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# Detection of Weld Defects in Radiography Films Using Image Processing

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**Abstract.** Todays, the range of applications of image processing in various fields such as medical, robotics, agriculture and meteorology spread. Several studies have been conducted in these areas, but little researches have been done regarding its application in weld inspection. To test the groove and complete joint penetrating high-strength welding defects (such as pressure vessels, heat boilers, etc.) used radiography testing method. In the case of defects that are similar but have different acceptance criteria, minimize or eliminate the errors in radiography films by optimizing images using image processing. In image processing, edge detection, improving image quality and accurate color diagnosis is possible and help to accurately identifying of defects and decreases errors in diagnosis of defects type. In this study, the method for detection of internal defects of weld in radiography films using image processing will be investigated that its results can be used to eliminate the need for human interpretation of film and fully automate it using a machine.so first the general and basic concepts related to image processing, as well as a variety of weld defects will be described, then, using the results of research and development, effective way to identify defects using image processing algorithms will be provided and implement procedures and methods of it, using MATLAB software will be explained.

**Keywords:** Radiography film, image processing, weld defects

## 1. INTRODUCTION

Identify internal weld defects such as porosities, longitudinal and transverse cracks, confined slags; lack of proper fusion, in the radiography films is an important objective of welding inspectors. The interpretation of radiography films often by inspectors, because of factors such as vision error, lack of proper quality of films and fatigue caused sometimes errors are huge in industrial projects that using image processing has been trying to eliminate these errors.

Felisberto and colleagues [1]. introduced an object identification system in the weld bead, by the extraction of digital radiography. They offered a way to, execute the system head function of interpretation of weld quality based on identify techniques in which genetic algorithms is used to manage levels of search parameters such as position, width, length and angle that are the most important of determinants in radiography image according to the original sample. Cogranne et al [2]. investigated Statistical detection of defects using a statistical model consistent with the content of the radiography images with hypothetical theory test. Da Silva et al. [3] studied the interpretation of radiography film of welding root using neural networks. The researchers investigated only the weld root defects, but they no investigation about weld body has not been done. Since defects in the weld body are sensitive, and the possibility of failure in structure there is, in this study determining of the defects and flaws in both weld bed and body will be investigated.

## 2. IMAGE PROCESSING

An image can be described by a two-dimensional function f (x, y) that the X and Y are coordinates of the location and the value of f at any point of image is called intensity of

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brightness at that point. Figure 1 shows an X-Ray Radiography film digital image samples. The main image processing operations are done include:

1. The geometric transformations: such as resize, rotate, etc.
2. Change the color: as well as change the brightness, resolution, or change the color space
3. The composition or subtraction images: combine or subtract two or more image
4. Segmentation of file: the decomposition of the image to some area with the means
5. Improve the quality of file: noise reduction, contrast enhancement, gamma correction, etc.
6. evaluate the quality of Image
7. The data storage in the picture
8. Compliance Pictures

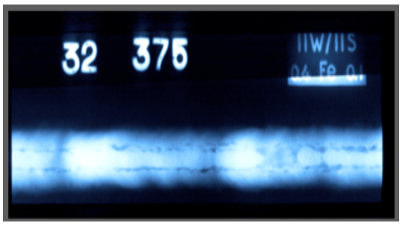


**Figure 1.** An example of digital radiography film image

## 3. WELD DEFECTS

Longitudinal and transverse cracks can occur in the root or the entire welding sites and according to AWS D.11 standard, crack with any size located in any place of welding, is rejected. Porosities caused by gases released in the welding process and the rest of the casting stage, which remain in the piece or weld and accept ion of them according to the standard depending on the load (static or dynamic), connection type (tubular and non-tubular), the diameter of the porosity and its frequency in the determined length of weld. Figure 2. Shows longitudinal crack and Radiography film image that longitudinal crack specified in it. End craters occur when the electrode ends by pulling the welders hand and the weld should be filled to the specified level of weld. Usually there is star crack in end crater that should be removed and then the hole should be filled.

