"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA

"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2015
Brasov, 28-30 May 2015

VALIDATION OF SPECTRAL ANALYSIS RESULTS USING PLC IMPLEMENTED AI TECHNIQUES

Grigore Vasiliu*

*Faculty of Automatic Control, Computers, Electrical Engineering and Electronics, "Dunărea de Jos" University, Galati, Romania

Abstract: *The purpose of this paper is the processing of a trace image of steel, which results from a spectral measurement system, using a programmable logic controller (PLC). The spectral analysis of the steel is made by investigating the trace image, generated by an electric arc, in a PLC. The PLC makes simple images to be processed, so it can recognize some traces undetectable by the measurement results. The validation or the invalidation of the final result is provided by the data analysis obtained from the processing, with artificial intelligence techniques, (like fuzzy techniques) of the arc trace image. The image processing with PLC is slow, but possible because the processing time isn't critical, as in real-time application. Using this method, huge amounts of energy can be saved (in order to avoid an unnecessary batch of the steel processing).*

Keywords: *spectral measurement system, programmable logic controller, image processing,*

1. INTRODUCTION

Spectral system of steel analysis must be very sure when it is offered the measurement result. The PLC are the most accurate control numerical systems. The autonomous measurement systems have to proceed successfully a lot of operations usually executed by a human operator. One of these operations is to validate the analysis results of a spectrometer arc, if the trace image aspect results after the electric arc between a wolfram electrode and a measurement probe. The electric arc represents the information source for the composition of the measurement probe. The continuous frequency of the source spectrum, represented by the arc contains the specific information: figure no. 1 [14].

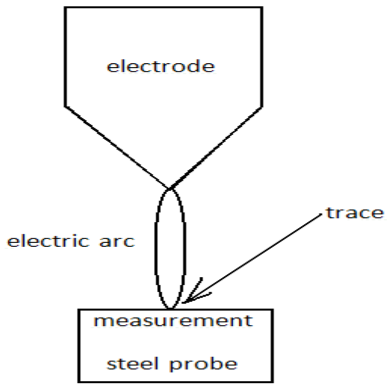

Fig. 1. Trace image after spectral analysis

The validation of spectral analysis results using artificial intelligence techniques implemented with PLC, it is possible due to the following aspects:

1. The objective of this research was not a complex image processing analysis (medium

resolution images). The final result was to obtain a validation decision, or an invalidation decision.

2. The continuous expansion of the numerical systems of the PLC family, through:

- the expansion of the instruction set
- the possibility to generate complex program structures through the defining of some functional blocks.
- the expansion of the hardware variables number which can be implemented in this system
- complex interfaces which can process the dates from the process (the acquisition of a medium resolution images, for processing, using the available resources of the system)[8].

2. THE INDUSTRIAL BENEFITS OF THE TRACE IMAGE PROCESSING

2.1 The recognition of the small black dots. The text one of the advantages of visual analyze of the trace image[5], is the recognition of the small black dots from the trace image, (figure no. 2) which indicates the presence of the carbon disulphide in the metallic structure, which does not affects the material procentual composition, but after the lamination, the material properties are compromised.

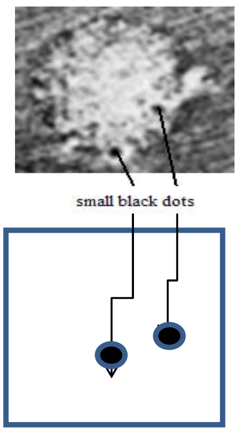

Fig. 2. Recognition of small black dots
2.a. Initial arc image trace
2.b. The points recognition

In figure no. 2, in the second image, the only thing that remains are the black dots; the rest of the dots will be replaced by the white dots [9]. Due to this way of action, it will result the cracking of the steel sheet, followed by the whole lot cassation. Because of this simple recognition of the black dots in the metal sample, which is the composition of 200 tons of steel, the unnecessary lamination of the whole lot is prevented.

