

DIAGNOSTIC NEWS

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Your Source For Monitoring the Reliability of Electrical Equipment

In This Issue:

Repairing Mechanical Damage to Stator Windings, part 2.... pg 1-3

Product Ideas.... pg 3

Focus on Development Team.... pg 4

Development News.... pg 4

Repairing Mechanical Damage to Stator Windings - Part 2

Earl Goodeve and Ron Wheeler

In our first article we covered the factors to be considered or which influence the nature and extent of winding damage repair. Paramount in this was the decision on "cost". In this second article we will assume that repairs are to be attempted and will discuss what can be done in various circumstances. Only the most common types of damage that can be easily repaired during a short outage of a few days with readily available tooling and materials are discussed. Often preparing the area around the repair site is more time consuming than performing the actual repair and can determine if the repair is successful or not.

Materials

Tapes and resins used for the repair must be compatible with the existing winding insulation.

Insulating Tapes: There are several different tapes that are available such as yellow/red Dacron and mica tapes. Mica tapes are compatible with virtually all winding insulation systems whether asphalt, polyester or epoxy. All Tapes should be flexible; mica tapes can either be mica flake with a fibreglass or Dacron™ backing or mica mat tape with a Dacron weave. All tapes should be applied in half lap layers using a resin binder between layers. Mica flake tapes should be fresh to avoid excessive flaking during the re-insulating. For most repairs a 2cm (¾") wide tape is sufficient since wider tape widths are more difficult to lay flat and result in a bulkier/loose taped joint.

Armor Tape: A layer of glass or Dacron tape is applied overtop of the mica tape as a protective layer.

Resins: For asphaltic windings, an air dry varnish is a suitable replacement for the original asphalt varnish. A hard winding insulation (thermosetting) will require polyester or epoxy resin. Epoxies used for taping should be fairly thin in nature and have a working life around 30 minutes (remain tack free).

Mica Dust: Mica dust mixed with epoxy is used to create a smooth paste which can be used to fill depressions and gouges in the insulation. It is also good to use under the base (first) layer of tape to ensure all voids are filled.

UPCOMING EVENTS

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| IRMC Orlando, FL | June 21, 2010 |
| HydroVision, Charlotte, NC | July 27, 2010 |
| EPRI TUG, St. Louis, MO | August 16, 2010 |
| EPRI LEMUG, Philadelphia, PA | August 2010 |
| GE 7EA Users Conference, Memphis, TN | October 26, 2010 |

Message from Iris President - Joseph Mbuyi



During times of economic strife, for those of us concerned with industry, maintenance and performance of our revenue generating assets, there are substantial commercial pressures to implement austerity measures and to rein in our focus on innovation. A simple characterization of innovation may be doing the same things better, or in a more cost effective manner, resulting in an overall benefit to the manufacturer and the user. Alternatively, adding new incremental or unique features that augment the overall value of the solution to the user.

As Iris moves into our 20th year of operation, I am happy to report that the company has continued its product development and innovation efforts through this difficult time. We have spent the last few years trying, evaluating and experimenting with electronics solutions that would ensure that measurements made with our instruments today are compatible with all our previous instrument models, and we selected technologies that would accommodate our development and enhancement efforts moving forward. Today all our portable and continuous instruments are built on this new technological platform. We have, therefore, fulfilled part of our innovation plan which is to make our products better and based on the latest and scalable electronic technology. The development plan for the next 3 years is full of projects to augment our product offering to help you look after your large rotating machines.

Within the organization we continue to be vigilant and work on maintaining our impeccable Health and Safety record, and we are grateful to all our customers for helping us maintain this track record when we visit their installations. The Quality Management System was subjected to detailed internal scrutiny in early 2009 and subsequent successful recertification; we applied and achieved registration to ISO 9000-2008. We opened a new Iris office in Brazil, and we are continuing our efforts to expand the technical and commercial support for our representatives around the world. We continue to spend aggressively on internal and external training of our employees, because we believe that our underlying value is the knowledge, information and expertise that we make available to you through our product offering, or in person, if you use our services.

