An Effective Method for Defect Detection of Copper Coated Iron Wire Based on Machine Vision

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An Effective Method for Defect Detection of Copper Coated Iron Wire Based on Machine Vision

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Abstract. In this study, a defect detection system based on machine vision is established to distinguish the defective copper coated iron wires during electroplating. By collecting the real-time images in the production line using a CCD industrial color camera, this system could effectively identify different colors and connect the same pixel region based on Halcon. Also, image segmentation is applied to eliminating the interference of the bearings placed around the wires. Then, the division procedure is completed and the defective area is classified. This defect detection system could efficiently improve the level of automation during industrial production.

1. Introduction

Due to characteristics of good electrical conductivity and strong corrosion resistance, copper plays a significant role in the development of society. It's widely used in the power sector. However, considering the high price of copper, the copper wires are substituted by copper coated iron wires. During the process of electroplating, cupric ion concentration is essential to the quality of copper wire. If there is less and less cupric ion in the solution, it would affect the quality of copper wire. The copper wire would not only have insufficient thickness but also have numerous defects. It would greatly reduce copper wires' electrical conductivity and corrosion resistance. Therefore, it is important to distinguish the defects of the copper wires from high quality products.

Traditionally, artificial detection is the primary method for defects detecting, which mainly relays on human vision. Considering the high speed during wire production in the industry and the human eye fatigue in the long time of work, human vision is unreliable to a large extent. Besides, the accuracy of detection and recognition rate would gradually decrease, which indicates the unreliability of the artificial detection. Also, due to the different hold standards of different people, numerous flawed copper wires have been omitted, resulting in the low quality of overall copper wires. With the rapidly increasing demand for high quality copper coated iron wire, the traditional methods are unable to meet the precise and rapid requirements. Thus, new method is urgent for defect detecting with high precise and high speed. Among many new methods, machine vision[1-3] has already been successfully applied in many circumstances of defect detecting with high accuracy, fast speed and high automation.

In order to solve this problem, we establish a defect detection system based on machine vision to distinguish to the defective copper coated iron wires during electroplating in this study. By using a CCD industrial color camera, the real-time images in the production line are collected. According to

the calculated HSI values, a threshold is set to distinguish the defective and nondefective products based on Halcon [4-6]. Also, image segmentation is applied to eliminating the interference of the bearings placed around the wires. Then, the division procedure is completed and the defective area is classified. This defect detection system could efficiently improve the level of automation for real-time monitoring during industrial production.

2. Design of Image Processing Algorithm

Fig. 1 shows the procedure of the defective copper coated iron wires. Firstly, the original image is decomposed, through which the RGB parameters are obtained. In order to minimize the influence of environmental brightness, the RGB parameters are converted into HSI color space. According to the obtained HSI values, the saturation segmentation image from the hue diagram is subtracted and Identify different colors are identified. If the copper is highly qualified, the Hue values of the images must range between the set threshold. Otherwise, the defective area would have different Hue values during the process of detection. Finally, the same pixel area is connected, according to which the region is selected. After that, the division is completed and the wire area is calculated. The key component of the detection system is a CCD industrial color camera with 2048×1536 pixels at a frame rate of 12 fps, which is perfect for moving object inspection, low-light and in high-speed automation with very short exposure times.

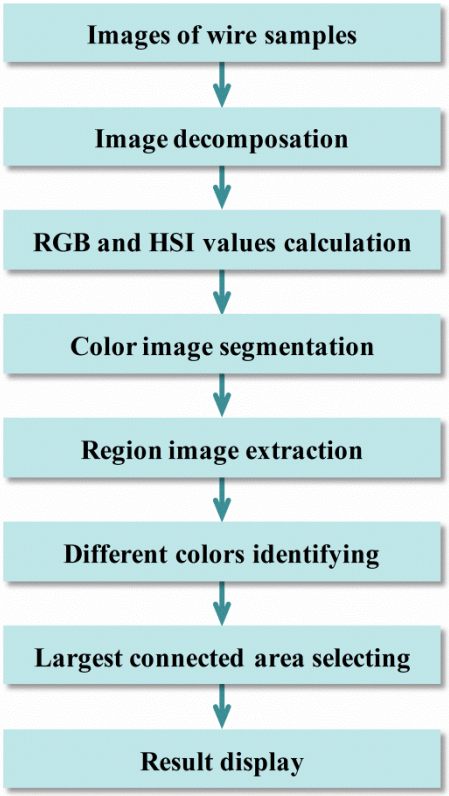

Figure 1. The procedure of defective cooper wires detection.

