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Development of Automated Spark Testing Technique by Image Processing to Measure Carbon Content in Steel Materials

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Abstract: The spark testing is a method to determine the classification of the steel materials from the characteristics of sparks emitted by the grinding wheel. This spark testing is used because it is quick, easy and inexpensive. And it especially could determine carbon content in an instant. However, the mastering of this spark testing is very difficult, unstable and there is individual difference to identify the steel materials. So, strict management of the steel materials was expected by realization of automated spark testing technique which has no individual difference and high stability to confirm process. The automated spark testing technique which we developed for determining the carbon content was consisted of automatic grinder, high speed camera of per second 200 images and high speed image processing computer. Result showed that the carbon content measurement accuracy is about ±0.05% in carbon steel. This would mean that this automated spark testing technique is very precise, and has potential for practical use. Therefore, strict management of the steel materials could be realized by this automated spark testing technique.

Keywords: spark testing, image processing, carbon content

1. INTRODUCTION

In the quality check process of steel materials, spark testing is a simple and effective inspection method to determine the classification of the steel materials. The spark testing is used because it is quick, easy and inexpensive. It determines the classification of the steel materials by sparks emitted by the grinding wheel which has high stability at any time. The important spark characteristics are color, volume, nature spark, and length. However, the main disadvantages of this spark testing are that it is very difficult to master, unstable, and there is individual difference. In order to acquire clear and suitable images of sparks emitting at high speed, the high speed camera was adopted. The automated spark testing technique machine is consisted of an automatic grinder pushed stably, a high speed camera of per second 200 images, and a high-speed imaging processing computer. This automated spark testing technique could measure the carbon content in the carbon steel with a good accuracy of ±0.05%.

Fig.1. Photograph of hand spark testing

Fig.2. Photograph of explosion sparks by hand spark testing

2. DESCRIPTION OF AUTOMATED SPARK TESTING

Fig.3 shows the view of automated spark testing machine. In order to acquire clear images of sparks emitting at high speed, the high speed camera of per second 200 images is adopted. Further, for cutting materials stably and reducing a cutting damage into the minimum, the air cylinder of low friction to grinding wheel is adopted and the power of pushing grinding wheel is about 400 g. With this equipment composition, the images of 200 flames are captured in between 1 second, and the explosion sparks by the carbon included in carbon steel, and carbon content are calculated by imaging processing computer in about 10 seconds.

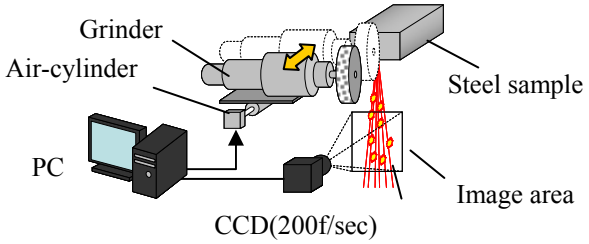
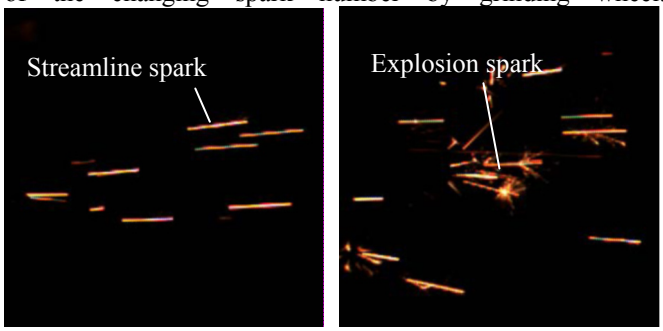


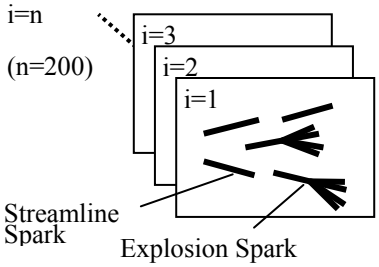
Fig.3. Schematic view of automated spark testing

3. MEASUREMENT PRINCIPLE

Carbon content was determined by volume of explosion sparks which increased by included carbon in steel materials. Fig.4 shows the spark patterns by carbon steel. So, the grinding wheel by air cylinder must have stabilized cutting condition. However, cutting condition by grinding wheel is still unstable, and it is difficult to control the number of the sparks which changes at any time. Then, this automated spark testing technique detects the explosion sparks, and streamline sparks in all captured images, and calculates the number of all sparks in these images. Now, we proposed the explosion sparks ratio shown in Fig.5. The explosion spark ratio is defined as percentage of the explosion spark number to the all spark number, and carbon content can be calculated from this explosion spark ratio. Therefore, there is little influence of the changing spark number by grinding wheel.



(a)Streamline spark (b)Explosion spark



A_i:Number of All Spark / flame

B_i:Number of Explosion Spark / flame

n :Number of flame

$$\text{Explosion Spark Ratio (\%)} = \frac{\sum_{i=1}^{i=n(200)} B_i}{\sum_{i=1}^{i=n(200)} A_i} \times 100$$

Fig.5. Introduction of the explosion spark ratio

4. RESULTS

This time, we evaluate the carbon content measurement accuracy by this development technique for carbon steel sample included 0.1% to 0.44% carbon content. Fig.5 shows the carbon content measurement result for carbon steels. It is seen that the measured explosion spark ratio has a good correlation between carbon contents range 0.1% to 0.44%, and that carbon content measurement accuracy is about ±0.05%. But it was the result of small pipe samples in the laboratory, so it is necessary to measure real pipe materials in the future. This automated spark testing technique is effective to confirm the process. This technique has the potential for practical use in the future.

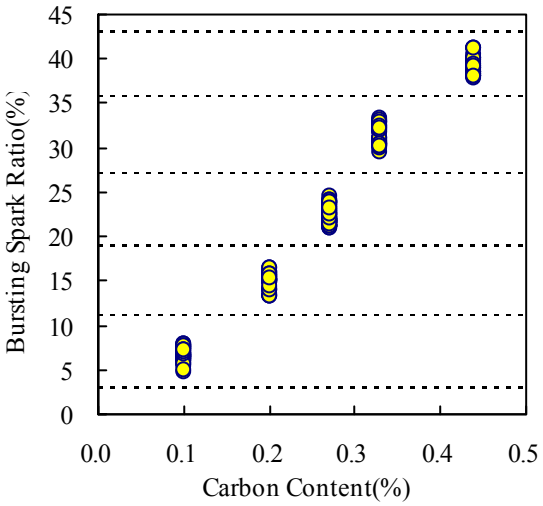


Fig.6. Comparison result with carbon content and explosion spark ratio

5. CONCLUSION

For strict management of the steel materials and realizing the stable spark testing, we developed automated spark testing technique with imaging processing. It was consisted of high speed camera of per second 200 images, the air cylinder of low friction to a grinding wheel, and high speed imaging processer. It calculated the number of explosion sparks and that of streamline sparks in all images within 1second, and calculated the explosion spark ratio and carbon content in about 10 seconds. This method of measurement carbon content by the explosion spark ratio has a good correlation between carbon content, and that carbon content measurement accuracy is about ±0.05%.This would mean that this automated spark testing technique is very precise, and it has potential for practical use, and would be able to effective in strict quality measurement of the steel materials. From now on, we would raise the carbon content measurement accuracy more, and consider this application to real pipe material and to alloy steels.

REFERENCE

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