Grid Solutions

HERMETIK

Low-maintenance Power Transformers

Power transformers are a vital link in the energy supply chain. They must have a long service life coupled with a high degree of operational reliability.

Get More Out Of Your Transformer!

The insulation system of conventional transformers is subject to load/temperature-dependent aging. This is further aggravated by oxygen and moisture absorbed from the atmosphere. As power transformers are required to be more and more efficient and loaded to maximum capacity more often - and for longer periods of time - hermetically-sealed transformers have become the optimal solution.

A Longer Service Life

The primary reason for developing hermetically-sealed transformers was to reduce cellulose and oil aging.

This development started in Germany in the 1960s in the field of distribution transformers, with initial power ranges from 50 to 1,600 kVA. The temperature-dependent increase of the oil volume was not absorbed by the traditional conservator but by specially designed tank corrugations. This type of transformer has already seen more than thirty years of reliable and trouble-free service in industry and in energy supply. Today this technology is available with ratings up to 8,000 kVA.

Innovative Technology Developed for Power Transformers

GE Vernova started the development of hermetically-sealed power transformers more than a decade ago. With the ongoing changes in the energy supply industry, power transformers are expected to maintain a higher degree of operation and must have a longer service life. Maintenance, or the so-called life-cycle costs, also play an ever increasing role. The answer to all these requirements is GE Vernova's hermetically-sealed transformer, which thanks to its innovative technology, offers applications up to 245 kV and 250 MVA*.

Key Benefits

- Substantially longer service life
- Higher load ratings
- Reduced maintenance thanks to:
  - lower oil aging
  - no dehydrating breather
  - no hydro-compensator
- On-load tapchanger (OLTC) with vacuum switch, hence no contact erosion

GE VERNOVA

Low-maintenance, Hermetically-sealed Power Transformers

It Is the Technical Differences That Count!

GE Vernova standard power transformer design (Fig. 1) from 12.5 to 80 (100) MVA, 110 kV, is laid down in DIN 42508 in Germany and other international standards such as IEC 60076-1 or IEEE standard C57.12.00. These standards decide the outer appearance and configuration of a transformer, which basically consists of the tank with the active part (core, windings and on-load tapchanger), the HV and LV bushings, the conservator with associated piping, dehydrating breathers and the radiators, which only serve to radiate lost heat.

Hermetically-sealed power transformer design (Fig. 2) largely follows DIN 42508 for Germany, or international standards such as IEC 60076-1 or IEEE Std C57.12.00, with the exception that it has neither a conservator nor any dehydrating breathers. The radiators are of a special design in order to fulfill two functions:

- to radiate lost heat
- to accommodate insulating liquid volume changes

In addition, a new type of low maintenance on-load tap-changer can be used, such as the Vacutap OLTC. This is fitted with vacuum contact chambers, so that arc extinction does not take place in the tap-changer oil but in the individual vacuum contact cells. The result is that there is no oil decomposition due to switching operations and hence no contamination of the tapchanger oil. Compared to a conventional tap-changer, the service interval for the Vacutap switch has been extended up to 15 years. The conventional wedge-type gate valves have been replaced by stainless-steel spherical valves for increased reliability.

Another way to seal the transformer oil against the atmosphere is to use an airtight oil/air separator, such as a rubber bag fixed via a flange in the oil conservator. The inside of the rubber bag is connected to the ambient atmosphere via the flange, piping and dehydrating breather. This method presents disadvantages:

- The rubber bag requires a dehydrating breather to protect it
- The rubber bag may need replacement or maintenance

Advantages of Hermetically-Sealed vs. Conventional Transformers

Transformer oil is sealed against the atmosphere:

- Limited oil aging due to oxidation
- Limited moisture in oil
- Limited cellulose aging in solid insulation

No oil conservator and no associated devices with maintenance needs:

