Production of induction coils using 3D printing

Faster, more cost-effective and also optimally designed

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

The conventional development of complex inductive heating processes not only requires a lot of time, but also expensive trials.

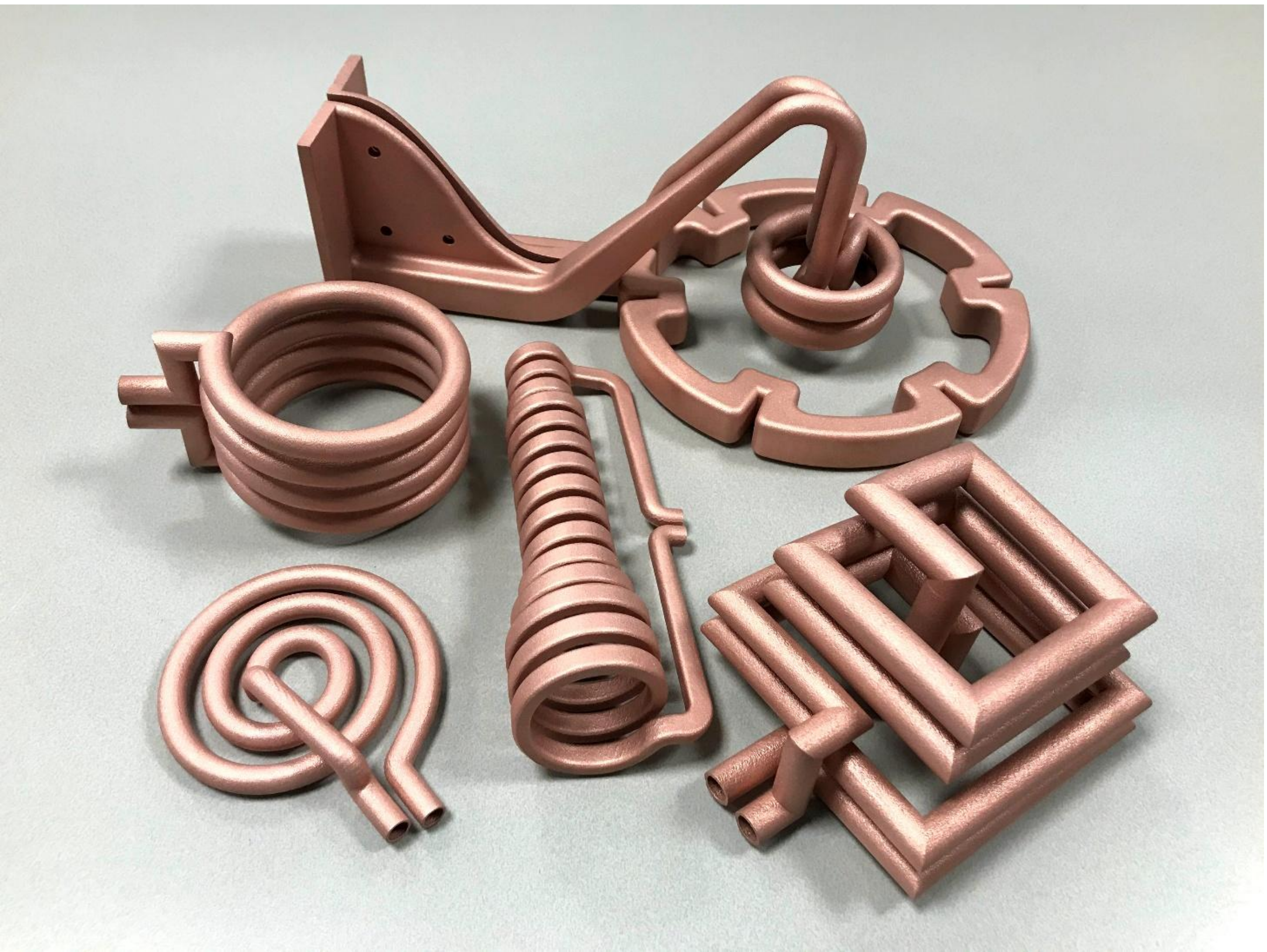
Protiq GmbH shows that things can be done differently.

