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PERSONALIZATION OF A PRODUCT FROM MASS PRODUCTION

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Abstract: *The aim of this work is to show how the varnishing effect influences on color differences and changes gamut of color printed on wood surface. The most widely used wood products combined with brand new digital printing technologies can yield non-serial artifact. After the printing, varnish has to be used to achieve a film to protect the ink on the wood surface and to prevent the mechanical damages. After applying, varnish is changing the hue and saturation of color.*

Key Words: ***personalization, printing on wood surface, varnish, CIA L*a*b* value, gamut, color differences CIEDE2000***

1. INTRODUCTION

Mass production of wood products offer user an inexpensive and reusable substrate which can reflect their particular personality through flat-bed printers with great print size and superb adhesion of ink which provide an endless variations determined by user's individuality and creativity.

These printers are ink jet printers that print directly on: glass, metal, stone, wood, plastics and lot of other surfaces. They are using solvent ink based on alcohol gel that is inexpensive type of ink. Wood products as print substrates are characterized by great thickness, specific structure that achieves different surface properties (great absorption, surface roughness and possibility of different surface textures). Various surface properties in personalization process increase the uniqueness and diversity. For easier maintaining the wood surface in household the varnish is used. Varnish is a transparent and protective film with glossy or semi-glossy reflection. For matte wood finish there is a special process. Varnish is using for increasing a mechanical properties of wood surface and for protecting (printed) ink. Varnish price is slightly higher than the ink price which means that is acceptable. However, in the contact with wood surface, varnish is changing the hue and saturation of the printed color. Colorimetric differences, before and after applying varnish on the wood surface, can be measured with standardized colorimetric method based on CIE L*a*b* values.

L*a*b* (CIELAB) and L*u*v* (CIELUV) color space were designed to be device independent and perceptually uniform. They were introduced in the 1976. by the Commission Internationale de 1´Eclairage (CIE - the primary organization responsible for standardization of color metrics and terminology). The CIELAB color space is widely used in color imaging and printing industry while CIELUV is commonly used in the display industry. These spaces are defined in terms of transformations from CIE XYZ tristimulus values to these spaces [1]. Based on CIE L*a*b* values the gamut of reproduction can be also constructed. Color gamut is the range of a set of colors and can be represented as location in a three-dimensional color space. For the gamut of reproduction the ICC profiles are necessary.

The ICC (International Color Consortium) is a consortium of those vendors founded in the year 1993 with the aim of developing a universal color management solution. The ICC profile format, defined by the ICC Profile Specification, consists of various data structures, which provide a mechanism for color transforms [2].

2. MATERIALS AND METHODS

The research was carried out on an ink jet printer DTS (direct to substrate). The printer driver takes RGB values as inputs. A standard X – Rite profile 343 Patches test chart was printed on wood surface – chipboard, MDF board and spruce board. After the chart was printed and dried, L*a*b* values were measured using a spectrophotometer i1 Pro with 45º/0º measuring geometry, under conditions 50D illumination and 2º observer. The obtained data consisted of values of RGB inputs and their corresponding spectral reflectance.

As a wood finishing the varnish was applied, two layer of basic varnish and one waterborne. When varnish was dried the L*a*b* values were measured again under equal conditions. The evaluation was carried out by the values before and after varnishing for each of the 343 test chart patches using the equation for color difference CIEDE2000 [3].

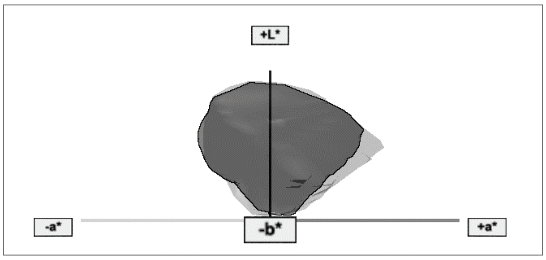
$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T\left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)} \quad (1)$$

The obtained ΔE errors are Euclidean distances in the L*a*b* space. The minimum, mean, median and maximum of errors were calculated and the results are displayed in Table 1.

