Enhancing Weld Inspection Through Image Processing: Detecting Defects in Radiography Films

Shailesh Kumar Verma[1], Devnarayan Dewangan[2*], Govind Sahu[3]

[1]Department of Mechanical Engineering, Shri Shankaracharya Institute of Professional Management & Technology Raipur,Chhattisgarh, India 492015

[2]Department of Mechanical Engineering, Shri Shankaracharya Institute of Professional Management & Technology Raipur,Chhattisgarh, India 492015

[3]Department of MechanicalEngineering, Government Engineering College Raipur,Chhattisgarh, India 492015

Abstract

The use of image processing is becoming more widespread in a variety of industries, including robotics, agriculture, medicine, and meteorology. Numerous investigations have been carried out in these domains; however, there has been minimal research on its utilisation in weld inspection. The groove and complete joint piercing high-strength failures in welding (such as pressure vessels, heat boilers, etc.) were examined using the radiographic testing method. Image processing can be used to optimise images and minimise or remove faults in radiography films when there are similar flaws with variable acceptance criteria. Edge detection, better picture quality, and precise colour diagnosis are all feasible in image processing, and they all aid in precisely identifying defects and reducing errors in defect type diagnosis. This project will look into the process of employing image processing to detect internal weld faults in radiography films. The goal is to fully automate the process, doing away with the requirement for human interpretation of the film. First, it will be important to discuss both the various types of weld imperfections and the general and fundamental notions of image processing in order to efficiently identify defects using image processing approaches. Subsequently, using the findings of research and development, procedures and methods for implementing these algorithms will be explained, along with an explanation of how to use MATLAB software.

Keywords: Image Processing, Radiography Film, Weld Deficiencies

1. INTRODUCTION

Weld inspectors' primary goal is to locate internal weld faults, such as porosities, longitudinal and transverse cracks, restricted slag, and improper fusion, in the radiography films. The interpretation of radiography films by inspectors is frequently a source of errors in industrial projects that use image processing to try to reduce errors caused by factors like eyesight error, improper film quality, and weariness.

By extracting digital radiography, Felisberto and associates [1] established an object identification system in the weld bead. They provided a method for carrying out the system head function of interpreting the quality of the weld using techniques that employ genetic algorithms to control search parameter levels like position, width, length, and angle—which, according to the original sample, are the most significant factors influencing radiography images. Cogranne et al.'s study [2] looked into statistical flaw detection utilising a statistical model that was in line with the information contained in radiography images and a theoretical test. Neural network interpretation of welding root radiography footage was investigated by Da Silva et al. [3] investigated the use of neural networks for the interpretation of welding root radiography film. The only weld root flaws that the researchers looked into were those that did not involve the weld body. Determining the faults and flaws in both the weld bed and body will be explored in this study because weld body defects are sensitive and there is a chance that the structure may fail.

2. IMAGEPROCESSING

A two-dimensional function f (x, y) that takes X and Y as location coordinates can be used to describe an image. The intensity of brightness at every given position in the image is determined by the value of f. Digital picture examples from X-ray radiography film are displayed in Figure 1. The primary tasks associated with image processing are as follows: Thegeometrictransformations:suchasresize,rotate.

1. Geometric transformations: resizing, rotating, and so forth.
2. Alter the colour: in addition to adjusting the contrast, brightness, or colour space
3. The images that compose or remove: merge or subtract two or more photos
4. File segmentation: the process of breaking up an image into a specific area using
5. Enhance the file's quality using gamma correction, contrast improvement, and noise reduction, among other things.Thedatastorageinthepicture
6. CompliancePictures
7. Thedatastorageinthepicture.

Figure1. Digitalradiographyfilmimage example.

3. WELDDEFECTS

The AWS D.11 standard states that any size crack discovered during welding is rejected. Cracks that are longitudinal and transverse may develop in the weld sites themselves or in their root. Gases released during the welding process and the remaining casting stage cause porosities, which remain in the piece or weld and are accepted in compliance with standards based on the load (static or dynamic), the diameter and frequency of the porosity in the determined length of the weld, and the type of connection (tubular or non-tubular).The longitudinal crack and the radiography film image connected to the crack are shown in Figure 2. End craters happen when the welder pulls their hand to remove the electrode, and the weld needs to be filled to the designated weld level. Usually, the end crater has a star fracture that needs to be fixed before filling the hole.