3. Results and discussion

Fig. 2 shows the nondefective and defective copper coated iron wires. It is obvious that the feature of nondefective copper coated iron wire is quite different from that of the defective one. The nondefective wire is colored with yellow and the defective one is colored with grey. It is especially easy for human to distinguish these two kinds of products by color.

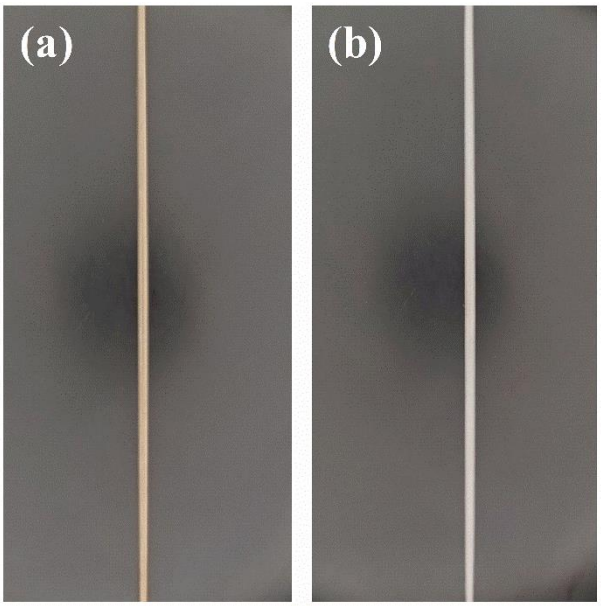

Figure 2.(a) The nondefective and (b) defective copper coated iron wires

In order to set a reasonable threshold to distinguish the high quality from defective copper wires, the values of hue and saturation are calculated for the nondefective and defective wires, as presented in Fig. 3. According to Fig. 3, it is observed that the distributions of Hue and Saturation parameters are quite different. A large quantity of products are clustered and only a small amounts of them are far away from the cluster, which indicates that we can ignore the effects of these small amounts. Also, the Saturation values of defective copper wires generally ranges from 3 to 14, while it varies from 0 to 90 for the nondefective one. As for the values of Saturation, it varies from 3 to 40 for defective copper coated iron wires, while it ranges from 15 to 31 for the nondefective one. Therefore, the threshold is initially set around 15.

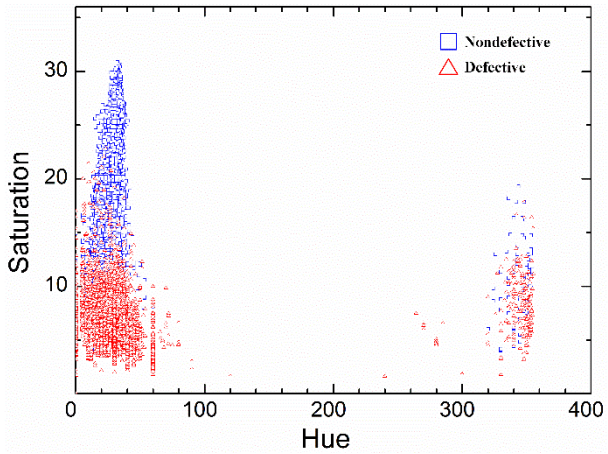

Figure 3. The calculated HS parameters of the nondefective and defective wires

During actual production process in factory, the iron wires are moved from the plating pool at high speed, which would cause severe vibrations and potential risks. In order to reduce vibrations and avoid danger, bearings are usually placed next to the wires. However, to some extent, the presence of bearings would affect the detection of defects. Therefore, the bearing interference should be eliminated. The placement of bearings beside a nondefective and defective wire is shown in Fig. 4 (a) and 4(b), respectively.

