DETERMINATION OF DEPTHS OF CORROSION PITS IN PIPES ASSOCIATED WITH DEPOSIT BY RADIOGRAPHY

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ABSTRACT

Pipings and pipelines are vulnerable to internal and external corrosion and subjected to deposit accumulation because of chemical effects. Determining the extend and progress rate of corrosion and deposit provides useful information about the operational life and safety of the equipments and plants.

The condition of pipings and pipelines can be monitored by the proper use of non-destructive inspection methods even while the plant is in operation.

Pitting is a special kind of corrosion, which is very often encountered in pipes. Detection of corrosion pits in pipes can easily be performed by using tangential radiographic and film density measurement methods. Detection of pits, which are associated with deposit can not be directly performed by density measurement method and requires special simulations. This study describes the determination of depths of pits in pipes associated with deposit by radiographic density measurement method. Special simulations were made in order to obtain density-deposit thickness reference curves for the evaluation of deposit thickness and thus pit depth. Difficulties and limitations of the method were discussed.

1. INTRODUCTION

Transportation of liquid and gaseous substances by using piping and pipelines is most economical and efficient way. The reliability and safety of industrial equipments especially in the industries such as petroleum, power and heat stations, refineries, petrochemical and chemical plants desalination pipelines, urban gas installations and water pipe lines, etc. are substantially influenced by degradation processes such as corrosion, erosion, deposits and blocking of pipes which might cause fire, leaks, reduced production or unpredictable and costly shutdowns due to repair and replacement. The condition of critical components in these industries can be monitored by using various non-destructive inspection methods while the plant is in operation, thus making possible the planning of component replacements, repairs, deposit removal and shutdown. Remaining wall thickness and pit depth in corroded pipes are the most important parameters to be monitored. Ultrasonic, magnetic and eddy current methods can be used in periodic inspections of pipelines. However these methods are used on limited number of sections and only in the piping maintenance time because they require the removal of insulating

materials. Only radiographic method assures inspection without costly removal of insulating material during operation of the plant. An additional advantage is that the radiography can even be applied in high temperature environments.

Pits in the pipes are localised corrosion cells caused by oxidation or chemical action of the corrosive materials. The shape of a pit is then like a hole on the surface of the metal. Deposits are formed by the accumulation of sludges and the precipitation of carbonates, silicates, sulphates, etc. which results in reduction of the effective cross-section of the pipes.

The principles of corrosion measurement by means of tangential, film based radiography are already known for a rather long time, and many studies have been carried out on this subject [1-3].

Determination of remaining wall thickness, corrosion pits and deposits by means of tangential radiography and radiographic density measurement methods was deeply studied by the authors of this work [4]. Measurement of corrosion pits, which are covered with deposit, is fairly complicated and requires special simulations for the evaluations. This study describes the measurement of corrosion pits by means of radiographic density measurement method and simulations required for pit depth and deposit thickness evaluations. The performance and the limitations of the method were discussed.

2. EVALUATION OF CORROSION PITS AND DEPOSIT BY RADIOGRAPHY

All the non-destructive test methods can be used to some extent in corrosion evaluations. Among them, the ultrasonic method seems to be the least expensive and the most widely used for detection of corrosion and the resulting wall thickness reduction of pipes. However, this method shows inadequacies when confronted with laminations, inclusions and segregations in the pipe material, which may cause uncertainty in measurements, or when the pipe is insulated or in an inaccessible position that prevents probe contact. The method is also unable to detect deposits.

Radiography is a powerful method for determining all kinds of corrosion, wall thickness variation and deposits, and can be applied without the above difficulties. Radiation precautions, the necessity to access to both sides of the pipe, greater cost and time are obvious disadvantages of this method.

Tangential radiography is the fundamental technique for pipe wall thickness and deposit measurements and has already been applied in corrosion examinations [1-3]. This technique was also applied for pit depth measurements [4]. In this technique, a view of the pipe cross-section, including a view of the pipe wall, is projected on to the film, enabling direct measurement of the pipe wall and deposit thicknesses and pit depth.

Radiographic density measurement method is alternative and complementary of the tangential technique. Remaining wall thickness and pit depths can be readily determined by measuring the radiographic densities of the sound and pitted areas, using density-thickness graphs. The radiation reaching the film changes with the thickness of the material. Any discontinuity, pit or

wall thinning of the material allows more radiation to pass and therefore causes higher density areas on the film. The density-thickness curve can be established by exposing a stepped block having the same material as the pipe and covering the thickness range up to twice pipe's wall, and correlating the thickness with the densities of each step. It should be noted that a density-thickness curve represents only one condition of film type, radiation energy and metal. The stepped block and the pipe can be exposed either together on the same film as shown in figure 1, or separately, but under same exposure conditions.