- No dehydrating breather
- Limited protection devices

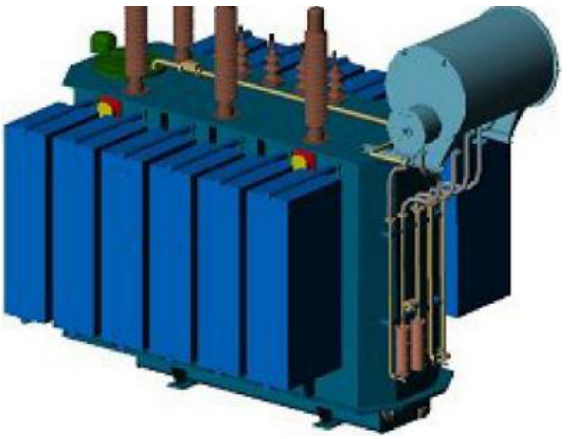

Fig.1: Power transformer to DIN 42 508, IEC 60076-1, IEEE Std C57.12.00

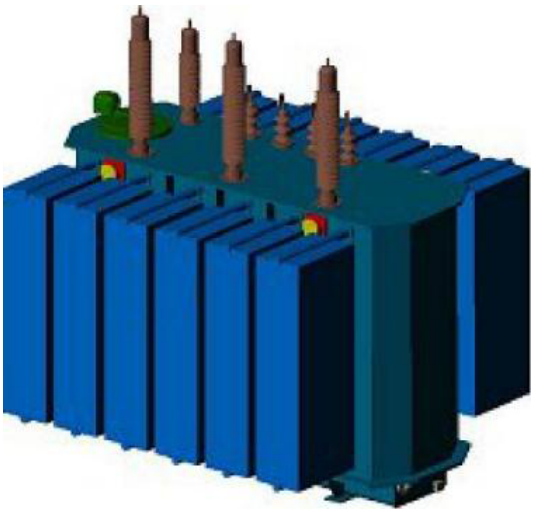

Fig. 2: Hermetically-sealed power transformer

Optional Use of Low-maintenance On-load Tapchanger with Vacuum Interrupters

This offers major customer benefits:

- Substantially longer service life
- Higher load ratings
- Reduced maintenance needs
- Low life-cycle costs

Limited Needs for Protection and Monitoring Devices

Since hermetically-sealed transformers do not need a conservator, detection of faults does not require an oil flow relay. Therefore, only two devices are required for the protection of the transformer:

- A simple gas monitoring Buchholz relay mounted on the tank cover, monitoring both the oil level and any gas accumulation in the oil level pipe. Gas samples can be taken via an adapter.
- A pressure relief valve fitted to one of the face-end tank walls. It opens at a preset pressure and resets automatically. Oil escaping while the pressure relief valve is in action is directed to the transformer base (via pipe on request - Fig. 3). The tap-changer is also fitted with a pressure relief valve. Both valves are set to act at an overpressurisation of 0.48 bar.

Cellulose Aging Limited to Thermal Aging

The insulating system of a transformer consists of insulating oil and solid insulation such as: paper for the winding conductors, pressboard for the coil cylinders, insulating caps, spacers, etc. Insulating paper and pressboard are made of cellulose. Cellulose is a chain molecule, made up of glucose rings, linked by OH bridges (Fig. 4). The number of glucose rings in a cellulose molecule is also known as the degree of polymerisation (DP), which is about 1000 for new cellulose.

Cellulose is subject to aging which, in a conventional transformer, is made up of three components:

Fig. 3: Buchholz relay and pressure relief valve

Thermal Aging

Under thermal aging, the glucose rings disintegrate, which happens at temperatures of about 105 °C (or higher for thermally upgraded paper). Typical aging elements are free glucose, water, carbon monoxide and carbon dioxide.

Oxidative Aging

Under oxidative aging, oxygen leads to a further disintegration of the glucose rings producing - among other things - acids, ketones and phenols. This also occurs at normal transformer operating temperatures. Tests on insulating paper samples have shown that the presence of oxygen increases the aging rate by three compared to the absence of oxygen.

Hydrolytic Aging

Under hydrolytic aging, water is both the cause and the product of cellulose aging. The reason is usually poor (or no) maintenance of the dehydrating breathers.

