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Design and Development of a Scanning System for Monitoring Corrosion Under Pipe Supports

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***Abstract* - Corrosion under pipe supports is a serious challenge faced by the oil and gas industry now a days because of its inaccessibility to inspect. This is due to the presence of the sacrificial pad which is welded to the support location to mitigate the pinhole type and stress corrosion at the pipe supports. This paper aims for Designing and developing of a scanner for monitoring corrosion under pipe supports. Ultrasonic testing in Non –Destructive Evaluation is used for detecting the defects in pipe. Designing part of the scanner is done using solid works. Because of access limitations to the pipe support region in actual field testing, the transducer was always placed at a fixed circumferential position and moved axially along the length of the pipe. The defect position along the circumference was ascertained from the time of flight while the defect size was estimated using the amplitude data obtained.**

***Index Terms* - Designing of scanner using solid works, Non-Destructive Evaluation, Ultrasonic Testing**

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1 INTRODUCTION

Pipelines form the heart-line of any process industry. Pipelines are extensively used in oil and gas refineries. As most of the petroleum refineries are located near seashores, these pipelines are exposed to aggressive corrosive environment (i.e.: high chloride content in the air). Also these pipelines carry hydrocarbons and any small leak or rupture in these lines may lead to a hazardous situation as well as unplanned plant shutdowns. These lines have to be inspected periodically to assess the damage before any catastrophic failure occurs. So to ensure efficient and safe operation of the plant, it is necessary to have effective corrosion monitoring of these pipelines. Among the various techniques used for the detection of corrosion like defect in pipelines, ultrasonic NDE plays a major role to perform a conventional ultrasonic inspection in such inaccessible region (i.e. at support locations).

The pipes have to be lifted out of the supports, which involves complete shutdown of the flow lines and the risk of stressing a pipe that would have been already weakened by corrosion. So it is necessary to come up with an alternate method of NDE inspection where the hidden portion of the pipelines has to be inspected without disturbing the structural arrangement. In order to mitigate the corrosion to pipes at these locations, the industry often resorts to providing a sacrificial plate (often called sacrificial welded pad) that is placed in between the pipe and the support. The plate is tack welded around the boundaries of the plate. However, it has been observed that while this sacrificial pad reduces corrosion, this does not completely prevent it. The inspection of the pipe in this region with the welded pad is more difficult, when compared to the case without the pad.

Fig 1.1 Pipe support locations, without sacrificial pads, in a refinery

Fig 1.2 Welded supports in pipe

2. SCANNER DESIGN AND FABRICATION

A scanner is important for any portable scanning system for ease of inspection and straight line scanning. Also, the scanner ensures that uniform pressure is applied on the wedge which makes the amplitude values in the signal more reliable when compared with each other. The scanners can be automated using a stepper motor integrated to a shaft of wheel or can be left as it is for manual scanning. Important criteria for making a scanner is that the whole system should be lightweight and portable and it should easily be applied to different cases with slight modifications. For example, a scanner made for a four inch pipe should also be useful for a three inch pipe with slight or no modification. Another important criteria for a scanner is that all parts in the system should be easily detachable and should be assembled again very easily.

The important parts in a typical scanner are

- Provision for wedge placement
- Encoder
- Wheels

Wedge should be easily placed and removed, so that different wedges can be used for different applications. The wedge should also fit in to the provision without any unwanted movement. Any such unwanted movements should be arrested. There may also be a provision for a spring loading so that uniform pressure is applied.

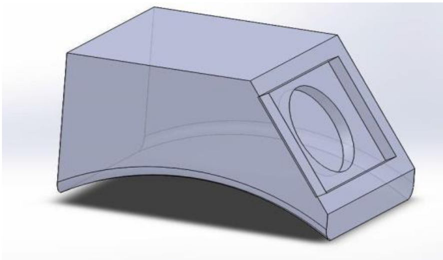


Fig 2.1 Solid works model of wedge

Fig 2.2 Manufactured wedge

An encoder is a device which records the movement of the wheel. Usually the encoder is attached to the shaft and when the shaft rotates the encoder records the movements and sends the data to a data acquisition system. Usually the data can be seen in a laptop with suitable software. Wheels are to be designed in such a way that the scanners sits on the pipe surface comfortably. The design of scanner wheels should enable the scanner to scan not only on the top but also in an inclined position like 2 O clock position. The wheels are tapered in such a way that the scanner will sit on the surface of the pipe in any position.

Fig 2.3 Tapered wheel design

Fig 2.4 Wheel placement on pipe

Fig 2.3, 2.4 shows the design of the tapered wheel which is done in such a way that the wheels sit comfortably on the surface of the pipe. Fig 2.4 shoes the side view of the pipe along with the wheels and the perfect contact between the wheel surface and pipe surface. This will ensure the free movement of the wheels on the surface of pipe. Overall design of the scanner is shown in Fig 2.5 where there is a provision for placing the wedge, screws for loading the wedge and space between the wheels so that the encoder can be placed.

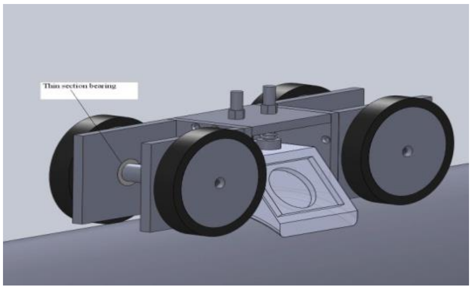


Fig 2.5 Scanner design

Fig 2.6 Fabricated scanner

Fig 2.6 shows the manufactured scanner as per the design and one can observe the encoder fitted on the shaft. The shafts are fitted to the plates using a thin section bearing.

