 ± 10 MPa	up to 58 MS/m

How 3D printing works with PROTIQ



You configure your 3D object

Upload your own CAD file and design your 3D model as per your requirements. The cost is displayed directly online.



We print your 3D model

As soon as your order is received the production job is automatically forwarded to PROTIQ.



You receive your product

Manufacture of your 3D object can begin as soon as we receive your order, so that your product is ready for delivery as soon as possible.

Advantages of additively manufactured copper inductors

For the hardening of different shapes of component, induction hardening requires inductors that fit that shape exactly. Up to now these have been mostly hand-made in a highly time-consuming process. Today PROTIQ can manufacture inductors to your specification quickly and cost-effectively by 3D printing.

✔ Economical production of customized geometries

Our online configurator allows you to design inductors to specific requirements in just a few clicks. Configuration is done using a modular principle and takes account of the specific requirements of industrial customers. Of course you may also use your own 3D files.

✔ Precision implementation true to your data

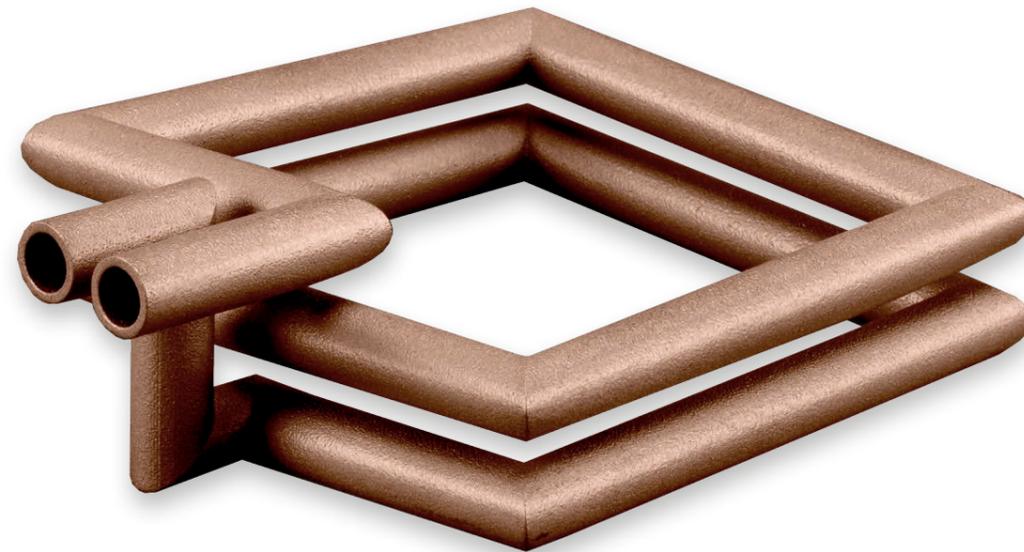
Thanks to the entirely digital business process at PROTIQ you benefit from 100% data consistency along with the highest manufacturing precision and reliability.

✔ Longer service life

Since the stresses caused during heating are more uniform, inductors produced by additive manufacturing are longer lasting. You can therefore reduce ongoing costs for new acquisitions significantly.

✔ Short delivery times even with complex shapes

With 3D printing, complex shapes can be created without the need for special tools which have to be purchased or even produced in advance. As a result, production can begin as soon as the order is received. You then receive your inductor, ready for use, in a matter of a few working days.



Disadvantages of conventionally produced inductors

- Soldered joints cause interference in the current flow and give rise to high energy losses. The more complex the inductor shape, the more joints are required.
- Manual production restricts the possibilities for shaping. Complex geometries cannot be achieved by means of manual bending and soldering.
- The slightest deviation from the required shape results in high setup times for the user. Setting up a new inductor can take several weeks.
- The quality of manually produced work cannot be reproduced one-to-one. As a result, the service life of two inductors of identical shape can vary greatly.
- The manufacture of inductors by hand is highly demanding and thus intensive in terms of both time and costs.

✔ Reproducible quality

Our quality management system is inspected and certified according to ISO 9001. Standardized processes guarantee consistently high quality for your copper inductors.

✔ Better control of the induction process

Since the inductor is matched optimally and uniformly to the workpiece, the heat spreads more evenly through the material and less energy is required. As a result, the hardened components are tougher and longer-lasting.

✔ Shorter cycle times

Thermal output is improved thanks to optimal shaping, which in turn enables cycle times for tool production to be effectively reduced.