Water dissolves the oxygen bridges between the glucose rings. Tests have shown that in the presence of oxygen and a water content of 2% in the paper insulation, the aging rate is increased by a factor of 20. At a DP of 200, according to the LCIE report and the IEC 60076-7 standard, the insulating paper reaches the end of its service life, i.e. it loses its mechanical stability and thus its dielectric capacity. Any short circuit stress would directly lead to transformer failure.With hermetically-sealed transformers, aging processes are largely limited to thermal aging.

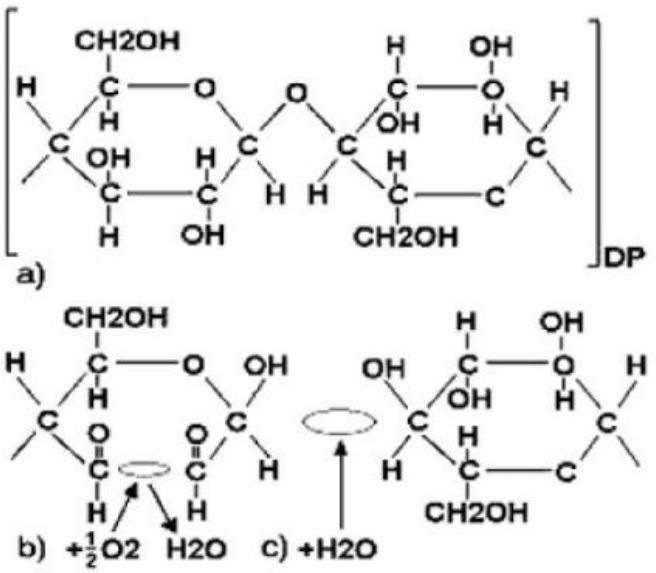

Fig. 4 : Formula and depolymerisation of glucose

Innovative Variable-Volume Radiators

A new type of radiator has been developed for hermetically-sealed power transformers. The design is based on conventional radiators to make it cost effective, but the volume is variable to the largest possible extent without affecting useful service life. In co-operation with radiator specialists, several types of radiators were designed, manufactured and subjected to endurance tests. The result was a variable-volume radiator which passed the endurance tests with 5,800 load cycles. In accordance with DIN 42 500-6 and EN 50216-6 standards, this corresponds to a service life of 87 years. In parallel with the development studies undertaken with the Hochschule Aachen, the elite German engineering university, theoretical stress investigations were carried out. The theoretical results were fully confirmed by endurance test results.

The radiators are designed in such a way that under maximum temperature / pressure, their expansion does not affect the natural convection of cooling air between the radiator elements. In the design of the new radiators, two compromises had to be made:

- The upper, outer edges of the radiators cannot be sloped, which is necessary to ship a transformer within the rail loading gauge, i.e. for transport by rail, the radiators have to be removed.
- They cannot be hot-dip galvanised.

Drastically Reduced Life-Cycle Costs

In the study of the life-cycle costs, transformers with identical technical data (voltage ratio, impedance voltage, vector group and losses), but with three different design formats were compared:

- A hermetically-sealed transformer
- A conventional transformer with conservator (to DIN 42,508 or IEC 60076-1)
- A transformer with hydro-compensator in the conservator

Over an operating period of 40 years, certain recurrent maintenance work is carried out on a transformer:

- Usually, about four times a year, the dehydrating breather has to be serviced, i.e. the silicagel has to be replaced
- The standard OLTC has to be serviced every seven years
- After about 20 years, it may be necessary to re-condition the transformer oil
- On a transformer with an oil/air separator such as a rubber bag, the rubber bag might need maintenance

Over its entire service life, the hermetically-sealed transformer does not require any particular maintenance or service work. Only the low maintenance OLTC, if present (such as a Vacutap OLTC), has to be serviced about every 15 years but, without any oil decomposition or contamination, the work is much less than a standard on-load tapchanger.

When calculating and comparing the maintenance cost in the overall life-cycle costs for the different types of transformers, it becomes evident that hermetically-sealed power transformers offer considerable savings in addition to reduced paper and oil aging.

For more information, visit
gevernova.com/grid-solutions

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