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The state of the sprayed paint measuring system: through monitoring the spray cone profile

Joon-Kil Kim*, Sang-Whee Kim, Sang-Ki Chi***, and Young-Jun Park****

*Department of Manufacturing & Measurement Research, Mechatronics center, Samsung Heavy Industries, Yuseong-Gu, Daejeon, Korea (Tel: 82-42-865-4784; Fax: 82-55-630-7673; E-mail: joonkil.kim@samsung.com)
**Department of Robot System Research, Mechatronics center, Samsung Heavy Industries, Yuseong-Gu, Daejeon, Korea (Tel: 82-42-865-4674; Fax: 82-55-630-7673; E-mail: sangwhee.kim@samsung.com, pyjcruiser.park@samsung.com)
***Department of Coating Research, Samsung Heavy Industries, 530, Jangpyung-ri, shinhyun-up, Geoje, Korea (Tel: 82-55-630-8175; Fax:82-55-630-5139; E-mail: sanggi.ji@samsung.com)

Abstract: The automation of painting process in shipbuilding is arisen as vital issue because of the insufficiency of painting workers and frequent quality claims. The increase of the painting quality is the main achievement made by the automation of the painting process. In order to maintain the good painting quality, even though the spray depth, angle and velocity are considered principally, measuring the state of the sprayed paint is as important as above parameters. In this paper, the system which measures the state of the sprayed paint through monitoring the spray profile to use the laser diode and vision sensor is proposed for the increase of the painting quality. To apply this system at the preparation of the painting, we expect to not only increase of the accuracy of the thickness but also calculate the adjustment amount of CPS data if the measuring results do not equal to the predetermined spray profile.

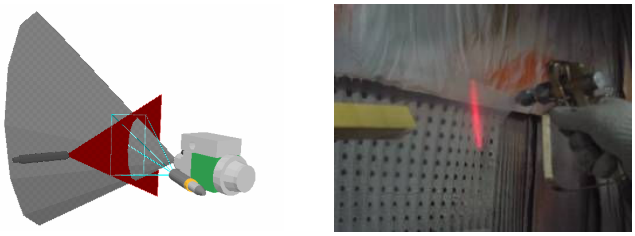
1. INTRODUCTION

The painting process is two of the most important parts in shipbuilding together with the welding process. Currently, the painting process is facing with difficulties of insufficiency of painting workers and frequent quality claims. In order to solve these problems, the automation of the painting process is an inevitable solution. For the automation, increasing the accuracy of painting thickness is an important factor. However, it is rather difficult to control the painting thickness because there are too many factors affecting the painting thickness. There are two main factors affecting the painting thickness which are external and internal parameters. The external parameters are the spray depth, the painting speed and the spray angle to the substrate area. The internal parameters are the pump pressure, the temperatures of the paint and substrate, the viscosity, the thinning ratio of the paint, the SVR, the class and abrasion of the nozzle tip, the length of hose, which are affected with the spraying state of the paints. To control these various parameters, the CPS (Coating Procedure Standard) is used. The CPS is the database indicating the recommended pump pressure on the basis of the internal parameters. However, this pump pressure does not guarantee the exact degree of atomization nor the profile of the spray paint, because there are many internal parameters which are difficult to measure and control such as the variance of each pump performance and so forth. Therefore, new measurement system is needed in order to correct the CPS which determines the painting quality.

In this paper, we propose the system which measures the state of the sprayed paint through monitoring the spray cone profile at the preparation. The Spray cone profile is cross section view of the spray with perpendicular to direction of the spray gun. By applying the proposed system, the spray profile which is set on the basis of CPS is obtained. This system minimizes the influences of the uncertainties of the internal parameters and makes it convenient to set the initial set up.

2. SYSTEM CONFIGURATION

The system which is proposed in this paper measures the slit laser beam on the sprayed particles through the vision sensor. This system is fast, easy and do not require any test samples for the wet film thickness measurement. Moreover, if the experimental results are different from the predetermined spray profile, it may calculate the adjustment amount of CPS data.



(a) Virtual system configuration (b) Actual system configuration

Fig. 1 System Configuration

Fig. 1(a) shows a schematic diagram of the proposed system. The slit laser is positioned orthogonal to the direction of the

spray and the vision sensor is used to monitor the laser reflected image at the position close to the spray gun. It is important to determine the distance between the spray gun and the position where the slit laser is being projected. In case the distance is too far, near to painted surface, the images observed by the vision sensor are affected by the paint particles. In opposite case, the reflected image is not shaped properly lacking the distinctiveness. The experimental result showed the optimum distance is about 10~15cm from the tip of the spray gun.