Figure2. Radiography film image of the longitudinal crack that has been shown in it and longitudinal crack

Figure3.Porosities in radiography film picture and fillet weld

End craters happen when the welder pulls their hand to remove the electrode, and the weld needs to be filled to the designated weld level. Usually, the end crater has a star fracture that needs to be fixed before filling the hole. According to standards, incomplete penetration happens at the weld's root and is rejected in any size. The margins of the incomplete penetration remain sharp, and a thin black line may be seen in the middle of the weld on the radiography film since it can only occur in the roots. Undercutting happens at the weld face, and the standard states that the depth of the undercuts determines whether the weld is accepted or rejected under both static and dynamic loading.The weld profile in groove welds should not exceed 3 mm; if it does, it will be deemed defective and visible as a bright white across the weld's width on the associated radiography film. The weld root can penetrate up to two millimetres, and excess penetration that looks brighter white in the middle of the weld on radiography film is permitted. The overlap is visible upon eye inspection at the weld surface. Burn through affects the entire weld, as visible in the weld root, and is rejected. It appears as a black area on radiography film. Concavity of the weld root visible as a thin black line in the centre of the weld (root). It is unacceptable to underfill in accordance with the standard; instead, the weld profile stated in the standard must be filled. Darker areas of the weld appear on radiography film. The portion that needs to be welded together during assembly is unnecessary. The two parts that need to be welded together are not aligned during assembly, and as a result, there is half-darkness and half-light on the radiography film. The standard rejects incomplete fusion, which frequently happens in the weld wall—the area where the base and weld metal join—as well as in the spaces between successive passes.

Figure4. The accompanying radiography film image defines the end crater and star crack.