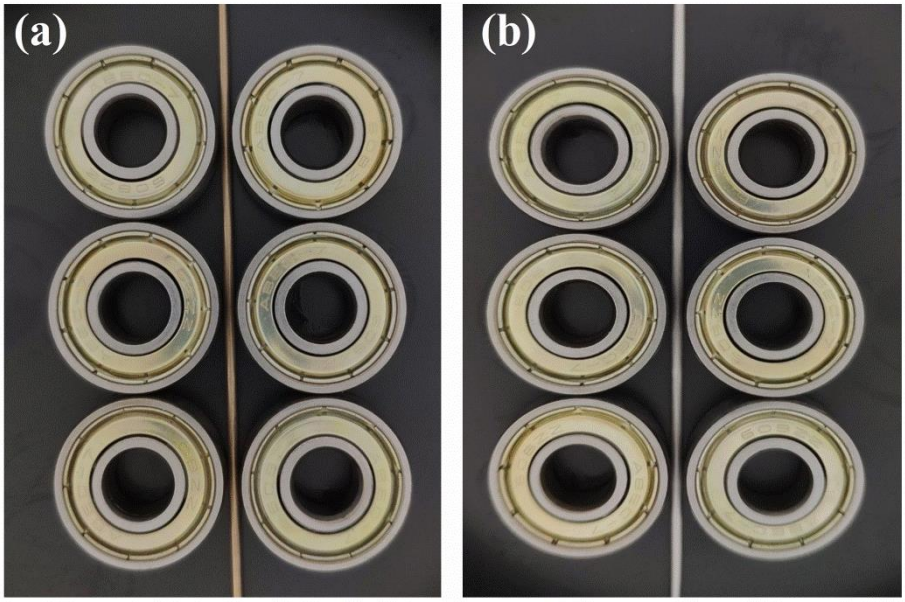

Figure 4. The nondefective and defective copper coated iron wires with bearings around

In order to separate the area the bearing and wire located, the image is segmented according to the Saturation set threshold. The presence of bearing pixels still causes interference at this point, which would result in substantial statistical errors. Then, the Hue value is subtracted from the original image to weaken the influence of the interference. After dividing the picture by the Hue value and connecting the same pixel area, the Hue value of the bearing only brings a small amount of interference points. Finally, the maximum connected area is extracted to minimize the influence of the bearing and the wire area is separated. After that, the division is completed and the wire area is calculated.

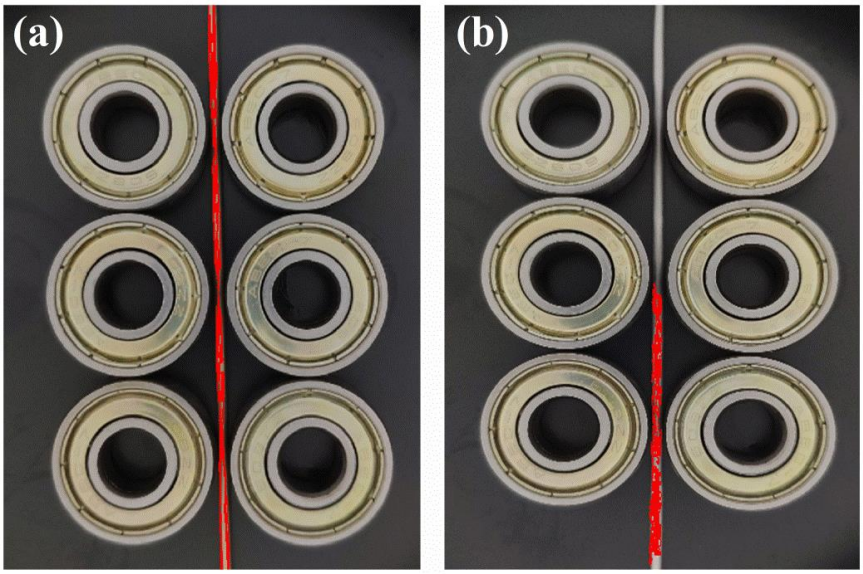

Figure 5. Identification results of (a) nondefective and (b) defective wires, respectively

Fig. 5 displays the detection results of the nondefective and defective wires, respectively. It is found that the difference between nondefective and defective wires could be clearly recognized. The number of red dots distinguished by the defective wire is very small, while it is fully covered by red dots for the nonfective one. According to the number of the red dots, the threshold could be set to determine the defective product. Based on machine vision, the defects could be quickly identified during the plating process. A device could be set to give feedback in time when detected defects

achieve a certain number. Therefore, the copper ions could be added to the plating solution in time to achieve real-time monitoring, which could avoid the problem of uneven plating.

4. Conclusion

In this paper, we proposed an effective method to identify defects based on machine vision during the process of wire electroplating. The real-time images in the production line are collected by using a CCD industrial color camera. According to the calculated HSI values, a threshold is set to distinguish the defective and nondefective products. Also, in order to eliminate the interference of the bearings placed around the wires, the image segmentation is applied. Then, the defective area is classified. By using this system, the real-time monitoring is realized, which could provide technical support for the actual production line to improve the quality of the products.

Acknowledgments

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