It Isn't Rocket Science. Well, Actually...

by **Laura Vandiver**

It may not be actual rocket science, but proper transformer cooling is imperative and can become quite complicated, especially when dealing with transformer overheating and the thermal conditions surrounding it. Also, various cooling system designs and configurations, some of which have been discontinued or are in a dilapidated operating state, have further complicated things.

Laura L. Vandiver began her career in the energy sector with Advanced Power Systems in 2006 as an agent representing brands like Cooper Lighting Solutions, Cooper Power Systems (now Eaton's Cooper Power Systems), Salisbury, QEI, GE-ITI, and Digital, Federal Pacific, Huskie Tools, Nordic Fiberglass, and BMC in the Caribbean and Latin American markets. In 2010 she transferred to Paradoxe Corporation to help spearhead a new transformer cooling fan initiative. In 2014, Laura transitioned into a Business Development Manager position for the U.S. and Canadian territories. Today she continues her work to provide transformer cooling solutions and packages to utilities, industrials, service companies, repair shops, and transformer manufacturers worldwide.

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Photo: Paradoxe Corporation

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With an aging transformer fleet coupled with increased loads due to economic growth and advancement, routine maintenance and attention to the transformer's cooling system are critical. It is instrumental to extending the transformer's overall life and safety.

Excess transformer loading in liquid-filled transformers, which generates heat, can lead to avoidable catastrophic events like fire, unplanned outages and unnecessary aging of the asset. Though fire is rare in a properly maintained, inspected, and tested transformer; if catastrophe does strike, it is not only a safety issue but impacts the environment, and can tarnish the reputation of the utility, given that HSE (Health, Safety and Environment) issues are tremendously important for utilities of all sizes, from generation to distribution.

Many utility and maintenance managers consider cooling system upgrades to increase the load capacity in their liquid-filled transformers. And with capital funds and projects delayed due to the pandemic, reliability managers choose to add or replace existing cooling packages as a possible cost-effective solution if buying a new transformer is not an option [1].

It is always recommended to assess the overall thermal condition of the transformer, consult the original transformer manufacturer for the required cooling capacity and load information, and never overload the transformer, beyond the OEM rating. After proper inspection and testing of the transformer to determine the current condition, adding or upgrading existing transformer cooling fans to the radiator may prove to be a cost-effective solution to increase capacity. Along with that, transformer cooling fans tend to start to fail around the same time, so it may be beneficial to replace all fans once they start going out instead of only one at a time.

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Figure 1. Old and new transformer cooling fan

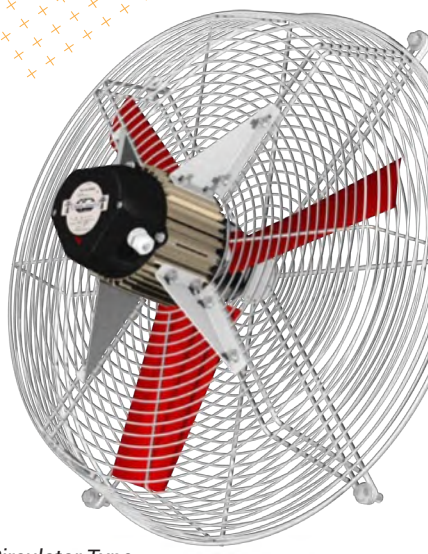

Figure 2a. Circulator Type

Figure 2b. Venturi Type

Types of Cooling

Transformer cooling is achieved in several ways.

Dry Type Transformer:

AA: Ventilated self-cooled
AFA: Ventilated forced air-cooled
AA/FA: Ventilated self-cooled forced air-cooled
ANV: Nonventilated self-cooled
GA: Sealed self-cooled

Liquid Filled Transformer:

First Letter – Insulating Medium

O: Mineral oil or synthetic insulating liquid with fire point of 300°C
K: Insulating liquid with fire point >300°C
L: Insulating liquid with no measurable fire point

Second Letter – Internal Cooling Medium

N: Natural circulation
F: Forced circulation
D: Forced directed circulation

Third Letter – External Cooling Medium

A: Air
W: Water

Fourth Letter – Circulating Method for External Cooling Medium

N: Natural circulation
F: Forced circulation

The code nomenclature for liquid filled transformers changed after the year 2000, moving from a two-letter code to a four-letter code to better articulate the cooling. Considering the classifications listed above, we will move forward speaking only about liquid-filled transformers with forced-air cooling using fans [2].

Transformer Cooling Fan Options

Another factor to consider when upgrading a transformer cooling fan package is what kind of cooling fan to choose. Many different types and manufacturers of cooling fans are available in the marketplace right now, ranging in price, performance, and durability. A key aspect to consider would be the environmental conditions in which the transformer cooling fan is exposed. For instance, a fan with non-corrosive characteristics would be well suited for wetter, more humid areas that experience accelerated weathering.