Computer-aided simulations and the production of induction coils using 3D printing can significantly reduce development costs.

Additive manufacturing of induction coils made from highly conductive copper materials offers new possibilities, to produce even more complex coil geometries; the optimized inductors are determined at Protiq using numerical simulation methods.

Protiq GmbH | Flachsmarktstraße 54 | 32825 Blomberg | Tel.: +49 (0) 5235 3 – 43800 E-Mail: info@protiq.com

3D printing - also known as additive manufacturing - has been driving innovation in numerous sectors of industrial production for years. Thanks to rapid production based on the CAD data available, components can be manufactured within a few hours to a few days. This means there is no need to produce expensive tools or go through lengthy manual manufacturing processes. Users benefit from the advantages of 3D printing, particularly in the development phase of a new product. Overnight additive manufacturing of prototypes enables early testing and thus saves time and money. If computer-aided simulation processes are also used during product development, the components can also be designed in the best possible way and the number of costly tests required in advance can be reduced at the same time.
Protiq GmbH uses the resulting opportunities to design and produce new, innovative coils for use in induction heating, among other things.



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

High demands on dimensional accuracy

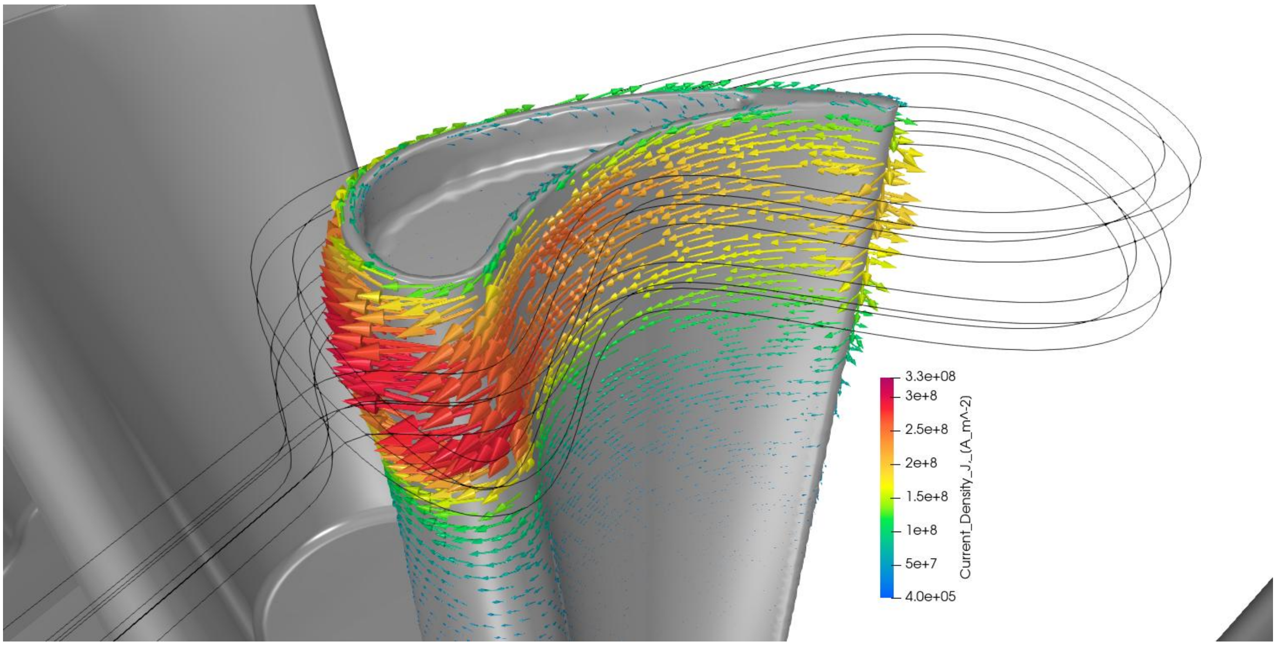
In induction heating, the so-called inductor generates an alternating magnetic field, which induces an electric current in the component and heats the material through Joule heating. This effective and easily reproducible process has become the industrial standard, particularly for the surface hardening of components subject to high mechanical stress, such as gear wheels or gear components. The coils are made of electrically conductive copper due to the high flowing currents. At the same time, the inductor must meet high requirements in terms of dimensional accuracy because the coil geometry directly influences the quality of heating.

