Evaluation of the Reflection Properties of Embroidery Yarn by Graphic Image Analysis

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Abstract

The gloss of embroidery yarns is very important as it affects how finished embroidered designs look. In the past, the gloss of embroidery yarns was studied by obtaining a light reflection distribution pattern with a goniophotometer. In the present study, however, an attempt is made to examine the luminance distribution pattern with a graphic image analyzing system (SPICCA-II made by Nippon Avionics Co., Ltd.). Using four kinds of samples, white cotton, black cotton, white rayon and black rayon embroidery yarns, measurements are taken by setting two different angles of incidence and receiving: 45° - 45° and 45° - 0°. In addition, the incident light beam is irradiated in parallel and perpendicular to each sample, and the graphic images are evaluated by an image analyzing system.

The results obtained are as follows:

1. The use of an graphic image analyzing system makes it possible to:
   (a) observe high luminance points on the surface of the yarn;
   (b) evaluate the yarn's gloss in terms of its average luminance level based on the number of pixels at each level of luminance.

2. A comparison of the 45° - contrast gloss revealed that:
   (a) a higher level of gloss is measured for both the white and black yarns when the sample is placed parallel to the incidence light beam rather than perpendicular to it;
   (b) rayon yarn is glossier than cotton yarn;
   (c) black yarn is glossier than white yarn.

3. The relationship between the 45° - contrast gloss obtained by the graphic image analyzing system and by the goniophotometer show a high coefficient of rank correlation.

1. Introduction

The gloss of embroidery yarns is very important as it affects how finished embroidered designs look. In the past, the gloss of embroidery yarns was studied by obtaining a light reflection distribution pattern with a goniophotometer (GP-IR made by Murakami Color Laboratory). In the present study, however, an attempt was made to examine the luminance distribution pattern with a color image processor (SPICCA-II made by Nippon Avionics Co., Ltd.) in order to obtain more information concerning the gloss.

Although a wide range of studies on fibers and paper using a graphic image analyzer have been conducted in the past [1][11], no reports have been made on evaluating the gloss by graphic image analysis. Therefore, in the present study, four kinds of samples, white cotton, black cotton, white rayon and black rayon embroidery yarns were used and measurements were taken by setting two different angles of incidence and receiving: 45° - 45° and 45° - 0°. In addition, the incident light beam was irradiated at a parallel and perpendicular angle to each sample.

2. Sample

Four samples were used in the test. Black and white cotton yarns, widely used at present in European style embroidery, and black and white rayon yarns, widely used in embroidery by sewing machines. Details of the sample are given in Table 1.

The lateral side and cross section of the sample yarns were examined using a scanning electron microscope (35CF made by JEOL Co., Ltd.) and optical microscope (BH-2 made by Olympus Optical Co., Ltd.).

This examination revealed that the cotton yarns were finished with mercerizing and from their fiber length, they were also found to be combed yarns.

The examination of the fiber surface and cross section of the rayon yarn revealed that it was regular type rayon fiber and that the yarn was composed of a small number of single filament yarns since the single filament yarns were comparatively thick. Furthermore, an examination of the lateral side revealed that it was filament yarn without any fuzz.

The colors of the yarns were measured by using a multi-light source spectro-colorimeter (MSC-1S-2B made by Suga Test Instrument Co., Ltd.).

In preparing the samples, the four yarns were wound up evenly in one direction and densely around a white 5cm × 5cm FRP board by using a winder.

3. Testing Method

3.1 Outline of the graphic image analyzing system
A schematic diagram of the graphic image analyzing system used in the test (made by Nippon Avionics Co., Ltd.) is shown in Fig. 1. The samples were irradiated by a light source (flood light PRF-150W·100V with two light bulbs made by Panasonic Corp.) set up next to the camera stand and a CCD color camera (KY-F30-CCD made by Victor Company of Japan, Ltd.) was used to transmit the graphic image onto a monitor display. This graphic image was then analyzed using a color image processor (SPICCA - II made by Nippon Avionics Co., Ltd.) and a computer (PC-9801FX made by NEC Corp.) and the result was finally output onto Polaroid film by a film recorder (FR-1100 made by Nippon Avionics Co., Ltd.). During the test, the lens opening was adjusted to a position halfway between 8 and 11 so that the entire surface of the sample would be in focus when the sample was tilted at an angle of 45°. The test was also conducted inside a dark room to prevent interference by outer environmental lighting.

We know from the spectral distribution characteristics that the lamp used as the light source has characteristics similar to those of A-illuminant in the visible region.

3.2 Spectral sensitivity characteristics the CCD color camera

Figure 2 shows the spectral responsibility of red, green and blue of the CCD color camera. In the present study, the luminous intensity was measured by using green, which is close to the luminosity curve, since the colors of the samples were the achromatic colors, black and white.

3.3 Conditions of image input

The graphic image was analyzed for 512×480 pixels and 256 steps in gradient. The schematic diagram of the light source, samples and CCD color camera is shown in Fig. 3. The sample stand was placed directly under the CCD color camera and the samples were set up so that the yarns were either parallel to or perpendicular to the incidence light beam. In each case, the angles of incidence (direction of light source) and receiving (direction of CCD color camera) were adjusted to 45° - 45° and 45° - 0°. When the sample was horizontally laid, the graphic image for an area of 1 cm² was taken by the color image processor. The intensity of light on the sample surface was 1,200 lx.

4. Results and Discussion

4.1 Properties of the sample surface as taken by the image analyzing system

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Fig. 4 shows an example of a Polaroid picture of the graphic image of the yarn surface which was taken by the color image processor and output by the film recorder. From this photograph, the twists on the yarn surface appear as the high luminance points and the properties of the sample surface can be observed. Compared with the conventional method by using the goniophotometer, the unique feature of using a graphic image analyzing system is that the sample surface itself can be studied.

