Gas-insulated transformers are nowadays manufactured for voltages up to 500 kV and the rated power up to 400 MVA

Gas-insulated transformers

Technology overview

ABSTRACT

This article aims to draw attention of utility companies and their technical staff to the advantages of installing gas-insulated transformers in substations, and the main environmental benefits. The article also presents the most important characteristics and components of these transformers, as well as the maintenance cost savings that can be achieved by using gas-insulated transformers.

KEYWORDS

gas-insulated substation, sulphur hexafluoride, gas coolers, space saving

1. Introduction

A rising demand for electricity in large cities, the lack of space to construct new substations or upgrade the existing ones, and adverse environmental conditions that we are faced with today have encouraged a trend in overpopulated urban areas to tuck away large-scale substations underground. This has led to a growing demand for incombustible and non-explosive, large-capacity gas-insulated transformers (GIT) in order to prevent accidents and ensure compactness of equipment.

Environmental concerns, whether climatic conditions or high levels of pollution in populated areas where the substation is being installed, are another factor justifying the use of GITs.

The main manufacturers of these type of transformers are based in Asia and include Toshiba and Mitsubishi (Japan), Hyosung (South Korea) and Shinlin (Taiwan).

2. Basic construction principles of gas-insulated transformers

The basic construction of GITs is similar to that of oil-immersed transformers. The windings and the core have the same type of construction as those used in oil-immersed transformers, and they are installed inside a sealed tank filled with gas, normally sulphur hexafluoride (SF6), with a pressure between 0.14 MPa and 0.5 MPa. There aren't any accessible live parts, so a conservator is not needed. An alternative gas that can be used is octafluorocyclobutane (C_4F_8), although this technology is yet to be fully developed.

To limit the rise of the temperature of the windings manufacturers use insulating materials which feature high thermal resistance.

GITs are nowadays manufactured for voltages between 20 kV and 500 kV and the rated power goes up to 400 MVA. Similar to oil-immersed transformers, GITs can also be equipped with an on-load tap changer (OLTC). While different types of OLTCs with arc-quenching in oil are sometimes used in oil-immersed transformers, the gas-insulated transformers only use vacuum-type OLTCs.

3. Cooling systems

Commonly used cooling systems in gas-insulated transformers are:

- GNAN – natural circulation of the air and the gas
- GDAN – forced directional circulation of the gas and natural circulation of the air
- GDAF – forced directional circulation of the gas and forced circulation of the air
- GDWF – forced directional circulation of the gas and forced circulation of water

In all types of cooling systems, and similar to the oil in oil-immersed transformers, the gas functions both as an insulating material and a cooling fluid. In GD-cooled transformers the gas is directed to the hot spot of the transformer.

Since GITs are mainly installed indoors, and sometimes underground, most of the manufacturers use the GDWF system, with a forced liquid system to cool the gas (a commonly used liquid for GIT cooling is $C_2F_3Cl_3$ – trichlorotrifluoroethane), which is complex and has large dimensions. Other manufacturers use a forced system with a gas blower to make SF6 circulate into a gas water cooler that works as a heat exchanger. This is a much simpler procedure and has lower dimensions. Figure 1 shows a schematic diagram of a GDWF gas-insulated transformer.

4. Protective devices and accessories

The common protective devices and accessories of gas-insulated transformers are:

- Gas temperature indicator
- Windings temperature indicator
- Gas density relay
- Compound gauge
- Sudden gas pressure relay (for OLTC)

5. Common maintenance program

Maintenance of gas-insulated transformers is simpler than that of oil-filled transformers and maintenance activities have longer intervals between them.

