Specially Tailored Converter Transformers

Best Transformer

R&D Center

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BEST TRANSFOMER

by Emre KERVAN

Challenging Design for Challenging Grid

Converter Transformer Design is no Joke

BEST Transformer (www.besttransformer.com); has experience in distribution, power and dry type transformers. Transformers like converter (rectifier), SVC, phase shifting, arc furnace transformer or reactors are called “special transformer” in BEST and we could manufacture these high-tech products according to customer needs as called as “tailor-made”.

Converter transformers are produced according to usage by customer; how many rectifiers will be used, how many outputs are necessary, what are the harmonic levels, over-excitations and over-currents. BEST could design the output of transformer for different pulse numbers such as 12, 24 and more. Biggest challenge is harmonics for such designs, which could be handled with expert knowledge. Additionally; active part design with middle limb (double stage core) is always considered so there are multiple solutions depending on design.

1) Converter Transformer Technology

Converter transformers are used for industrial processes which require a significant Direct Current (DC) supply. Duties of converter transformers serving special industrial loads are more stringent than conventional transformers. Design and manufacture of transformers for the rectifier duty poses certain challenges. Complex winding arrangements, high currents and associated stray field effects, additional losses and heating effects due to harmonics, the necessity of maintaining constant direct current are some of the special characteristics of the converter transformers. The converter transformer winding losses are around 60-80% of total losses, so cooling system design under changing electrical conditions is essential [2 – 3].

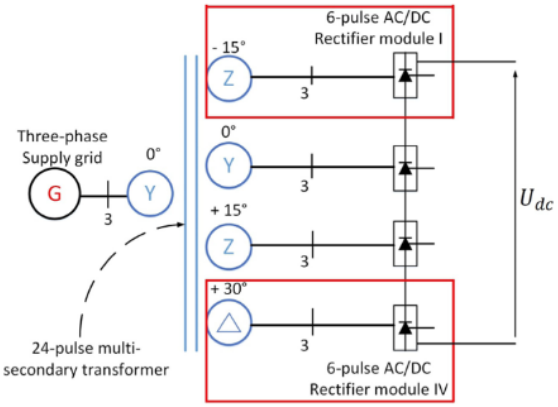

Figure 1: 24-pulse converter used in HVDC systems [1].

2) Challenges and Solutions

Converter transformers are subjected to harmonics due to non-sinusoidal current duties. Harmonics changes at every frequency and every frequency effect must be calculated with

care. Total Harmonic Distortion (THD) levels could go up to 30-40% for these types of transformers. BEST make more detailed loss calculations for these converter transformers compared to conventional transformers, taking harmonics into account during the design process. In cases where harmonic components are included, we perform Finite Element Method (FEM) analysis when detailed loss analysis is required for windings. Electromagnetic screen could be is used between the windings in order to reduce the effect of high-order harmonic components. It is necessary to design insulation of secondary side with consideration of over-voltages and their durations, higher level insulated secondary side could extend the lifetime of transformer. Mechanically; LV side bushings and complete active part design of converter transformer must be done carefully. High currents could affect each other and they could create overlapping magnetic field and vibration, thus additional losses and vibrations [4 - 5].

Figure 2: Converter transformer top view

Non-uniformities or asymmetries in valve firing angles produce DC magnetization of the transformer core increasing the magnetizing current. Appropriate designs are made by our

design department by taking into account the DC magnetizing current in order to avoid excessive loss and noise in the core. To reduce the noise level due to harmonics and possible dc magnetization, the operating flux density value is chosen lower than conventional transformers.

