Transformers for Networks of the Future

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Introduction

Future transformers will need to be able to integrate with networks of the future, and should also be designed to address the critical issues that networks of the future will address. They should therefore be efficient and reliable, and should also be designed with consideration for both safety and environmental issues. Eco designs may result out of complete life cycle assessments of transformers for networks of the future.

Efficiency

Environmental concerns and possible legislation will result in pressures to reduce losses from the power system where possible. If the cost of energy increases, the losses of transformers will be more and more capitalised during the procurement process providing a financial incentive to reduce these losses. Through improved design and manufacturing techniques, it may be possible to reduce both load and no-load losses of new transformers. Further development of materials may also help in producing lower loss transformers in the future.

Reliability, Economics and Maintenance

Vacuum OLTC (On-Load Tap Changers), have reduced the need for tap changer maintenance. As manufacturers further develop these products, and the premium cost of this new technology reduces, it is likely that the use of these tap changers will increase.

The use of on-line monitoring and control systems will increase as the infrastructure to transmit this data, and the systems that turn the masses of data into more useful information, become more readily available. This will assist in the reliable operation of transformers and allow their economic life to be optimised, by reducing the need for maintenance tasks that are performed to evaluate the transformer's condition.

This will be achieved by:

- allowing existing or developing faults to be assessed without taking the transformer off line;
- enabling informed decisions about transformer loading to be made so that the transformer life can be balanced against the benefits of supplying higher loads.

The remaining life of a transformer may therefore be estimated more accurately. This will assist with replacement planning, but also in the decision making when repairs or complete refurbishments have to be considered eg, as part of lifetime extension projects.

Rapid changes to technology will probably make any on-line monitoring or control system obsolete in a few years, as spare parts and support may not be available in the longer term, and the cost maintenance of these systems may be expensive. These issues should be considered when determining the economic benefits of installing on-line monitoring or control systems.

Information from other components or systems in the substation, eg protection relays, may similarly be used to provide information about the transformer which may be useful in ensuring its reliable operation. Examples of information that may be available include:

- magnitude and duration of fault currents supplied through the transformer; and
- both normal and harmonic load supplied by the transformer.

Environmental

The use of alternate insulating fluids may increase in the future, particularly those that are biodegradable and produced from a renewable source. These alternate fluids generally have higher fire points than mineral oil, as well as providing potential environmental benefits.

Recycled, refurbished or re-refined mineral oils may also become more popular in the future. The increased use of these fluids will, however, be dependant upon future development and favourable in service experience with current liquids. It should be noted that some users have reported very favourable experience using recycled oil, particularly on lower voltage transformers.

Further development of dry type or gas insulated transformers will also assist with adverse environmental impact of liquid filled transformers, oil containment issues, improved fire safety, reduced segregation, and more compact substations. Many users are now using dry type bushings on their transformers, in place of the oil / paper bushings.

Transformer noise is a major issue when transformers are installed near residential areas. Hopefully designers will be able to continue to further reduce both load and no-load noise. The noise resulting from harmonic loads on transformers may also need to be addressed.

Noise levels from cooling systems are often more of a problem than the noise from the active part of the transformer. Lower noise cooling systems will therefore be required. This may be achieved by the use of cooling control systems, which minimise use of the fans at their highest speed, yet ensure that the transformer life is not compromised by continual operation at high temperatures.

Safety

Safety during operation and maintenance will be a major consideration for transformers of the future. There will possibly be a continuing move away from paper oil bushings with porcelain insulators and towards the use of dry type bushings with composite insulators. However, this will depend on continued development of these products, and favourable in service experience.

Transformer tanks of the future may be better designed to withstand the overpressures, that may result during fault conditions, and may include better methods of pressure relief, containment and fire prevention.

To ensure safety of staff maintaining transformers, future transformers may be designed to eliminate where possible the need to work at heights. For example, the increased of use plug in terminations would eliminate the need to climb on the tank to make connections to bushings.

Network Issues

Many transformers may be loaded differently in the future as demand management attempts to remove peaks from the system and results in a more constant load. This will potentially result in more efficient use of some transformers as they operate constantly near their rated load. Many utilities operate their transformers on an "N-1" basis so that loss of a transformer does result in the loss of supply. A more constant load should also allow better utilisation of these transformers. However, network operators, who have enjoyed very long lives from transformers that have only been loaded heavily at times of peak demand and high temperatures, may find that their future transformers will have a reduced life.

Transformers that are connected to renewable generation sources, eg wind and solar generation, may be subjected to extreme peaks in load followed by sudden drops. This may result from wind or solar generators. This may cause voltage regulation problems with the changes in transformer load. It may be possible to overcome these issues through the development of control systems that integrate with the generators. The rating and loss of life of these transformers will also be an issue to be addressed by monitoring systems.

It is likely that embedded generation will result in reverse power flows on some transformers. Designers will need to ensure that this does not create issues for the transformer or its ancillary components. This issue is currently under consideration by Cigre.

Some sources of generation may result in higher levels of harmonics than have otherwise been experienced on the network. Furthermore, many loads connected to the power system are also increasing the level of harmonics on the network. This will need to also be considered in the design of the transformers. Dynamic rating systems will need to monitor harmonics and ensure that they are considered when providing rating information.

It should also be noted that system transients are increasing on the power network. The interaction of the power system and the transformer is currently being considered by Cigre.

Cigre Publications

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