2.2 The black dots detection method (representing the carbon disulphide, figure no. 3):

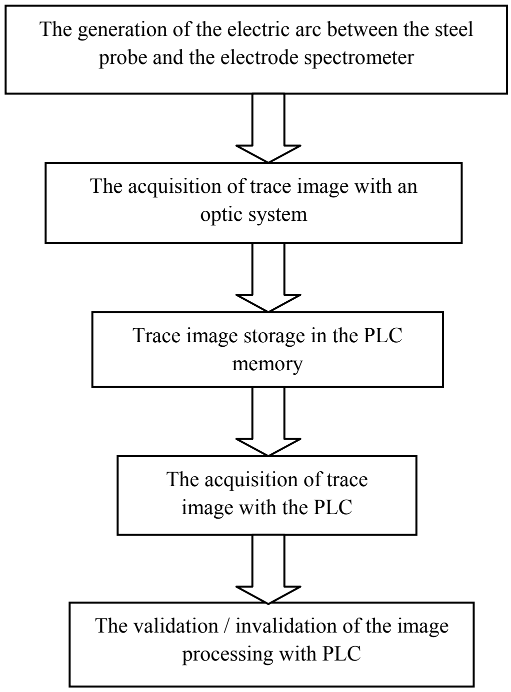

Fig. 3. The black dots detection method

This information can be obtained only through the trace image analysis[1,2]. It will not result from the spectral analysis.

For the recognition of the carbon disulphide dots (black dots of small size), a specific technique, similar to the well-known selective technique, was implemented. How does this technique works? It was calculated the sum of all the pixels intensity from the image, following the dots counting with maximum intensity (dots with much higher intensity than the average sum). If the resulted number is relatively small and the dots are situated next to each other, then the presence of a carbon disulphide dot is validated. Similar, the second major point of this paper was analyzed: images with good contrast and images with poor contrast. The images with poor contrast appear only if in the area there are some cracks in the sample probe, visually unnoticed, due to the grinding process of the surface. Before the attained electric arc between the electrode and the probe, the surface of the probe, where the trace image will appear, must be well polished. Through this process of grinding, the possible cracks which may result from the probe solidification are covered. But, when the process of the attaining electric arc is over, these cracks compromise the measurement results.

2.3 The recognition of nonviable images using the brightness and the contrast. Examples of viable images and nonviable images [15]:

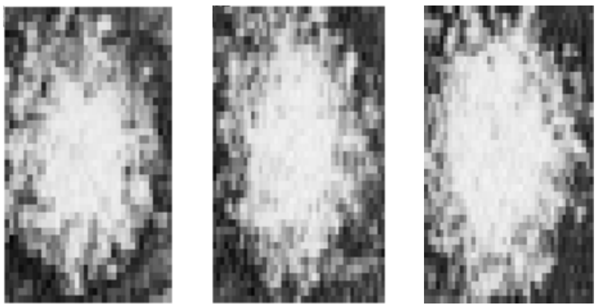

Fig. 4. Viable arc trace images

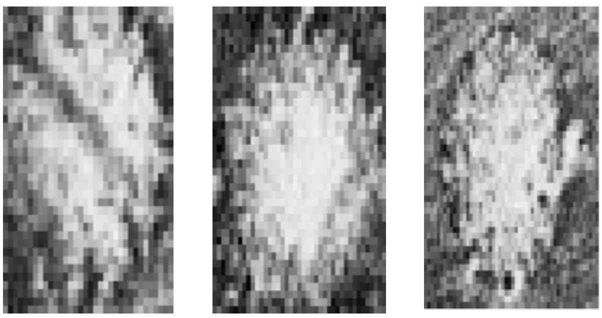

Fig. 5. Nonviable arc trace images

3. MATHEMATICAL ASPECTS

3.1 Introduction. The image processing is made using the selective main method, where the images are loaded dot by dot in the PLC. The first phase, is to calculate the average sum for all the pixels of light intensity. The second phase is to reload the image, and after that to count of the pixels which are that are above a certain value. If the counting is within a certain value range, it means that we have a carbon disulphide point.