✔ No soldered joints

3D-printed copper inductors are produced "from a single mold" and feature a highly uniform surface. As a result, they require considerably less energy than conventionally produced inductors for a comparable output.

Induction hardening in industry

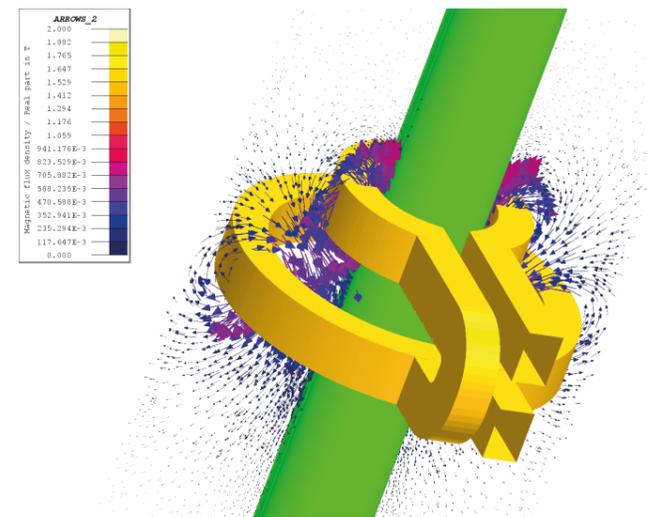
Induction hardening is a widespread technique in the metal working industry. The process is particularly suitable for hardening components that are subjected to

the highest levels of stress and is used, for example, in toolmaking or in the production of gearboxes, camshafts or gear wheels.

Induction heating creates a part with exceptional surface hardness and a high case hardness depth (CHD), giving the workpiece outstanding toughness.

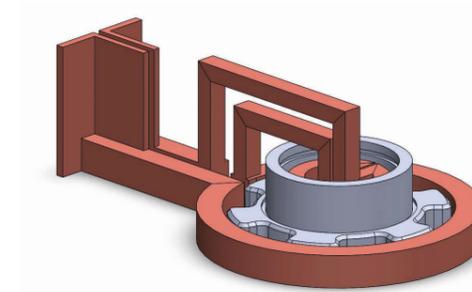
In induction hardening only specific areas of a component are hardened. It is therefore also common to speak of “partial hardening”. Since heat is only produced in the areas of the workpiece in which the electromagnetic eddy currents are induced, the precision of shape of the inductor is an important quality factor.

With PROTIQ you can have copper inductors manufactured in special shapes for unusual applications. Thanks to its vast specialist knowledge in the field of simulation-based magnetic field design, the PROTIQ team is your partner for optimizing your existing induction processes. Using magnetic field simulations we can determine the ideal basic shape for your inductors. In this way the efficiency of inductive heating can be greatly improved.



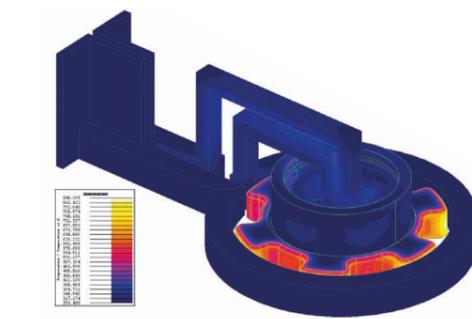
The simulation of the magnetic field indicates the points at which the electromagnetic flux enters the component.

Optimized inductors from PROTIQ



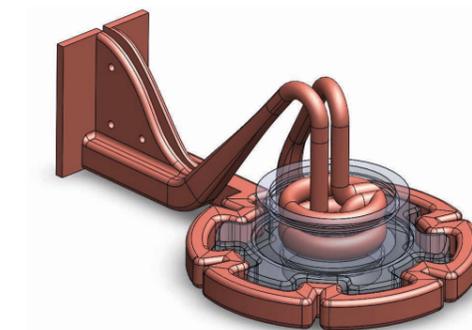
Step 1:

Analysis of conventional inductor geometry. The shape of the copper conductors is a function of the maximum diameter of the workpiece to be hardened. A circular inductor profile would not be able to reach the recesses in the component.



Step 2:

Simulation of heat distribution during the induction process. The variable air gap between the component and inductor results in differences in the heating pattern, which can have a negative effect on the hardening process.



Step 3:

Design of the optimized geometry. The shape of the copper conductor is matched to the contour of the component to be hardened. This achieves uniform temperature conditions over the entire component surface.



