# coolgap

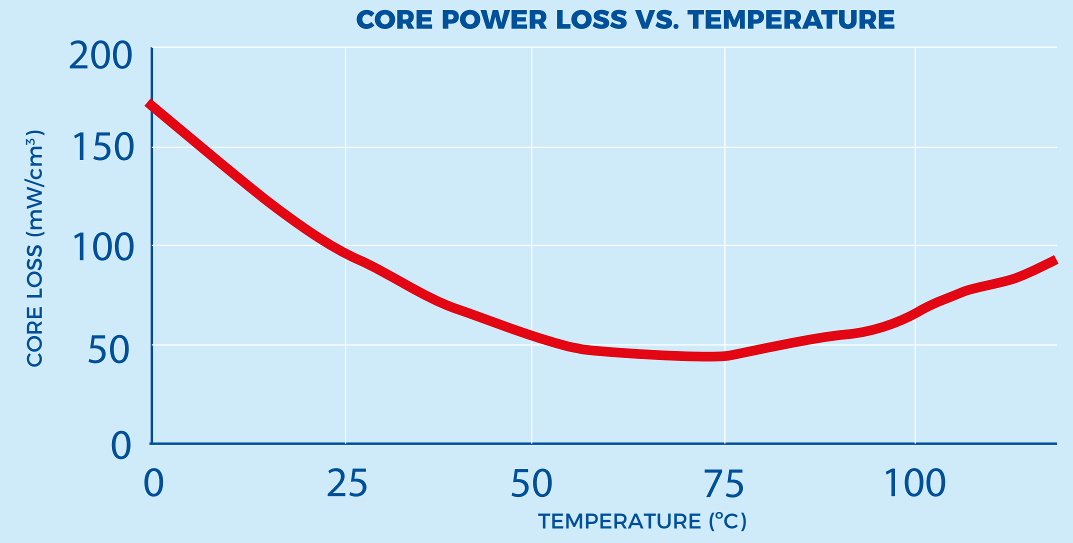
DISRUPTIVE TECHNOLOGY FOR HEAT TRANSFER

# Heat dissipation challenge

## HEAT DISSIPATION IS ONE OF THE BIGGEST CHALLENGES IN THE FIELD OF INDUCTIVE COMPONENTS.

During the conversion of electrical energy to magnetic energy, losses are transmitted in the form of heat. The increase in power density causes these losses to be greater for a same part volume. It is critical to evacuate this residual heat from the magnetic component. An inadequate design in terms of heat dissipation can make the component reach extremely high temperature, causing unwanted failure.

CORE POWER LOSS VS. TEMPERATURE

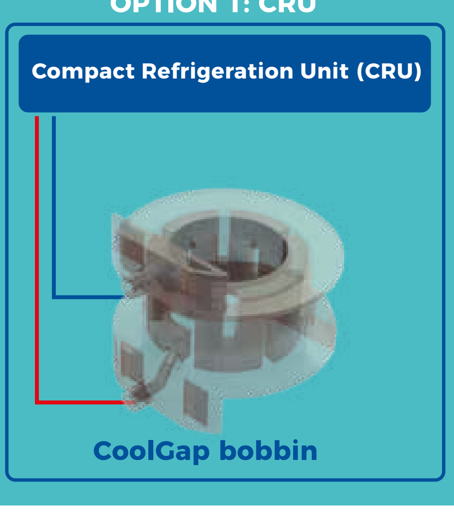



## CoolGap solution

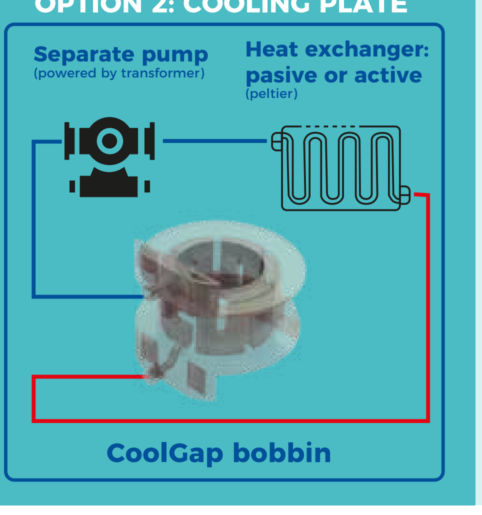
### A COOLING BREAKTHROUGH

**CoolGap** is the most recent in the field of inductive components heat dissipation. CoolGap concept can be applied to a bobbin (coil former) for wire wound magnetic devices which is refrigerated by a non electro-conductive coolant liquid. This bobbin appears to be particularly useful for magnetic components used in on board power converters for electric and hybrid vehicles that make use of customized magnetic power components in order to increase power density.