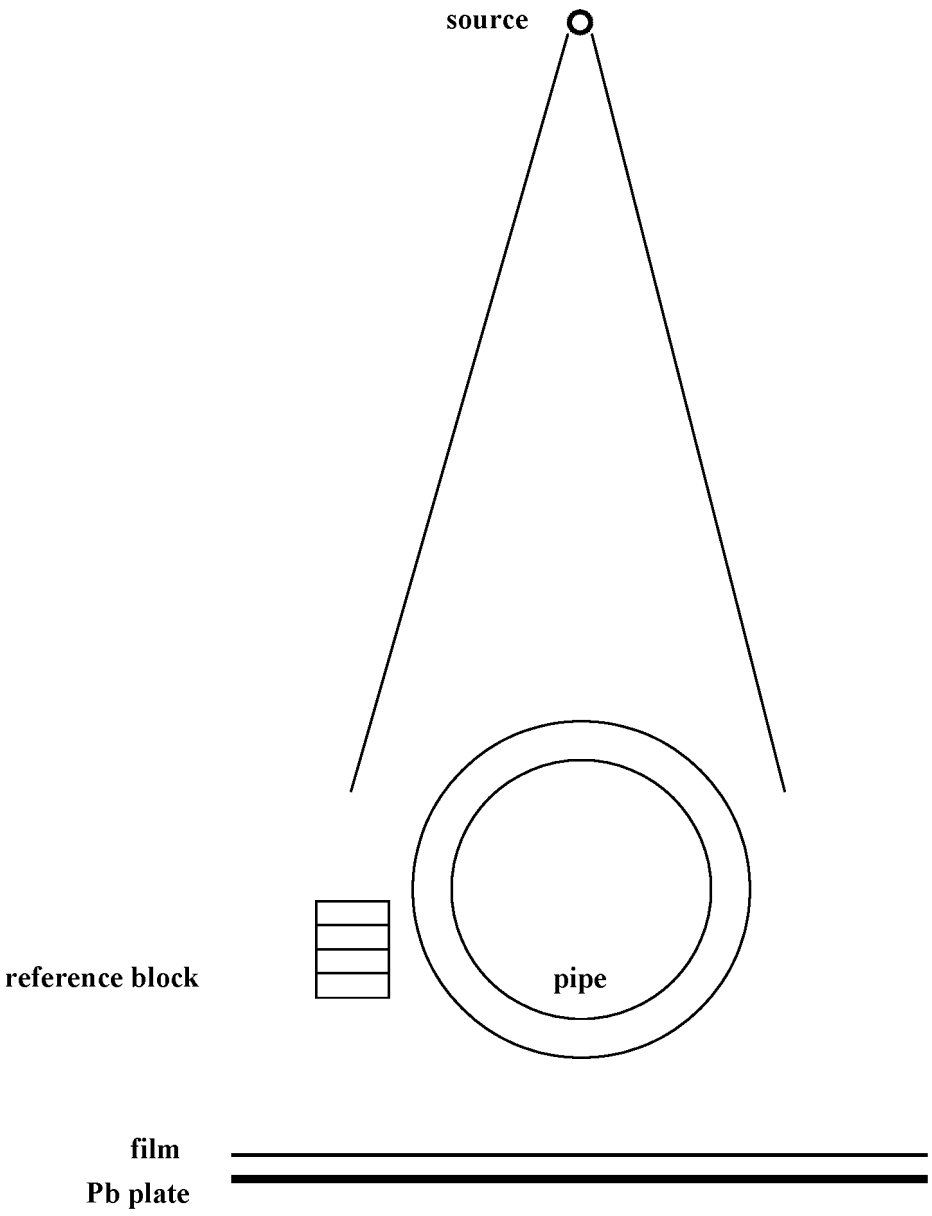


Figure 1. Exposure arrangement for density measurement method

Determination the depth of corrosion pits, which are associated with deposit, by using radiographic density measurement method is quite complicated. Since the density of the pitted area will belong both to pit and deposit, this requires special simulations in order to distinguish the density of the pit and that of deposit. Therefore for different depths of pits and different deposit thicknesses, particular density-deposit thickness correlation curves have to be established. These curves also help to determine the wall thickness of a pipe which is covered with deposit.

3. ESTABLISHMENT OF DENSITY-DEPOSIT THICKNESS CURVES

Density-deposit thickness reference graph represents only one condition of exposure parameters and material. The reference block used in this work to establish the reference graph was selected to represent a pipe made of carbon steel and having a nominal wall thickness of 4 mm. Therefore, the block had the same material as pipe and 8 mm thickness which is the double wall thickness of the pipe considered. Corrosion pits were represented with 7 artificial holes between 0,5 mm – 3,5 mm in depth and with 0,5 mm increments. Figure 2 shows the reference block. The block was covered with artificial deposit up to 10 mm thickness by 2 mm increments for each exposure.



