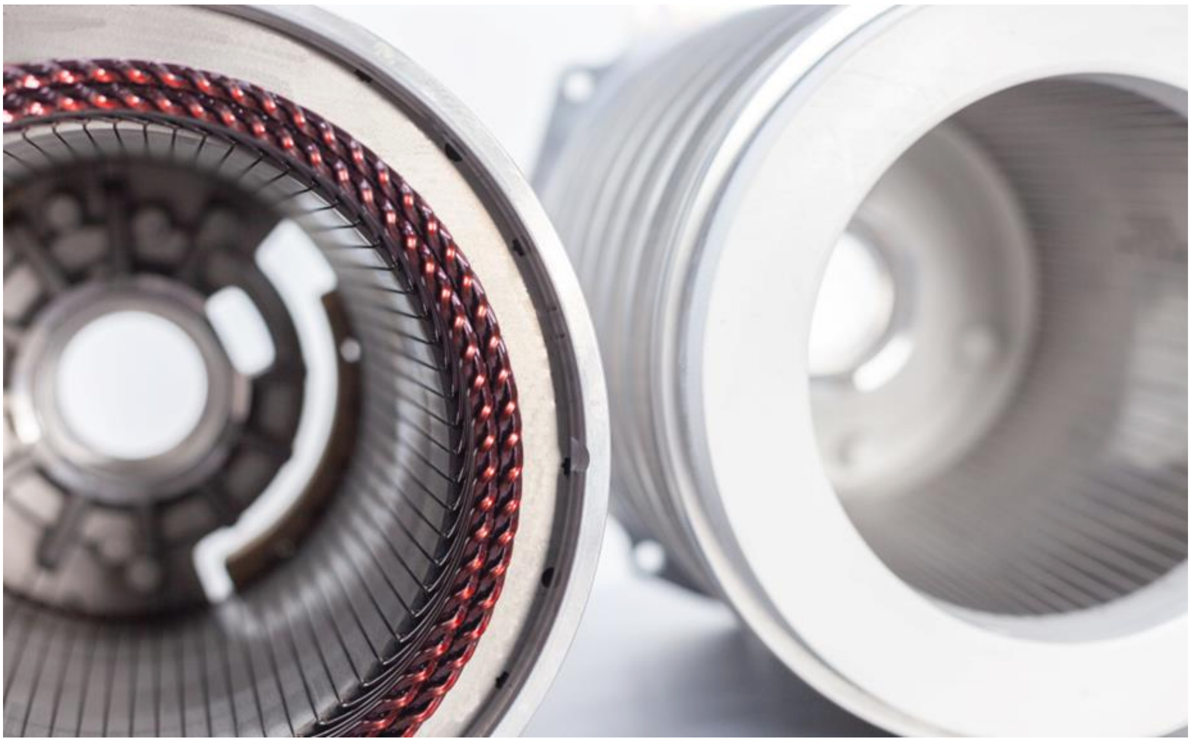
The Game Changer



The Solid Cooling System

Lambdapox®

The turbo for electric drives

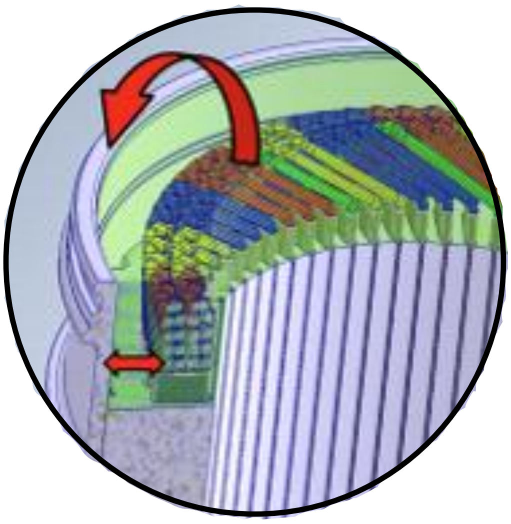
A product developed by Lambda Resins GmbH Germany

Heinkelstrasse 10 50169 Kerpen +49 2237 6000211 info@lambdaresins.de Web: lambdaresins.de

Lambdapox® *Solid Cooling System*

For the Challenges of an increasingly electrified automated and electromobile world.

Industry is demanding ever smaller and more powerful electric drives. The enormous power density with comparatively low volume is increasingly causing thermal problems. The thermal limits are usually exhausted and thus form the performance-limiting factor.

