

MANUFACTURING INDUCTION COILS WITH 3D PRINTING

Faster, more cost-effective and optimally designed as well

(A technical article from 2021, author: Max Wissing, Technology Manager, Protiq GmbH, Blomberg)

The conventional development of complex inductive heating processes requires not only a great deal of time but also expensive trials. Protiq GmbH shows that there is another way. The production of induction coils using 3D printing significantly reduces the development effort. Computer-aided simulations also contribute to this.



3D printing – also known as additive manufacturing – has been driving a wide range of innovations in numerous sectors of industrial production for years. Thanks to fast manufacturing based on the available CAD data, components can be produced within a few hours to a few days. There is therefore no need to laboriously produce expensive tooling or to go through lengthy manual manufacturing processes. Users thus benefit from the advantages of 3D printing particularly in the development phase of a new product. Prototypes produced additively overnight enable early testing, saving time and money in the process.

Protiq GmbH uses the resulting possibilities, among other things, to produce new, innovative coils that are used in induction heating. If computer-aided simulation processes are also used in product development, the components can additionally be designed in the best possible way while at the same time reducing the number of costly trials required in advance.

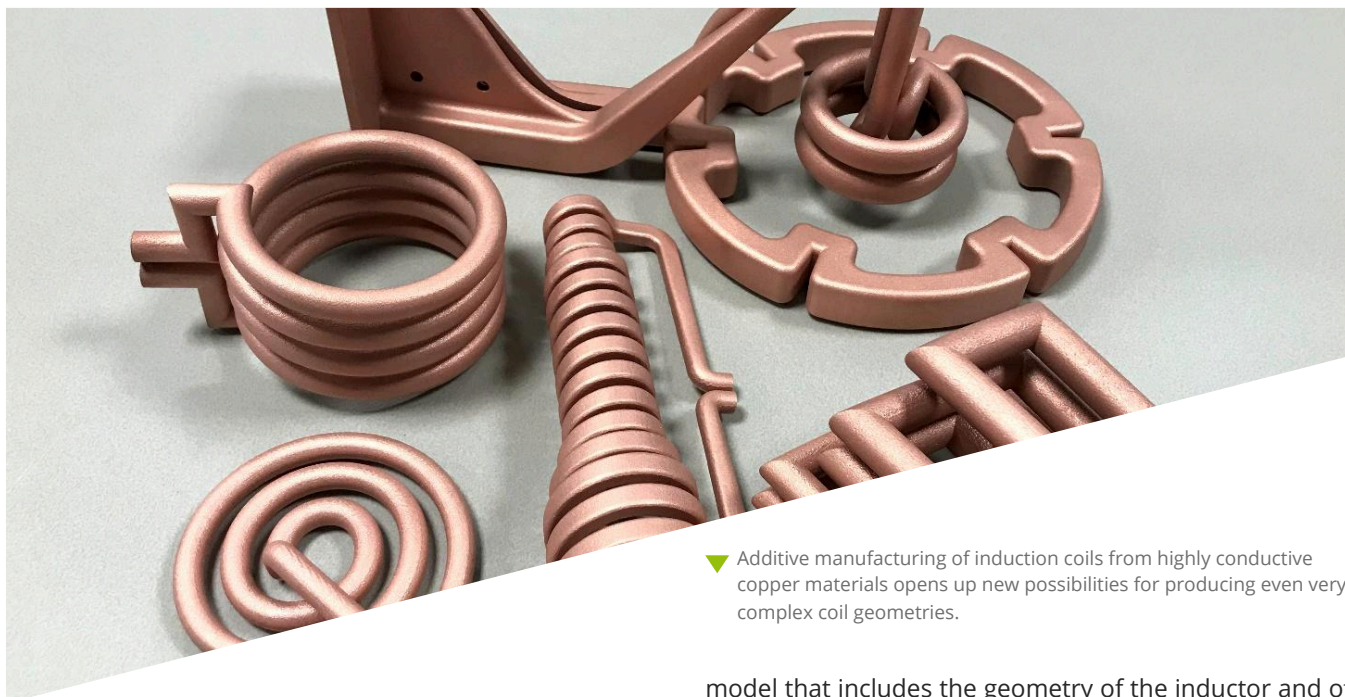
High demands on dimensional accuracy

In induction heating, the so-called inductor generates an alternating magnetic field, which induces an electric current in the component and heats the material through Joule heating. This effective and highly reproducible process has become the industrial standard above all

▼ Additive manufacturing of induction coils from highly conductive copper materials opens up new possibilities for producing even more complex coil geometries; the optimized inductors can be determined using numerical simulation methods

for the surface hardening of mechanically highly stressed components – such as gears or transmission components. Because of the high currents flowing through them, the coils are made of copper, which has good electrical conductivity. At the same time, the inductor must meet high demands on dimensional accuracy, as the coil geometry directly affects the quality of the heating.

