Practical Treatise on the Transformer

Second of a Series of Articles on the Transformer Appearing in the Power Edition. This one Deals with Waterproofing Compounds, Drying Out Transformers, and Cooling of Transformers. Others will Deal With Transformer Oil, Transformer Cases, Terminals and Bushings, Transformer Connections and Transformer Testing. This is a Very Complete and Reliable Series of Articles.

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Use of Waterproofing Compounds After Completion of Winding

Let us now discuss the advisability of the use of waterproofing compounds after the transformer windings are completed. The use of these compounds has in view the purpose of keeping the windings free from moisture from the time they are completed at the factory until the time they are immersed in the oil in their cases, where they are to be used. The compound, whatever it may consist of, has to do this work perfectly or else it is of no service at all, or at least very little.

In many transformers waterproofing compounds are used which may or may not be soluble in the oil in which the transformer is immersed. These waterproofing compounds are necessarily good insulators. The materials used may have either an asphalt, coal tar or linseed oil base. When asphalt or coal tar base compounds are used they are always somewhat soluble in oil, especially when the oil is hot. Compounds having a linseed oil base, when thoroughly dry, are practically insoluble in mineral oil.

When large quantities of waterproofing material, with asphalt or coal tar as a base, are used in transformers, the compound resulting from the combination of the waterproofing material and the transformer oil may form a pasty mass, which will close up the ventilating spaces and consequently cause dangerous heating of the transformer due to the lack of ventilation. From an insulation standpoint there is no objection to the waterproofiing compound being dissolved out after the transformer is put in service provided the design is such that the ventilating spaces, which are essential to the cooling of the transformer, are not filled up.

Any compound, which is soluble in mineral oil should not be depended upon for cementing parts of the transformer or for closing spaces when this compound may be dissolved out by the oil later. The linseed oil compounds are waterproof in the sense that they will not allow water to pass through where there is an unbroken film, but they are not waterproof in the same way that asphalt and coal tar base compounds are waterproof, i.e., they are not water-repellant. When transformers are treated with linseed oil compounds more care must be taken to prevent the absorption of moisture than when the other class of compounds is used.

Drying Out Transformers.

Before filling our transformer case with oil, when the winding is placed there, it would be well to know whether the winding is in a fit condition to receive the oil, which is to act as part of its insulation, and as the medium which is to convey to the air or water the heat generated in the various coils and core of the transformer.

The use of insufficiently dried insulating material and the failure to dry out apparatus which has become damp, are probably responsible for a great majority of the failures which have occurred with high voltage apparatus. But trouble from this cause is not confined to high-tension apparatus alone, but appears in all classes of electrical machinery. The severe insulation tests applied to high-voltage apparatus have served, however, to emphasize the dangers of moisture, and the improvements required in the treatment of the insulation of high-voltage apparatus has resulted in a marked improvement in the quality of the insulation of all other apparatus.

With each increase in voltage, new difficulties develop. Materials and methods of manufacture which are entirely satisfactory for one voltage, may prove quite inadequate for a higher one. The inspection and care, which may be ample in the operation of apparatus at one voltage, may be wholly insufficient for a higher voltage. So called "dry wood," for example, which at 5,000 volts gives excellent results as an insulator, proves to be quite "wet" and a good conductor at 30,000 volts. To-day wood is not used as a high-voltage insulator unless first dried in a vacuum oven, then boiled in oil or otherwise treated to prevent the re-entrance of moisture. This method of treating wood is applied in a general way to almost all insulating materials, and a plant for manufacturing high-voltage apparatus is not complete without drying ovens, vacuum ovens, dripping tanks and vacuum impregnating tank.

By these improved methods of treatment the moisture danger is largely eliminated during the period of manufacture and factory test, and to prevent the apparatus from taking up moisture during transit it is usually shipped in a hermetically-sealed case. Instances may arise, however, when the apparatus cannot be so shipped, or the case may be damaged, or during installation the apparatus may become wet, thus necessitating drying out before it is put in operation.

On high voltages the necessity for perfectly dry insulation is even more imperative than on low voltages, and as transformers are usually wound for a much higher voltage than other electrical apparatus, drying out is more frequently required on them than on other apparatus.

One of the chief difficulties in the installation of transformers is to know whether drying out is required; also when the drying out is completed. An inspection of the transformer, when it is received, and a knowledge of the manner in which it has been handled during installation, may often make it clear that drying out is necessary, but when there is any doubt as to its condition, drying should be done. The insulation resistance should be taken at frequent intervals as the drying progresses, and the values plotted in a curve, for this is the only way of judging of the condition of the insulation.

In general, it is well to be on the safe side—drying out whenever there is doubt as to the condition of the apparatus, and continuing the drying out process until it is certain that the insulation is thoroughly dry.

Granting that we have received our transformers at the transformer station, how are we to know the condition they are in as regards to moisture: Probably they come in cases lined with tin and sealed to exclude all moisture—all well and good if the tin remains sealed, but if a hole has accidentally been punched through it why, then, it is useless and might just as well be left off altogether. However, if the lining is in good condition, and there are no evidences of moisture on the transformer, such as rust on the laminations or inside of case, drying out is usually not necessary. But if the lining was not perfect it is better to run no chances and dry out the transformer by some one of the following three methods, insulation readings being taken at various intervals during the process, and finally at the working temperature of the transformer.

Methods of Drying Out.

The three methods usually used are as follows:

(a) By internal heat.
(b) By external heat.
(c) By external and internal heat.

(a) By internal heat. Alternating current required.

The transformer should be placed, if possible, in its case, though this is not essential, as it may be left in its shipping case or even placed on the floor of a dry room. If dried out in a case the cover should be removed to give free circulation of air. The low-tension winding should be short-circuited, and a sufficient voltage impressed on the high-tension winding to circulate the desired current through the coils. For large transformers (250 to 500 k.w.), approximately one-fifth normal full-load current will be sufficient to raise the coils at the desired temperature, viz.: approximately 90 degrees C. (194 degrees F.) For small transformers a somewhat larger current will be required.

For circulating this current through the windings, from 1% to 2% of the normal high-tension voltage at normal frequency will be required, thus for a 10,000 volt transformer from 100 to 200 volts is necessary. For controlling the current a rheostat may be placed in series with the high-tension winding.

(b) By external heat.

The transformer should be placed in a wooden box, the packing case answering the

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