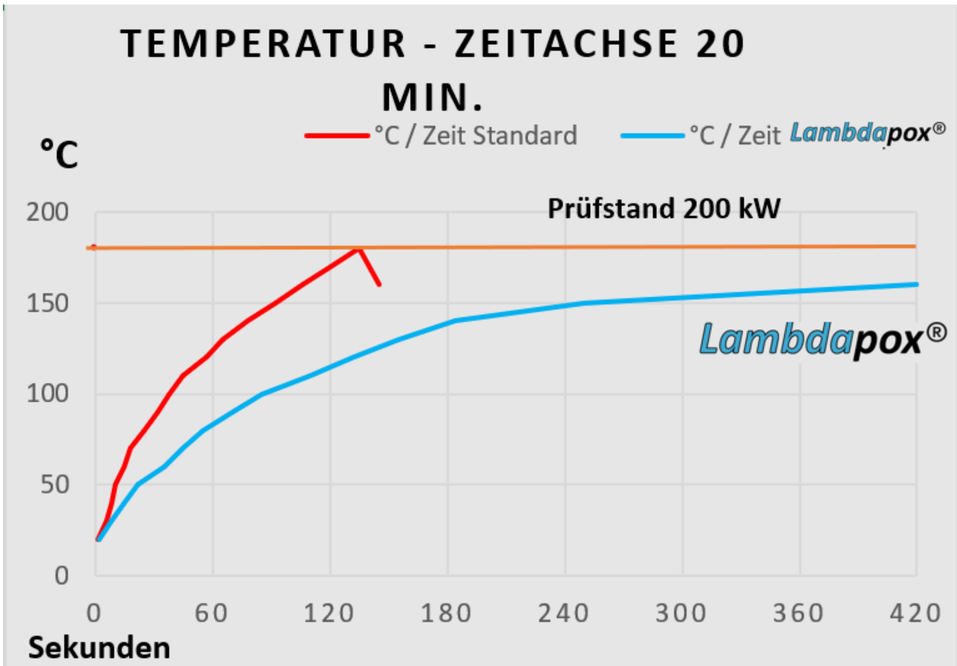


Electric motor for hydraulic pump 60% more continuous power from 130 kW to 210 kW

In order to dissipate the temperature from the copper winding, the winding head is often encapsulated with a heat-stabilized casting resin. The casting resin serves as an electrical insulator and as a medium for heat dissipation between the copper winding and the cooling housing. How effectively the heat is conducted into the cooling jacket depends on the thermal conductivity of the dielectric. Stator potting is nothing new. It is often dispensed with because the effort to benefit ratio (performance improvement) does not seem appropriate. With Lambdapox, offering up to **8 W/m*K** thermal conductivity, we are moving into another dimension.

Depending on the engine design, power increases of 60–100% are possible with continuous power (compared to the impregnated engine). That's a temperature difference of 50–60°C, as the chart shows, <u>with the same performance.</u>

Hairpin electric drive >100% more continuous power from 100 kW to 203 kW * (see graphic)



Comparison motors at 240 kW continuous output

Standard-Impregnation

Messungen (Standard Imprägnierung)						
Wassertemparatur	Wassermenge	Drehzahl	Drehmoment	Wickelkopf	Spannung	Strom
[°C]	[l/h]	[U/min]	[Nm]	[°C]	[V]	[A]
74,9	723	4999	-271,35	179	750,7	203,28
78,1	720,1	9999	-208,03	180	750,77	307,2
83,85	720,6	13000	-137,19	175	750,72	266,05

Vacuum potting with Lambdapox

Messung (Verguuss mit Lambdapox)						
Wassertemparatur	Wassermenge	Drehzahl	Drehmoment	Wickelkopf	Spannung	Strom
[°C]	[l/h]	[U/min]	[Nm]	[°C]	[V]	[A]
73,2	723	4999	-277,04	130	750,3	206,87
78,1	721	9999	-211,67	142	750,2	311,27
82	721	13000	-140,34	144	750,3	271,2