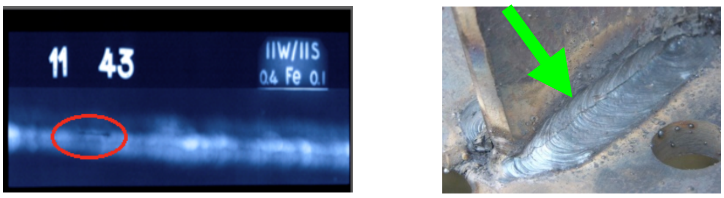


**Figure 2.** longitudinal crack and Radiography film image that longitudinal crack specified in it

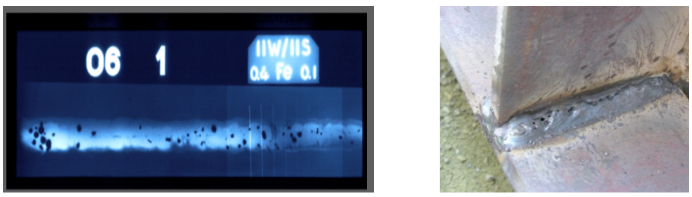


**Figure 3**. Porosities in fillet weld and radiography film image

Incomplete penetration occurs at the root of weld and with any size, according to standard, is rejected. In the incomplete penetration ,the edges of part remain sharp, and because it can only occurs in the roots , a narrow black line in the middle of weld in radiography film be seen.

Undercut occurs at the face of weld and according the standard, in both static and dynamic loading, to determine acceptance or rejection of it depends on the depth of undercuts. The weld profile in groove welds should not be more than 3 mm and If be more than 3mm will be determined as defect, that in related radiography film as a bright white in whole width of weld will be seen. The maximum allowable penetration of the weld root is 2 millimeter and excess penetration, in the middle of weld in radiography film appears brighter white. The overlap is in weld surface where it can be detected by visual inspection. Burn through occurs in the whole weld and can be seen in weld root and in radiography film appears as a black spot, while is rejected. Weld root concavity as a Narrow black line in the middle of the weld (root) is seen. Under fill according to standard is unacceptable and must be filled to the specified profile of weld in the standard. In radiography film appears darker parts of weld. During the assembly, the piece to be welded together is not justified. During the assembly, the two pieces to be welded together are not aligned and because of misalignment of two part, in radiography film, half dark and half-light seen. Incomplete fusion often occurs in weld wall (the junction of the base metal and weld metal) and also between consecutive passes and according to the standard is rejected.

