ISSN : 0974 - 7435 Volume 10 Issue 8

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(8), 2014 [2916-2922]

Visualization method research of butt weld magnetic flux leakage

Ma Yun-Kuo

Institute of Higher Education, Northeast Petroleum University, Daqing, 163318, (CHINA)

E-mail : maykpaper@163.com

ABSTRACT

Basing on butt weld magnetic flux leakage datum on steel plate, a kind of visualization method for welding line magnetic flux leakage (WLMFL) based on pseudo color is proposed. This visualization method is based on principle of WLMFL and relays on the magnetization direction being perpendicular to the marching direction to design out a new type of magnetic flux leakage system. Magnetic flux leakage system can gather the leakage magnetic field information of the rectangular slot defects along the distribution position, such as rectangular slot defects respectively in the weld and in the heat affected zone, to generate three-dimensional spatial distribution, then the distribution diagram is converted into two-dimensional gray diagram by using gradation line conversion method, at last, the gray diagram is converted into pseudo-color image by using gradation-color conversion method. The exploration tests results indicated that the characteristic information of welding line defects can be visually shown through pseudo-color image, this method can enrich the detail information and sense of depth of leakage flux image, and can enhances the recognition capability for the characteristics of defects with better visual effect.

KEYWORDS

Butt weld of steel plate; Magnetic flux leakage; Visualization; Pseudo-color; Gradation image.

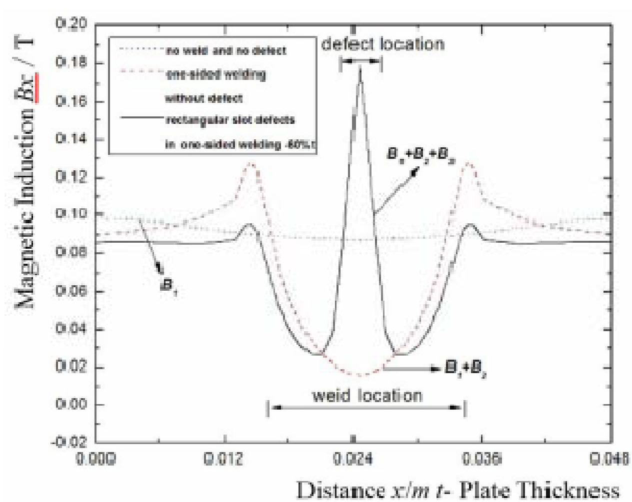
INTRODUCTION

Welding line was the key part of connection for welded equipment such as storage tank and pressure pipe and always has defects in the processing of manufacturer and using. In general, the welding line easily exist in the weld bead and heat affected zone because that this zones are uneven in geometry and uneven in mechanical property with maximum stretch residual stress in the whole construction. At present, the nondestructive testing method for welding line on active service include radial method and ultrasound method et al, but the study of MFL aiming to weld defects were so rare in china because that the magnetic leakage signal aroused by weld bead outline complexly interferes with defects signal[1-6]. This paper proposed a new signal processing method being different to the traditional method, it called WLMFL that used the pseudo-color technology in the steel plate butt weld MFL and proposed a new type of visualization method for welding line non-detective testing.

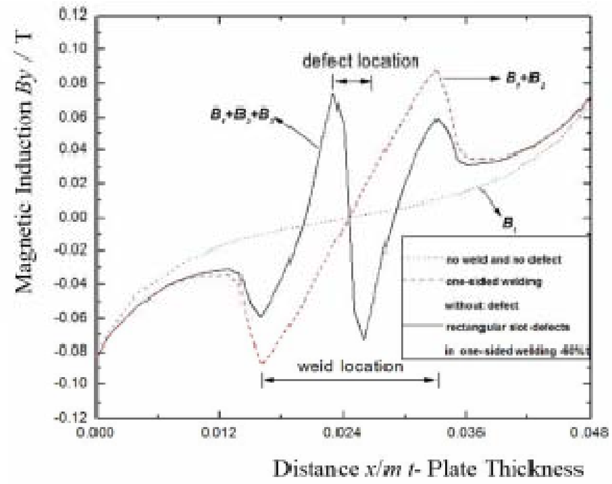
Resolving power of human eyes for color is much greater than gray level, so the method of the gray level image being converted to pseudo-color is an effective technology for image enhancement, and it was widely used in many regions such as medical image, remote sensing image and atmosphere cloud image[7-9]. This paper translated the gray level image formed from welding line leakage flux signal into pseudo-color image that can highlighted the welding line defects with visualized signal and enhanced the weld defects characteristic signal.