A common maintenance procedure for a GDWF gas-insulated transformer recommended by manufacturers usually includes the following activities:

- Gas analysis: every 2 years
- Replenish bearing grease of gas blower: every 3 years
- Gas blower bearing: every 10 years

Advantages of gas-insulated transformers over oil-filled units are safety, compact design, easier installation and simpler maintenance

In densely polluted areas, GITs combined with GIS enable space saving and withstanding adverse environment conditions

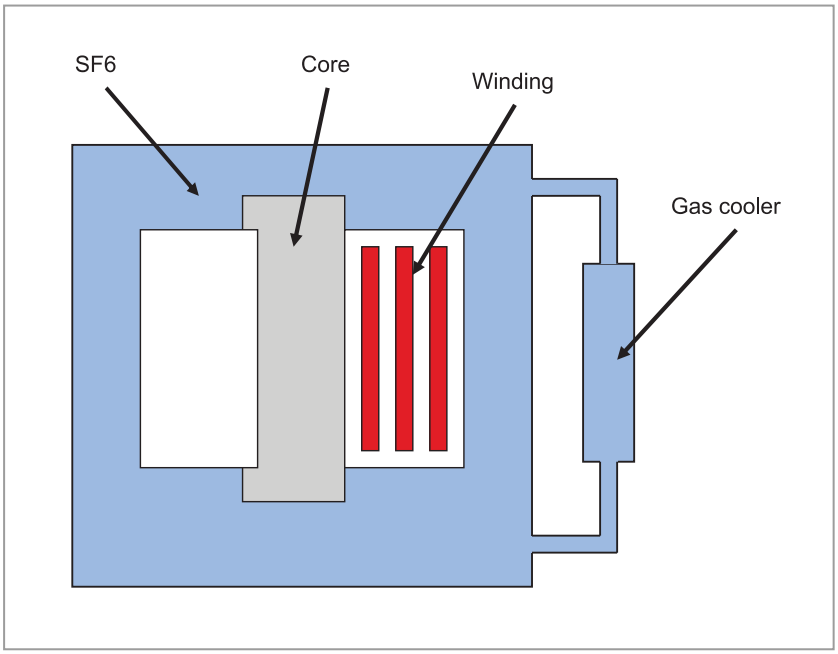

Figure 1. A Schematic diagram of a GDWF gas insulated transformer

- Replace gas blower: every 15 years
- Indication and protection devices: every 10 years
- Replace gas pressure relay: every 5 years
- Replace bushings: every 30 years
- Replace control cable wiring: every 30 years
- Inspection of OLTC: every 5 years
- Replace a cooler: when a failure occurs
- Replace O-rings and gaskets: when a failure occurs
- Running repairs of small gas leakage: when a failure occurs

6. Advantages and disadvantages of GITs

The main advantages of gas-insulated transformers are:

- Non-flammable (GITs using incombustible SF6 gas as an insulation and cooling medium)
- Explosion-proof tank (pressure tank withstands pressure rise in case of internal fault)
- Compactness (since conservator or pressure relief equipment is not necessary, height of the transformer room can be reduced by approximately 2-2.5 meters)
- Easy installation (oil or liquid purifying processes are not necessary with GITs)
- Easy inspection and maintenance work (basically, only SF6 gas pressure needs to be monitored during periodic inspection)
- Environmentally friendly

Since GITs do not have a conservator, it is possible to reduce the height of the transformer room. Also, considering that SF6 is non-flammable and there is no risk of an explosion of the transformer tank, it is not necessary to install firefighting equipment in that room.

Thanks to these features, and the fact that there are no accessible live parts, GITs as well as gas-insulated shunt reactors, gas-insulated switchgears (GIS) and control panels can all be installed in the same room, without any compartments. With this installation, a fully gas-insulated substation is achieved.

The main disadvantage of gas-insulated transformers is that when the gas is cooled by a liquid system, its rated power normally does not exceed 60 MVA because the space that is saved using this type of transformers is used for the equipment of the liquid cooling system. However, designs with a gas cooler system may go up to 400 MVA.

Conclusion

Safety, easier installation and maintenance of gas-insulated transformers are all factors that add value to utilities and their substations, since they contribute to both cost reductions and time saving. Also, in substations installed in dense and highly polluted areas, gas-insulated transformers combined with gas-insulated switchgears are a solution that saves space and is able to withstand adverse environment factors.

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