IRIS POWER ENGINEERING

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Iris Power Engineering

SPRING 2005

DIAGNOSTIC NEWS

Your Source For Monitoring the Reliability of Electrical Equipment

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James Thompson, the first resort for all of your product support needs.

COURSES

May 10-12, 2005
Hydro Maintenance Course
Coeur d'Alene, Idaho

May 24-26, 2005
Turbo Maintenance Course
Long Beach, CA

For a complete list of Iris' courses, visit www.irispower.com

CURRENT SIGNATURE ANALYSIS: DETECTING ROTOR PROBLEMS IN SQUIRREL CAGE INDUCTION MOTORS

Ian Culbert & Hasnain Jivajee, Iris Power Engineering

MCSA TECHNOLOGY

Motor current signature analysis (MCSA) technology has existed for many years to help diagnose problems in induction motors related to broken rotor bars, air gap eccentricity, drive-train wear analysis and shaft mis-alignment

A trace of the motor supply current is obtained by using a clamp-on current probe either from one of the main phase leads to the motor or from the secondary side of a motor CT. A Fast Fourier Transform is performed on the time-domain data to obtain a frequency spectrum. Once the frequency spectrum is obtained and stored, empirical formulae are used to "look" for frequency signatures in the spectrum within various frequency ranges depending on the problem to be diagnosed. For example, broken rotor bar frequencies (also called sidebands or pole-passing frequencies) can usually be found within ±5Hz of the motor supply frequency; for air gap eccentricity a wider range is required for the search, from a few hundred up to a few kHz. If the predicted frequency patterns are present in the spectrum a positive diagnosis is returned.

In all cases, accurate estimate of the operating slip of the motor is a pre-requisite to reliable diagnosis as the predictor equations require operating slip as one of the input parameters. In an induction motor slip is dependent on the load and increases with increased load. In most cases, the only knowledge a tester would have regarding slip is at full load: the motor nameplate data contains the rated speed at rated horsepower and the slip can therefore be easily derived when the motor is running at full rated load. However, as motors rarely operate at exactly full load determining the operating slip becomes a challenge.

There are several ways to determine operating slip: a stroboscope or axial flux measurement are two examples. However, between the time the speed is determined using these techniques and the current measurement taken the load can change leading to an inaccurate slip estimate. Not to mention the fact that these methods are cumbersome and time consuming.

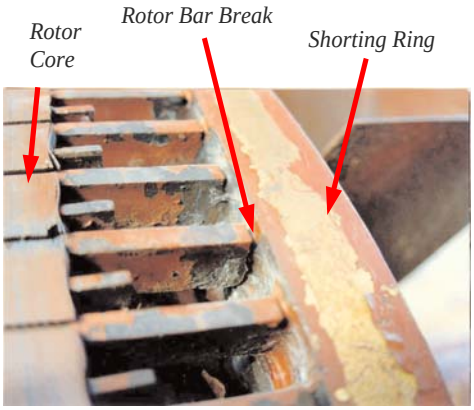

Figure 1: A 1700hp motor with broken rotor bar

Much work has been done in recent years to make MCSA technology reliable and user-friendly by calculating the slip based on motor nameplate parameters and measured load current. As well, advances in pattern-recognition technology have now made it possible that systems rely less on expert knowledge, thereby making these systems useable by non-experts who may not have in-depth knowledge of current signature analysis.

RMTS ANNOUNCEMENT

Have you ever

(i) had a HV machine winding insulation failure and wanted a credible independent opinion ?
(ii) had to accept a machine failure and carry out full rewind, only for the same winding to fail again a few years later ?
(iii) wanted to improve your technical specification for winding design / manufacture?
(iv) wished you had an independent party to monitor the manufacture or rewind of your machine ?
(v) wanted an independent inspection of a rotor or stator winding?
(vi) needed specialist off line investigation / diagnostic testing to help establish your machine condition or locate a problem ?
(vii) wanted an independent training seminar tailored to meet your particular plant issues ?
(viii) needed to assess the electrical condition of a rotor and stator prior to purchase ?

Well now Iris Power Engineering can help :

On January 3rd, 2005, Iris Power launched the Rotating Machine Technical Service Group. This group was formed following pressure from clients to provide an independent specialist service for large motors and generator windings.