TESTING PRINCIPLE OF WELD MAGNETIC LEAKAGE FLUX

In the weld magnetic leakage flux testing system, the magnetic flux density B collected by sensor included three parts; air coupling magnetic field B_1, welding line leakage flux field B_2; Defect leakage flux field B_3. In order to visually express the principle of weld leakage flux testing, three simulation analysis models of thesteel plate without welding line, the welding by one side without defects and butt welding line by one side were respectively established, three rectangular slot defects were respectively located in every models. The thickness of steel plate was 8mm, weld width of welding line was 18mm, weld reinforcement was 3mm. There was a rectangular slot in the middle of welding line. The slot was 40mm length, 7.8mm depth. By means of the magnetic flux density respectively extracted from the relevant path, the correlation curves of magnetic leakage flux density component at above three state were shown as Figure 1.



(a) Horizontal Component



(b)Vertical Component

Figure 1 : Contrast curves of magnetic induction component under three states

As Figure 1 shown, at the three condition; non-welding line without defects, welding line without defects, welding line with defects, the magnetic leakage flux density component curves had the same characteristic; the minimum value of magnetic flux density horizontal component B_x was achieved at the center line and was symmetric with the center line; the curve of vertical component By was dissymmetric with center line because that the polarities of two center line side were opposite to each other, and the extremum value of By could be achieved at the welding line or defects location.

When the steel plate was without welding line, the magnetic leakage flux field gathered by sensors was air coupling magnetic field B_1, contrasting to steel plate without welding line, a valley appeared in the horizontal component curve of magnetic leakage flux field intensity, the vertical component curve firstly appeareda valley then appeared peak value because that the texture of welding line was ferromagnetism and some welding line traversed along welding line that resulted in reduction of magnetic flux density across steel plate, therefore the balance, formed by the original magnetic leakage flux field and air coupling field, was broken. The welding line signal and air coupling were overlaid, the presenting curve was thesuperposition results of B_1andB_2.

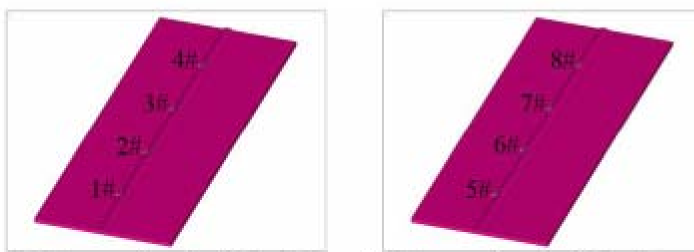
When there was a rectangular slot defects in the welding line, contrasting to welding line without defects, the horizontal component curve of magnetic leakage flux density changed from valley into peak, but the vertical component curve firstly represented valley and then peak. At the certain scanning direction and only existing vertical component condition, the appearing sequence of peak and valley were just opposite. Because the thickness of steel plate at the rectangular slot defects decreased so as to its magnetic flux density of steel plate increased and the magnetic leakage flux density increased too. Magnetic leakage flux B_3, produced by rectangular slot, occupied leading condition, the presenting curve was the superposition result of $B_1$and B_2andB_3.