3. Experimental Setup and Methodology

3.1 Experimental setup

Fig 3.1 Wedge placed at 12 O clock position

Fig 3.2 Pipe sample with notches

The Fig.3.1 shows the experimental layout used for the group velocity measurement. As shown in the diagram, the pulser-receiver (Panametrics PR 5077) excites the transducer and the data was transmitted through analog to digital convertor data acquisition card (NI 5133) and then stored for data processing in the PC. The functions of the each component that makeup the experimental setup is explained below.

3.1.1Piezoelectric Transducer

It is the primary source for generation of ultrasonic wave. It consists of a piezoelectric crystal with suitable backing. Generally the piezoelectric effect creates a mechanical stress in a piezoelectric material, usually a crystal, when an electric field is applied (as a voltage) across it, or conversely it generates a voltage when a mechanical stress is applied. An oscillating voltage produces an oscillating stressing in the crystal, which excites propagating oscillatory waves in the material that is coupled to the transducer.

3.1.2Pulser-Receiver

The pulser receiver produces an electrical pulse to excite a transducer that converts the electrical input to mechanical energy, creating an ultrasonic wave. In pulse-echo applications, ultrasound travels through the test material until it is reflected from an interface back to the transducer. In through-transmission applications, the ultrasound travels through the material to a second transducer acting as a receiver. In either case, the transducer reconverts the mechanical pulse into an electrical signal that is then amplified and conditioned by the receiver section. The resulting RF is then made available for further analysis.

3.1.3 Data Acquisition System (DAQ)

The signal received from the transducer via pulser-receiver has to be taken through the data acquisition system into the laptop or to any computer to do the post processing analysis. The data of variation of voltage with respect to time, which is in the analog form, has to be converted to digital before being transferred into the computer. Basically DAQ card serves the above purpose.

Experimental setup components specifications

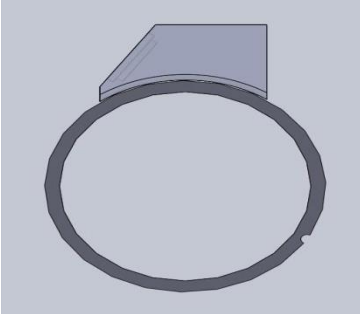
Components	Brand name	Specifications
Transducer	Panametrics videoscan V104	2 Mhz frequency
Pulser receiver	Tecnhofour UTUSB	Operating range-below 5 Mhz.
Oscilloscope	Laptop	

3.2 Experimental Methodology

Notches are then made on the 4 inch pipe on a straight line with uniform distance between them. Five 1mm diameter notches are made of different depths along a straight line on the surface of the pipe as shown in the Fig 3.2.Depths of 10%, 30%, 50%, 70%, 90% are made on the surface of the pipe. These notches are equivalent to the reduction in the wall thickness of the pipe. Since the wall thickness is 7 mm, the notch depths are 0.7, 2.1, 3.5, 4.9, 6.3 mm. Experiment is performed by placing the wedge is placed in the 12 O clock position where as the notches are present in the 4 O clock position. The probe is scanned linearly along the surface of the pipe and the signals are captured at the locations where the signal from defect arrives.

4. Results and Discussions

The following figures 4.1 shows the 4 O clock position of the defect with respect to the scanner



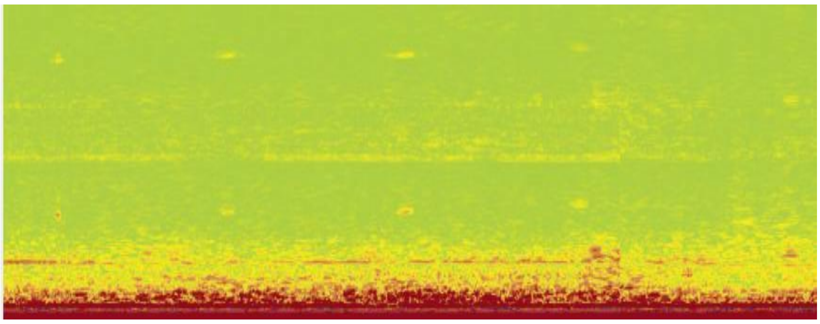


Fig 4.1 4 O clock position Fig 4.2 B scan in 4 O clock with gain 45 dB

Table 4.1 Notch size vs peak amplitude results in 4 O clock position (45dB gain)

Notch size (in mm)	**Peak amplitude**
30%	13.92
50%	20.25
70%	26.32
90%	29.71

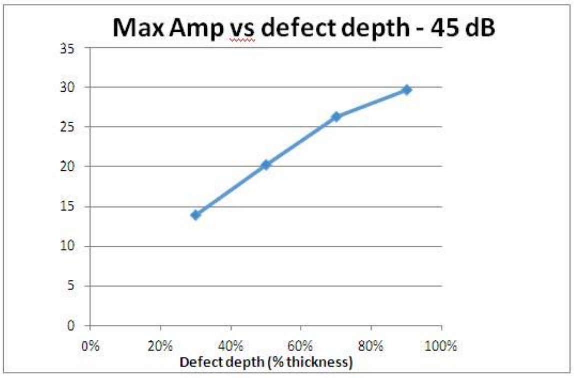


Figure 4.73Maximum amplitude vs defect size – 4 O Clock -45 dB

4.1 Defect Sizing

To find out the unknown defect size from the amplitude of the signal obtained from the defect, one requires a defect sizing curves. Graphs are plotted for the peak amplitudes obtained from 4 O clock position with 45 dB gain from table 4.1

5. Conculsion

Expermentation is done on a 4 inch pipe . Initialy notches were made on the pipe at a known distances and a scanner is deigned and tested on pipe using NDE ultrasonic techniques. The results are taken depending upon the depth of the notch and amplitude frequency obtained .

6. Acknowledgement

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