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Capacitor Cells - Wet and Dry Types 5/05

When comparing different types of low voltage capacitor construction there are several factors to consider. There is more to it than simply "wet or dry." Eaton Electrical uses the Metallized polypropylene (MPP), dry-type gel filled design, which is one of the designs discussed herein.

Dielectric Material

The long-standing dielectric materials are polypropylene film, kraft paper, and dielectric oil. The paper/film system is an older design which has higher heat losses (due to the paper), and less energy density.

Metallized paper ("MP") uses an oil-impregnated all film system. This features lower heat losses and higher energy density, plus it offers self-healing.

Metallized polypropylene ("MPP") is a non-impregnated all film system. It features the lowest heat losses with self-healing properties. It has a very high energy density. It can be configured in a wet-oil filled version, a dry-type resin filled version, a dry particulate filled version or a dry epoxy filled version.

The liquid fill media needs to penetrate the capacitor end connections to minimize partial discharge damage and to facilitate heat dissipation. This usually requires the expensive oil vacuum impregnation process. It also leaves the case susceptible to seam leaks and oil discharge in the unlikely event of a case rupture. Depending upon the oil media in use, there may also be environmental and safety labeling considerations. The Commonwealth Sprague dry type resin media is unique in that the material is liquid when it is first introduced into the case, thus assuring penetration of the media into the capacitor end connections, and hence reducing partial discharge damage. But after a period of hours, the media transforms into a solidified resin, eliminating concerns for liquid discharge from leaks or ruptures, also meriting the safety status of a dry construction. When compared to dry systems, the resin (as a semi-solid) has improved heat transfer capabilities and maintains rupture protection.

Dielectric System

Dielectric systems usually refer to the type of electrode system in use.

Discrete aluminum foils with "flag" taps are used in paper/film systems to connect within the individual capacitor elements. While it has excellent current carrying capability, this construction is expensive. This electrode is not self-healing, hence the dielectric materials are usually thicker to provide adequate transient voltage capability. This, too, adds to their size and cost.

Metallized Paper and Metallized Paper/Foil systems were developed in Europe to provide self-healing properties to paper film and all film systems. The vacuum deposited conductor, (usually zinc or aluminum), is so thin that current inrush from dielectric faults cause localized vaporization of the electrode, thus "clearing" the instantaneous short circuit and rendering a self-healing property. These are oil-impregnated systems because of the paper carrier for the electrode and are thus more expensive to manufacture. Because of the gas build-up over time due to these clearings, these systems require rupture protection.

Metallized Polypropylene systems use the dielectric material itself to be the electrode carrier, thus use less material and are simpler to manufacture. They have the highest energy density and have distinct size advantages over competing systems.

Fill Media

While the most common delineation of fill systems is "wet" versus "dry," it is probably more accurate to think in terms of impregnated and non-impregnated. Impregnated systems depend upon the fill media, usually oil, to provide both dielectric constant and dielectric strength to the system. Processing these systems is more demanding and expensive because of the need to remove water vapor from the dielectric and insulating materials themselves.

The Commonwealth Sprague cells are unique in that the wet non-impregnated status changes within a few hours of manufacture into a solidified resin in a non-impregnated state. Thus it has the benefits of the wet constructions (transient capability, improved partial discharge capability, and rupture protection) without the drawbacks of expensive vacuum processing, liquid discharge, and environmental/safety labeling.

Dry non-impregnated systems use a dry granular vermiculite particulate fill, or epoxy to "cast" the capacitor element within the case. Rupture protection is difficult to provide for and these systems suffer from partial discharge damage and poor heating. They have the highest energy density but are relegated to low voltages.

Conclusion

One can oversimplify the discussion if they simply try to compare wet versus dry capacitors. Wet capacitors can be impregnated with oil or non-impregnated. Common types of wet capacitors are:

- Wet (oil filled with soggy film kraft paper)
- Wet (oil filled with metallized polypropylene insulation)
- Resin filled (wet when set, but hardened during production)

As discussed above, capacitors that use metallized polypropylene don't use "soggy film" (kraft paper) as insulation so there's really nothing there to wick oil between the layers and help conduct heat from the center of the cylinder. Consequently, the oil won't be as helpful as people think, if they're thinking back to the kraft paper & oil-filled days. Basically, with the metallized polypropylene construction that some use, the oil won't be there to help conduct out of the center of the cylinder anyway, thus negating the perceived advantage of wet capacitors.

There are no clear advantages of wet impregnated cells that are evident. As technology and manufacturing processes advance, the vast majority of the international market has standardized on resin-filled MPP construction.

Advantages of this design include:

1. Self-healing MPP construction, ability to withstand transients
2. Low dielectric loss (heating) polypropylene dielectric, <.5W/kVAr
3. Environmentally straightforward disposal
4. No oil leakage from seams due to inadvertent rupture
5. Lower weight and size per kVAr