TESTING SYSTEM AND ACQUISITION OF SIGNAL

Aim to butt welding construct characteristic of steel plate, a new type magnetization system was designed out, its magnetization direction was perpendicular to march direction. The untouched magnetic leakage flux system for welding line defects was shown in Figure 2. This system wasmade up of magnetization structure, driving structure, signal gathering system and so on. The welding structure was sensitive to crack. The crack was one of the main defects factor for influencing the mechanical property of welding line, it might appear in the welding line or heat affected zone. Therefore some prefabricated rectangular slot was designed in different position of weld testing plate, the signal of magnetic leakage flux, such as of rectangular slot defects in the welding line, of rectangular slot defects in the heat affected zone, was taken as object of study. Two welding line type of testing plate was shown in Figure 3.

Because the depth of rectangular slot defects directly influenced the welding line and the life of steel plate, the other size of rectangular slot defects except depth was invariant, the depth size was selected as variables to study the characteristic of magnetic leakage flux image. In Figure 3, the material of testing plate was Q235, thickness was 8mm, the single side butt welding reinforcement was 3mm, weld width was 18mm, length and width of rectangular slot were respectively 40mm and 1mm. the depth of rectangular slot in welding line was as followed;1#~4# respectively reached 20%~80% of steel thickness, 1# was 20% (4.6mm), 2# was 40%(6.2mm), 3# was 60%(7.8mm), 4# was 80%(9.4mm). The depth of rectangular slot in heat affected zone was as followed; $5^{\#}$~$8^{\#}$ were respectively 20%~80% of steel thickness, 5# was 20%(1.6mm),6# was 40%(3.2mm),7# was 60%(4.8mm), 8# was 80%(6.4mm).

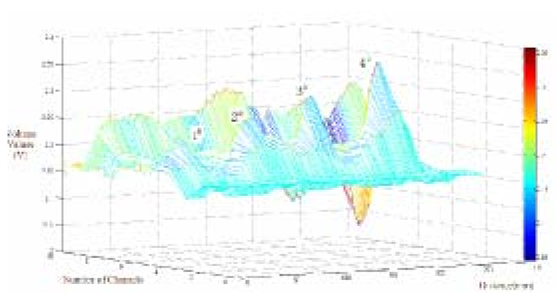
The interval among the adjacent prefabricated rectangular slot was 140mm and didn't influenced each other. Two welding line types of test was conducted on the single butt welding plate by using untouched magnetic leakage flux testing system for welding defects, the three-dimensional space distribution of gathered magnetic leakage single was shown in Figure 4.



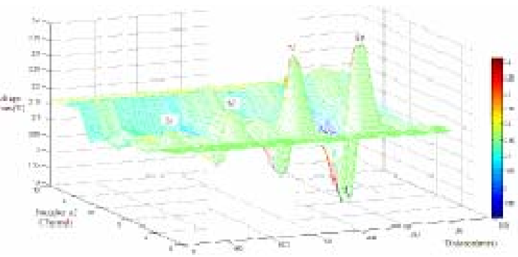
a) Rectangular slot defects in the welding line   b) Rectangular slot defects in the heat affected zone

Figure 2 : Steel plate for testing

Figure 3 : Continuous non-contact scanning MFL system for the weld



(a) Rectangular slot defects in the welding line



(b) Rectangular slot defects in the heat affected zone

Figure 4 : Two dimensional distribution of magnetic leakage signal weld in two weld condition

GRAY IMAGE DISPLAY OF DATUM

Three-dimensional distribution diagram in welding line and heat affected zone were shown in Figure 4, the distance was selected as horizontal axis, the number of channels was selected as vertical axis. At this distance and number of channels condition, the size of amplitude was selected as gray value for this pixel point, and the 3D leakage flux signal of welding defects, gathered from testing, was converted to 2D gray image. In order to extracting characteristic of image, the gray value of image was conducted on gray level linear transformation, and the original gray value was mapped in the matrix scope of [0,255]. The converted gray image has 256 gray levels, “0” indicated pure black, “255” indicated pure white, the middle numbers from small to big indicated gradient ramp from black to white. Therefore, the variation of welding defects magnetic leakage flux could show the gray level. The gray images of two type welding line were respectively shown in Figure 5-(a), (b). The information of welding line and defects could be virtually seen from Figure 5 and was clearer, more comprehensive than the leakage flux signal of three-dimensional space image in Figure 4.