3.2 Harris detector. Harris detector is used due to its specific pixels recognition ability. A particular property is the detection of pixels which low variations of light intensity. The detection process is made by the analyzing of the local auto-correction function properties for a general position [4]. The auto-correction function c is defined by :

$$c(x,y,\Delta x,\Delta y) = \sum_{(u,v)\in W(x,y)} w(u,v)[I(u+\Delta x, v+\Delta y) - I(u,v)]^2 \quad (1)$$

Where w(u,v), is the Gaussian nucleus

$$e^{-\frac{(u-x)^2-(v-y)^2}{2\sigma^2}} \quad (2)$$

and W(x,y) is a media of the points which are situated next to each other [3]. According the Taylor series, from the very first term up to the last one:

$$I(u+\Delta x, v+\Delta y) \quad (3)$$

$$A(x,y) = \begin{bmatrix} \sum_W w(u,v) I_x(x,y)^2 & \sum_W w(u,v) I_x(x,y) I_y(x,y) \\ \sum_W w(u,v) I_x(x,y) I_y(x,y) & \sum_W w(u,v) I_x(x,y)^2 \end{bmatrix} \quad (4)$$

$$R(A) = det(A) - k[Tr(A)]^2 \quad (5)$$

The Harris detection method has been implemented using programmable logic controller for the recognition of the dots which contains carbon disulphide.

3.3 Fuzzy aspects in image traces of carbon disulphide. A simple fuzzy selector can solve the problem of the arc trace recognition by processing a set of logic statements [11]. First, it is compared the dot from the initial loaded image with an average dot sum, obtained after the whole image was loaded. If it is smaller, it is replaced by the white color [7]. If it is bigger, it is replaced by the black color, and it is counted (one black dot was found). Also, if the nearest dot is black too, the counter increases [12]. In the image with black and white dots, it will be considered as impurities of the carbon disulphide, only the areas where the number of black dots is within a certain value range. This range is offered by the human operator experience.

4. EXPERIMENTAL RESULTS

The experimental results were taken using trace images, from some probes of ArcelorMittal Steel, Galati. The image processing was realized using the PLC DirectLogic 205. For receiving the trace images, a video camera was used, in order to transform the image in a pixels matrix with a grey tone, from white to black (for 8 bits per pixel – 256 tones). It had been used 8 numerical inputs and one numerical output, for the next character request. A more efficient technique, included into the DL205 system, is the transfer of these images through the Ethernet ports, implemented on a UC of the DL260 system (it also contains instructions for the neuro-fuzzy implementations techniques) and also through an Ethernet port embedded in the specialized module H2-ECOM.There are video cameras which can be connected directly on the internet, frequently used for surveillance systems. The image acquisition and processing doesn't have to be achieved in a very short time, because the resulted data is not used for a real time application. The most important aspect is that the final decision must be correctly, due to the data processing. Also, the necessary time for the neuro-fuzzy algorithms in order to provide results, isn't critical, as the neuro-fuzzy algorithm implementation can be made by using an adjustable number of iterations which can ensure the validation of the final result, according to the desired level of safety. Though the carbon and sulphur concentrations are correctly in the P1 , P2, ... , P9 spectral analyses cases (see table no. 1) the recognition of the small black dots, using Harris detector method, implemented using programmable logic controller, has been validated by the appearance of some fissures in the steel during the lamination process (figure no. 6).

Sample	C	Si	P	S
P1	0.025	0.004	0.005	0.015
P2	0.037	0.043	0.012	0.027
P3	0.049	0.150	0.024	0.035
P4	0.102	0.180	0.033	0.231
P5	0.195	0.190	0.051	0.412
P6	0.243	0.250	0.054	0.324
P7	0.416	0.310	0.061	0.457
P8	0.523	0.510	0.075	0.763
P9	0.862	1.912	0.093	0.934

Table no. 1 The results of the spectral analyses of the P1, P2,... P9 samples.