I would like to take this opportunity to congratulate the founders of Iris, who are all still engaged in this organization directly or indirectly, all my peers, colleagues, suppliers, customers and friends who have supported Iris Power over the past 2 decades. We are proud of our past, and we look forward to the journey into the future maintaining our commitment to technological excellence and to solving problems for our utility and industrial customers concerned with large electrical machines. Please join us if you can be in Toronto later in the year, or at the Iris Rotating Machinery Conference in Florida to mark this momentous achievement of the men and women that work for you daily.

Endwinding Repairs

Space is always at a premium when doing repairs on the endwinding. Remove any blocking, lashes or ties that may inhibit access to the repair area taking care to not further damage the insulation and increasing the size of the repair area.

Regardless of type of damage to the insulation, whether due to impact damage, cuts or gouges, the basic repairs are similar with all repairs requiring taping around the circumference of the coil. All damaged and loose insulation must be removed so only solid insulation remains. The sound insulation around the repair area should be tapered back to facilitate re-insulating and to get an overlap on the existing good insulation layers. A 2 cm (3/4") long taper is preferred but this may not be possible in some locations. Use of a mica dust-epoxy paste to fill depressions, gouges and cuts can ensure that the repair area is relatively void free.

If the damage / repair is in, or encroaches on, the silicon carbide grading and semi-conducting coating systems, all traces of the coatings must be removed. If this is not done the repair will almost certainly fail. After the repair the coatings must be re-established.

Insulation Damage

Impact Damage: Where an object has hit the insulation with sufficient force to damage or crush the insulation. The full extent of the damage may be less evident, and the extent of the damage is not known until all the loose insulation has been removed.

Cut Insulation: A clean cut from a wood chisel can appear to be insignificant on the surface, but can penetrate deep into the insulation and possibly right to the copper.

Scalped/Gouged Insulation: Where the insulation has been sliced with a sharp object removing multiple layers of insulation. Localized damage and easy to determine the number of insulation layers affected.



Impact damage to the groundwall insulation exposing the copper strands

Repair

While 2 cm (3/4") tape is recommended for most repairs, it is sometimes necessary to use a narrower tape for the first couple of layers to ensure that the base layers of tape are tight. This is especially true when re-insulating a gouge in the insulation.

- Inspect the damaged area and assess the extent of the damage.
- Remove all the loose and damaged insulation, back to the point where the insulation is solid.
- Impact Damage: Feather back (i.e. taper or chamfer) the insulation about 2 cm (3/4") all around the affected area. Feathering (tapering) back the insulation should reveal the different layers of exposed insulation.

Depending on the size of the damaged area and the amount of material that has to be removed, use of a rasp, knife or chisel may be required, with the final finishing done with garnet paper.

- Cut: Determine the depth of the cut. As with a gouge (below), chamfer back the insulation on each side of the cut to the point where the insulation is undamaged and proceed as with repairing a gouge.
- Gouge: If a gouge is deep into the insulation it may not be practical to feather (taper) back the insulation to the bottom of the gouge. In this case only taper back to half the depth of the gouge. Mix a mica dust/epoxy paste (to a consistency similar to Vaseline) and fill the narrowest part of the gouge up to the tapered area. Slit the 2 cm (3/4") wide tape into a 1 cm width. The first layer will go directly overtop the mica paste, and then half lap the next layer overtop of the first. Build up the groove to the top with the narrow tape and then over tape with the 2 cm tape. The narrow tape and mica paste will ensure the insulation is applied tight and as void free as possible.
- Apply the appropriate number of mica tape layers, finishing with a final layer of glass tape and apply any stress coatings overtop as required.



Completed insulation repair, awaiting application of the semi-con and grading coatings.

Damage in the Stator Slot

Many coils have been damaged in the stator slot by careless use of sharp tools during the un-wedging / re-wedging maintenance procedures. The likelihood of a successful repair is lower if the damage is in the slot – both because of the closer proximity of ground, and since the working area is very confined. However, some damage of this type can be repaired depending on the coil voltage and the type of damage inflicted on the coil. Coils or bars operating at low voltage have a greater probability of being successfully repaired in the slot.

