APPLICATION OF THE NEUGEBAUER COLOUR PREDICTION MODEL TO THE CERAMIC SECTOR

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ABSTRACT

The present paper sets out an experimental methodology for the analysis of the degree of application of the Neugebauer Prediction Model to the ceramic sector.

1. INTRODUCTION

The first Models for the colour prediction of a surface printed with half tones, from the ink used as well as from the substrate printed, were developed more than 80 years ago. We refer to the well-known Models of Murray-Davies [1], Neugebauer [2], or Yule-Nielsen [3]. These led to others known as "First Principals", which focus in the study of light propagation processes and phenomena such as Physical and Optical Dot Gain [4]. All of these have been till now been applied to paper. In this communication, the degree of application of the Neugebauer Model on glazed and engobed fired tile bodies, printed by means of an inkjet system, has been analyzed.

2. EXPERIMENTAL DEVELOPMENT

We generated digital files of images of 3x3 cm rectangles of the different possible printings of a single colour, binary colour, and three colour prints of the primary CMY (Cyan, Magenta, Yellow) on a white background, with different mesh angulations, with a resolution of 180 dpi and ruling of 60 lpi. The images corresponded to a printing surface of 20x30 cm. Elliptical dot geometry was chosen.

In the printings of a single colour and in the binary ones, two rows of rectangles were generated, one in increasing order and the other in decreasing order of the occupation percentage (10% variation from rectangle to rectangle). In the ternary print, two of the three primary colours remained fixed at 20%, whereas the third varied from 20 to 40%. These digital files were used to print with the inkjet system. The samples were printed with 180 dpi resolution, and ruling of 60 lpi. After the pieces had been printed, they were fired in a double-firing cycle in a laboratory kiln at a peak temperature of 1070°C.

2.1. IMAGE ACQUISITION PROCEDURE

A CCD digital colour camera and a system of 4 "daylight" fluorescent lamps each of 36W, with a frequency of approx. 40 KHz and colour temperature of 5400 K, were used. These lamps were arranged in two sets, placed symmetrically in respect of the vertical axis through two axes forming the same angle in relation to this vertical. The camera was held in a vertical position on a metallic arm. A 70X type optical zoom was coupled to the camera, which allowed acquiring images of 5.5x7.5 mm at a distance of 40 cm from the base to the holding axis.

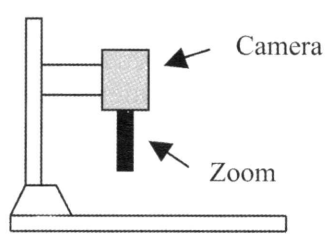

Figure 1. Schematic illustration of the image acquisition assembly

Four images were acquired for each rectangle printed on every tile, each consisting of these rectangles in a certain printed occupation percentage of one or more colours.

2.2. APPLICATION OF PREDICTION MODELS TO THE SAMPLE TILES

The Model whose behaviour we analyzed was the Neugebauer model. The resulting spectral reflectance curve is the linear combination of the spectral reflectance curves of each of the primary colours, when these have been printed with 100% occupation. The "weights" of this combination would be the fractions of one of relative area occupied by each printed dot. In order to determine the relative areas, two procedures were used: 1) Manual segmentation of the image, counting the number of pixels that belong to these printed dots. 2) The second consisted of 2 image processing methodologies to obtain this information in an automatic way, Fuzzy c-Means [5], and a small variant of this algorithm that enabled its initialization [6].

3. RESULTS

From the results obtained on applying the Neugebauer Model, we may highlight:

1. In general, the Model has errors that increase as the occupation percentage of each / some of the primary colours used rises.

2. The colour differences $\Delta E_{L^*a^*b^*}$ between the result of the manual segmentation and that obtained by [8] and [9] vary between 0.7 (for the Yellow Sample at 30%) and 15.63 (for the Sample of Cyan at 20% and Yellow at 70%).

4. CONCLUSIONS

Analysis of points 1 and 2 of section 3 allows drawing the following conclusions:

1. The fact that the error increases when the percentage of printed dot occupied area rises may be due to non-linear light propagation phenomena acquiring importance. These phenomena cannot be studied with the proposed Linear Model, but can be analyzed by non-linear experimental Models, like the Yule-Nielsen Modified Neugebauer Model.

2. The feasibility of the Prediction Models on printed and fired pieces opens up the possibility of using these in controlling colour variations by adapting the procedure, applicable to pieces before firing.

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