ROYAL SMIT TRANSFORMERS

Company profile

Royal SMIT Transformers manufactures large power transformers and reactors for the transmission of electrical energy on HV Grid, mostly in the voltage range of 138kV to 525kV. SMIT is an ‘engineer to order’ company, with maximum power ratings of 1200 MVA and voltage levels up to 765kV, located in the centre of Nijmegen (Gelderland) since 1913, with 650 employees (including 70 highly skilled engineers). SMIT is part of the larger SGB-SMIT Group of companies, with factories in Germany, the USA, Malaysia, Romania, the Czech Republic, India, China, South Africa and France, see - https://www.sgb-smit.com/products/large-power-transformers/overview/

A 360MVA, 400kV Generator Step-up Transformer ready for delivery to the customer

Royal SMIT exports its products to the USA, Europe and the Middle East. To comply with the requirements of international standards and to remain competitive in a fast changing world, Royal SMIT must further develop its technical knowledge concerning the detailed modeling, calculation, design and manufacture of large power transformers and reactors.
Some Ideas for Projects /Internships

1. Optimized Stacking of Magnetic Steel Laminations – MSc Level
A large power reactor possesses a magnetic shield to provide a controlled, low loss path for the magnetic flux of the reactor windings. This magnetic shield is made from a complex pattern of many 1000’s of stacked magnetic steel laminations. The task of this project is to investigate by theory (by calculation and by using a finite element software tool) and practice (by direct measurement) the influence of different stacking patterns on the magnetic flux distribution within the magnetic shield. The final target is the construction of an optimized magnetic shield, taking into account the total losses, temperature, vibration (audible noise), overall weight and cost (material plus labour).

2. Zero sequence impedance of a transformer without delta winding – MSc/HBO Level
Transformers and the transmission system, are in general designed for balanced (symmetric) operation. However, when a transformer is loaded with an unbalanced (asymmetric) load, for example a single phase short-circuit or an unbalance load in the grid, a zero sequence component exists.

In a transformer lacking a delta connected winding, this zero-phase sequence current results in additional high losses, which causes unwanted heating of the structural steel parts of the transformer. The cause of these losses is unknown. The task of this project is to investigate the cause of these additional losses and to propose a solution if possible.

Certain transformers have the start and end of the winding not at the same side of the core. If the start of the winding is at one side of the core and the end of the winding is at the other side of the core a half turn is used to get from the side where the winding starts to the other
side where the winding ends. A part of the task is also to investigate the influence of the “half turn” during load and no-load losses, because this will also result in a zero sequence current.

3. GIC modelling – MSc Level

Solar activity or “solar storms” are geomagnetic disturbances that can cause severe problems in large power grids. Large DC currents (Geomagnetically Induced Currents or GIC) are induced in the surface of the Earth. Where the ground has a naturally high electrical resistance, the DC currents may enter the transformer windings via the grounded neutral terminal of the transformer.

Transmission System Operators (TSO’s) request the transformer manufacturer to deliver a GIC study which illustrates the transformer’s ability to withstand this phenomenon.

Schematic of GIC in the EHV transmission system

The DC currents in the transformer can cause (half cycle) saturation of the magnetic circuit (core), higher harmonic currents, excessive noise generation and overheating of structural parts. This can eventually lead to gassing or even catastrophic failure. This effect is very dependent on the duration and magnitude of the DC current, but also on design concept of the transformer.

Single phase or three phase units, or the design of the core with three or five core limbs, have great influence on the behaviour. Also internal construction details, such as the location of structural parts and their material choice have an effect.

The thesis is to create a simplified transformer model with enough accuracy to determine the effects on the critical elements, such as the core, windings and structural parts which are influenced by the magnetic field.

Input from main transformer design parameters shall be used by the model, to expose the weak spots and possibly generate maximum duration and amplitude of the GIC event in order to prevent failures.

4. Radial spacer winding voltage distribution during Lightning Impulse test – MSc Level

The task is to investigate theoretically and by measurements the voltage distribution across a radial spacer winding in case of a lightning strike hits the transformer. The voltage distribution across the winding can be influenced by changing the capacitance between turns of the winding. One way of influencing the capacitance is to use shielded (floating) conductors inside the winding. These shielded conductors are wound in between the current carrying conductors.
For the practical measurements a test winding has been produced and already shipped to TU Delft where the test will be performed in the high voltage laboratory.

![Test winding for measurement of transient voltage distribution](image)

### 5. Calculation of Transformer Overload Capabilities – HBO Level

A transformer has core (no-load losses) and winding losses (load losses) during operation. These losses must be dissipated by means of coolers. The cooling is arranged in such a way that the temperature of the windings remain within guaranteed limits. Transformers face conditions during operation that can cause the rated operating temperature of the windings and oil to be exceeded. This can be caused, for example, by the failure of a transformer in parallel operation. The remaining transformer is then loaded with double the power. Another example could be the failure of part or all of the cooling. This causes the transformer to be thermally overloaded.

When purchasing a transformer, a utility (TSO) would like to have an idea of the possibilities of overload and possibly the time that a transformer can remain in operation after the cooling failure (residual operating time). This is important for a TSO to be able to guarantee a stable energy supply to end users. The possibility of overload or residual life is indicated by the OEM (SMIT) when making the offer and / or after the final inspection on the basis of the measurement results in the test lab. SMIT does not currently have an up-to-date program for calculating the limits to overloads or the remaining operating time in the event of a cooling failure.

**Targets**
The aim is a computer program with which, according to the latest standards, the possibility of overload and residual operating time can be calculated and presented in a fast and efficient...
manner for different cooling methods. The presentation consists of graphs and tables that are tailored to the specific needs of a large group of different customers.

- Knowledge of the transformer with a focus on the different cooling principles.
- Knowledge of the various IEC / IEEE standards regarding the overloading and cooling of transformers.
- A calculation method for determining temperatures and service life consumption when part or all of the cooling is lost.
- An inventory of the various customer requirements with regard to the presentation of overloads and residual operating life in graphs or tables.
- A set of requirements (pseudocode) for a programmer for drawing up a program in C# based on the above points.
- A program in C# that fulfills the objective.

500/230kV 400MVA 1-phase Autotransformer ready for the temperature rise test