(a)Rectangular slot defects in the welding line

(b) Rectangular slot defects in the heat affected zone

Figure 5 : Three gray image condition of welding line

V. PSEUDO-COLOR DISPLAY

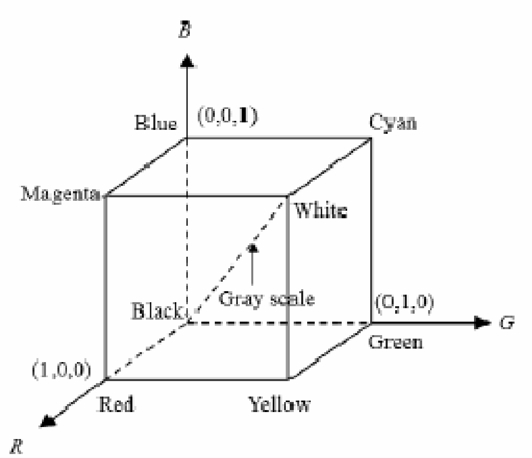


Figure 6 : RGB color model

PSEUDO-COLOR DISPLAY

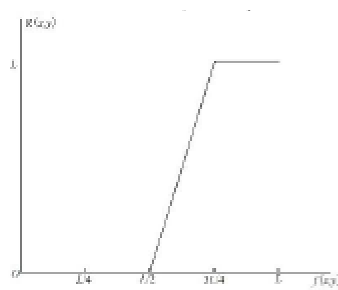
In the color space, the color of image can be indicated by three-dimensional space coordinates, Figure 6 indicated RGB color model based on Descartes coordinate system, the value scope of R, G, B were all [0,1], R, G, B were located respectively in three vertexes, black was located in the original point (0,0,0), white was located in the vertex (1, 1, 1), the six vertexes of cubic respectively were red, yellow, green, cyan, blue, pinkish red. All the points mapped by gray level were located in the diagonal line linked by white and black, the different colors were located on or in the cubic that can be defined by vectors distributed from original point.

There are three pseudo-color processing[10], density stratification method, gradation-color conversion method, frequency domain filtering method. This paper adopts gradation-color conversion method. This method map the gray value of gray image into gradually varied color by a certain function relationship. According to principle of three primacy color, every color may be made up of red, green, blue primacy color by different proportionally-mixed. By constructed map operator ξ_R, ξ_G and ξ_B, gradation-color conversion sets up the map relation between three primacy color R, G, B and gray level $f(x,y)$. The gray value of original gray image $f(x,y)$ are respectively third-conversion :

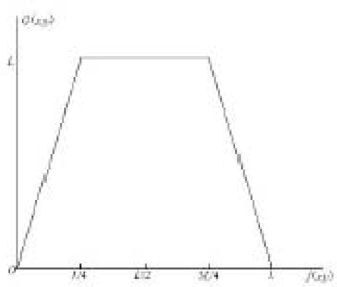
$$
\begin{aligned}
\mathbf{R(x,y)} &= \xi_{\mathbf{R}}\{\mathbf{f(x,y)}\} \\
\mathbf{G(x,y)} &= \xi_{\mathbf{G}}\{\mathbf{f(x,y)}\} \\
\mathbf{B(x,y)} &= \xi_{\mathbf{B}}\{\mathbf{f(x,y)}\}
\end{aligned}
\qquad (1)
$$

In Formula.1, $R(x,y)$, $G(x,y)$, $B(x,y)$ respectively indicate the three primacy color value from pseudo-color. Map operator ξ_R, ξ_G, ξ_B indicate the transformation relation between three primacy color and primacy gray value $f(x,y)$, the proper map operator ξ_R, ξ_G and ξ_B are selected to make different gray value corresponding to different color and then map the corresponding R, G, B combination.