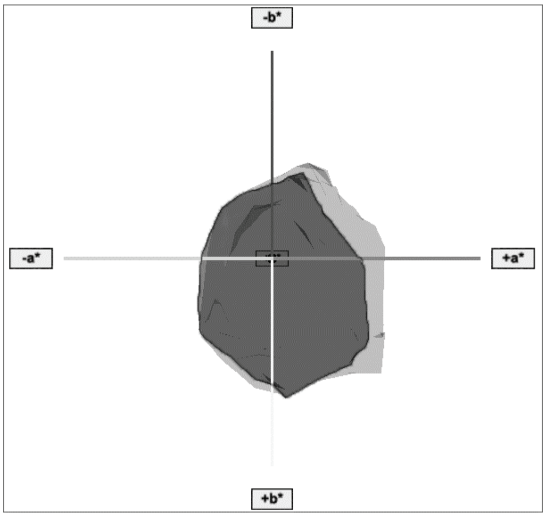
Table 1. *Evaluation results*

	Min ΔE	Mean ΔE	Median ΔE	Max ΔE
CHIPBOARD	0,6686	5,3392	4,8394	15,2802
MDF	0,8630	4,1760	3,1186	32,0223
SPRUCE	1,9271	6,2595	6,2434	9,9459

Once the L*a*b* values were measured the ICC profiles are made using Profile Maker 5.0. ICC profiles are required for construction of color gamut. In Color Shop X application the reproduction of gamut were made. Color gamut can be represented as a volume in three-dimensional color space. Therefore, the comparison in 3D color space of color gamut before and after vanishing can be seen for chipboard on Figure 1; for MDF board on Figure 2; and for spruce board on Figure 3. in various views.

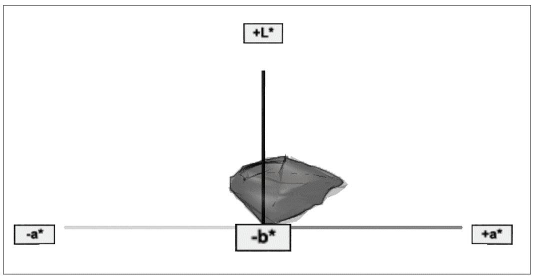


(a) *front view*

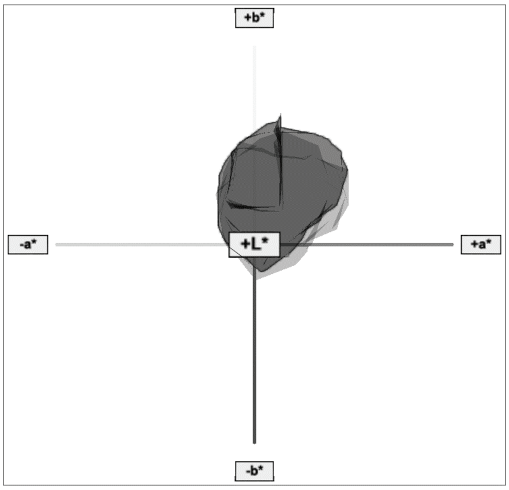


(b) *bottom view*

Figure 1. *(a) front view and (b) bottom view of color gamut before varnishing (shown as light gray color) and after vanishing (shown as dark gray color) on chipboard*

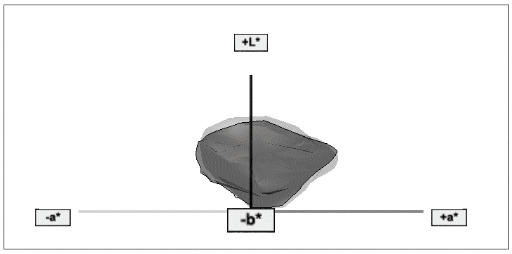


(a) *front view*

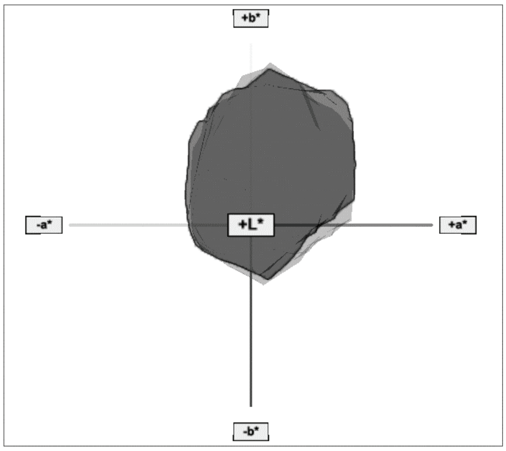


(b) *top view*

Figure 2. *(a) front view and (b) top view of color gamut before varnishing (shown as light gray color) and after varnishing (shown as dark gray color) on MDF board*



