Inspection Report

1. Abstract

2. Photograph for easy reference

3. Basic principle of Eddy Current Testing

4. Sample Eddy current display (CRT screen) based on electrical conductivity of material

5. Tried with general purpose eddy current equipment at BEL valve on 22.10.2010

6. Suggested Digital Display Eddy Current equipment

7. Summary

Location : BEL valve, UK
Visit Duration : 18.10.2010 - 22.10.2010
Project : Kizomba satellites
Technical Justification

1 Abstract:

- Technique evaluation report towards use of *Eddy Current Testing* for measuring *Tungsten Carbide coating thickness* on *Duplex Stainless Steel*
- Aiming to give complete information regarding Eddy Current Testing and justifying to the above application and optimizing the confident of using this NDT method

2 Photograph for easy reference:

Seal Ring

3 Basic Principle of Eddy Current Inspection

- **Eddy Current** testing can be applied to cylinders, tubing, sheet and coating and provides a means for measuring *electrical conductivity*, detecting discontinuities and *determining the thickness of coatings or plating* on articles.
- When alternating current is applied to the conductor, such as copper wire, a magnetic field develops in and around the conductor.
- This magnetic field expands as the alternating current rises to maximum and collapses as the current is reduced to zero.
- If another electrical conductor is brought into the close proximity to this changing magnetic field, current will be induced in this second conductor.
- Eddy currents are induced electrical currents that flow in a circular path.

Note:

- If a *flaw in the conductive material* or *other conducting or non-conducting materials are coated* will disturbs the eddy current circulation, the magnetic coupling with the probe is changed and a *defect or electrical conductivity variation signal (Electrical Impedance Variation)* can be read by measuring the *coil impedance variation*
4 Sample eddy current display (CRT screen) based on electrical conductivity of material

IACS (International Annealed Copper Standard)

5 Tried with general purpose Eddy Current Equipment at BEL Valves on 22.10.2010

Response from Duplex Stainless Steel (1.9 % IACS)

Response from Tungsten Carbide (31.5 % IACS)

DSS Reference block coated without Tungsten Carbide side

Eddy current response

DSS Reference block coated with 0.012" Tungsten Carbide side

Eddy current response

Prepared by,
R. Baskar
ASNT level 3 RT,UT,MT,PT
AWS SCWI
CSWIP 3.2
Important Note

After noticed the below response from the eddy current equipment, increased my confident level to use Eddy Current method to measure the Tungsten Carbide coating thickness on Duplex coating thickness.

Reference Table for Relative conductivity

<table>
<thead>
<tr>
<th></th>
<th>Relative Conductivity ($\sigma_r$)</th>
<th>Relative Permeability ($\mu_r$)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Maximum</td>
<td></td>
</tr>
<tr>
<td>Sendust</td>
<td>0.022 - 0.029</td>
<td>30,000</td>
<td>10% Si, 5% Al, 85% Fe (cast)</td>
</tr>
<tr>
<td>Silver</td>
<td>1.004</td>
<td>1</td>
<td>0.4% - 0.5% C, bal. Fe</td>
</tr>
<tr>
<td>Steel</td>
<td>0.078 - 0.133</td>
<td>50</td>
<td>0.1% C, 11% Cr, 8% Ni, 73.9% Fe</td>
</tr>
<tr>
<td>Steel, silicon</td>
<td>0.034</td>
<td>500</td>
<td>4% Si, 96% Fe (hot rolled)</td>
</tr>
<tr>
<td>Steel, stainless</td>
<td>0.019</td>
<td>7,000</td>
<td></td>
</tr>
<tr>
<td>Superalloy</td>
<td>0.029</td>
<td>100,000</td>
<td>79% Ni, 5% Mo, 16% Fe</td>
</tr>
<tr>
<td>Tin</td>
<td>.131</td>
<td>1,000,000</td>
<td></td>
</tr>
<tr>
<td>Titanium</td>
<td>.036</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Tungsten</td>
<td>.015</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>.087</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
6 **Suggested Digital Display Eddy Current Equipment**

