The way towards 800 kV DC converter transformers

01/28/2015 - 4.25 pm

HVDC MESHED GRIDS
POWER TRANSFORMERS

The sheer size of converter transformers for ultra-high voltage DC (UHVDC) systems poses special challenges, not only for integration with other equipment, but even for design, testing, manufacturing and transport to the site.

Post a comment

The names and even external shapes of many electrical components are often the same whether for small household appliances or gigantic industrial structures. For manufacturers, however, it is not simply a matter of scaling up the structure. Today, Alstom offers 800 kV converter transformers, but as David Wright, Senior Expert Engineer in the Power Transformer Division, explains, “Developing UHVDC systems meant practically starting from scratch in many cases. Initially there was little information available about the performance of insulation materials for converter transformers at the very high AC and DC voltages involved, so detailed testing on prototypes was needed to generate comprehensive design information.

Even before testing prototypes, bushings had to be developed. When you think of the complexity of grid equipment, power electronics probably come to mind, but even a seemingly simple mechanism like a bushing presents challenges. In a converter transformer, both AC and DC can be present, which adds to the complication. The voltage distribution of a bushing is determined by the capacitance between the foils for an AC voltage but by the resistance between the foils for DC. Special measures are needed to control voltage distribution when the bushing is in the transformer turret.

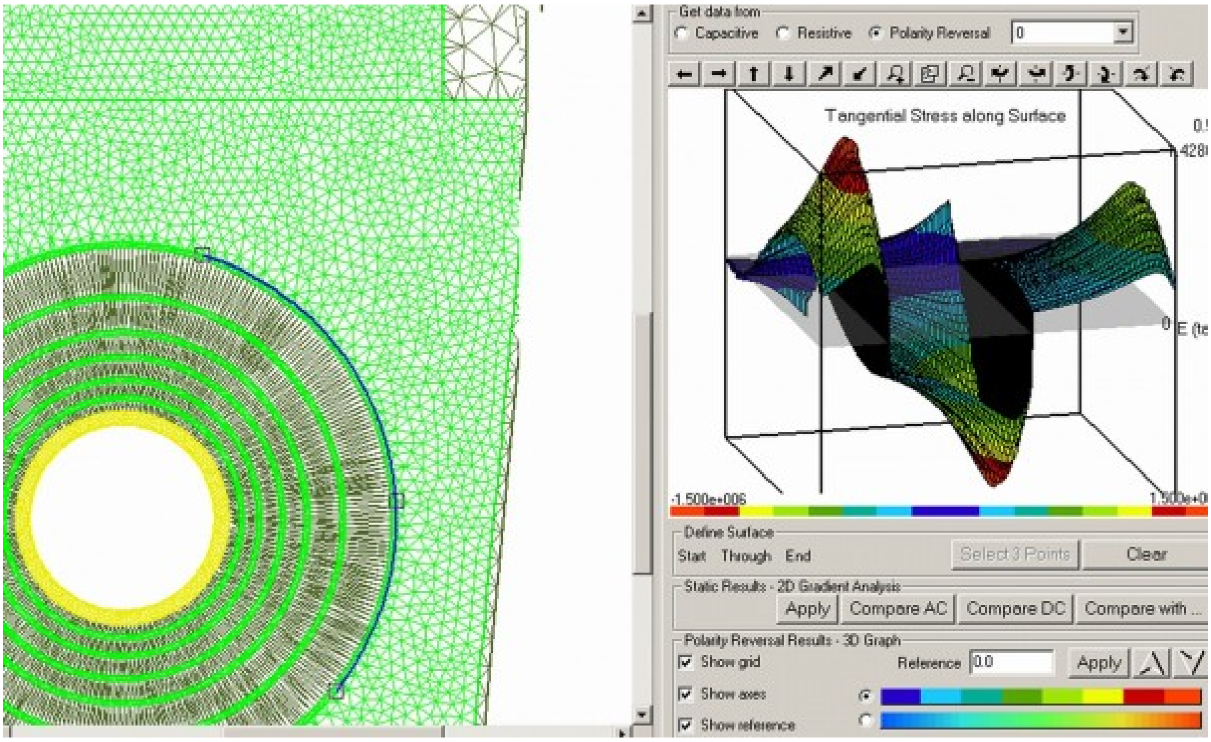
Alstom Grid - 800_kVDC bushing being tested in Graz, Austria

Getting it out of the door

There are physical constraints, too. Ratings have been increasing to achieve higher power transmission levels, but size cannot simply be increased proportionately. “The size and weight of the transformer is limited by shipping constraints,” says Wright.

The size and weight of the 800 kV converter transformer is limited by shipping constraints

“So if you want to get it out of the door and delivered to the site, insulation design has to optimise the clearances and component structures to produce the most compact transformer possible but still maintain its thermal performance and respect IEC norms.” Trial and error would be too costly, so Wright and his colleagues took Alstom’s SLIM finite element modelling package and added the capability to analyse the particular challenges of UHVDC bushings and transformers for studies of the core design, harmonics, hot spots and dielectric components.



Finite Element Modelling

With the results suggesting that the proposed solutions were feasible, the next stage was building a prototype. The Technical University of Graz had a hall big enough for initial tests of the bushing, but to meet the requirements for test voltage supplies and very low levels of background partial discharge for a transformer weighing over 100 tonnes, Alstom upgraded the facilities at its transformer factory in Wuhan, China, where the prototype was manufactured and tested successfully in 2011.

800 kV converter transformers being tested in Wuhan, China

One of the challenges Wright's team had to overcome in moving from prototype to on-site installation was the fact that the internal, valve-side connections require large electrical clearances and can have a significant impact on the size of the transformer tank. To reduce the clearances, a system of preformed barriers with controlled oil duct spacing was developed and implemented for both 600 and 800 kV DC converter transformers. This allows the connections to remain inside the transformer tank while respecting the size limits for shipping the converter transformer.

Success justifies the investment

Converter transformers for Rio Madeira 600 kV DC bi-pole 2 were manufactured and tested in upgraded facilities in the Alstom factories in Canoas (Brazil), Stafford (UK), and Wuhan (China). The 800 kV DC Champa-Kurukshetra transmission network in India involves the supply of 28 transformers from Alstom in the UK and Vadodara, India. Looking back, David Wright insists that "success required a major commitment of resources, expenditure and coordination of the many skills of the Power Transformer Product Line. Our approach enables us to offer transformers comprising the best available technology throughout, no matter which of our factories worldwide is producing them."

RATE THIS ARTICLE

COMMENTS

SIGN UP FOR OUR NEWSLETTER

LEARN MORE

EXPERTS

David Wright

Power Transformer Senior Expert Engineer - HVDC

SEND A MESSAGE TO OUR EXPERTS