Conventionally, inductors are produced by manually bending and brazing hollow profiles. To design the right coil shape and process parameters, iterative testing is required and real heating trials have to be carried out. This results in high costs and long development times, as the design process requires the production of several inductor variants as well as iterative changes to the coil shape. In addition, minimum bending radii and the selected profile shape restrict design freedom, so that the full potential of the inductor often cannot be exploited.



▼ Additive manufacturing of induction coils from highly conductive copper materials opens up new possibilities for producing even very complex coil geometries.

Additive manufacturing from RS copper and pure copper

Because ProtIQ manufactures the inductors additively, the disadvantages of manual production can be overcome. As a pioneer in the field of 3D-printed coils, the company has been offering additive manufacturing from materials including RS copper and pure copper for several years. RS copper is an alloy with a copper content of 99 percent that achieves an electrical conductivity of 52 MS/m. The pure copper processed contains no other alloying elements and corresponds to the industrial standard material Cu-ETP, which is characterized by an electrical conductivity of 58 MS/m or 100 percent IACS (International Annealed Copper Standard).

Compared with the manual bending process, the automated production process offers better repeatability and higher accuracy. In addition, ProtIQ provides users with the 3D-printed inductors not only much faster, but also more cost-effectively.

The previous delivery time of several weeks for a complex coil geometry is reduced to a few days.

Deeper analysis of process behavior

Using computer-aided numerical simulation reduces the number of expensive tests and the amount of valuable development time. The CENOS Induction Heating program can be used for this purpose. In CENOS, the inductive heating process is represented in a simulation

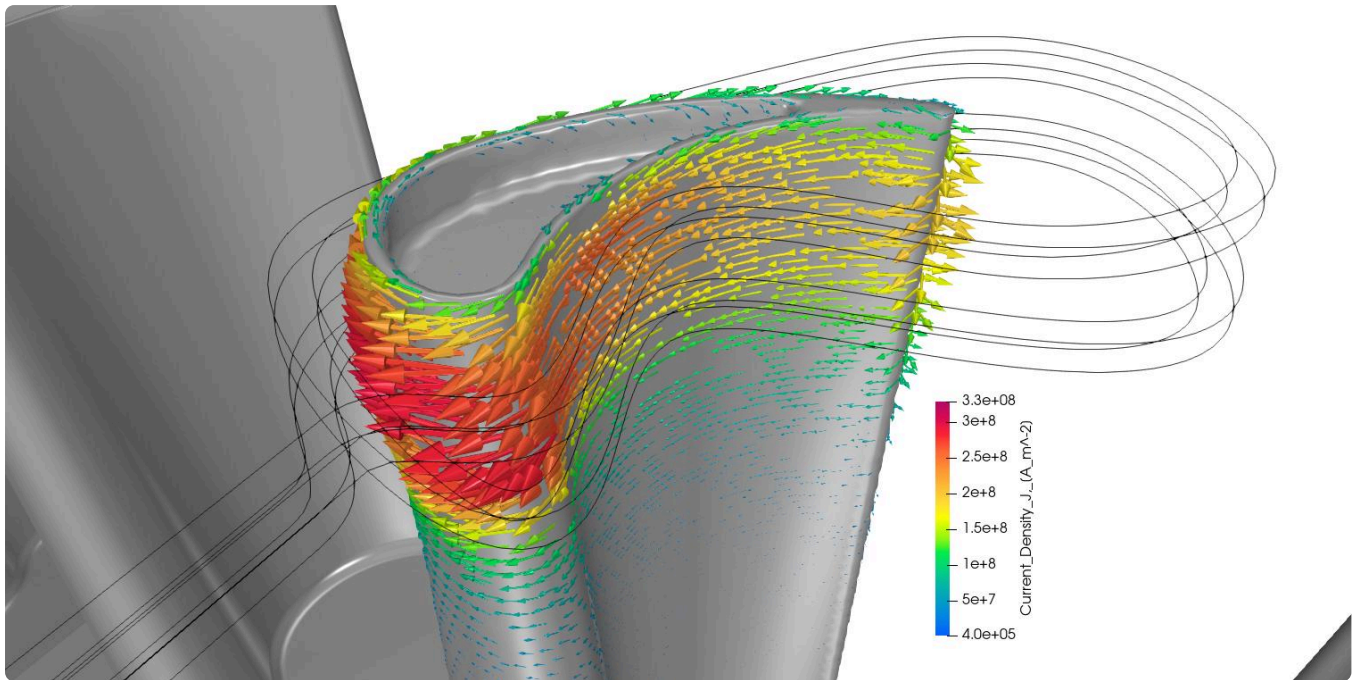
model that includes the geometry of the inductor and of the component to be heated as well as information on the prevailing boundary conditions and process parameters. On this basis, the thermal heating behavior of the component and the electromagnetic properties of the coil can be investigated.