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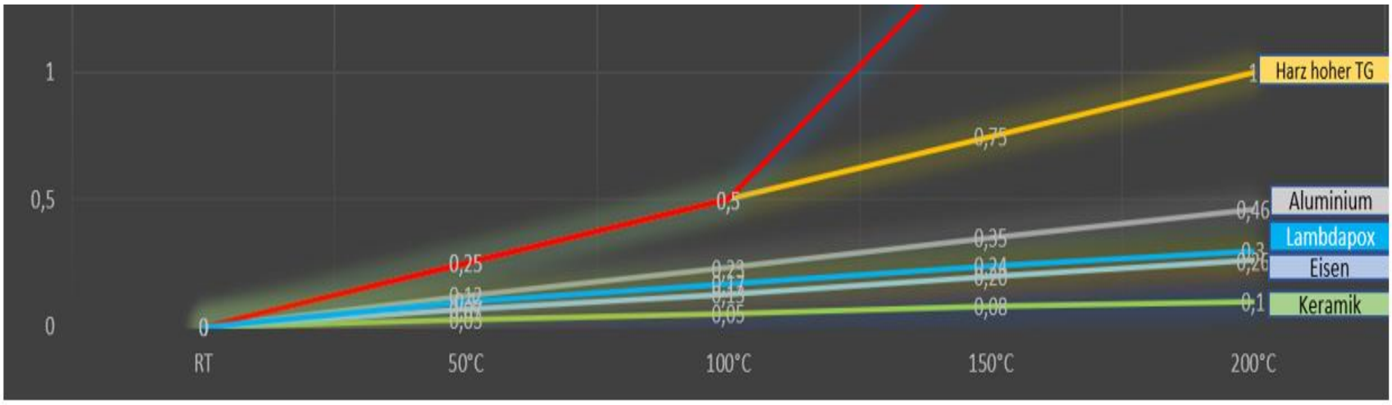
Problem of cracking and ageing:

The biggest concern is the mechanical durability of the potting. Over the lifetime of a drive, major temperature changes cause material stresses that lead to premature aging and thus to embrittlement and cracking. Given the usually large differences in thermal expansion (10–100ppm°K) of the materials metal and cast resin many rightly fear material cracks appearing in the cast resin.

In order to avoid mechanical stresses, it is important to have a coefficient of expansion in the thermal working window that is as similar as possible to the surrounding materials.

It is ideal if the expansion of all materials runs parallel during temperature changes, so that there is no shear at the interfaces. This avoids detachments and cracking's.



PU materials are particularly susceptible to ageing, as they change the net structure significantly at over 130°C.

At these temperatures, the polymer network breaks down and the reactive NCO groups form replacement bonds to heat-stabilizing additives. The resin matrix and thus the properties therefore change with aging. To prevent aging, the casting resin should have thermal reserves. A class "H" (180°C) or better should be given at least for modern high-performance engines. Lambdapox can be exposed to over 200°C for a short period of time without having worry about problems.

Thermal shock test passed without crackings.

The test duration is calculated as follows:

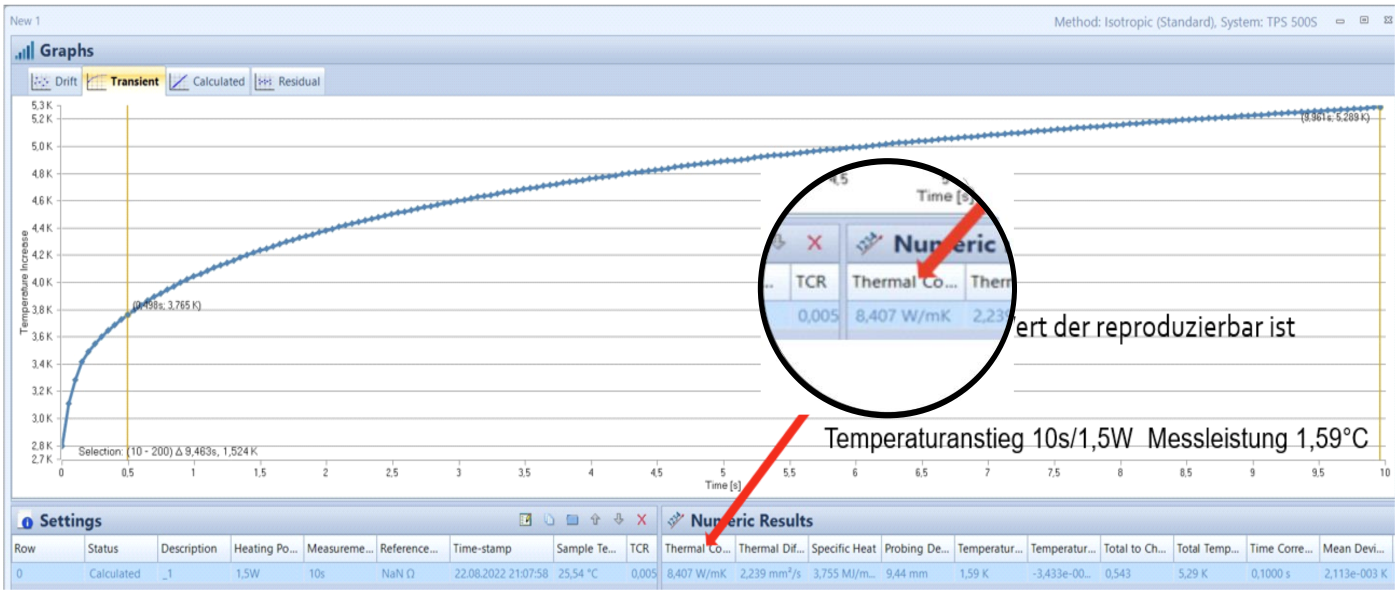
Cycles:	**100**
Ramp-up:	**40 min**
Duration:	**240 min at 180 degrees °C**
Ramp-down:	**40 min**
Duration:	**240 min at -40 degrees °C**