There are a couple of different types of transformer cooling fan designs. One would be a circulator type fan with a basket style cage, and another would be an axial style fan, sometimes referred to as a venturi style fan with a tube or duct around the motor and impeller. Depending on the transformer design, both fans can be mounted on the side, top, or bottom of the radiator.

Another consideration would be the mounting configuration. There are three typical positions in which to mount cooling fans on the transformer. The most common mounting configurations are on the side of the radiator (horizontal airflow) and the bottom of the radiator (vertical airflow). Still, fans may also be mounted on the top of the radiator.

Photo: Paradoxe Corporation

Choosing a Transformer Cooling Fan

Choosing a transformer cooling fan can be further complicated because it is hard to know the transformer's airflow requirement and the cooling capacity of the existing fan. It is always recommended to refer to the original transformer manufacturer to determine the required cooling, where the original transformer documents may hold some insight. Also, as noted earlier, it is recommended to inspect and test the transformer to determine the current condition.

Another factor that may complicate choosing an adequate cooling package is there is no transformer industry standard for measuring airflow. There are various ways to measure airflow in a fan. According to the Air Movement and Control Association (AMCA), the methods differ according to which type of fan you are testing. For instance, AMCA recommends using the AMCA 230 method to test circulator type fans as it measures for thrust, which is different from the testing method for a venturi style fan. At this time, each cooling fan manufacturer has its way of determining airflow, so it is hard to compare.

Figure 4. Existing fan nameplate to replace

One way to find a comparable option is to match the transformer cooling fan's nameplate data and size as closely as possible. Some transformer cooling fan manufacturers have selection tools on their websites to help with this process. For instance, some of the information can be matched from the existing fan label. Although, please note, the existing fan nameplate may only reflect the performance data for the motor and not the entire fan.

Absence of transformer industry standard for measuring airflow is another factor that may complicate choosing an adequate cooling package.

Figure 3a. Side mount airflow configuration

Figure 3b. Side mount fan tree configuration

Figure 3c. Bottom mount airflow configuration

Figure 3d. Bottom mount venturi configuration

Figure 3e. Top mount airflow configuration

Mounting Bracket Configurations

Another complicated aspect of replacing and upgrading a transformer cooling fan package is matching the mounting configurations. The transformer cooling fan cage's outer diameter and mounting footprint are essential when replacing or upgrading a cooling fan project. Once the footprint is set, a flush mounting kit, which generally consists of a threaded rod and brackets that affix in between the radiator fins and panels, can be used for side mount applications.

Figure 5a. Fan footprint

Figure 5b. Threaded rod

Some other side mount applications for transformer cooling fans include using a fan tree, baseplate mount, stand-off mount, and yoke mount. The latter three mount from the motor instead of the fan cage like the flush mount and fan tree mentioned earlier.

For bottom mount applications underneath the radiator, a header mount, j-bolt, or Unistrut kit can be used. The bottom mount applications typically mount from the cage but occasionally mount from the motor with a stand-off mount application.

Figure 6. Unistrut bottom mount configuration

Transformer Cooling Fan Cord Selection

Upon choosing the perfect fan with the appropriate cooling characteristics, you will also need to select a power cable. There are a few different types of cords, for instance, quick disconnect (male and female connections) and hardwired. The quick disconnect cords typically come in lengths of 6 and 12 feet and are a plug and play application. A portion of the cord comes with either a male or female connector, and then there is a shorter cord often referred to as a "pigtail" or "whip" with the receiving connector. Usually, the female receiving connector is placed on the live side of the transformer instead of the male end. These connections offer a plug and play application as opposed to the hardwired. Some manufacturers offer these cords in a set, and some sell them separately, so make sure to verify before ordering. The hardwired cords usually come in lengths of 6, 8, and 12 feet as well but are easily customized. This cord is hardwired at the transformer cooling fan and then into the transformer side as well.

Summary

As stated earlier, transformer cooling may not be actual rocket science, but it certainly does feel like it sometimes. One notion remains constant; that aging transformer fleets with increased loads due to economic growth and advancement will require routine maintenance and attention to the transformer's cooling system, as mission critical. Choosing whether to upgrade and which cooling package is the most cost-effective and safe solution can be complicated. While the configurations can be taxing, there are professionals in the industry with years of experience in cooling and transformer manufacturing available to help assist in selecting the proper cooling system.

References

[1] 1. Transformer Cooling System Improvements: Analysis and Recommendations, EPRI, Palo Alto, CA, 2005, 1010585

[2] Power Transformers, A. (Ed.), "Types of Transformer Cooling," retrieved January 19, 2021, from https://voltage-disturbance.com/power-engineering/types-of-transformer-cooling/