3. IMAGE PROCESSING AND ANALYSIS

The images that are captured by vision sensor go through the image processing consisted of 5 steps as shown in Fig. 2.

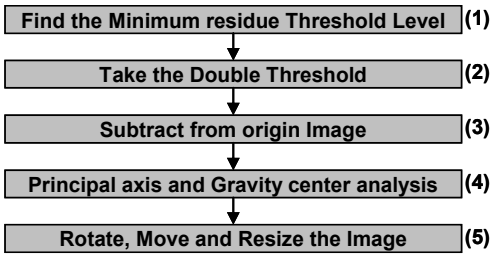
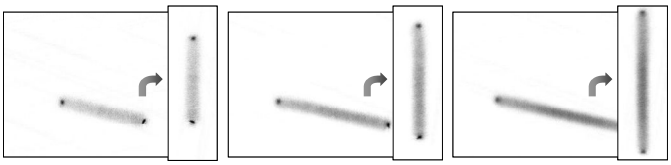


Fig. 2 Step of Image Processing

Here, the image processing step is briefly described. The optimal threshold level is chosen from the image histogram to use minimum residue method (1). The pixel values below threshold level are set equal to the threshold level and the others are set zero (2). The processed images are subtracted from origin image. Then the interest object indicated spray is obtained (3). The principal axis and gravity center are calculated on the interest object (4). The object is moved and rotated to position it to the centre of image (5). Fig. 3 shows the origin and the processed images.



(a) 2.5bar (b) 3.5bar (c) 5.5bar

Fig. 3. Spray Image (Used Tip number: 527)

Those are spray profile images with varying the pump pressures under the same conditions. The proper pressure is commonly set up about 3.5~4 bar for the auto spray gun. Former Fig. 3(a) is low pressure and later Fig. 3(b) is high pressure.

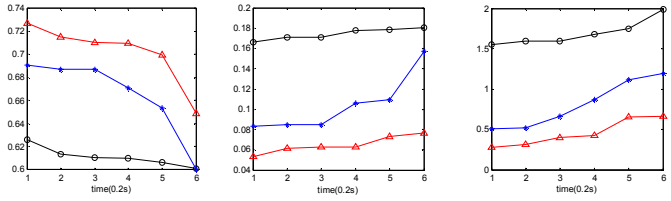
In order to analyze the characteristic of the spray profile from the images captured under the different pressure, two factors are considered, the shape and intensity of the spray cone profile. First, the shape of the spray cone profile is analyzed following features, Area of interest object, Limit width and height, σ_{XX} and σ_{YY} (centered moment of inertia on the principal and secondary inertial axis).

P	Area	Width	Height	σ_{XX}	σ_{YY}
2.5	10521	52.3	318	7420	115.3
3.5	13443	49.5	393	11570	111.6
5.5	16004	46.1	487	17429	98.8

Table. 1 Analysis of the shape of the spray cone profile

The shape indicates the degrees of atomization. Table. 1 is shown as the results of analysis of the shapes. The results are average value calculated on the six images of each pressure.

Next, the intensity of the spray cone profile is analyzed. The intensity indicates the density of the sprayed particles. The pressure of the spray may be altered even though pressure was initially set fixed value, because the spray which uses the pump has a regular pulse beat. Accordingly, we analyze the images which are captured along the pulse beat cycle. Fig. 4(a) shows the mean of intensity of pixel in the interest object. The variance of intensity of pixel calculated across the image. The mean and the variance of the variance data are shown in Fig. 4(b) and Fig. 4(c). The variance of variances is described the variance of vertical direction of spray profile.



(a) mean of intensity (b) mean of variances (c) variance of variances

Fig. 4 Analysis of the intensity of the spray cone profile (5.5bar: triangle, 3.5bar: star, 2.5bar: circle)

From the results, it has been concluded that the pump pressure is higher as the intensity is higher and the variances are smaller. And finer atomization is made as the size, width and σ_{XX} are larger and height and σ_{YY} is smaller. The experiment proved that sufficient information can be obtained by observing the spray cone profile to measure the pump settings and check the degree of the atomization.

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