CHAPTER 5

AUTOMATIC DETECTION OF POROSITY AND SLAG INCLUSION IN BOILERS USING STATISTICAL PATTERN RECOGNITION TECHNIQUES

The automatic weld inspection system can be used for training weld quality inspectors and for weld quality assessment in the welding industry. The system is aimed at increasing inspection speed, accuracy and at the same time reducing subjectivity associated with the manual interpretation of the weld radiographs. The system detects the weld defects, classifies it, and displays the output with greater accuracy compared to the previously existing methods. It implements fuzzy logic that helps in the automatic recognition of weld defects efficiently.

5.1 INTRODUCTION

In industrial production, the annual production of welded structure is about 45% of steel’s, due to the inherent defects in welding technology and the characteristics of metal, there are always certain flaws in welding structure. In addition, welded structure is often used in more important equipment and structure. Therefore, nondestructive testing (NDT) of welded structures is very necessary and important. In the detection of welding defects, it is universally acknowledged that ultrasonic testing is one of the most effective conventional nondestructive testing methods, and has obvious advantages compared with other methods. With new materials, new technologies widely used, various welding parts have developed in the
direction of high parameters and large capacity, and it is imminent to realize the digital, imaging, real-time and intelligent welding seam nondestructive testing. Therefore, people have been exploring the principles and methods of ultrasonic imaging, and applied it into welding seam inspection. Ultrasonic imaging technology is a new remarkable technology in modern nondestructive testing, but the existing ultrasonic imaging equipments have difficult access to high-resolution images because of the restrictions of imaging conditions and methods, and its identification capability for welding defects, especially for fine defects such as tiny cracks, is less subtle.

Ultrasonic imaging technology is a new remarkable technology in modern nondestructive testing, but the existing ultrasonic imaging equipments have difficult access to high-resolution images because of the restrictions of imaging conditions and methods, and its identification capability for welding defects, especially for fine defects such as tiny cracks, is less subtle. However, lateral resolution of ultrasonic plays a vital role for the quality of the ultrasound image for ultrasound imaging systems, and it is of great significance to enhance lateral resolution. Due to the problems associated with manual detection, there is currently a great deal of work and research on non-destructive testing (NDT) methods for detecting welding defects. The objective is to develop an automated method for the detection of defects that is precise and objective.

Some of the most important achievements in this area are presented below search for potential defects in the X-ray image: Assuming that the defects will be smaller than the regular structure of the test piece, potential defects are classified as those regions of the image where higher frequencies are significant.

The spectrum of the X-ray image is determined with the help of a fast Fourier transformation, which is calculated either row by row or column
by column in small $32 \times 32$ windows. When the sum of the higher frequencies of a window is greater than a given threshold value, the entire window is marked as potentially defective. There are structures that use welds for critical functions, such as high pressure equipment, chemical compounds, etc, where any kind of flaw can trigger catastrophic consequences. Because of this, there are conventional forms for detecting welding flaws by means of visual inspection of radiographic images. These images are generated by means of X-rays and $\gamma$-rays which penetrate the material generating a radiological image on a photographic plate.

5.2 LITERATURE WORK

According to national standards, weld defects are classified as

1. Cracks
2. Lack of penetration
3. Lack of fusion
4. Slag inclusion
5. Porosity

The weld image is preprocessed to extract defect features, according to which 5 characteristic parameters are selected and the FNN model used for defects recognition is set up. Weld defects type determines the degree that the defects do damages to the work piece. Radiographic inspection can checkout so many inside defects as porosity, undercut, lack of penetration, lack of fusion inclusion, etc

5.2.1 Types of Defects

1. Porosity

![Porosity Image](image1)

*Figure 5.1 Porosity*

2. Slag inclusion

![Slag Inclusion Image](image2)

*Figure 5.2 Slag Inclusion*
3. Transverse Crack

![Figure 5.3 Transverse Crack](image)

4. Incomplete Penetration

![Figure 5.4 Incomplete Penetration](image)

5.3 SYSTEM DESIGN, ANALYSIS AND INVESTIGATIONS

The objective is to develop an automated method for the detection of defects that is precise and objective. An image processor does the functions of image acquisition, storage, preprocessing, segmentation, representation, recognition and interpretation and finally displays or records the resulting image. The following block diagram gives the fundamental sequence involved in an image processing system. The image processing method involves five steps through which the defects are classified.
Defects are detected and analysed using statistical pattern recognition techniques and Fuzzy Neural Networks.

THE EXPECTATION STEP

With initial guesses for the parameters of our mixture model, partial membership of each data point in each constituent distribution is computed by calculating expectation values for the membership variables of each data point. That is, for each data point $x_j$ and distribution $Y_i$, the membership value $y_{i,j}$ is:
\[ y_{i,j} = \frac{a_i f_y(x_j; \theta_j)}{f_x(x_j)} \]  
\hspace{10cm} (5.1)

**THE MAXIMIZATION STEP**

With expectation values in hand for group membership, plug-in estimates are recomputed for the distribution parameters. The mixing coefficients \( a_i \) are the means of the membership values over the \( N \) data points.

\[ a_i = \frac{1}{N} \sum_{j=1}^{N} y_{i,j} \]  
\hspace{10cm} (5.2)

The component model parameters are also calculated by expectation maximization using data points \( x_j \) that have been weighted using the membership values.

5.5 **RESULT**

![Figure 5.6 Detection of porosity](image)
5.6 CONCLUSION

It is a new approach to classify the weld defect for radiogram images using EM algorithm. The EM algorithm is very sensitive to the choice of the initial values of parameters. The experimental results show that the proposed algorithm has given better results than the existing algorithms. The defect detection efficiency in this case is 95%.