Conventionally, inductors are manufactured by manually bending and soldering hollow profiles. In order to design the correct coil shape and process parameters, iterative testing and real heating tests must be carried out. This results in high costs and long development times, as the design process requires the production of several inductor variants and iterative changes to the coil shape. In addition, minimum bending radii and the selected profile shape restrict the design freedom, meaning that the full potential of the inductor can often not be exploited.

Additive manufacturing from RS copper and pure copper

By manufacturing the inductors additively at Protiq, the disadvantages of manual production can be overcome. As a pioneer in the field of 3D-printed coils, the company has already been offering additive manufacturing using materials such as RS copper and pure copper for several years. RS copper is an alloy with a copper content of 99 percent, which achieves an electrical conductivity of 52 MS/m. The processed pure copper contains no other alloy components 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 to the manual bending process, the automated production process is characterized by better repeatability and higher accuracy. In addition, Protiq not only provides the user with 3D printed inductors much faster, but also more cost-effectively. The previous delivery time of several weeks for a complex coil geometry is reduced to just a few days.



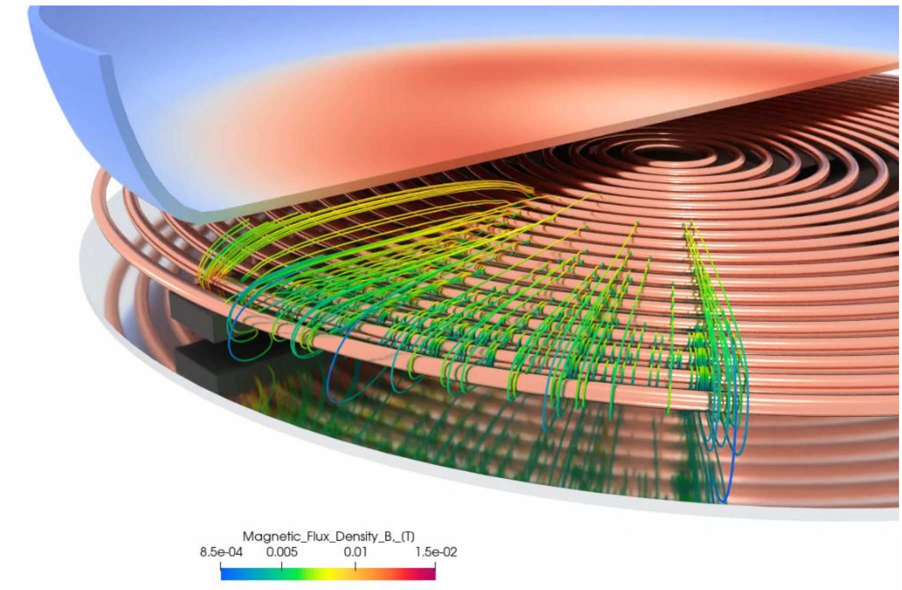
Heating of a turbine blade: Numerical simulation of the inductive heating process and the magnetic field makes it possible to avoid expensive tests; the simulation results allow a detailed analysis of the electromagnetic behavior. (Source CENOS)

In-depth analysis of the process behavior

By using computer-aided numerical simulation, the number of expensive tests and valuable development time can be reduced. The experts at Protiq use the CENOS Induction Heating program for this purpose. CENOS maps the induction heating process in a simulation model that includes both the geometry of the inductor and the component to be heated as well as information about the existing 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 the coil and component geometry can be analyzed quickly and easily. Previously required real heating tests and the production of different test coils can be reduced to a minimum in this way. This saves time and money.