4.2 Interpretation of data by graphic image analyzing system

Fig. 5 shows an example of a histogram made from the measurement results of the luminance distribution of the 1 cm² area of the sample, whose graphic image was taken by the graphic image analyzer.

The vertical axis represents the luminance level from 0 to 255. The upper horizontal axis represents the number of pixels and the lower horizontal axis represent the number of pixels converted into terms of percentage. In addition, the basic statistics (Average (AVR), Maximum (Upper), Minimum (Lower), Range, Variance (VAR), Standard Deviation (S.D.), Standard Error (S.E.), Coefficient of Variance (C.V.)) of the luminance level are displayed on the right side of the histogram.

The fact that the average luminance level is close to 0 indicates that the luminance level is low, and that it becomes higher near the value of level 255. Also, it seems that the gloss can be evaluated not only by the average luminance level but also by the value of the standard deviation and maximum number of pixels (the value at the upper right hand corner of Fig. 5).

4.3 Evaluation of 45° contrast gloss

In order to determine if the graphic image analyzing system can be applied to measure the 45° contrast gloss, a standard surface of relative-specular glossiness (to be called "specular glossiness plate" henceforth) and a Mg surface (having a surface with nearly perfect diffusion (to be called "standard diffusion plate" henceforth), were measured for the two angles of incidence and receiving, 45°-45° and 45°-0°. The results are shown in Fig. 6. The upper column shows the measurement results for the specular glossiness plate for incidence and receiving angles 45°-45° (specular reflection) and 45°-0° (diffused reflection) and the lower column shows...
similar measurements for the standard diffusion plate. The 45° contrast gloss can be calculated by the following equation:

\[
\text{Contrast gloss} = \frac{\text{Luminance of specular reflection (Luminance for } 45° \text{ - } 45° \text{)}}{\text{Luminance of diffused reflection (Luminance for } 45° \text{ - } 0° \text{)}}
\]

Fourt et al. have reported that there is a proportional relationship between the 45° contrast gloss and the gloss by eyesight, although the range is narrow. With the specular glossiness plate, the average luminance level is a high 233.0 for 45° - 45° and a low 21.87 for 45° - 0°. As a result, the 45° - contrast gloss is a high value of 10.65 (233.0/21.87=10.65).

With the standard diffusion plate, the average luminance level is 166.52 for 45° - 45° and 155.25 for 45° - 0°. As a result, the 45° - contrast gloss is a low value of 1.07 (166.52/155.25=1.07).

In other words, the specular glossiness plate has a high 45° - contrast gloss and the standard diffusion plate has a low 45° - contrast gloss.

4.4 Analysis result of the luminance distribution and evaluation of the 45° - contrast gloss of the sample yarns

Fig.7(a) and Fig.7(b) show the 45° - contrast gloss obtained from the results of the graphic image analysis and the average luminance levels of the white and black sample yarns. The meaning of the title above each diagram is explained by the following example; "1 Rayon, white, 45° - 45°, parallel" (Fig.7(a) upper left) indicates that the white rayon yarn sample was placed with the yarn parallel to the incidence light beam and that the angles of incidence and receiving were 45° - 45°.

An examination of Fig.7(a) and 7(b) shows that for both the white and black yarns, when the sample is set up with the yarn parallel to the incidence light beam, the peak of the luminance level shifts to a lower position and the average luminance level becomes lower when the angles of incidence and receiving are changed from 45° - 45° to 45° - 0°. On the other hand, when the angles of incidence and receiving are 45° - 45°, the average luminance level becomes higher for both the white and black yarns when the sample is placed with the yarns perpendicular to the incidence light beam rather than parallel to it. However, when the angles of incidence and receiving are 45° - 0°, the average luminance level is lower when the yarns are parallel rather than perpendicular to the incidence light beam.

Taking a look at the value of the 45° - contrast gloss shown in the central part of Fig.7(a) and 7(b), it can be seen that when the yarns are parallel to the incidence light beam, black rayon yarn has the highest value, then white rayon, then black cotton, then white cotton in that order. Also, the 45° - contrast gloss is higher when the yarns are parallel rather than perpendicular to the incidence light beam.

4.5 Comparison of the 45° - contrast gloss obtained by the graphic image analyzing system and by the goniophotometer

Table 2 shows the 45° - contrast gloss obtained by the graphic image analyzing system (from Fig.7(a) and 7(b)) and by the goniophotometer (GP-IR made by Murakami Color Laboratory).

A high coefficient of rank correlation, r=0.929, has been obtained between the 45° - contrast gloss measured by the
Fig. 7(a) Measurements of white yarns
Fig. 7(b) Measurements of black yarns
5. Conclusions

The summary of the results obtained in this study are as follows:

(1) The use of a graphic image analyzing system made it possible to:
   (a) observe high luminance points on the surface of the yarn;
   (b) calculate the 45°-contrast gloss in terms of the average luminance level obtained by expressing the luminance numerically based on the number of pixels at each level of luminance.

(2) A comparison of 45°-contrast gloss revealed:
   (a) a higher level of gloss was measured for both the white and black yarns when the sample was placed parallel to the incidence light beam rather than perpendicular to it;
   (b) rayon yarns were glossier than cotton yarns;
   (c) black yarns were glossier than white yarns.

(3) The relationship between the 45°-contrast gloss obtained by the graphic image analyzing system and by the goniophotometer showed a high coefficient of rank correlation.

In the future, we plan to conduct quantitative and qualitative analyses of the gloss of various products by using the graphic image analyzing computer system.

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References

[16] ibid, p.41