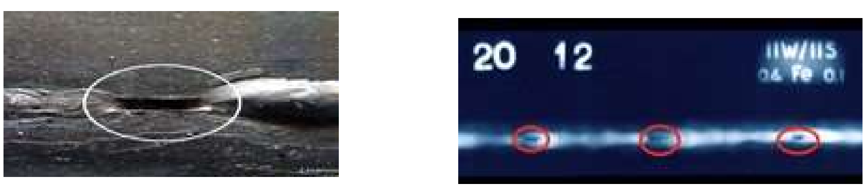


Figure5. Partial infiltration and associated radiography film image

Figure6. Undercutradiographyfilmimage

Figure7. Overweld metal and the image of radiography film

Figure8. The radiography film image of excess penetration

Figure9. The corresponding radiography film image of burn through

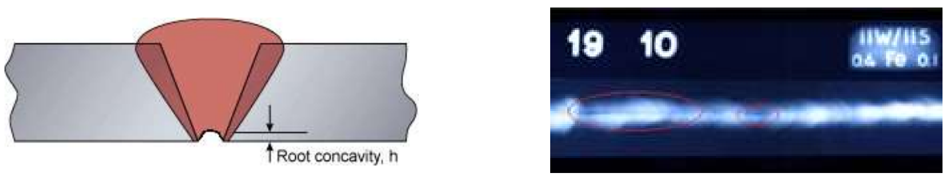


Figure10. Concavity of the weld root and associated radiography film picture

Figure11. The image of under fill and its radiography film

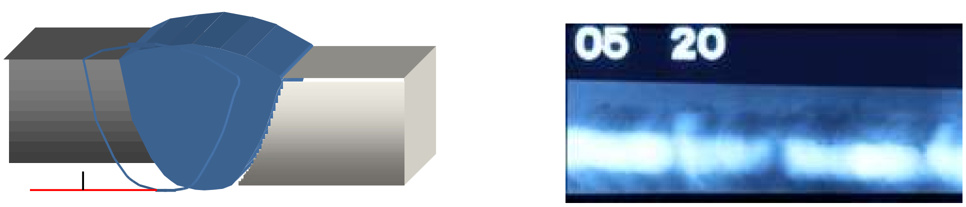


Figure12.Misalignment, or Hi-Low, and radiography film

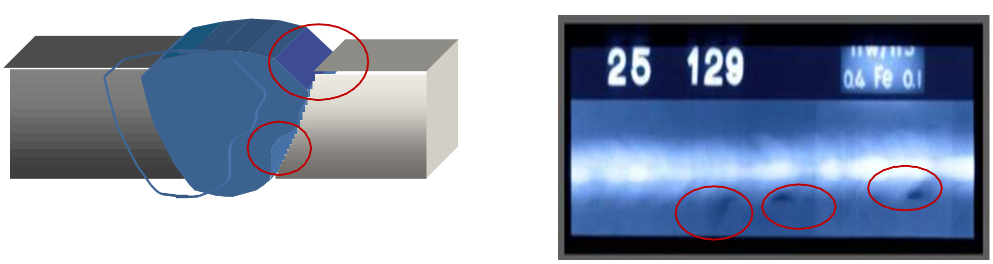


Figure13. Radiography film image with incomplete fusion

4. IMPLEMENTATIONOFIMAGEPROCESSINGOFRADIOGRAPHYFILMS

Importing a radiography film image into the MATLAB program's environment is the initial step. The visual file extensions JPEG, TIFF, GIF, BMP, and PNG may all be read by MATLAB. You can use commands like "imread" and "imshow" for this.To separate the colours in the image for clustering in the second stage, the image's colour should be transformed from RGB to L × A × B. In the L × A × B model, colours are defined as absolute if the white point is identified, in contrast to the RGB model where colours are described as mixed clear and printed colour. The colours acquired in the previous phase are utilised in the third step to cluster using the K-Means algorithm. This method divides the image's related colours up to a predetermined distance into a predetermined number of clusters, each of which contributes to the final outcome. As seen in Figure 14, the welded portion is divided into two sections for clustering: the surface and the root, and the weld surface is divided into three sections: the edge, the weld interior, and the part side.

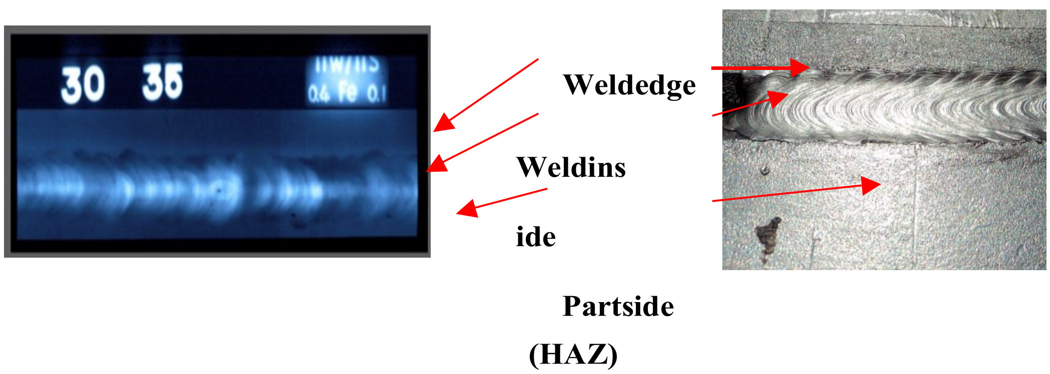
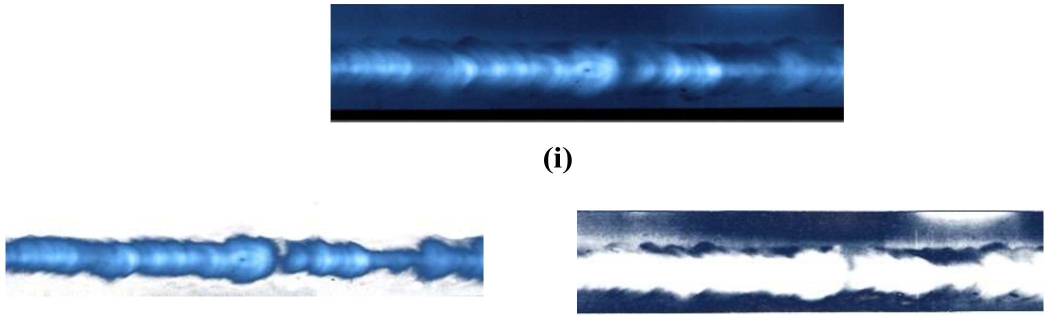