The simulation results obtained by Protiq also enable a much deeper investigation of the process behavior than real heating tests can offer. For example, the heating can also be observed inside the component or the magnetic field that builds up can be visualized. This allows the evaluation and improvement of new and existing inductors as well as the design of parameters with regard to new heating tasks. In addition, 3D printing opens up much greater design freedom, as there are no minimum bending radii or specified cross-sections to consider. This makes it possible to develop new, innovative inductor geometries with optimized magnetic field guidance and improved process properties.



Design of an induction hob: The coils optimized by simulation allow for more precise heating and reduced cycle times. (Source CENOS)

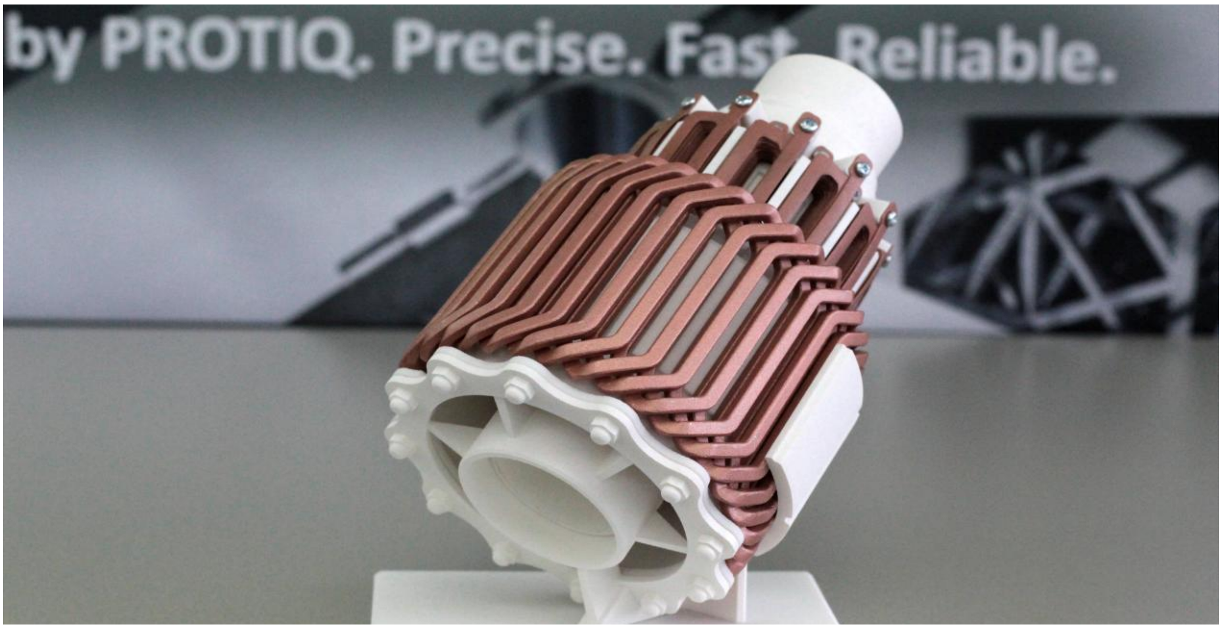
PROTIQ
A Phoenix Contact Company

Faster and more precise heating behavior

The inductors designed with CENOS as described above and additively manufactured from copper by Protiq impress during operation with their faster and more precise heating behavior. As a result, more precise hardness patterns can be set on the component and even cycle times in series production can be reduced.

Innovative use in electric motors

The process developed by Protiq for processing pure copper using selective laser melting also opens up new possibilities in other technical areas. The good electrical conductivities of up to 58 MS/s or 100 percent IACS allow it to be used in innovative motors for the expansion of e-mobility. Using additive manufacturing, prototypes of complex hairpin windings, for example, can be produced within a few days in order to carry out rapid functional tests. Furthermore, the degrees of freedom offered by 3D printing make it possible to implement higher packing densities and greater drive power in a small space.
One example of this is the use of new types of sheet metal packages that can be taken directly from the 3D printer.



Further information:

www.protiq.com

Protiq GmbH | Flachsmarktstraße 54 | 32825 Blomberg | Tel.: +49 (0) 5235 3 – 43800 E-Mail: info@protiq.com