

TRANSFORMER OIL COOLER DESIGN PARAMETERS

Transformer Oil coolers are heat exchangers used to cool the dielectric oil in a transformer. The cooling medium is typically air or water. Transformer designers, rather than heat exchanger manufacturers, drove the evolution of transformer oil coolers, so the approach or terminology is slightly different than typical heat exchanger applications.

TOP OIL RISE OR AVERAGE OIL RISE

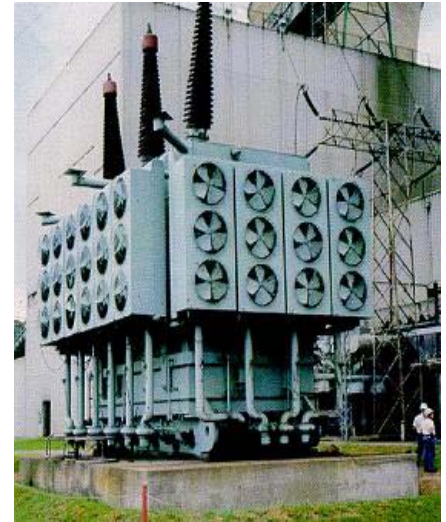
Unlike heat exchangers in other applications, the oil temperature is expressed as a rise in relation to the cooling water or air temperature. If the Top Oil Rise (TOR) is given, the temperature represents the number of degrees that the hot oil is greater than the cooling water or air temperature. For example, a 30°C Top Oil Rise means that the hot oil is 30°C degrees hotter than the cooling water temperature or cooling air temperature.

If the Average Oil Rise (AOR) is given, the temperature represents the number of degrees that the average oil temperature is greater than the cooling water or air temperature. The average oil temperature is simply the cooler inlet oil temperature minus the cooler outlet oil temperature divided by two.

Examples:

1. Given a 40°C TOR over a 30°C ambient air temperature; the hot oil temperature is 70°C and the cooling air temperature is 30°C. In this case a cooler would be designed to remove the appropriate amount of heat, and maintain the oil temperature in the transformer at 70°C when the air temperature is 30°C
2. Given an AOR of 35.5°C over a cooling water temperature of 25°C; the design average oil temperature $\{ (oil\ inlet - oil\ outlet)/2 \}$ would be 60.5°C.

The TOR and AOR are only meaningful when the cooling water or cooling air temperature (design ambient temperature) is given. It is also important to note that the oil rise gives an appreciation of whether the sizing parameters are appropriate for the conditions. The lower the oil rise, the more demanding the sizing parameters for the cooler (more cooling). It is important to understand that although a 30°C design ambient temperature and 40°C TOR results in a 70°C as does a 40°C ambient and 30°C TOR, the second design condition with the lower TOR will result in more cooling capacity. This is particularly relevant in cases where a transformer oil cooler is sized with a 30°C ambient air temperature and then is installed on the side of a hot transformer and surrounded by fire walls – it is unlikely the ambient cooling air temperature will be 30°C. If a transformer under these conditions was sized for a 30°C ambient / 40°C TOR, it might be more appropriately redesigned for a 40°C ambient / 30°C TOR.



HEAT LOAD

The other parameter that is required to size a transformer oil cooler in all applications is the heat load or total losses in the transformer. The heat load is a function of the load and no-load losses in the transformer and is typically expressed in kW. The heat generated by the transformer losses is picked up by the oil and the heat is removed from the oil by the heat exchanger.

NATURAL OIL FLOW TRANSFORMERS

Transformers that experience lower loads can operate without pumps. The oil is circulated naturally by the flow that develops as a result of the density change due to the temperature change in the oil. As the oil is heated up from the losses in the core and windings, it becomes less dense and rises to the top of the transformer. If the cooler is located at the top of the transformer, the cooled oil becomes more dense and is piped down into the bottom of the transformer. As that oil passes over the core and windings it is again heated, and the process continues.

Thermally sizing Natural Oil Flow Transformer Oil Cooler is difficult because the naturally induced oil flow rate is difficult to estimate. Experimental Data is typically used to select transformer oil coolers for natural oil flow transformers.

FORCED OIL TRANSFORMERS

Forced oil transformers are transformers where the oil is circulated by a pump at a constant flow rate. When the oil is circulated the heat transfer equation becomes more typical.

$$\text{HEAT LOAD} = k * \text{mass flow rate} * (\text{oil inlet temperature} - \text{oil outlet temperature})$$

or

$$Q = mC_p\Delta T$$

[More Heat Transfer Equations Can Be Found Here](#)

So a cooler can be sized for a forced oil transformer given the heat load, oil flow and either TOR or AOR.

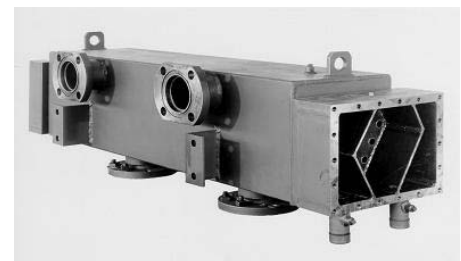
GENERAL TYPES OF TRANSFORMER OIL COOLERS

The types of transformer oil coolers we supply are;

[Forced Oil – Forced Air \(FOA\)](#)

[Forced Oil – Forced Water \(OFW\)](#)

[Natural Oil – Forced Water \(ONW\)](#)



INFORMATION REQUIRED TO SIZE A TRANSFORMER OIL COOLER

Forced Oil Flow (FOA)

Heat Load (required)
Oil Flow Rate (required)
Cooling Air Temp. (required)
Available Horsepower (optional)
Sound Level Limit (optional)

Forced Oil Flow (OFW)

Heat Load (required)
Oil Flow Rate (required)
Cooling Water Temp. (required)
Water Flow Rate (required)
Water Pressure Drop (optional)

Natural Oil Flow (ONW)

Heat Load (required)
AOR or TOR (required)
Water Flow Rate (required)
Cooling Water Temp. (required)
Water Pressure Drop (optional)