Novel solution for modern grid

Silent transformers and

BALIKESIR ELEKTROMEKANIK SANAYI TESISLERI (BEST) A.S. has been manufacturing power and distribution transformers since 1966. Today, thanks to 50 years of experience on five different continents, BEST has become the largest transformer manufacturer in Turkey, with its two manufacturing facilities located in Balıkesir city, TURKEY.

BEST has a total annual capacity of 40,000 MVA and capability to manufacture power transformers up to 800 MVA, 525 kV & 600 MVA, 750 kV; shunt reactors up to 250 MVAr, 525 kV; EAF transformers up to 350 MVA, and cast resin dry type transformers from 50 kVA up to 30,000 kVA, 52 kV.

SILENT POWER

Today's transmission and distribution grids differ from those developed in the previous century by an increased awareness of the environment. The rising power demand should be covered without further interference to the environment, or nature. This means moving to renewables, to intelligent grids, and to higher efficiency at every point. On the other hand, due to a rapid urban growth, the aged transmission and distribution infrastructure which was

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reactors

once located at the perimeters of the city has now come within densely populated residential areas. This has brought along some problems to overcome; for instance, the overhead transmission lines are taken underground due to health and security concerns.

As the phase cables are physically much closer to each other in underground cables than in the overhead lines, there is an increase in capacity, particularly when the network load is low. This causes over-voltages which are potentially harmful to equipment. Hence the increased demand for reactors worldwide.

A shunt reactor is a machine physically similar to a power transformer, but able to counteract the effect of the grid line parasitic capacitance, thereby stabilizing the system voltage within acceptable limits. The shunt reactor which is able to switch depending on the load variations by means of the on-load tap-changer is called a variable shunt reactor. This type of the shunt reactor brings flexibility and versatility to dynamic load variation compensation. It reduces the need to disconnect the reactor and instead, high efficiency can be achieved by simply using a tap-changer to determine the reactive power level.

Noise is another one of the concerns we are faced with today. The same infrastructure is required to become a lot more silent, and almost invisible. The power demand is increasing, but not as fast as the real estate value, so all this often has to be achieved in about the same space.

BEST has recently tackled both these issues at once: a variable shunt reactor that is extremely silent.

Working in the field of transformers for over a half century now, BEST has devel-

Rapid urbanization is forcing utilities to bury their systems underground – which significantly increases the need for reactors – and to reduce the noise from equipment to previously unseen levels

oped a new solution for its customer Energinet, exemplifying its expertise in reactor design.

THE CLIENT

Energinet is the national transmission utility of Denmark. Since 2008, the company has been working on burying underground its entire 132 kV transmission system and part of its 400 kV system. As of 2014, 1,900 circuit kilometers of cables are already underground. Denmark is also proudly the country with the highest proportion of wind power. This means the transmission network should also be highly flexible to suit the fickle nature of its main energy source. Both of these reasons make the Variable Shunt Reactors one of the main components of their grid.

This shift from fossil fuels to wind, and overhead lines to underground cables, is also a mark of commitment to environment. In fact, reducing the visual impact of the grid is one of the main purposes of this shift. From this perspective, it is no wonder that Energinet concerns itself with the other key factor in the environment - sound.

CHALLENGE

Transformer sound level plays a huge role in the tender evaluation of Energinet. In addition to the no-tolerance clause, the customer with the lowest possible sound level is prioritized.

Energinet wanted a variable shunt reactor 100-40 MVAr, 132 kV. Requested sound power level was 70 dBa, which is extremely low for this rating. On top of that, customer specified that this rating had to be reached at the maximum voltage level instead of the rated. For comparison, a 100 MVA, 400 kV three-phase power transformer BEST manufactured for Midtfjellet Vindkraft of Norway, had 80 dB sound power level guarantee. BEST was awarded this contract with an even lower guarantee: 68 dB.

In terms of sound pressure level, this corresponds to 48 dB, close to a small passenger car at idle.

THE DESIGN

From the beginning, creating a silent reactor transformer was at the basis of the transformer design. There are two main sources of noise in a transformer: the magnetic core, on the inside, and cooling fans and pumps, on the outside. This was a naturally cooled transformer, so the only concern was the prior.

The noise level of the magnetic core is based on three intertwined properties: the magnetic flux density, the total mass of the core laminations, and the properties of the silicone steel. A heavier core means also a louder core, and a lower flux density means a heavier core – and a larger overall transformer size. Even if size was not an issue, flux density can only be reduced so low before the core mass increases too much for the reduction to have any effect. It is a matter of finding the sweet spot where the noise level is at its minimum. Using a higher grade steel has its own limitations. Even the best grade of core steels cannot completely eliminate vibration. And, their differences are most noticeable at higher flux densities. At lower flux densities, like those generally used in reactor cores, the sound effect is negligible. For this reactor transformer, BEST opted for an extremely low flux density. Another step was the placement of anti-vibration rubber pads under the active part.

On the outside, the tank itself was utilized to be an effective noise reducing component. Therefore, vibration resistant tank walls were utilized. A more effective measure is to use sound insulation panels on the transformer tank. These are basically foam-like material placed on the tank, and then covered with another layer of steel. They act similar to heat insulation used in residential buildings. This means that the tank walls cannot dissipate heat, which has to be compensated by the cooling system. With a very low loss reactor, heat dissipation was not a concern.

