ACFM for Ship Hull Inspection Deployed by Crawler

1.0 INTRODUCTION

The ACFM technique is now widely used in the oil and gas industry for structural weld inspection. The technique provides significant benefits over conventional weld inspection methods and is being specified as a replacement to MPI by a number of major oil companies around the world.

Petrobras are adopting ACFM for their subsea platform inspection and are now considering its use for FPSO applications. TSC have been in discussions with Imetrix regarding the deployment of ACFM sensors on their subsea crawler, which has been specifically developed for ship hull operations.

The ACFM technique has been extensively used subsea, deployed both manually and robotically and has been successfully used deployed by crawlers, however, to date it has not been used with subsea crawlers.

2.0 KEY CONSIDERATIONS

Preliminary discussions with Imetrix has identified a number of areas which need to be addressed.

2.1 System

The ACFM system will comprise of a controlling PC, which also stores all of the data and provides data displays, a topside interface to the Imetrix umbilical, subsea ACFM electronics and a one dimensional ACFM array probe. The probe will be fitted with a number of sensors in line, these will be positioned perpendicular to the weld and scanned along the weld line. The width of the probe and spacing of the sensors will influence the scan area and scan speed.

All communications between topside and subsea will need to be via the existing Imetrix umbilical. Serial communications will be used and the communication protocols will determine the degree of “real time” display available during the scan.

2.2 Probe Width

The probe width will be determined by the weld cap width, the expected crack location site and the accuracy of tracking of the crawler. ACFM sensors used for weld inspection are typically spaced at 5 – 10mm centres, thus to scan a width of 50mm (2") six sensors would be deployed for 10mm spacing, eleven sensors for 5mm spacing. The lateral spacing of the sensors will be a function of the target defect size. The smaller the target defect, the smaller the chosen spacing. The weld cap width, inspection area and tracking tolerance will determine the width of the inspected strip. For cracking it would be expected that the weld cap and the weld toes would be the likely sites, and it is anticipated that inspections of these areas would be adequate.

2.1 Defect Orientation

For structural welds in service cracking is generally in the longitudinal (along the weld) direction. If transverse cracking is expected, this can be accommodated, but this requires more sensors and therefore a slower scan speed.

2.4 Scanning Speed

ACFM readings are obtained by scanning the individual sensors, whilst tracking along the weld. Sampling rates are typically about 200 Hz. Assuming eleven sensors, the sample rate along the weld is therefore eighteen samples per sensor, per second. Assuming a minimum of five readings are required from one sensor to reliably identify a defect, the minimum defect length detectable will be equal to the distance travelled in 0.3 seconds. Therefore, to detect a defect 25mm long, the maximum speed of scan is 83mm per second. This assumes longitudinal defects only.

The above figures are presented by way of example and are not recommendations.

2.5 Defect Size

The minimum detectable defect size is a somewhat notional concept and not something that is easily tied down, because it depends on so many factors. ACFM responds to crack length and depth, but depth is a primary factor when considering defect detectability. Defect depth determines the required lateral sensor spacing and the overall signal response. Deeper cracks give larger signals, require less dense sensor spacing and can be used with higher lift-offs between sensor and component. Minimum defect length determines the maximum speed of scan to achieve the requisite number of samples.

2.6 Lift Off

ACFM can typically work on lift-offs up to 5mm. For deeper cracks, larger lift-offs can be accommodated, but in general terms a defect 20mm by 3mm will be detectable with a lift-off of 5mm.

2.7 Crack Sizing

All the above factors refer to defect detectability. ACFM is also capable of predicting crack size. However, it is recommended at this stage that the emphasis be put on the defect detection. In general terms, a slower scan is required for accurate defect sizing, whilst a faster scan is capable of detecting the presence of a defect and providing a first estimate of defect severity.

In most ACFM systems it is usual for the detection and sizing of defects to be carried out by a trained operator looking at the data. Automated detection and sizing is possible in some cases if the inspection surface is regular and clean, but it is assumed in this case that manual interpretation is possible. Since the communication rates will not allow continuous display of data from an array probe, it is recommended that the inspection is carried out in a series of short lengths. This allows data to be displayed in a sufficiently high resolution for short defects to be detected, and also means that the crawler can reverse to rescan an area quickly if necessary. The scan lengths should be about 2 to 3m and could conveniently be fixed to coincide with the lengths of the constituent plates on the hull.

2.8 Data Correlation

From the original discussions, it is proposed that all ACFM data is recorded with "time stamp" and that this is correlated with position versus time data from the Crawler system, in order to provide a method of reporting the position of any defects identified.

3.0 HARDWARE REQUIREMENTS

TSC's standard U21 underwater Crack Microgauge is considered too large for this application. TSC's topside instruments have a cable length limitation of 50 metres. It is therefore proposed that the system be based around the electronics of TSC's new Amigo instrument, housed in a pressure housing on the crawler. TSC will provide the PCB's and interface details, in order to allow this to be integrated into the system. The board sizes and overall power requirements are given in Appendix 1. The existing communications are RS232 and these will need to be modified to provide RS485 comms to the surface. Appendix 1, also discusses the communication protocol. It is likely that this will be the area requiring the most effort, since it is assumed that the band width available to the ACFM system may necessitate some on-board storage of data packets.

4.0 OTHER CONSIDERATIONS

ACFM electronics are by their very nature, sensitive devices and due consideration must be given to localised electro-magnetic noise generated out of the crawler. This can be discussed in more detail, but is not expected to be a major problem.

Probe handling and wear resistance needs to be considered. It is anticipated that the probe would be spring mounted onto the hull to minimise lift-off, and perhaps a shoe could be used to provide the wear resistance and avoid damage to the probe from localised protrusions.

5.0 COST ESTIMATES

It is difficult to provide detailed costings until the final specification of the system has been discussed. As a guide the cost of an Amigo system, control software and an underwater 8 sensor array would be of the order of GB pounds £45,000. The cost of modifications to the communications and software would be estimated once the specifications and requirements have been discussed further.

Appendix 1

AMIGO System : Technical Details

The Amigo electronics comprise two main pcb's of sizes:-

170 x 146 x 20 mm
170 x 104 x 15 mm

The power requirements are:-

300mA at 20V d.c.

In the Amigo, this power is provided by a set of rechargeable batteries, but in this application this would be provided by the crawler to save space.
The other major factor influencing the size of the enclosure is the connector requirements. An array probe requires an 18-way connector, which should be densely-packed to minimise unnecessary loops and pick-up problems.

Communications to and from the Amigo Micro-processor are 4-wire RS232 with the protocol:-

19,200 band
8 data bits
1 stop bit
No parity
Hardware flow control .