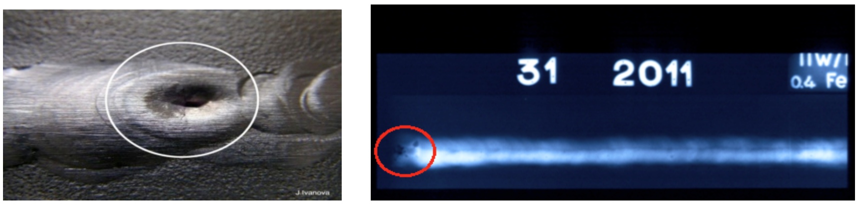


**Figure 4.** End crater and star crack specified in related radiography film image


**Figure 5.** Incomplete penetration and related radiography film image

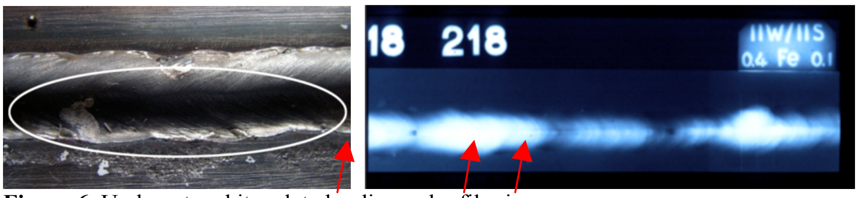


**Figure 6.** Undercut and its related radiography film image

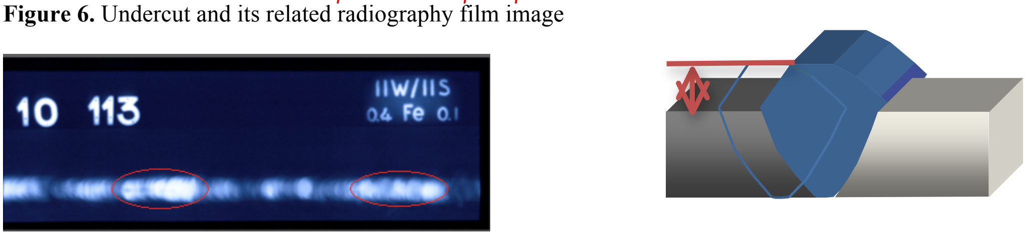


**Figure 7.** Excess weld metal and its radiography film image

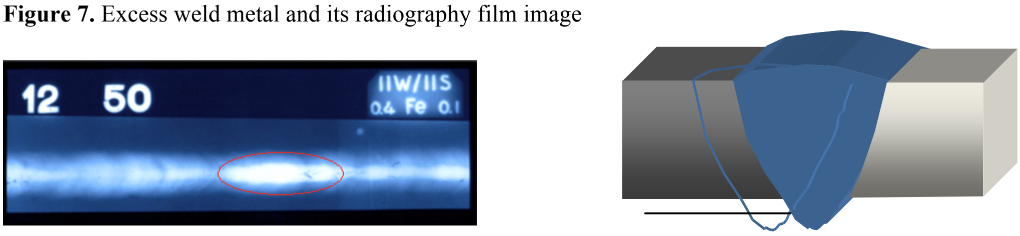


**Figure 8.** Excess penetration and its radiography film image


**Figure 9.** Burn through and its related radiography film image


**Figure 10.** Weld root concavity and related radiography film image


**Figure 11.** Under fill and its radiography film image

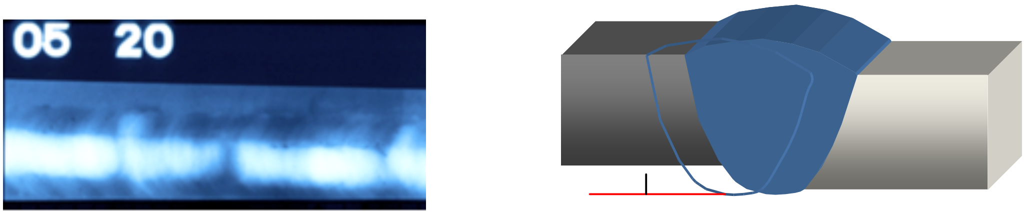


**Figure 12**. Hi-Low (misalignment) and radiography film image

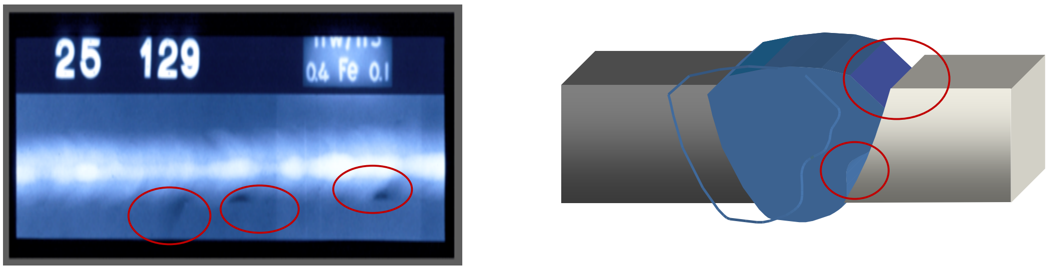


**Figure 13.** Incomplete fusion and radiography film image

## 4. IMPLEMENTATION OF IMAGE PROCESSING OF RADIOGRAPHY FILMS

The first step is importing of about be radiography film image into the MATLAB program's environment. MATLAB can read the graphic files with the extensions JPEG, TIFF, GIF, BMP, and PNG as graphic file. For this purpose, can use commands such as "imread" and "imshow". In the second step to separation of the colors in the image for clustering, the color of image should be changed from RGB to L × A × B. Unlike RGB model that colors are defined mixed clear and printed color, in L × A × B model, if the white point is determined, colors are defined as absolute. In the third step, the colors obtained from the previous step are used to clustering by K-Means method. This algorithm puts the similar colors of the image up to a certain distance that the programmer defines in a certain number of clusters that each of these clusters is part of the final result. For clustering, the welded part is separated into two parts include surface and root, and the weld surface divided into three areas, the edge, weld inside and part side shown in Figure 14.