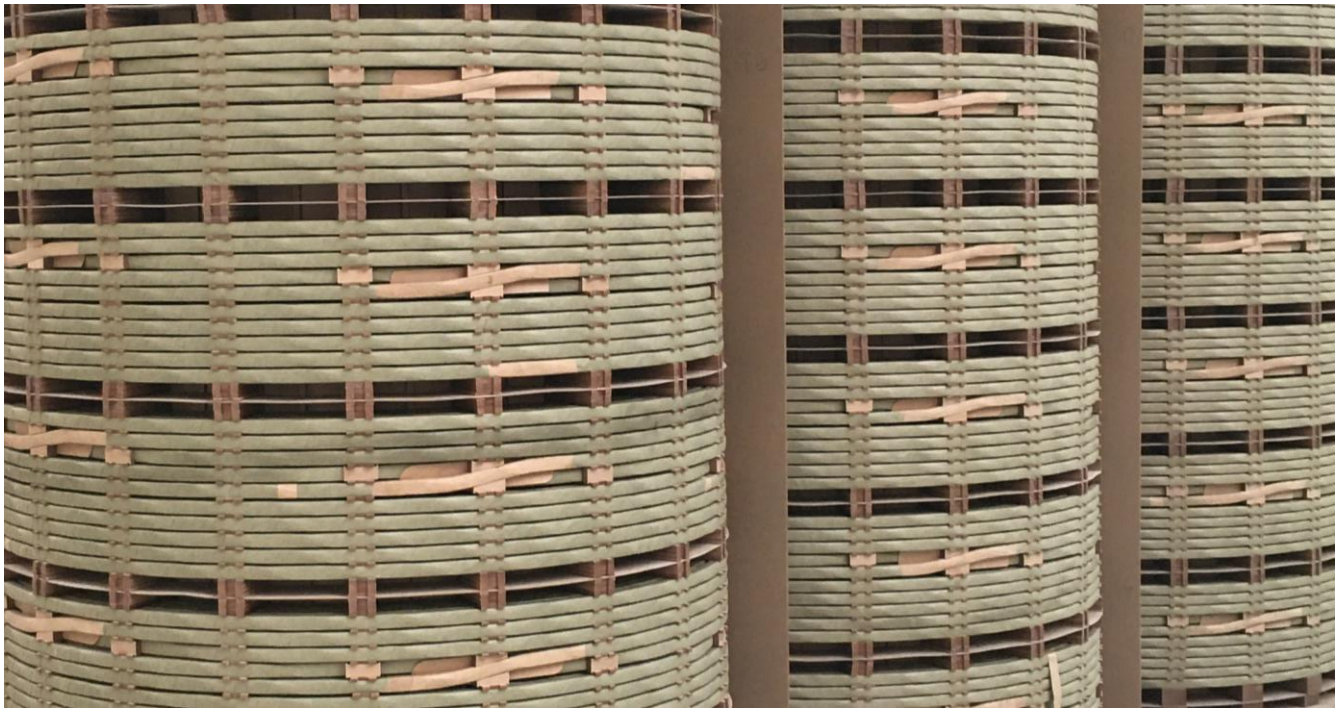

Figure 3: LV side multiple output design and manufacturing is key for these transformers.

Due to possibility of maloperations of valves resulting in high currents, the short-circuit withstand design of the converter transformers deserves more attention. Therefore short-circuit impedance are calculated between all windings. The leakage impedance of the transformer is chosen to limit the short circuit currents through any valve. Disk type windings are preferred to reduce short-circuit forces since they have better short-circuit strength compared to layer windings.

3) Experience

BEST manufactured converter (rectifier) transformers at 2020 for an off-shore project in Germany. Designed and produced converter transformer was a multi-winding transformer with 17.2MVA rated power, ONAN cooling system, 36-pulse and 110 kV rated voltage.
This converter transformer designed to be used for traction system in German railways passed all Factory Acceptance Tests (FAT) and earned its place in BEST's Honor Wall.

Figure 4 :Converter transformer before Factory Tests (FAT)

Key Points:

- Design considering harmonics and DC magnetization
- High short-circuit withstand ability
- To avoid heating problems, more elaborate loss calculations
- Special phase shifting for different pulsing numbers
- FEM analysis supported analytical calculations

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Organize San. Bölgesi 7.Cadde No: 1 BALIKESİR / TÜRKİYE
T: 0 266 281 10 70
F: 0 266 281 10 02


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