Figure 2. Reference block

An x-ray tube (Eresco 300 kV, 5 mA) and Agfa D7 Pb film were used for exposures. The exposure parameters used for taking radiographs from the reference block were selected in order

to be equivalent to that of the pipe, which provided an average density of 2 in the centre of the pipe's radiograph. The radiographs were taken at first without any deposit, then with deposit as filled in the pits only and with each 2 mm step of deposit covering the whole upper surface of the block. Densities were measured on base metal and on the pits. The density-deposit thickness curves were then drawn for base metal and each pit. Figure 3 shows the graph consisting of density-deposit thickness curves.

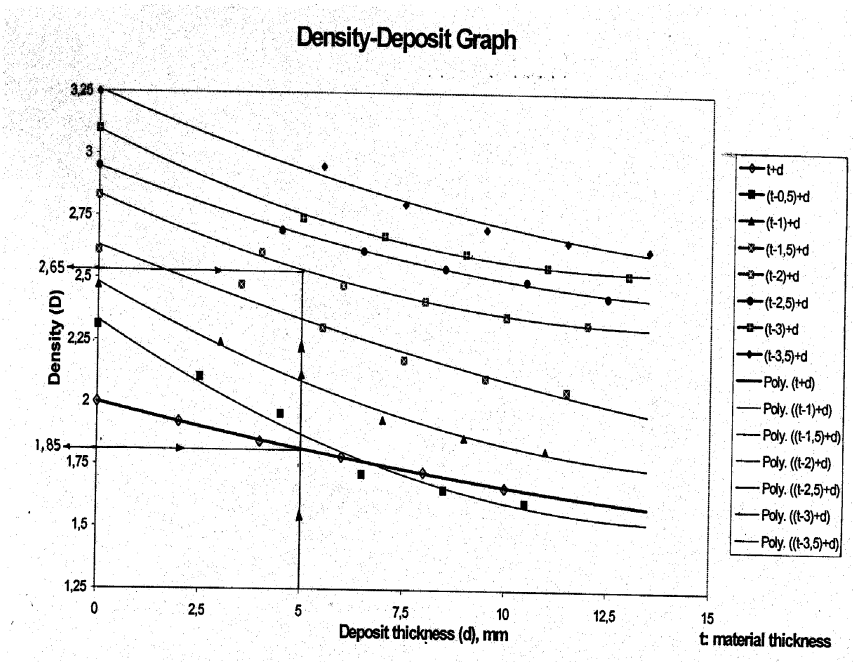


Figure 3. Density-deposit thickness curves (160 kV, 5 mA, 4-min, 700 mm)

These correlation curves make possible to determine the thickness of the pipe's wall covered with deposit and the depth of any pit associated with or without deposit. The thick lined curve can be used to determine the thickness of the deposit by measuring the density on a location, which is close to the pit. This thickness of the deposit measured from the graph will be the total thickness of deposit. The half of this value gives the single thickness of the deposit covering the surface of the pipe with assumption that it has the same thickness on overall surface; otherwise it will be the average deposit thickness. If the total thickness of the deposit is determined, the depth of a pit can be obtained by measuring the density on the pit image. The curve, which is passing through the intersection point of the lines, which are drawn, perpendicular from the deposit thickness axis and density axis, gives the depth of the pit. If the intersection point lies between two curves, an approach can be made by a suitable interpolation. An example can be demonstrated on this graph. In this example, let be the density of the deposited wall 1,85 and the corresponding deposit thickness determined from the thick lined curve, 5 mm. The density of the pit, which is also covered with the same thickness of deposit, is 2,65. The lines drawn from

the point of 5 on deposit thickness axis (vertically) and from the point of 2,65 on the density axis (horizontally) intersect on the curve which indicates a pit of 2 mm depth.

4. CONCLUSIONS AND DISCUSSION

Non-destructive methods can be used to some extend in the determination of remaining wall thickness and corrosion pits in pipes. Tangential radiography is a powerful technique for the evaluation of wall thickness, pit depth and deposit, however it has some limitations, if for example the pipe is containing liquid. Since the densities of a liquid and deposit are very close each to other, very poor or no radiographic contrast can be obtained from the deposit image on the radiograph, thus no interpretation can be made on deposit thickness. Precise estimation of a pit is also difficult by tangential technique because of alignment of the pit relative to radiation beam. Therefore many exposures may require obtaining an optimum pit position.

Radiographic density measurement method is also very effective as the tangential technique in the determination of remaining wall thickness, pit depth and deposit thickness, however this method requires special simulations depending on the pipe to be examined. Since this method is applied as double-wall technique, the wall and deposit thicknesses determined are the average thicknesses. No estimation can be made about the minimum and maximum values. The simulation presented in this study can be used for empty pipes during maintenance or for gas pipelines. The insulated pipes or the pipes containing liquids require another simulations for the examination corresponding to their conditions.

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