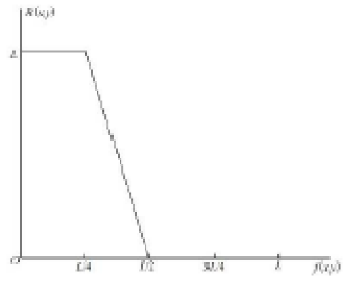
Map operator is adopted in this paper as Figure 7 showing. By pseudo-color processing to gray image asshown in Figure 5 based on above operator, we can achieve two pseudo-color images according to two welding line condition as shown in Figure 8. By means of seeing Figure 8, we can not only find the signal of welding line and defects, and also find the defects depth by color of image. The pseudo-color processing method can make the welding line and defects characteristic clearer than before, and enhance the ability of expression for defects.



(a) Red

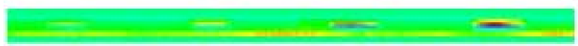


(b) Green

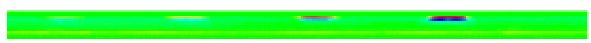


(c) Blue

Figure 7 : Pseudo-color processing map operator of gray level image



(a) Rectangular slot defects distribution in the welding line



(b) Rectangular slot defects distribution in heat affected zone

Figure 8 : Pseudo-color image of two welding line types state

CONCLUSION

The pseudo-color visualization method based on weld defects leakage flux signal is different to the traditional signal processing method and overcame the overlay complexity of analysis between welding line signal and defects signal. By distribution of pseudo-color image to detection signal, WLMFL can effectively enhance the characteristic signal of weld defects, and obviously improve the image detail, clearness degree and contrast ratio between target and background contrasting to the gray level image. WLMFL realized the visual distribution for the datum achieved by weld defects magnetic leakage flux, and provided a new type nondestructive testing method for weld defects.

REFERENCES

[1] D.Groslier, S.Pellerin, F.Valensi; Explorative approach of the spectral analysis tools to the detection of welding defects in lap welding. Nondestructive Testing and Evaluation, **26(3)**, 13-18 **(2011)**.

[2] J.Mirapeix, P.B.Garcı´a-Allende, A.Cobo et al; Real-time arc-welding defect detection and classification with principal component analysis and artificial neural networks. NDT&E International, **40(2)**, 315-323 **(2007)**.

[3] R.Kafieh, T.Lotfi, Rassoul Amirfattahi; Automatic detection of defects on polyethylene pipe welding using thermal infrared imaging. Infrared Physics & Technology, **54**, 317-325 **(2011)**.

[4] N.B.Yahia, T.Belhadj, S.Brag; Automatic detection of welding defects using radiography with a neural approach. Procedia Engineering, **10**, 671-679 **(2011)**.

[5] Feng Xing-Kai; Process equipment for welding. Beijing: Chemical Industry Press, 60-62 **(2003)**.

[6] Cui Wei, Dai Guang; Analysis of magnetic flux leakage field of weld’s defect based on 3D numerical simulation. Nondestructive Testing, **34(8)**, 10-16 **(2012)**.

[7] Jin Ming-xing, Zhang Chang-jiang; Pseudo-color enhancement for typhoon cloud image based on Berkeley wavelet transform. Journal of Computer Applications, **30(6)**, 1602-1605 **(2010)**.

[8] Lan Chun-Sheng, Lan Peng, CaoYu-Yuan; Pseudo-color processing of medical images. Chinese Journal of Stereology and Image Analysis, **7(3)**, 166-168 **(2002)**.

[9] Wang Zhi-wen, Liu Mei-zhen; Remote sensing image boosting based on wavelet analysis and fake chromatic processing. Computer Engineering and Design, **29(18)**, 4771-4773 **(2008)**.

[10] Luo Junhui, Feng Ping; Application of MATLAB7.0 in Image Processing. Bei Jing: Mechanical industry press, 151-152 **(2005)**.