These are all methods used in traditional power transformers and also utilized to their fullest in this project by BEST. In addition, the shunt reactors are plagued with the added vibration from the air gap core. The air gap core is used for higher linear reactance, up to 1.5xU/I, making it indispensable for high efficiency shunt reactors. To counteract this effect, noise dampeners are placed at regular distances on the tank. Normally, these dampers have the added effect of fighting eddy currents on tank walls, but in extremely low flux

densities like in this transformer, these are not a major issue. The tricky part is to install the noise dampers with the insulation panels. This requires precise planning and skilled handwork.

AND THEN THERE WAS SILENCE.

Utilizing all known methods of noise reduction on transformers and reactors, it was known, wouldn't be enough to reach the desired sound level. To come through on its promise to deliver a reactor that is – in terms of sound pressure level – almost as silent as a library, it was necessary to think outside the box. To get there, BEST cooperated with an expert in the acoustic enclosures, and built the reactor to fit inside a sound housing.

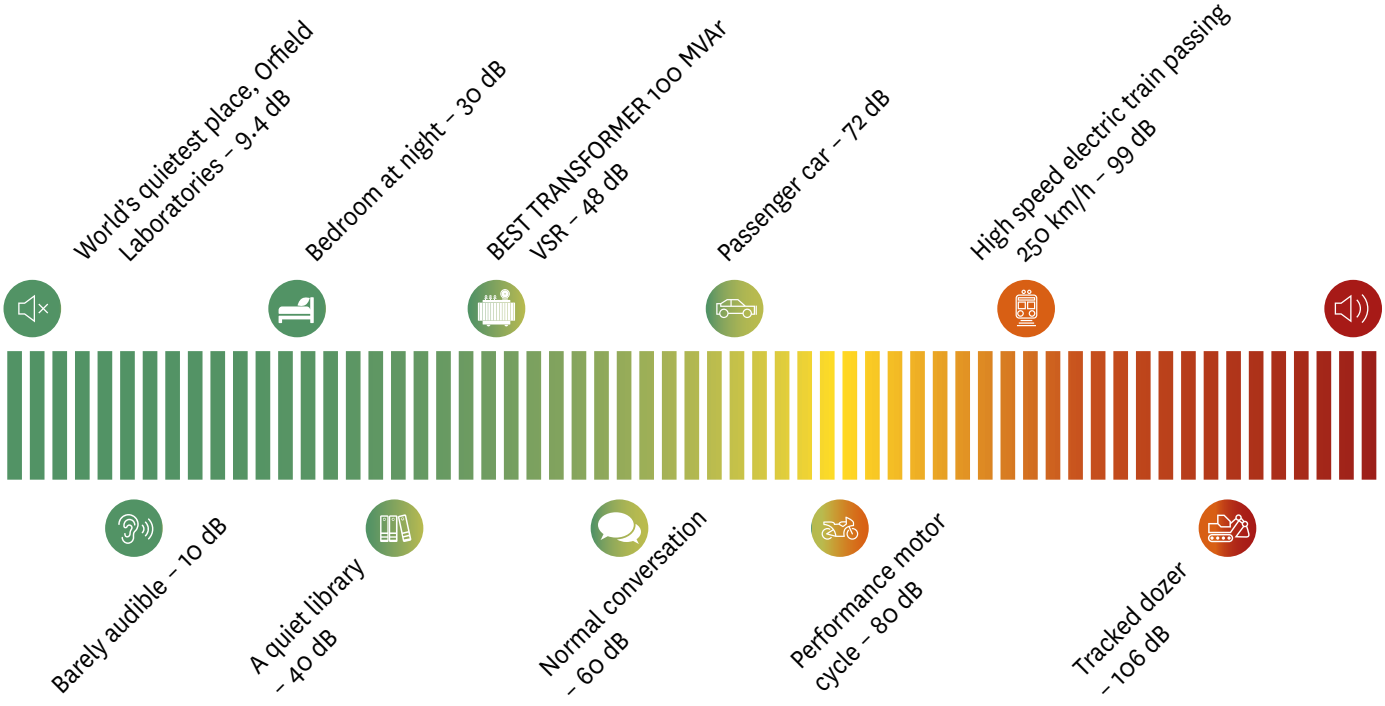
Utilizing conventional methods of noise reduction on transformers and reactors wouldn't be enough to reach the sound level required by the customer

Building a soundproof house for a transformer or a reactor creates new challenges. The enclosure has to be designed so that it can withstand all the weather conditions as the transformer, and retain its sound proofing quality for the full operating lifecycle. It has to be secure from outside intrusion, but also completely safe from inside – no one wants to get locked inside a soundproof enclosure next to a transformer. The bushings and cooling and oil expansion system is outside, meaning it has to accommodate these entry and exit points without compromise from its main purpose. It would even have its own internal lighting. Finally, the entire system had to be modular. The reactor would be tested at BEST factory in Balıkesir with the housing in place. Then, the entire thing would be dismantled, shipped to Denmark, and reassembled on site.

The result was a reactor which was definitely quieter, and arguably more appealing

Cooperating with an expert in acoustic enclosures, BEST has developed and built a quieter reactor, which is also more appealing to the eye than a typical reactor

Sound pressure level



to the eye than a typical reactor. Factory acceptance tests were performed at Balıkesir with the fully assembled housing in August. Tests were successful in all regards including sound level. The reactor was shipped to site in September and has been in operation since January 2017.

Unusual problems require novel solutions, and it takes an experienced manufacturer to satisfy an ingenious customer. With years of experience combined with a modern sense of innovation, BEST can rise to any challenge when it comes to transformers. Operating in all areas of the transformer manufacturing – power transformers, oil-filled distribution transformers, dry types or special purpose industrial transformers – as the largest independent transformer manufacturer in Europe, BEST is proud to be your BEST partner in power projects.