- The Eddy Current equipment used at BEL Valve was general purpose and output results are in graphical presentation, so it may not suitable for this specific application
- In order to have adequate accuracy, this digital type equipment will be more suitable
- Communicating with equipment manufacturer for the suitable model for our application

**Equipment Features:**

- Axial single tip probe with spring-loaded measuring system
- Measures *non-ferrous and non-metal coatings on steel or iron substrate*
- For the measurement of *non-ferrous metal coatings on steel or iron*

**For more information**

- Contact Person : Mr. Barry Golan
  
  Phone: + 44 7836200778
  E-mail: admin@fischergb.co.uk
  bgolan@fischergb.co.uk

- Still I am in contact with Mr. Barry Golan, for selecting the suitable Eddy Current Testing equipment for this specific application

**E-mail correspondence with Mr.Barry Golan**

```text
From BIT NDT CHENNAI <bitndtchennai@gmail.com> to admin@fischergb.co.uk
Cc bgolan@fischergb.co.uk
Date Fri, Oct 22, 2010 at 2:01 PM
Subject Re: COATING THICKNESS GAUGE - NICKELSCOPE NMP2

Dear Mr Barry Golan,

Herewith attached the photograph of the component to be checked. Please advise the suitable equipment based on Eddy Current principle.

Have a good week end.

with regards,
R.Baskar

On Fri, Oct 22, 2010 at 12:15 PM, BIT NDT CHENNAI <bitndtchennai@gmail.com> wrote:

Dear Mr Claire,

With reference to telephonic discussion with your office, we are looking for COATING THICKNESS GAUGE - NICKELSCOPE NMP2. We have noticed this model is working based eddy current principle.

Our requirement is that, we need to measure Tungsten Carbide coating thickness on duplex stainless steel. Coating thickness to be measured is 100 to 500 microns. We are in critical position in terms of dispatching of material to site. Your immediate response will be highly appreciated.

with regards,
R.Baskar
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Prepared by,
R.Baskar
ASNT level 3 RT,UT,MT,PT
AWS-SCWI
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7 Summary

- Based on the experiment, the response by Eddy Current equipment is excellent to measure the thickness of Tungsten Carbide coating on the Duplex Stainless Steel.
- Eddy current testing equipment distinguish the electrical conductivity of the material very well, so electrical conductivity of two different material can be correlated directly to the coating thickness measurement.

Our existing two challenges towards failure of Tungsten Carbide coating on the seal ring,

1) Right method to measure the thickness of Tungsten Carbide coating - Can be resolved by Eddy Current Testing
2) Tungsten Carbide coating bond integrity
   - Adhesion test - Tested and obtained satisfactory result
   - Microstructure - This was raised and discussed during meeting on 22.10.2010.

   1. This microstructure examination can be performed by BEL valve laboratory, they have equipment with capacity of 1000X magnification as shown below and competency personal, but need to check whether seal ring can be placed in the microscope table and examine. I will co-ordinate with Mr. Ray Jackson – Senior QA Engineer to check the possibility. If not possible we have to go for portable one.
2. We can also approach *Bodycote* for this testing

Dr. Rafal Tomaszek  
E-mail: Rafal.Tomaszek@bodycote.com  
Phone: +44 (0) 1633 245600

Already, I have approached him for other reason, i.e. to check coating thickness with using High Resolution ultrasonic equipment using with acoustic impedance difference principle.

He is very positive and he will help us for this micro examination also.

➢ I would like to thank all concern, supporting in this assignment. I will be available at Sandvika office from Monday (25.10.2010) onwards.

Contact details: rajamanickam.baskar@ge.com  
Private mail ID: bitndtchennai@gmail.com (when I am out of Sandvika office)  
Mobile no.: + 47 96812650  
Reporting to: Mr. Bjorn Sisselberg