Figure 14. Part surface segmentation Based on the flaws and the appropriate radiography film

The defects of the weld edge include undercut, overlap, and faults that should be addressed during visual inspection. The defects of the weld surface include cracks, a lack of fusion, gas porosity, burn through, end craters, and weak arc starting. The weld root's flaws include cracks, porosity, excessive root penetration, lack of penetration, and lack of fusing at the root. If imperfections exist, they will be seen in the middle of the welding process in the radiography film image. To find weld flaws, the three previously mentioned regions should be separated into clusters and then checked individually. Figure 15. shows the radiography film image (i), the weld inside the cluster (ii), and the cluster of the weld side that was split by clustering (iii).as shown in figure 16. The weld edge cluster and matching radiography film are displayed.



(i)

(ii)

(iii)

Figure 15. (i) Radiography film (ii) the weld inside cluster (iii) weld side cluster

The related normal clustering image and the defective weld portion are compared in order to discover the flaw. Two photos are subtracted in this section. The indexing of clusters is the following stage. An index of a cluster is produced for each area of the image that is input into the K-Means algorithm. Any area or group within the image is given a unique index in this stage.

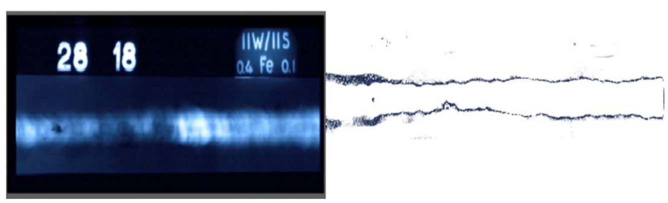


Figure16. Clusterofweldedge and Radiography film image.

5. RESULT AND DISCUSSIONS

Figures 17 through 25 display the findings from flaw detection and clustering. They are distinguishable from one another because of the shape and size of the weld flaws. Figure 17 displays the surplus weld metal cluster image as well as a radiography image. In Fig., excess weld metal due to higher density that is more visible in the film is indicated in red. A radiography film image and the images of the end crater, fracture, porosity, and burn through are displayed in Figs. 18 to 21, respectively. Because the welded portion is darker than the remaining portions, there is a reduced volume of metal that can cause cracks, porosity, burn through, incomplete fusion, and end craters. Cracks can appear in vertical or horizontal lines. Gas porosity has a tiny, spherical shape. It is possible to distinguish between burn through and end crater defects in terms of their morphology and image processing. Diagnosing burn through from end crater can be challenging at times. If end crater is found in the weld surface but burn through extends to the weld root, referring to the root can aid in detection. Weld shape investigations show that when there are faults in the weld edges, the weld edges go to the inside in an undercut. The edge is a flat line in incomplete fusion, denoting that the edge of the base metal has not melted. The weld line's edge strayed towards the part side. The radiography film image and the cluster of the weld edge in the event of an incomplete fusion and undercut are displayed in Figs. 22 and 23. Regarding the root flaws, a radiography film image and the cluster of incomplete and excess penetration are displayed in Figures 24 and 25. Images clearly show the distinction between the two flaws.