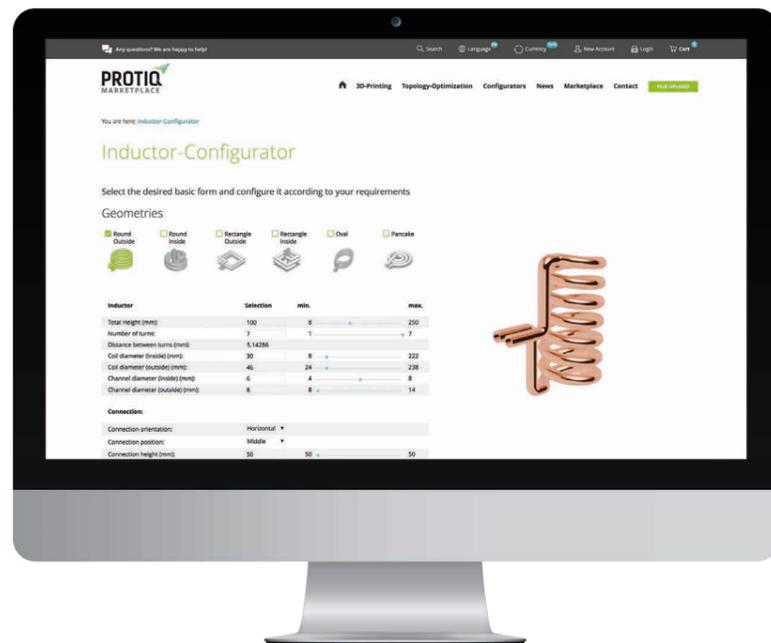
Step 4:

The final inductor is made using 3D printing with selective laser melting in high-conductivity copper. Thanks to the optimized geometry, the induction process can now be performed with even greater precision. The result: higher and more consistent component quality with fewer rejects and faster cycle times.

The PROTIQ inductor configurator

In combination with tool-less 3D printing, our inductor configurator significantly shortens the lengthy process of inductor manufacturing. You select the best base geometry from one of six basic shapes. A modular system

then lets you adapt this to your requirements in just a few clicks. You receive your inductor, ready for use, in just a few days after we receive your order, since production by industrial 3D printing can start straight away!



Advantages of the inductor configurator

- ✓ Custom design options
- ✓ Intuitive to use
- ✓ Guaranteed printability of 3D models
- ✓ Economical thanks to modular principle and tool-less manufacture
- ✓ Real-time price calculation
- ✓ Compliant with all EU data protection legislation

Configuring copper inductors online

Create application-specific inductors in four simple steps:



Step 1: Select basic shape

Select the best geometry for your requirements from six standard shapes for inner-field and outer-field inductors.



Step 2: Configure inductor

Define your preferred dimensions on the basis of height, cross-section, and diameter. Also specify the number of turns and the diameters and spacings of coils and channels.



Step 3: Define connector element

As an option you can provide a mounting for each inductor. For that purpose you can customize the dimensions of the base plate.



Step 4: Complete ordering process

The price of your inductor configuration is automatically calculated for you online. Choose one of the many convenient online payment methods and use our worldwide delivery service.

▶ Test our configurator: www.protiq.com/en/inductor-configurator

Quality assurance test procedures

Industry demands the highest standards of quality. To ensure that you can always rely on the quality of your copper inductors, we offer you an individual quality

assurance service. We will be happy to determine the following parameters before and during serial additive manufacturing:

- ✔ Component density (impermeable sintered metal materials and carbides) using the Archimedean method based on DIN EN ISO 3369
- ✔ Component hardness using the Vickers method based on DIN EN ISO 6507 and the Shore hardness method based on DIN EN ISO 868
- ✔ Static strength parameters using the tensile test method based on DIN EN ISO 6892 and DIN EN ISO 527
- ✔ Surface roughness using the profilometer method based on DIN EN ISO 4287
- ✔ Dimensional accuracy using computer tomography and stripe light projection
- ✔ Microstructure and micrographs using metallographic analysis
- ✔ Pressure testing with compressed air up to 6 bar
- ✔ Conductivity testing using eddy current testing



Contacting PROTIQ

PROTIQ is your competent partner for professional 3D printing. On the basis of our extensive experience with industry customers we have digitalized the entire order process on our platform and tailored it to the needs of companies.

Personal contact with our customers nevertheless remains very important to us. Whether you have a question about your product, our manufacturing process or how our online configurator works, we will be happy to assist you with your project.

Contact us:

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