The group consists of a core of key individuals with specific knowledge relating to Gas / Steam Turbine, Turbo-generators, Hydro Generators and large motors with the ability to provide specialist, independent, unbiased, knowledge and world wide experience to users of any high voltage machine on an international basis. The large number of specialists with overlapping knowledge increases the chances of an expert being available when you need one.

The core electrical expertise that RMTS can offer is based upon our experience gained in a variety of OEMS and Utilities around the world, backed up where necessary with independent associates. This puts Iris RMTS in an almost unequalled position to provide assistance to clients throughout the world on numerous machine problems.

Key Services

· AC motor and generator winding failure investigations
· AC machine rotor and stator winding condition assessment based on test results and visual examinations by Iris experts
· Preparation of specifications for new machine windings, rewinds, repairs and refurbishments
· Vendor qualification and proposal review
· Technical Quality assurance during manufacture and installation of windings (factory inspection, site inspection)
· Specialist Off-line partial discharge test services
· Customized maintenance courses and specialist PD courses
·Turbine generator life cycle management studies
·Maintenance strategies for plant motor and generator populations

RMTS Members

Eur Ing Andy Brown C.Eng, MIEE, MIEEE
Earl Goodeve P.Eng MIEEE
Greg Stone Phd,P.Eng, FIEEE
Ian Culbert P.Eng MIEEE
Joe Kapler P.Eng MIEEE
Ron Wheeler

PARTIAL DISCHARGE ANALYZER

A short history of the PDA-IV

Back when Ontario Power Generation was the mighty Ontario Hydro, with a 650 person strong research division, a world renowned group of research engineers and technologists worked to find ways to improve the lifespan and overall health of all their power generation assets. One of these groups focused on problems of generator stator windings. The team included Greg Stone, Steve Campbell and Blake Lloyd , among others.

Over a period of ten years a method was devised to measure partial discharges occurring in the stator windings of hydro generators. This method was to meet the requirements of the Canadian Electrical Association (CEA) that the system must function while the machine under test is on-line and that the equipment could be used by a non-expert and be designed to be safe against "false alarms". Partial discharges were already accepted world wide as an indicator of the health of a generator stator. Based on this knowledge of partial discharge and further insights discovered in the development stages, the Partial Discharge Analyzer for Hydro's (PDA-H) was born.

After several years of testing and proving the product by its designers, and some false starts with disconnected licenses, Iris Power Engineering was established in order to create the next generation of new and improved partial discharge analyzer for commercial manufacturing and distribution. The partners, Steve Campbell, Blake Lloyd, Greg Stone, Resi Zarb and later Ontario Hydro set up shop in 1990 and delivered the Partial Discharge Analyzer - Version Four (PDA-IV) in 1992 to their first customer.

As the product gained in popularity the partners' experience grew and they adapted to the world of private enterprise. With feed back from their customers, fast changing standards in the electronics industry and their own experience, the PDA-IV improved in its functionality and its looks and additional members to the line of on-line PD products were developed (TGA-B, TGA-S) to meet specific machine types and noise environments.

Today, with the continuous improvement of partial discharge testing based on a huge source of expertise within the company, the instrument family has expanded further to include other technologies for machine condition assessment (CSMeter, FluxTrac, PDAlert, and SurgAlert).

Orignial PDA- IV

Below is a short pictorial history of the PDA-IV

The first model of the PDA-IV came with an LCD display, keyboard, mouse, floppy and hard drive. It was a portable computer dedicated to measuring partial discharge and it was in an all-in-one package. This original version was built from off the shelf case assemblies.

Blue Box Model

CS METER
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CSMeter takes advantage of these recent developments to detect cracked or broken rotor cages and abnormal levels of air gap eccentricity in squirrel cage induction motors. It provides reliable diagnosis by incorporating intelligent algorithms to minimize the risk of false indications. At the same time the test is both repeatable and easy to perform, and provides objective diagnosis rather than subjective analysis. This obviates the need for extensive training and need for an expert in most cases.

DETECTION OF BROKEN ROTOR BARS

It is well-known that the location of the frequency components of the current due to broken rotor bars in the frequency spectrum is given by the formula:

$f_{sb} = f_1(1\pm 2s)$ Hz (1) where,

f_{sb} = frequency components of the current due to broken rotor bars, also known as "sidebands".

f_1= power supply frequency.

s = operating slip.