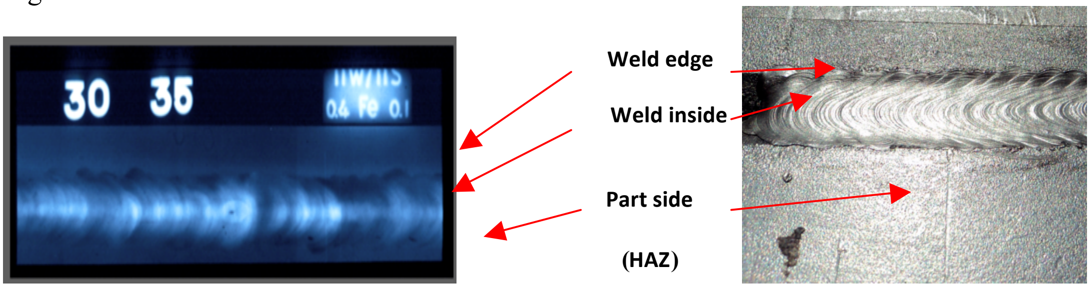


**Figure 14.** Segmentation of part surface According to the defects and the corresponding radiography film

The defects of the weld surface based on their location are cracks, lack of fusion, gas porosity, burn through, end crater, weak arc starting and the defects of weld edge are undercut, lack of fusion and overlap and defects the edge pieces should be removed in visual inspection. The defects of weld root include crack, porosity and excess root penetration, lack of penetration and lack of fusion at the root. These defects, if any, will be seen in the middle of welding in radiography film image. To identify weld defects, the three areas have mentioned above should be separated by clustering and each of them must be investigated. In figure.15 (a) radiography film image (b) the cluster of the weld inside (c) cluster of weld side that separated by clustering .in figure 16. The cluster of the weld edge and corresponding radiography film is shown.

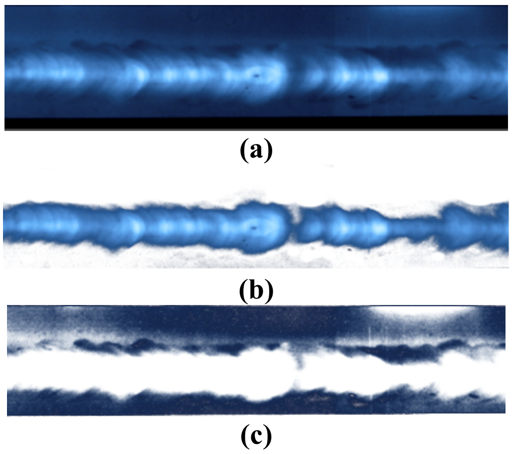


**Figure 15.** (a) Radiography film image (b) cluster of the weld inside (c) cluster of weld side

To detection of defect, the corresponding normal clustering image with faulty part of weld is compared. In this part, the subtraction of two images is used. The next step is the indexing of clusters. For each part of the image that imported into the K-Means algorithm, result an index of a cluster. In this step, any part or cluster of the image is labeled with its own index.

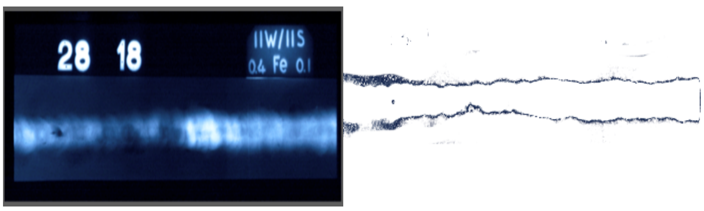


**Figure 16.** Radiography film image and the cluster of weld edge

## 5. CONCLUSIONS

Results of clustering and defect detection are shown in Fig 17 to 25. Due to the size and shape of the weld defects, they are separable from each other. In Figure 17, a radiography image and the image of the excess weld metal cluster is shown. Excess weld metal because of greater density more clearly seen in the film is marked in red in Fig. In Fig. 18 to 21, respectively, a radiography film image and the image of the clusters of crack, porosity, burn through and end crater shown. Crack, porosity, burn through, lack of complete fusion and end crater due to the smaller volume of metal darker than the rest of the weld parts seen. Crack occurs in horizontal or vertical lines. Gas porosity is round and small size. In the case of burn through and end crater, the difference between these defects with respect to their shape and image processing, can be detected. Sometimes the diagnosis between burn through and end crater is difficult, and while end crater is located in weld surface but burn through continue to the root of weld, then referral to the root, can help to detect. In the case of defects of the weld edges, in weld shape investigations, it is observed that in undercut, the weld edges go to the inside, In the case of incomplete fusion, the edge is flat line that represents the edge of the base metal has not melted. In the overlap, edge of the weld line deviated to the part side. In Fig. 22 and 23, the radiography film image and the cluster of weld edge in case undercut and incomplete fusion is shown. About the root defects, in Figures 24 and 25 a radiography film image and the cluster of excess penetration and incomplete penetration is shown. Considering images, the difference between the two defects is evident.