Scalp: Where several layers of insulation have been scalped out of the center of the coil face resulting in a smooth surface clearly showing the successive layers of insulation.

Chisel Point Damage: The corner of a chisel (or sharp object) has been driven into the coil usually resulting in a sharp puncture of the insulation, with the insulation around the puncture remaining solid. The problem with this type of damage is it is not possible to determine the depth of the puncture: i.e. whether it involves multiple layers or punctured to the copper. If this occurs near the center of the coil face there is a greater chance of a successful repair than if it is more toward the edge of the coil face.

- Remove all traces of semi-con paint/tape around the damaged area.
- Using garnet paper, sand the area to remove any loose materials and feather out the successive layers of insulation or in the case of a puncture any flared insulation.

Repairing Mechanical Damage to Stator Windings, Part 2 ...

- **Scalp:** Fill the scalped (depressed) area with mica dust/epoxy paste. The paste should have a sufficiently high mica dust content that it will not slump.
- **Chisel Point:** Depending on the location and how close to the stator iron the puncture is, it may be beneficial to create a slight depression in the insulation around the puncture by sanding away one or two layers of insulation around the puncture. Make a smooth mixture of mica dust and epoxy and work it into the puncture. Ensure that the mica paste is pushed to the bottom of the puncture and is void free.
- Slightly overfill the depressed area so that when pressure is applied the excess paste will extrude out of the repair area ensuring the repair area is completely filled.
- Place a mold release tape such as Teflon™ or mylar over top of the repair area. Place an under wedge filler strip on top, and lightly install a temporary wedge over top to provide some pressure and hold the paste in place until the paste has cured.
- Once cured, remove the temporary wedge and filler, gently sand away any excess resins and apply some semi-con paint. Ensure that there is sufficient overlap between the new semi-con paint and the existing semi-con surface.

Circumferential Cut: Where the coil is cut across the width of the slot. Damage of this type usually occurs during the wedging operation where a drive wedge or filler is trimmed with a chisel. Typically a cut of this nature will run the full width of the coil. Being a cut, it is difficult to assess the depth of cut and especially at the corners of the coil. Assuming the damage is near the neutral end, it may be possible to patch the coil. First remove the semicon paint/tape from around the slice. Using a thick electrical grade epoxy work the epoxy into the cut, wiping off the excess epoxy. A piece of mica tape can be applied over top of the cut extending from side to side, if possible have the tape go down each side of the coil ~ 1 cm (¼" to ½"). Assemble a temporary wedge over the repair area and allow the epoxy to cure. Once cured, paint the area with semicon paint allowing a sufficient overlap with the existing semi-con surface.

Conclusion

Once a repair has been made, a hi-pot (over potential) test should be performed to confirm the integrity of the repair work. Depending on the nature of the damage, and the age of the machine, test values may be anywhere from a few hundred volts over operating voltage to a full IEEE acceptance voltage (2E+1).

This article outlines some basic repairs that can be made successfully by powerhouse staff in a short period of time. Properly done, the repairs should result in many years of reliable service and last the remaining life of the winding.

Other repair methods such as coil splicing are more time consuming and require a much higher degree of skill. Such repairs are typically performed by the OEM or repair shops.

This article is abstracted from the report "Guide for Stator Winding Coil Insulation Repair", published by EPRI as Final Report 1014909 in 2007. EPRI members can order the full report from EPRI as a CD Rom, which contains hundreds of photos.

Meritorious Engineering Award - Blake Lloyd

The Meritorious Engineering award for the IEEE/IAS Pulp and Paper Technical Committee is presented annually to an individual who has exhibited a high degree of professional engineering excellence in significant state of the art equipment, systems, and/or installations in the Pulp & Paper Industry. Blake Lloyd, Vice President - Development, receives this award in 2010 —congratulations!



Product Ideas

by Blake Lloyd

The genesis of any product is a good idea. Through experimentation and field trials, some ideas prove out, and lead to the development of a commercial product. Iris has been fortunate to work with and employ many external industry experts whose good ideas have resulted in several new technology applications. One such advancement, on-line flux for hydrogenerator rotor monitoring, was brought about through the vision of two recently deceased industry pioneers – John Lyles, a well known expert on hydrogenerators, and Shalom Zelinger, the Director of Research for NY Power Authority.