Figure 2 illustrates the current spectrum from a 13.8kV primary air fan motor with broken rotor bars operating in a fossil power station. The motor supply frequency is 60Hz. Frequencies due to broken rotor bars are clearly visible. The positions of the sidebands in the frequency spectrum depend on the operating slip of the motor. The slip, in turn, depends on the load. As a result, one would expect to find the sidebands move "away" from the fundamental frequency at higher loads.

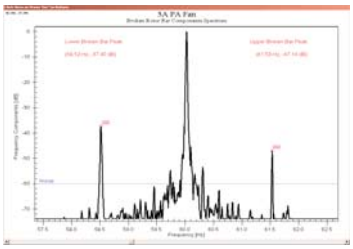

Figure 2: Frequency spectrum from a motor with broken rotor bars

$$f_{ec} = f_1\{(R \pm n_d)[\frac{1-s}{p}] + n_{ws}\}$$

With nd = 0, equation (2) gives the classical rotor slot passing frequency components - a series of components spaced at twice the supply frequency (2f1) apart. The signature pattern of specific rotor slot passing frequencies and the two components from equation (2) with nd = ±1 can be used to identify abnormal levels of air gap eccentricity. It is worthwhile to mention here that although equation (2) can be used to theoretically determine static as well as dynamic eccentricity separately, practically this is much more difficult.eccentricity separately, practically this is much more difficult. CSMeter gives a consolidated diagnosis based on both static and dynamic eccentricity components.

CONSEQUENCES OF BROKEN ROTOR BARS AND AIR GAP ECCENTRICITY

Broken rotor bars (Figure 1) rarely cause immediate failures, especially in large multi-pole (slow speed) motors. However, if there are enough broken rotor bars, the motor may not start for lack of sufficient accelerating torque. Regardless, the presence of broken rotor bars precipitates deterioration in other components that can result in time-consuming and expensive fixes. Replacement of the rotor core in larger motors is very costly, therefore by detecting broken rotor bars early, such secondary deterioration can easily be avoided. This is based on the fact that the rotor can be repaired at a fraction of the cost of rotor replacement, not to mention averting production revenue losses due to unplanned down-time. Some of the more common secondary effects of broken rotor bars are:

·Broken bars can cause sparking, a serious concern in hazardous areas

·If one or more rotor bars are broken, the healthy bars are forced to carry additional current leading to rotor core damage from persistent elevated temperatures in the vicinity of the broken bars and current passing through the core from broken to healthy bars.

·Broken bars cause torque and speed oscillations in the rotor provoking premature wear of bearings and other driven components.

·Large air pockets in die-cast aluminum alloy rotor windings can cause non-uniform bar expansion leading to rotor bending and imbalance that causes high vibration levels from premature bearing wear.

·As the rotor rotates at high radial speed, broken rotor bars can lift out of the slot due to centrifugal force and strike against the stator winding causing a catastrophic motor failure.

·Air gap eccentricity, both static and dynamic, could cause the rotor to rub against the stator winding leading to rotor and stator core damage and even a catastrophic fault.

CONCLUSION

Based on several case studies current signature analysis technology can reliably be used to detect problems in induction motors. Incorporating recent advancements CSMeter allows for easy, reliable and objective diagnosis for broken rotor bars and abnormal levels of air gap eccentricity in squirrel cage induction motors.

PARTIAL DISCHARGE ANALYZER
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The next 2 models of the PDA-IV came in the classic 'blue box' - the deep blue that Iris identifies with. The final version of the all-in-one instrument is pictured above. The lower height and swing handle was added in response to customer feedback. But the fast paced world of computers was changing

