Successful development of a 3.0 kA-class HTS cable conductor

David Lindsay, Dag Willén

Ultera™ – A Southwire/nkt cables Joint venture

11 Aug 2003

For general distribution (2 pages)

Background

Ultera has focused a part of its research effort in designing, building and testing low-loss cable conductors based on the high-temperature superconducting materials (HTS). This resulted in 1999 in a world-record low loss of 0.6 W/m at 2 kA(rms) current, 50 Hz by NKT Research. This was sufficient to power the AMK substation in the 30-meter Copenhagen demonstration project. The Copenhagen test facility supplied power to 50,000 users for about two years. The facility has now been dismantled, and the focus is turned to a longer demonstration project in Columbus, Ohio. This project is realised in collaboration with the utility company American Electric Power (AEP).

The AEP project requirements

In the AEP demonstration, a 300 m cable system is desired. The peak loads in the hot summer period is expected to reach 3.0 kArms by the summer of 2007. This is a significant increase compared to the 2.0 kA rating in the Copenhagen project and the 1.25 kA rating in the Carrollton project since energy dissipation and heating normally goes as the square of the current. In addition, the worst-case over-current rating is 30 kA in the AEP project – almost a factor two up from the 16 kA fault current level in Copenhagen and more than a factor of two for the 13 kA level in Carrollton.

Successful 3 kA conductor testing

Two main factors have enabled the realisation of a 3 kA-class conductor. The first is an improved selection and control of pitch angles and diameters in the cable conductor. The second is by the use of higher-current HTS tapes. Today each tape is capable of carrying 100-130 A instead of the 30-50 A per tape that was possible before. Ultera has worked intimately with the materials supplier American Superconductor Co (AMSC) in order to obtain HTS tapes with overall properties suitable for this target.

Through these improvements it has been possible to fabricate a 3 kA-class cable conductor from only two layers of HTS tape, where the older 2 kA-class cable was using eight layers of HTS tape, see Figure 1. The conductor was manufactured by Ultera, and tested at Oak Ridge National Lab (ORNL) at a frequency of 60 Hz. In Figure 2, the results have been scaled to 50 Hz in order to compare to the previous best results.

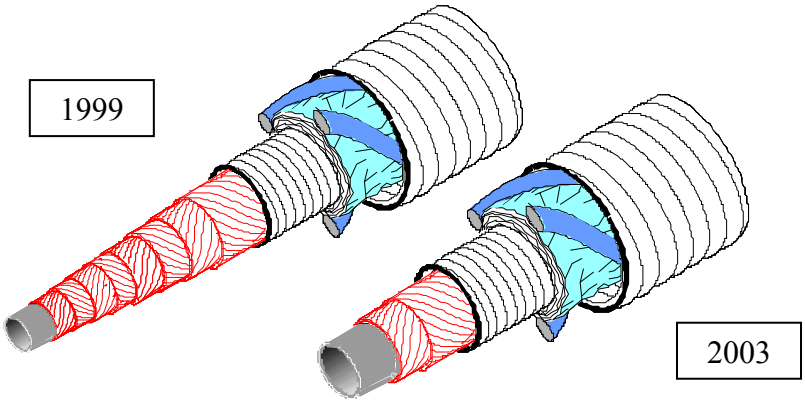

Fig 1.The 3 kA-class cable conductor fabricated and tested April-May 2003 uses only two layers of HTS tapes, compared to eight layers in the previously best conductor from 1999.

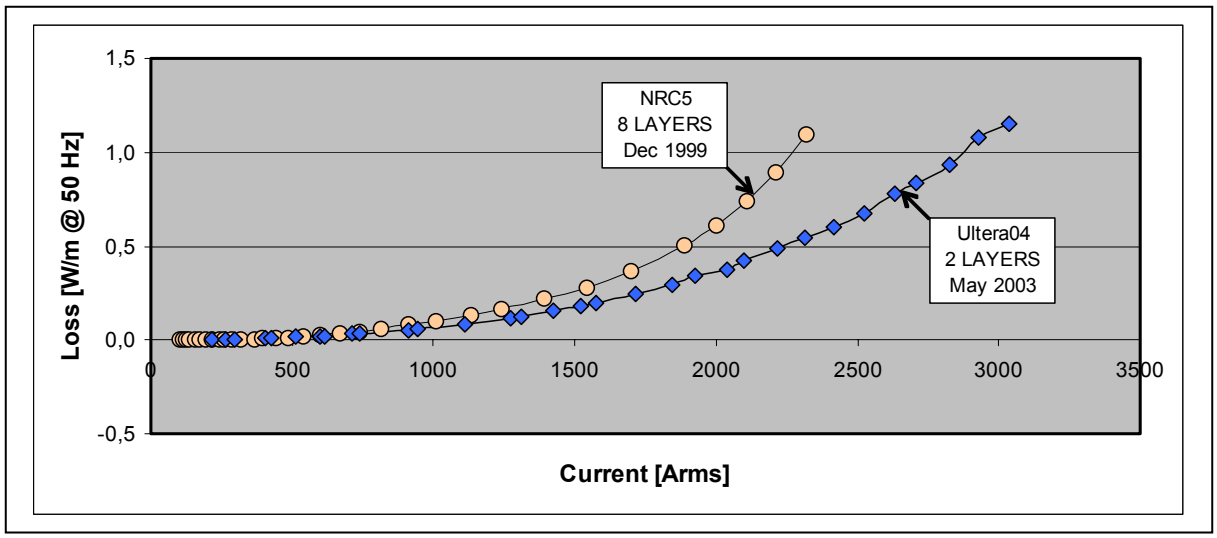

Fig 2. Test results of a 3 kA-class HTS cable conductor made from two layers of HTS tapes, compared with the previous best results of a 2 kA-class conductor from 1999 where eight layers of HTS tape were used.

Implications of these results

Three-kilo-ampere operation means that more users can be supplied from a single cable, or the same number of users can be supplied at a lower voltage level. This gives a new tool for utility planners to simplify their network and to re-locate unwanted transformers from down-town areas.

In conclusion, we can now get better performance with two layers of superconductor tapes than we previously could with eight layers. This greatly simplifies cable manufacturing, reduces cost, and makes the product a lot more realistic.