Changes to the process parameters or to the coil and component geometry can thus be analyzed quickly and easily. Real heating trials and the production of different test coils, which were previously necessary, can be reduced to a minimum in this way. This saves time and money.

The simulation results obtained also allow a considerably deeper investigation of the process behavior than real heating trials can offer. For example, the heating can also be observed inside the component, or the magnetic field as it builds up can be visualized. This makes it possible to evaluate and improve new and existing inductors and to design the parameters for new heating tasks. In addition, 3D printing opens up considerably greater design freedom, as no minimum bending radii or predefined cross-sections have to be taken into account. This allows new, innovative inductor geometries with optimized magnetic field guidance and improved process properties to be developed.

Faster and more precise heating behavior

The inductors designed with CENOS in the manner described and additively manufactured from copper impress in operation with faster and more precise heating behavior. As a result, more accurate hardening pat-

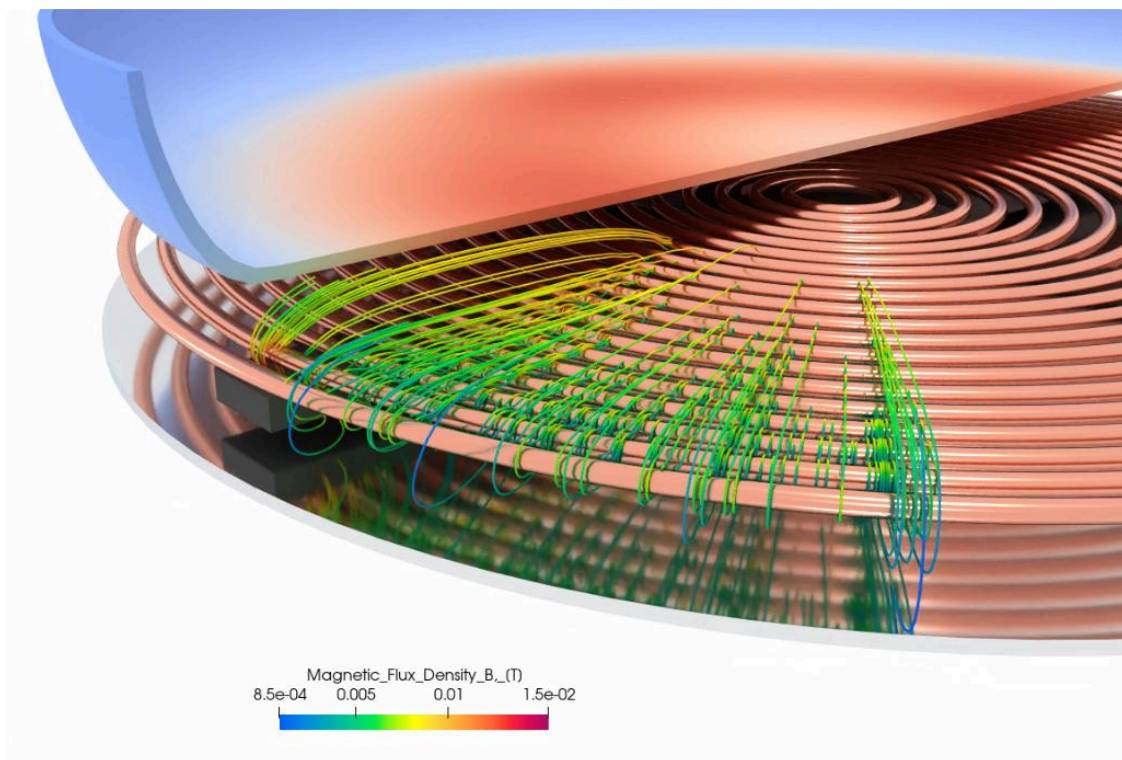


▼ Heating a turbine blade: Numerical simulation of the inductive heating process and the magnetic field makes it possible to avoid expensive trials; the simulation results enable a detailed analysis of the electromagnetic behavior. (Source: CENOS)

terms can be achieved on the component and even cycle times in series production can be reduced.

Further information:

www.protiq.com



▼ Design of an induction cooktop: The coils optimized by simulation enable more precise heating and reduced cycle times. (Source: CENOS)

Innovative use in electric motors

The process developed by Protiq for processing pure copper in selective laser melting also opens up new possibilities in other technical fields. The good electrical conductivities of up to 58 MS/m or 100 percent IACS allow it to be used in innovative motors. Based on additive manufacturing, prototypes of complex hairpin windings, for example, can be produced within a few days so that rapid functional tests can be carried out. Furthermore, the degrees of freedom of 3D printing make it possible to achieve higher packing densities and greater drive power in a small space.

One example of this is the use of novel lamination stacks that can be taken directly from the 3D printer.