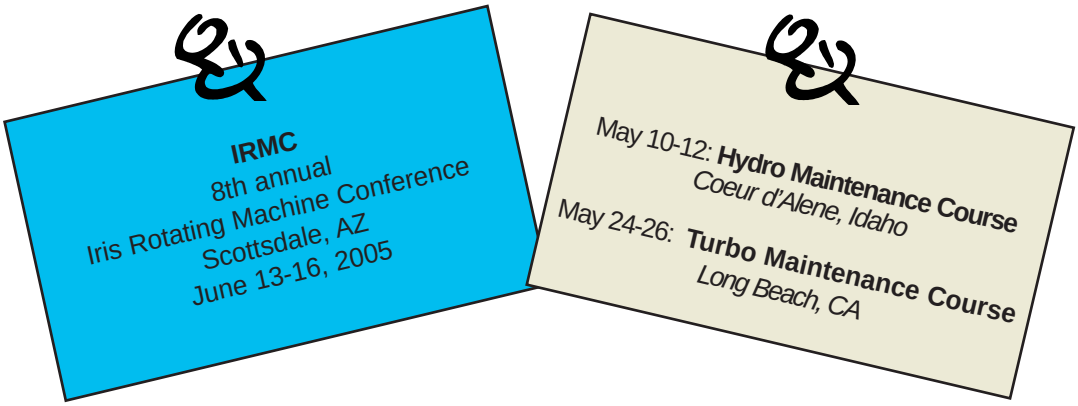
The next version of the PDA-IV was the PDA-IV Lite. This instrument was used with the state- of- the- art laptop computers, the newest thing in personal computers. Once again, Iris was finding solutions to their customer's need for a lighter and more compact product with faster speeds and bigger memory capacity to store their precious databases.

(PDA- IV picture of the Lite)

(PDA- IV - today's model)

Today, the PDA-IV, The TGA-B and the TGA-S are all available in the same streamlined package . Smaller than the blue box, it can hold two different types of partial discharge analyzers in one package. Now functioning exclusively with the users laptop, it is network ready and USB compatible. Accompanied by Windows XP compatible application and analysis software , the distinctive look and superior functionality allows the PDA-IV to stand out as the leading instrument in the world of partial discharge testing and analysis.

UPCOMING EVENTS



NEW PRODUCT ANNOUNCEMENT

PDGuardPro

Scheduled for commercial release in April 2005, PDGuardPro accompanies the hardware upgrade for our flagship line of Guard continuous monitors. Using PDGuardPro one can configure triggers and set alarm levels remotely as well as be able to remotely view the status of all machines on one page. Existing customers can upgrade their GenGuard line of monitors to the new hardware and software which can now be run from Windows 98 or higher operating system, is therefore more stable and more user-friendly.

OPC Communication Option

In 1994 a group of vendors representing industrial clients formed what is now known as the OPC™ Foundation. The goal of the OPC Foundation was to develop a client/server specification that would allow any vendor to create software that could share data in a fast, robust fashion, and do it in a way that would eliminate the proprietary interfaces that forced these same vendors to duplicate development efforts.

To support OPC interfacing, Iris has developed an OPC application that bridges our IrisBus based instruments to OPC. This software can be run as an application, or as a Windows™ Service (loaded before user login) on a computer running a Windows™ operating system. Almost all major data historian/viewing products, such as the OSISoft PI system or the Invensys Wonderware System, offer an OPC interface. Therefore, by using the Trac OPC Server, PD data (summary numbers and/or 2D data) can be stored in a central location alongside the relevant machine operating conditions. Then, by leveraging the viewing and data distribution power of these systems, PD trends (at constant operating conditions) can easily be viewed by anyone in the enterprise with access to the system.

AWARD NOMINATION

Iris Power Engineering has been nominated for a Research and Development award conferred by the Etobicoke Chamber of Commerce. Iris' nomination comes after a rigorous examination of its products and its people. The criteria for nomination are based on Iris' product innovation and technical achievements, marketing successes, sales growth, client satisfaction, employee satisfaction and community involvement. The awards will be presented on April 11, 2005

IRMC 2005

Predictive (condition-based) maintenance has become the most critical and effective tool for reducing overall motor and generator operating costs. A predictive maintenance strategy can prevent an unnecessary and expensive failure and reduce unnecessary inspectionsof motors and generators, saving hundreds of thousands of dollars.

The Iris Rotating Machine Conference (IRMC) is devoted to the discussion of predictive maintenance technologies for motor and generator stator and rotor windings.

This year's topics for discussion include:

- Condition -Based Maintenance Strategy
- Problems and Solutions for Hydrogenerator Rotor Poles
- PD as a Stator Winding Evaluation Tool
- On-line Monitoring of Generator Condition
- Physical Processes in Corona Suppression under Electrical Stresses

Conference Highlights include:

Iris 15th Anniversary Awards Dinner
Hot Air Balloon Ride Draw

Location
Renaissance Scottsdale Resort
6160 North Scottsdale Road, Scottsdale, AZ 85253
Reservation: 1-800-309-8138

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