**Figure 17**. Radiography film image and excess weld metal cluster

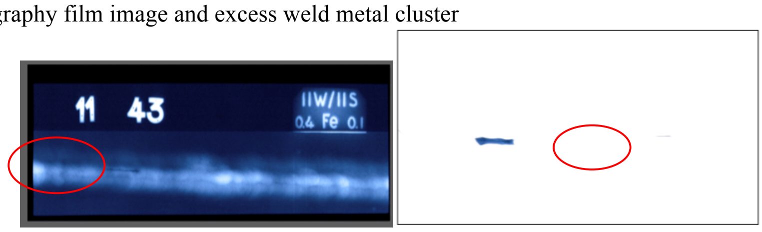


**Figure 18.** Radiography film image and crack cluster


**Figure 19.** Radiography film image and porosity cluster

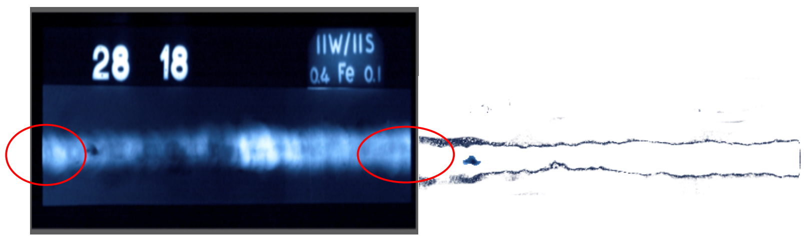


**Figure 20.** Radiography film image and burn through cluster

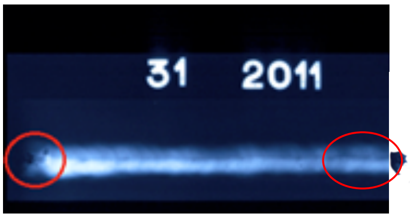


**Figure 21.** Radiography film image and end crater cluster

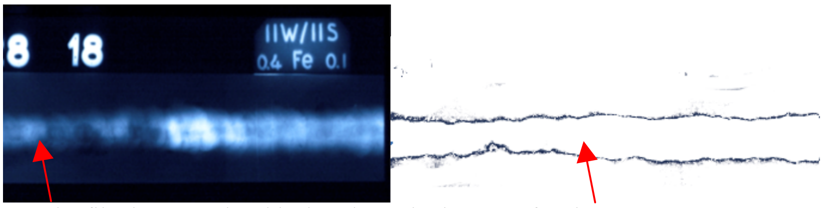


**Figure 22.** Radiography film image and weld edge cluster in the case of undercut

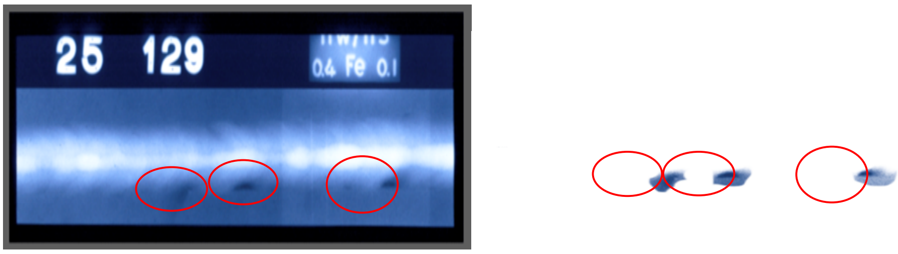


**Figure 23.** Radiography film image and incomplete fusion cluster

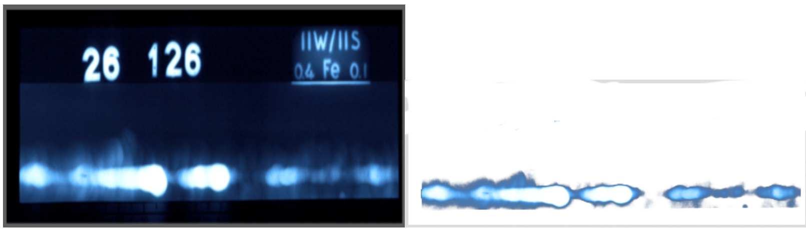


**Figure 24.** Radiography film image and excess penetration cluster


**Figure 25.** Radiography film image and lack of penetration cluster

## 6. ACKNOWLEDGMENT

The method of implementation of image processing to detect defects in the radiography films and processed images analysis is described in fourth and fifth headlines, The most important results of this processes are obtained, are summarized below:

1- Properly adjusting the camera and the amount of ambient light in taking image from radiography film to analyze, plays an important role. Therefore, the maximum should be carefully. To improve the multi-camera can be used with different angles.
2- End crater and poor arc starts may be confused with each other, but they both need to be repaired according to the standard, if it is wrong, not an important problem, also all of crack, lack of fusion, lack of adequate penetration and overlap are rejected if they are confused with

each other is not a problem because all are rejected, but the first group must never be confused with the second group mentioned.
3- Some defects such as burns burn through if there is in surface, and then must necessarily be at the weld root, so check the root and surface at the same time can be effective. This simultaneously investigations contribute to the detection of similar errors.

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