Life Is On Schneider Electric

PFC Detuned Reactors
Aluminum over Copper Reactors
Facts and Myths

LV Detuned Reactors

Revision 1

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Executive summary

There is a common misconception that transformer/reactors with copper windings are more efficient, more reliable, or have higher short circuit strength compared to a transformer/reactor with aluminum windings.

However, improvements in technology regarding the use of aluminum in transformer/reactors have made aluminum-wound transformers equally efficient and reliable, with greater short circuit strength when compared with copper wound transformers/reactors.

Introduction

Detuned reactors – three-phase inductors dedicated to attenuating the amplification of harmonics in harmonic-rich networks – are designed specifically to protect the different components of an electrical installation. A detuned reactor also safeguards its associated capacitors and switchgear against switching inrush, which can damage capacitors, circuit breakers, and contactors.

Both capacitor and reactor are configured in a series resonant circuit, tuned so that the series resonant frequency is below the lowest harmonic frequency present in the system. This paper provides the technical justification for using aluminum reactors over copper reactors. It also provides further guidance for the different technical parameters for making an effective selection.

Figure 1

Some electrical networks are polluted with harmonics due to non-linear loads, or motor startups.

Specification of Reactors

What needs to be specified when ordering a detuned reactor?

Parameters which define a detuned reactor's quality & performance include:

1) Maximum continuous current (I_{MP})
2) Class of Insulation,
3) Temperature rise when subjected at I_{MP}
4) Watt loss at I_{MP}
5) Saturation limit (Current at which the inductance drops below 90%)

For a given specification using the above parameters both copper and aluminum conductors can be used. In this case they both can provide similar performance. The only area where these reactors differ will be in size and weight. For the same specification an aluminum reactor is bulkier than copper in volume, and nearly half in weight compared to Copper. However, it is a myth that a copper reactor will have low watt loss as compared to aluminum.

If reactors are specified for the sake of getting low losses to have low operating cost, what needs to be specified is the watt loss of reactor and not the conductor of the reactor.

For the best reactor configuration and quality, what must be considered are those five points mentioned above, not whether it is constructed of aluminum or copper.

Figure 2

Detuned reactors are ideal for harmonic-rich networks to protect capacitors and other electrical system components.

Aluminum reactor technology over copper

Over the past two decades, new improvements in transformer winding technologies have been successfully adapted to Schneider Electric Aluminum Wound Reactors, making them outperform their copper-wound counterparts.

Schneider Electric manufactures reactors using aluminum foils of 0.2-0.6mm thickness, rather than thicker aluminum wires. The latest automated manufacturing technology is used, which results in optimum performance: correct winding tightness, use of high-quality insulation material, and high-quality impregnation methods. This ultimately results in 1. Compactness; 2. Reduced stray losses and over all losses due to aluminum foil vs aluminum conductors; 3. High insulation class (apart from the high quality what is provided by the efficient manufacturing lines).

- Using either cupped or split washers provides the necessary elasticity at the joint without compressing the aluminum joints in leads, which are equal in quality to copper joints even though aluminum is softer than copper. Due to its soft characteristic, aluminum does not have a 'spring back' nature, hence it can be wound tightly at lower tension. This helps to reduce mechanical stress on insulation, ultimately extending and improving the life of the insulation system.

- Thermal conductivity of copper is superior to that of aluminum in reducing hot-spot temperature rise in transformer windings. This is true only when copper and aluminum windings of identical conductor size and geometry. In fact, designs of transformer / reactors with acceptable hot spot temperature with larger area cross section of aluminum conductor. Thus, coil geometry is bigger, so more cooling surface area is available to dissipate the temperature.

- Aluminum has only 38% of the tensile and yield strength of copper. The use of larger-sized conductor results in aluminum winding strength equivalent to copper windings. The ability of a transformer to withstand the long-term mechanical effects of "high impact" loads depends more on adequate coil balance and lead support than on conductor selection. No significant difference in mechanical failure has been experienced between copper or aluminum low voltage transformers/reactors.

- At the same time, aluminum also has an advantage which cannot be fulfilled by copper. For example, copper conductors are joined to lead terminals by brazing. Technically, the brazing technique causes the copper connection to have lower conductivity than the copper base metal. Aluminum, in comparison, is joined by a welding process with no degradation of conductivity. However, the average user should not be too concerned about these theoretical considerations; both well designed copper and aluminum transformers have excellent records in long years of practical use.

Conclusion

Improvements in technology, specifically the use of aluminum in transformer/reactors have now made aluminum-wound transformers more efficient and reliable, with superior short circuit strength when compared with copper-wound transformers/reactors.

Improvements in transformer winding technologies have also optimized performance, and now allow aluminum to outperform copper-wound counterparts. Correct winding tightness, the use of high-quality insulation material, and high-quality impregnation methods result in compactness, reduced stray and overall losses, and a higher insulation class.

Last but not the least, usage of aluminum is greener for the planet compared to copper as the copper resources are limited and they are getting depleted. Also Aluminum as it is one of the most widely recycled metals in the world and through the recycling process it saves 95% of the energy that it would cost to produce new aluminum.

About the author

Jayajith is a Graduate in Electrical and Electronics engineering from National Institute of Technology Calicut, India. He began his career in protection relays application engineering and later moved to energy management domain handling metering and Power Quality. Jayajith has a total experience of 15 years where he secured application engineering and energy management knowledge. He spends about 10 years in Power Quality one of the Schneider Electric's specialty area, handling different roles.

Acknowledgements

Jacques Schonek graduated from the University of Toulouse, France, with a doctorate in Electrical Engineering. He took part in the development of Telemecanique variable-speed drives from 1980 to 1995. He was subsequently in charge of studies in the field of Harmonic Filtering and Electrical Distribution architectures and later in charge of developing solutions for the Water segment of Schneider Electric. He was also responsible for Knowledge Management for the Power Factor Correction line of business of Schneider Electric. Before fully moving to a happy retired life, Jacques train some of the Schneider employees on the Electrical Installation Design concepts.