OPTION 1: CRU

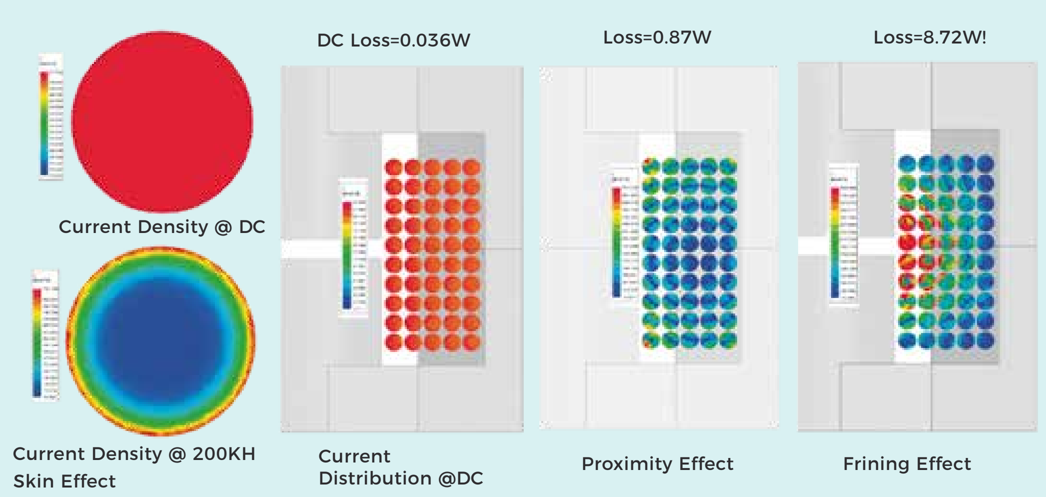



OPTION 2: COOLING PLATE




## DESIGN PRINCIPALS

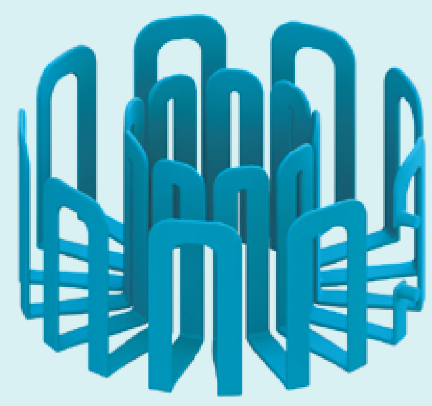
**CoolGap** takes advantage of the optimised cooling circuit of the car by moving its coolant to the point of maximum loss generation of the magnetic component: the core gap. This allows heat dissipation to be direct from the source of the heat losses. In addition, the remaining heat to be transferred to the cool plate by conduction is greatly reduced and a new shorter path of low thermal resistivity is generated by introducing a cool surface internal to the bobbin itself.




## DUCT FUNDAMENTALS

The bobbin has a serpentine-shaped duct in its interior that conducts the coolant. A deep micro-fluid dynamics study has been made to avoid non-desirable flow behaviour inside the duct. The duct cross-section, its path and bends have been carefully designed in order to keep the flow away from adverse effects, such as flow separation (which can cause the coolant to act as heat accumulator in bends) and the reduction of the effective flow cross-section (which increases flow speed and, consequently, duct's erosion).

OUTER TRANSPARENT BOBBIN VIEW
*BOBBIN COVER IS NOT SHOWN



INSIDE COOLANT VIEW

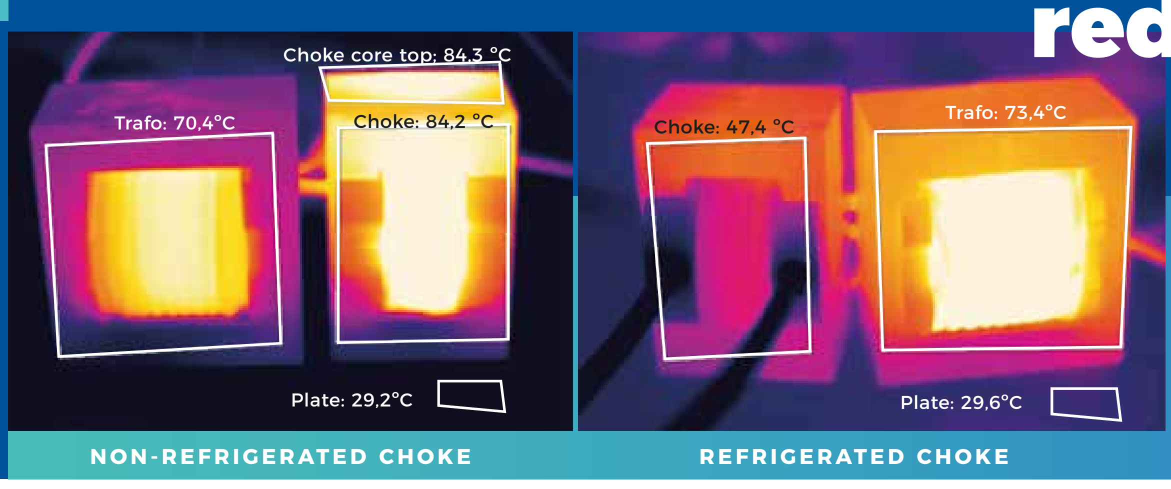
PREMO 3D POWER

## Test

### LOWER TEMPERATURE

**Many tests were done to verify the positive impact of CoolGap in the part temperature.** A transformer + choke part was tested at different duty points. At 2L duty point the standard part reached 55°C. The part temperature dropped to 31°C when using CoolGap with 25°C coolant (44% reduction). At 1L duty point the Coolgap part with 25°C coolant reached a 37°C lower temperature than the standard part. At 1L duty point the standard part reached 110°C. The part temperature dropped to 94°C when using CoolGap with 25°C coolant (14.5% reduction).

