Higher transformer loads thanks to optimum cooling

Using SITRAM® COOL cooling equipment control with lower noise emissions from TLM™ – Transformer Lifecycle Management™

Answers for energy.

SIEMENS

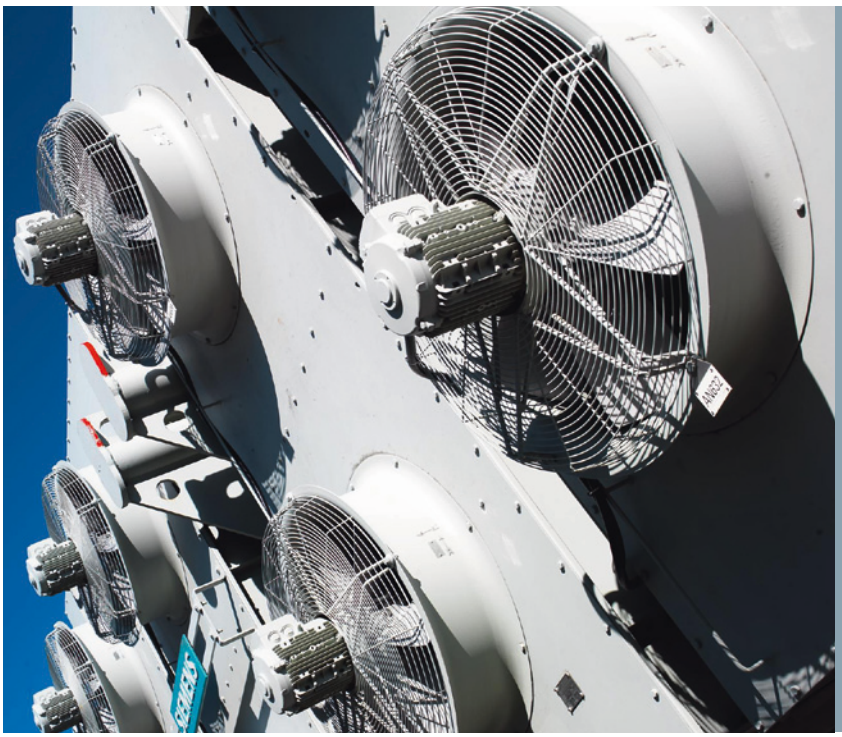
A cool calculation: Optimum settings for higher loads and less noise

The challenge:

Transformers are key components of the electric power grid. This means that failures come at a high cost.

One important criterion for the useful life of a transformer is temperature, which rises as loads increase.

Smart transformer cooling is not a simple matter, given the many variables involved. In addition to fluctuating ambient temperatures and load currents, compliance with noise protection laws is also required – while simultaneously keeping the inherent losses of the cooling equipment as low as possible.



SITRAM® COOL offers situational control of fans – individually or as a group.

To keep the transformer cool enough while simultaneously minimizing noise and the cooling equipment's own requirements, we offer SITRAM® COOL, a complete smart cooling control solution.

SITRAM® COOL contains the engineering for analyzing cooling equipment along with the usual control and program elements. We use speed-controlled fans to minimize noise and to minimize the cooling equipment's own requirements. And all of this is individually adapted to your transformer.

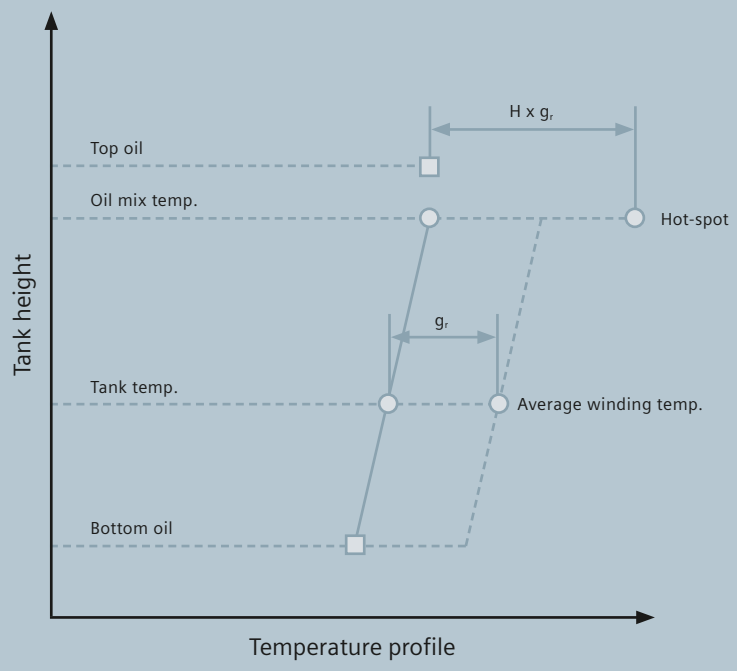
Thanks to SITRAM® CM, the optional monitoring system, all relevant parameters can also be viewed, supervised, and evaluated using remote servicing. Various communication interfaces naturally allow them to be retrieved "remotely" as well.

Thanks to SITRAM® COOL ...

- you will increase loads by optimizing your cooling equipment.
- oil can be precooled when peak loads are anticipated.
- you will optimize the inherent losses of the cooling equipment.
- you will reduce noise levels by individually switching cooling units and using speed-controlled fans.
- a constant oil temperature reduces the respiration of the transformer.
- you will have cooling equipment control, including engineering/retrofitting of the cooling equipment, that is tailored to your needs.

SITRAM® COOL also protects transformers in the expanded operating range.