Figure 17.Image from radiography film and cluster of additional weld metal

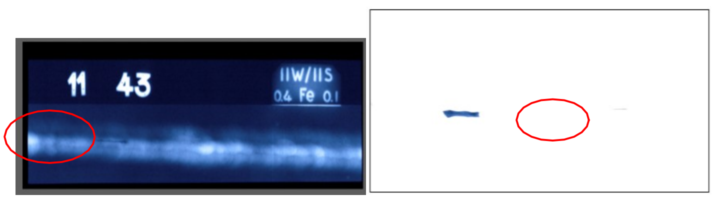


Figure18. Image from radiography film indicating cluster of cracks

Figure19. Image from radiography film and porosity cluster

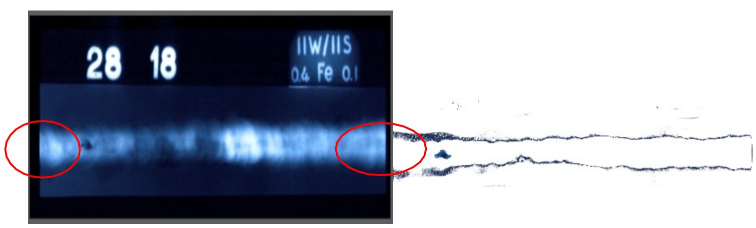


Figure20.burn through cluster and Radiographyfilmimage

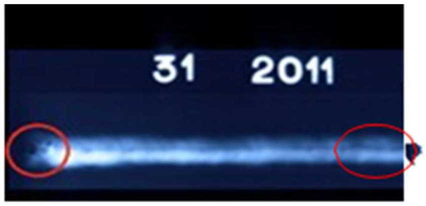


Figure21.image from radiography film and final crater cluster

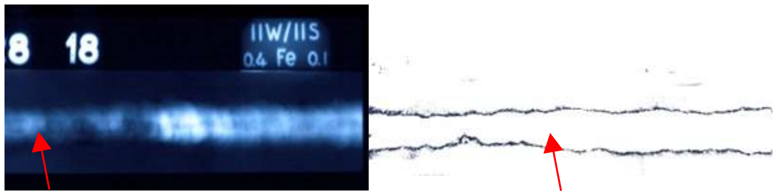


Figure22.weld edge cluster andRadiographyfilmimage

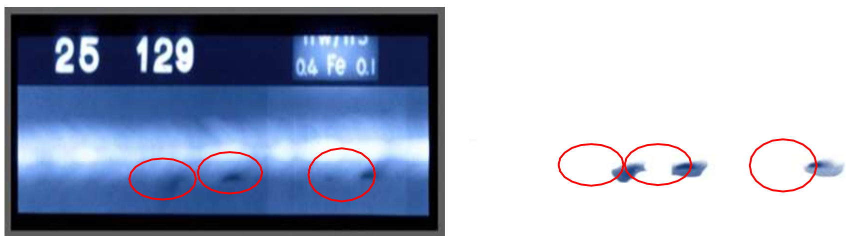


Figure23. An incomplete fusion cluster and radiography film image

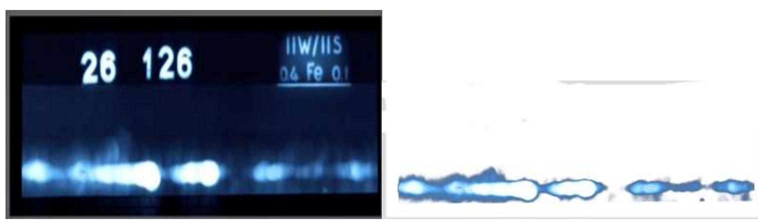


Figure24. The radiography film image and the cluster of extra penetration

Figure25. Picture from radiography film and missing penetration cluster

6. CONCLUSIONS

The fourth and fifth headlines discuss the image processing approach used to identify flaws in radiography films and the analysis of processed images. The key outcomes of this process are outlined below:

1. One of the most crucial aspects of capturing images from radiography film for analysis is adjusting the camera and ambient light levels properly. As a result, the maximum needs to be used cautiously. Several camera angles can be employed to enhance the multi-camera.
2. Poor arc starts and end craters may be mistaken for one another, but they both need to be fixed in accordance with standards; if one is incorrect, it's not a major issue. In the same way, all cases of overlap, fusion failure, cracking, and insufficient penetration are rejected; if they are confused for one another, that shouldn't be an issue since these are all rejected. But the first group and the second group mentioned are never the same.
3. It can be useful to evaluate both the surface and the weld root at the same time since some flaws, such burns, must inevitably be at the weld root if they burn through the surface. Concurrent investigations aid in the identification of related faults.

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