John Lyles was the domain expert for an EPRI and NYPA funded project to develop an on-line diagnostic expert system software program (called HydroX). During one of the knowledge engineering sessions, John kept coming back to the need for the system to measure and correlate air-gap with air-gap flux. On the fly, he developed a table relating air-gap deviations during different modes of the machine (mechanically spinning, field flashing, synchronized, loading, etc) with what the flux signal would be expected to do during normal and fault conditions.

During a later review of the expert system rules with NYPA, Shalom Zelinger recognized this synergy, and encouraged Iris to start a project to develop an economic continuous flux monitoring system to be used as an input to HydroX (four years earlier NYPA had funded the development of a similar economic monitor for PD called HydroTrac™). Several years of field investigations by Steve Campbell of Iris, resulted in the now commercial Total Flux Probe and a continuous HydroFluxTrac for air-gap flux monitoring on salient pole machines. The HydroFluxTrac went on to win an R&D100 award as one the top 100 most technologically significant products of the year, and has resulted in the second generation product developed by Iris called FluxTracII-S™.

We would like to thank John and Shalom for their vision and their unwavering tenacity in driving innovation in rotating machine monitoring.

Our Development Team

Iris continues to dedicate significant resources to research and product innovations. The Product Development group is responsible for reducing field research into user-focused instrumentation and software for diagnostic monitoring of rotating machines. Supported by our Technical Services Team, these individuals design, field verify, release for manufacture, and support, all the sensor and instrumentation technologies Iris offers. The group consists of the electronic hardware designers, firmware programmers, and Windows™ software engineers.



From left to right: Vladimir Grigoriev, Blake Lloyd, Anthony Bendz, Jim Law, Mark Susnik, Razvan Ghiici, Jeremy Russell, Mathew Castiglione, Oleg Koubrak, Peter Lewis, Wei Zhang. Absent—Dan Lee.

Development News

Product Development has been working to round out our Flux line of products and will soon be releasing a portable RFAII-S instrument for flux measurements on Salient Pole machines. This instrument can be ordered standalone (RFAII-S) or as a combination instrument with our round rotor product (RFAII-RS). We also expect to release continuous versions of these portable instruments called FluxTracII-S and FluxTracII-R.

A new release of RotorFluxPro software is also imminent. This software includes improved peak-pick algorithms for the RFAII-R, support for the RFAII-S, as well as support for the future continuous FluxTracII instruments.

As our customers' test databases grow with more measurements, it is important that they keep up with latest revisions in Iris software to take advantage of feature enhancements. Until now, our database structure allowed for up to about 65000 measurements after which new measurements could not be added to the database. Since some of our customers have approached that limit, newer software revisions of PDLitePro, PDTracPro, PDGuardPro and PDView have that restriction removed - one more reason why customers should keep their software updated. If you are not sure whether you have the latest version, please contact us at techsupport@irispower.com and we will gladly advise.

UPCOMING EVENTS

IRIS ROTATING MACHINE CONFERENCE 2010 (IRMC)

June 21-24, 2010

The Iris Rotating Machine Conference is the ideal forum for the discussion of tools, techniques, methodologies and practical solutions available to professionals who operate, maintain, repair and monitor large motors and generators.

Topics for discussion at the 13th Annual conference include:

- Stator and rotor winding issues and experience
- Converter fed drive issues
- Recent motor and generator failures and repairs

Plan also to attend the User Group Meeting and Walk-In Clinic. Full and half-day seminars are offered by leading experts in the field of Partial Discharge and Machines.

Register at www.irispower.com



The Sheraton Safari Hotel & Suites
Lake Buena Vista, Orlando, FL 32836

COURSES

Hydrogenerator Maintenance Course
April 13 - 15, 2010, Portland, Oregon, USA

Turbogenerator & Motor Maintenance Course
November 2010, Houston, Texas, USA

Partial Discharge Course
November 16 - 18, 2010, Orlando, Florida, USA