Use of Phased Array Ultrasonic Equipment for Fatigue Crack Characterization for Underwater Inspection of Offshore Structures

D. Choqueuse  
IFREMER  
Brest, France

A. Lamarre  
R/D Tech.  
Québec, Canada

ABSTRACT

Non destructive tests are used on steel offshore structures for underwater inspection. These inspections are carried out to guarantee the integrity of the structure, mainly for fatigue crack detection on welded tubular joints. Despite its potential the use of ultrasonic equipment is not very common in this area and the detection and sizing of cracks is mainly performed by electromagnetic methods (Magnetic particle inspection, Eddy current, Alternative field measurement, ...). Given this state of affairs and bearing in mind the poor capabilities of the electromagnetic methods for fatigue crack characterization, an evaluation of the capabilities of phased array ultrasonic equipment has been performed. This equipment allows, without specific motion of the ultrasound beam, by means of electronic scanning and focusing, the characterisation of fatigue cracks on complex welded joints. The inspection is performed with only one probe, this being placed on the external part of the welded tube. This paper presents the process of the evaluation of the technique, the choice of the probe (size, frequency, number of elements, ...), the methods used (tip detection by rebound, creeping waves, ...). The results are very promising and the system will now be tested for inspection and repair tasks.

Keywords: Ultrasonic Inspection, Phased Array, fatigue crack, offshore structure

KEYWORDS: Ultrasonic Inspection, Phased Array, fatigue crack, offshore structure

PRESENTATION

It has been noted, by Dover (1995), that in the North Sea offshore infrastructure the fatigue is the main cause of repair of the structures. The complex geometry of tubular joints results in high stress concentration located along the weld of the chord-brace connection. It is these areas where the fatigue cracks appear and grow (fig. 1). More than 90% are located at the chord toe.

In order to guarantee the safety of the platform, inspection campaigns are scheduled and different Non destructive Techniques (NDT) are used. These techniques have been evaluated within the ICON (InterCalibration of Offshore NDT) program by Ifremer (1996). Detection possibilities have been clearly identified by methods such as MPI (Magnetic Particle Inspection), ACRA (Alternative Current Field Measurement) and EC (Eddy current). However for all except ACPD (Alternative Current Potential Drop) the capabilities of sizing cracks are insufficient with regards to operations such as structural calculation which take into account crack sizes and to repairing (grooving, ...) in NDT & E (1996).

In order to avoid the constraints linked with an ACPD measurement (good cleaning and very accurate positioning and moving of the probe, Ifremer has decided to verify the possibility of using Ultrasonic (US) inspection to characterize accurately the fatigue cracks located in these types of structure.

A review of the US techniques, in use for such applications, has been carried out by Ciorau (1997), Lilley (1996) and Mudge (1996). The use of Creeping Wave (CW) is limited by the poor surface state generally encountered on offshore structures. TOFD (Time Of Flight Diffraction) presented as very promising, is not adapted to such geometry and very poor results have been obtained in an evaluation program by Ifremer 1996. A previous study was carried out by Chauveau (1990), showing the potential of using sensors able to generate and receive at different angles so it was decided to evaluate the capability of a « phased array » technique.

PHASED ARRAY

Principles

A phased-array transducer is composed of many independant elements which could be organised as a linear array, 2-D matrix, annular array and many others. Beam focusing and beam sweeping can be achieved by applying an electric excitation with appropriate delay time to each element. The combination of excitation delay time is called a focal law. With one probe by using different focal laws, the beam could be focalized at different depths and can be swepted at different angles (fig. 2).

The beam sweeping could be achieved with very small angle increment to distinguish the corner reflection angle and the tip-diffraction angle at different angles at one fixed position. By