Know what's happening in your transformer



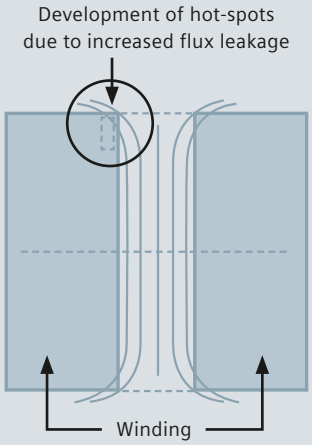
Temperature distribution in transformer according to IEC 60076-7

Thermal distribution in the transformer

Current standards such as IEC 60076-7 and the technical literature assume that there is a linear increase in the oil temperature within the tank from the bottom to the top. The excess temperature of the conductor increases in parallel to the excess temperature of the oil with a constant difference.

At some places, known as hot-spots, the temperature is higher than the excess temperature of the conductor at the upper edge of the winding, which is shown by hot-spot factor H. The cause of this is the magnetic flux leakage, which locally increases flux density and dissipated heat. Fluctuations in the local oil flow can also be responsible for this.

Insulation ages fastest where the temperature is highest, in other words at the hot-spot. The aim is to use appropriate cooling to minimize that temperature.



Minimizing noise and the intrinsic consumption of the cooling equipment

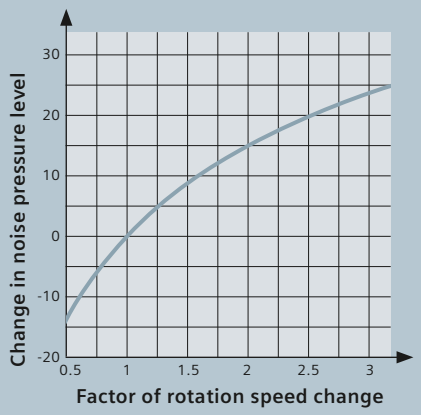
Noise avoidance measures are required by law. Possible approaches include using quieter equipment or appropriate insulation. However, costs can skyrocket as the noise level increases, while the actual noise reduction that is achieved tapers off.

The sound pressure level shows how loud a sound is. It corresponds to the logarithm of the sound pressure in relation to the reference sound pressure, the hearing level, so two noise levels cannot simply be added together. This means that +3 dB corresponds to a sound source that is twice as loud, while +7 dB means that the sound source is five times as loud.

SITRAM® COOL is part of TLM™ – Transformer Lifecycle Management™ and helps to minimize temperatures in spite of higher loads.

Speed-controlled fans							
Fans	n [1/min]	V_{total} [m³/h]	P_{total} [kW]	L_{Wtotal} [dB]	V [m³/h]	P_1 [kW]	L_W [dB]
8	1,240	192,000	15.92	89	24,000	1.99	80
4	1,240	96,000	7.96	86	21,500	1.39	77
5	1,050	100,000	6.3	83	20,000	1.26	76
6	950	108,000	5.64	82	18,000	0.94	74

SITRAM® COOL can easily coordinate the number of active fans, cooling power, noise emissions, and intrinsic consumption.



The rotation speed of the cooling fans has a strong effect on noise emissions.

Various countries prohibit exceeding specific noise levels, such as 50 dB during the day and 35 dB at night, in exclusively residential areas. The guidelines are based on exposure, which means that all noise-emitting equipment must comply with the limit values at a residence.

The transformer in the example above is equipped with eight fans. At the temperature that is currently set, cooling power of approximately 100,000 m³/h is sufficient. That volumetric flow rate can be achieved by switching off four fans if the other fans operate at full speed.

Another possibility is to run more fans at a lower rotation speed. The table clearly shows that a lower speed reduces the noise level and the inherent losses compared with four fans.

An enhanced cooling equipment with smart fan controls optimizes the cooling capacity in relation to the noise emission. The design of the cooling equipment is based on the required cooling power, the available space, and applicable noise limits.

Fan noise is produced as a function of circumferential speed and blade design. Staggered fan activation and the adjustment of rotation speed when preset limit values are reached offer numerous possibilities for reducing noise emissions.

The volumetric flow that is responsible for cooling power is proportional to the rotation speed, while the cooling equipment's own requirements are cubed. As shown by the graphic, doubling the rotation speed increases the noise level by 15 dB.

SITRAM® COOL – a solution as flexible as its modules

SITRAM® COOL is made up of multiple modules that are independent of each other and yet coordinated with each other. That makes it possible to produce a custom solution for every customer, every transformer, and every plant.

Diverse activation options

Fans are preferably activated using the load current as a switch-on value and the hot-spot or top-oil temperature as a switch-off value. Cooling of the transformer begins as soon as the higher load current is applied, but it is not switched off again until the oil has truly cooled. Other approaches are available depending on requirements.

With the hot-spot temperature method, the fans are activated as a function of the hot-spot temperature at the critical location in the winding.

An alternative to that is controlling by the load current. This allows cooling even before the oil heats up.

The differential temperature method can be used for applications that are subject to large fluctuations in the ambient temperature. The difference between the oil temperature and the ambient temperature is kept as constant as possible, thereby minimizing respiration of the transformer.

Staggered activation of the fans begins when a predefined limit value is reached. Cooling power can be further increased by raising the rotation speed, either stepwise or proportionally.

Smart switching

The fans are deactivated when the level falls below the switch-off value. Hysteresis is simulated using different switch-on and switch-off values. This prevents the fans from continuously switching on and off when the parameter value (temperature or current) fluctuates around the switch-on value.

Increased reliability

Like the other parameters, failure handling can also be adapted to the individual application. The fan rotation speed is increased to a predefined level if a temperature or current sensor fails or if the fans are no longer receiving a signal from the control unit.

The rotation speed of the other fans is also increased if there is no response to the control unit by the activated fans.

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