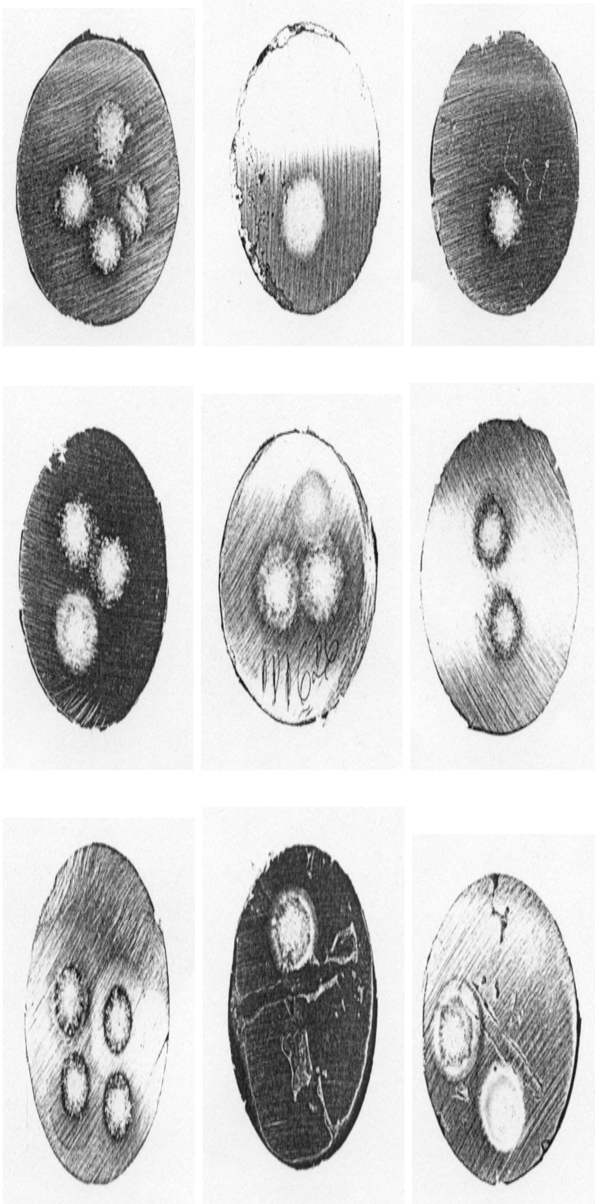

Figure no. 6 The images of the P1, P2, ... P9 samples.

5. CONCLUSIONS

The proposed objectives can be achieved, for a certain degree of image resolution, which is taken from the optic systems of the PLC memory, by using the adequate interfaces [6]. Using this method, the PLC can successfully replace the human operator, and, with correct learning algorithms, the PLC can reach, in time, more superior outcomes. The human operator job which works in a spectral laboratory, can be replaced by a PLC network, as an autonomous spectrum analyzer.[10] This system, can ensure a high precision of the final result, by executing, at the highest standard, the calibration and the testing operations. Neuro-fuzzy techniques can be implemented through modern PLC networks, with are comparable microcontroller networks. Nowadays, the speed transfer between PLC networks had increased extraordinary [13].

REFERENCES

1. Ayache,N. Lustman,F.,*"Fast and Reliable Passive Trinocular Stereovision"*. ICCV (1987).

2. Beaudet, P., R., *"Rotationally Invariant Image Operators"*, IJCPR, (1987).

3. Burlacu, A., Lazăr C., *"Visual feature tracking using Kalman filter"*, ICCSCS, Bucharest. (2009).

4. Burlacu, A Ph.D. Thesis : *"Imagine processing algorithms for object movement applications"*. (2009).

5. Canny,J.F.*"Finding Edges and Lines in Images"*. MIT(1983).

6. Charnley, D., Blissett, R. J., *"Surface Reconstruction from Outdoor Image Sequences"*. AVC88 (1988).

7. Filipescu, Adrian, I. Susnea, I. et al. *"Control of mobile platforms as robotic assistants for elderly." ASCC 7th*. IEEE,. (2009).

8. Harris, C. G. Pike, J. M,*"Positional Integration from Image Sequences"* AVC87, (1988).

9. Kitchen, L., Rosenfeld, A., *"Grey-level Corner Detection"*. PRL (1982).

10. Sargur, S.,*"High-Performance Reading Machines"*. Pr.IEEEvol80 (1992).

11. Susnea, I., Vasiliu, G., Filipescu, A.,*"Real-Time, Embedded Fuzzy Control of the Pioneer 3-DX Robot for Path Following"*. WSEAS. (2008).

12. Susnea, I., Vasiliu, G., et al.*"Virtual pheromones for real-time control of autonomous mobile robots"*. S.I.C., Bucarest,. (2009).

13. Susnea, I. *"Distributed Neural Networks Microcontroller Implementation and Applications"*, S.I.C., Bucarest, (2012)

14. Vasiliu, G. *Ph.D. Thesis :* "Research on increasing the precision of multichannel measurement systems, with aplications in electrical and electronics engineering*"*. (2005).

15. Vasiliu, G., Susnea, I. "*Computerised systems of measurement*". Bucarest, Matrix Rom, (2009).