## 44 % temperature reduction




NON-REFRIGERATED CHOKE

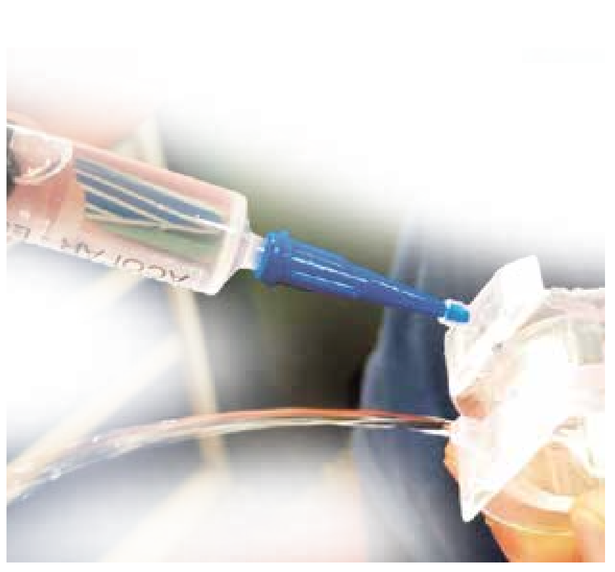
REFRIGERATED CHOKE

*These parts were tested at 1 L duty point and 25°C refrigeration.

## Features

### Manufacturing

Stereolithography or similar 3D printers (SLS, SLA) are perfect for manufacturing parts with internal cavities sealed to the liquid. It is very important that once installed there are no refrigerant leaks throughout the life of the component. A leak would be a catastrophic failure, as the liquid would leak into the interior of the magnetic component. Another method to manufacture the bobbin is thermoplastic injection. Once the two halves are injected, both pieces can be fitted and welded using ultrasonic plastic welding. This welding guarantees the tightness of the internal refrigerant circuit.

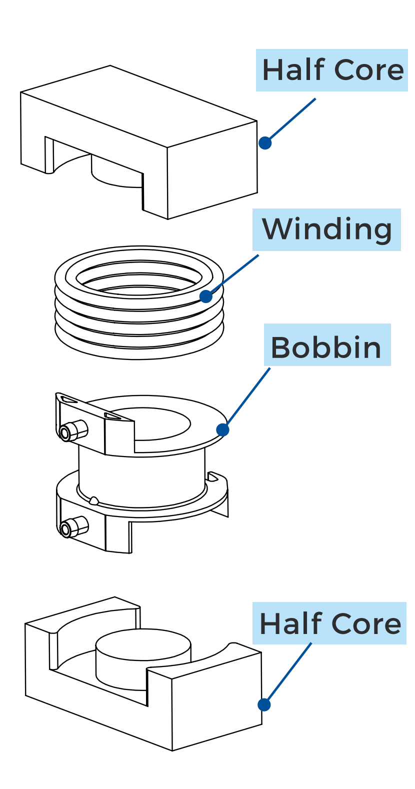


*Alcohol is used to clean the internal duct after the bobbin is 3D printed.

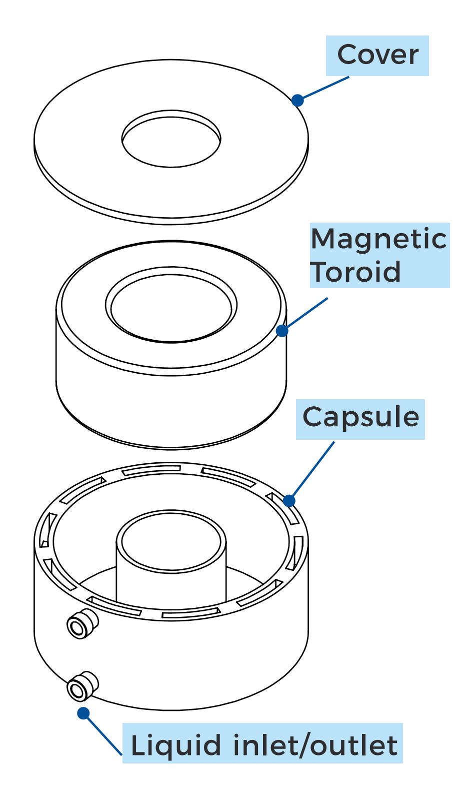
### Easy to assemble

The bobbin aseembly is easy. However, there are some aspects to take into consideration in order to avoid undesired failures. **It is important that the cooling liquid is not electrically conductive, does not have free ions or metallic particles in which currents could be induced by the magnetic field generated in the gap.** The inlet and outlet flexible tubes are connected with O-rings to the bobbin. Another possible configuration is the direct connection of the part to the cooling plate with holes with O-rings. This is a more robust design.

CHOKE




3D POWER




CoolGap.com