Total duration 56.000 min = 934 h = 5.5 weeks

Lambdapox® *Solid Cooling System*

8 W/m*K and still with good flowability is that possible?

YES it is!



Above is a measurement curve based on the generally accepted HOT-DISK measurement method. A defined energy is introduced into the test sample over a fixed period of time. The measuring device calculates the amount of energy and the temperature rise over time using an algorithm to calculate thermal conductivity.

In the industry some say that the level of thermal conductivity of the casting resin is not crucial. The main thing is that the stator is potted. That statement is not entirely wrong, but it is not the entire truth. Starting from a purely impregnated engine, a standard encapsulation makes a difference in contrast to air as a heat conducting medium. The air has a thermal conductivity of 0.02 W/m*K, a standard resin of approx. 1 W/m*K. That's 50 times. This allows conclusion that a further increase from 1 to 4, 5, 6 or even 8 W/m*K no longer brings any significant advantage, because the delta between 0.02 and 1 W/m*K is (50 times) greater than between 1 and 8 W/m*K (8 times). Why is this consideration not apriority? Because at higher thermal conductivity values, 4 to 8 times the energy of 1 W/m*K can be dissipated. Depending on the construction of the motor design, thermal reductions of 50–60°C and more are possible. Depending on the configuration of the drive, the continuous power can even be doubled. A highly thermally conductive potting compound such as Lambdapox in an electric drive is like the turbocharger in a combustion engine.

Lambdapox® Solid Cooling System

World leader in flowable thermally conductive casting resins

Maximum thermal conductivity combined with excellent casting properties and relatively low viscosity, plus good wetting properties that´s Lambdapox.

Lambdapox flows thinly over surfaces

In the quest for top performance, Lambda Resins has come very close already to realizing the theoretically optimal recipe. In doing so, we pushed the boundaries of physics and chemistry finding the narrow way to develop a well-flowing casting resin with maximum thermal conductivity. Any slight deviation and the system collapses the casting resin becomes pasty or loses other important properties.

At 0.2 W/m*K, epoxy resin generally does not have good thermal conductivity properties.
Only by adding fillers with good thermal conductivity is it possible to significantly increase the conductivity of the casting compound. The higher the filling content, the better the conductivity. Of course, the filler itself must be electrically insulating. With a density of almost 3.3 g/ml, Lambdapox has a very high packing density, so that the resin only serves as a binder. Nevertheless, it has been possible to keep the material flowable.

Viscosities of 3000-6000 mPas are possible. Water-thin is different, but it doesn't have to be that way to cast a stator under vacuum. Due to its high density and good flow properties, Lambdapox optimally fills the installation space to be encapsulated.

With a parameterized process, high-quality components can be produced efficiently in a reproducible manner.

Lambdapox® *Solid Cooling System*

Example hairpin motor unencapsulated and encapsulated

Another advantage: As a solid cooling system, Lambdapox is absolutely maintenance-free. Once potted, the heat-dissipating effect lasts a lifetime.

What if you don't need the high-power output? Then you benefit from getting maximum performance from ever smaller motors. And minimizing size saves installation space and money.

Overview:

1. Very high thermal conductivity up to over 8 W/m*K
2. Low viscosity from 3000–6000 mPas
3. Excellent wetting properties and good adhesion
4. No measurable shrinkage during hardening.
5. high mechanical strength in the working area even at 180°C
6. Reactivity adjustable via chemical accelerator
7. Heat class H 180°C
8. High thermal resistance at peaks even above 200°C
9. Extremely low coefficient of thermal expansion 12-14 ppm
10. No cracking between -40 and 180°C in thermal shock
11. Very high insulation resistance even at 180°C >1.3 G-Ohm
12. Flammability meeting the UL94 V0 Standard (in preparation)

Lambda ***Resins*** *GmbH*

Solid Cooling System

Info unter: www.lambdaresins.de

*Lambda**pox***®

the TURBO for your electric drive

A product developed by *Lambda* *Resins* GmbH Germany

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