(a) *front view*

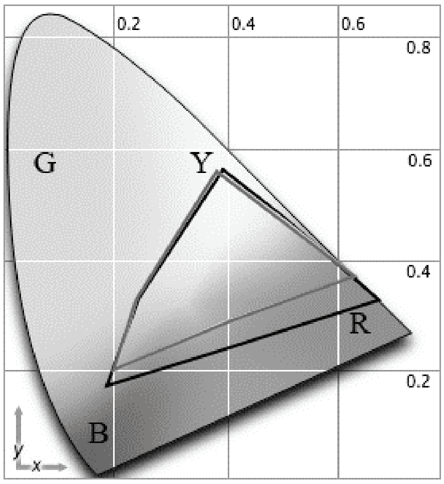


(b) *top view*

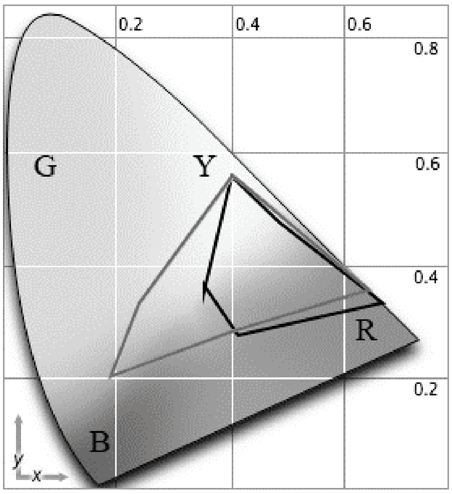
Figure 3. *(a) front view and (b) top view of color gamut before varnishing (shown as light gray color) and after varnishing (shown as dark gray color)on spruce board*

In the L*a*b* color space: *L** represents the lightness, *a** encodes the red – green sensation and *b** encodes the yellow – blue sensation. Positive +*a** indicates a red color and negative -*a** a green color; and positive +*b** indicates a yellow color and negative -*b** a blue color [4].

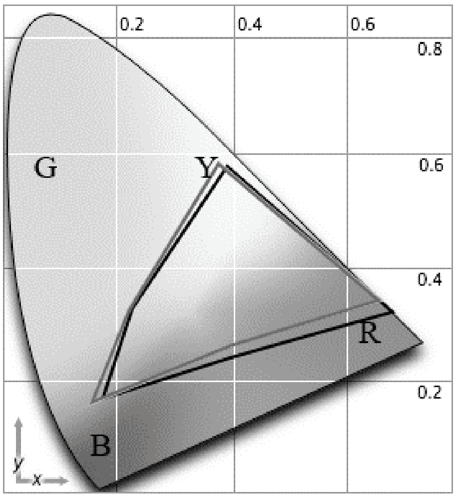
Furthermore, color gamut can also be represented as a vector in two-dimensional space as a unit plane known as spectrum locus in chromaticity diagram (Diagram 1.) [5].



(a) chipboard



(b) MDF board



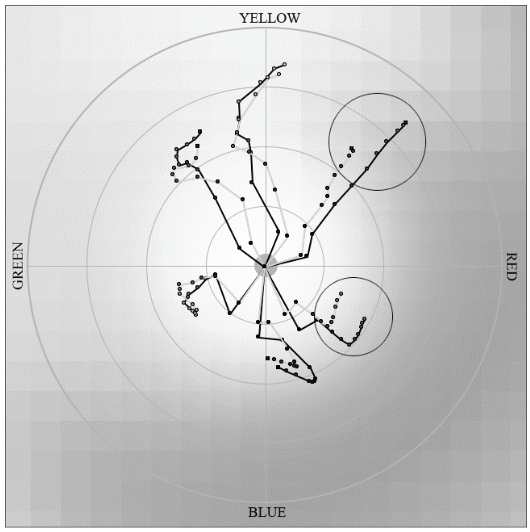
(c) spruce board

Diagram 1. *CIE xy chromaticity diagrams for (a) chipboard, (b) MDF board and (c) spruce board (black stroke shows gamut before vanishing, gray after)*

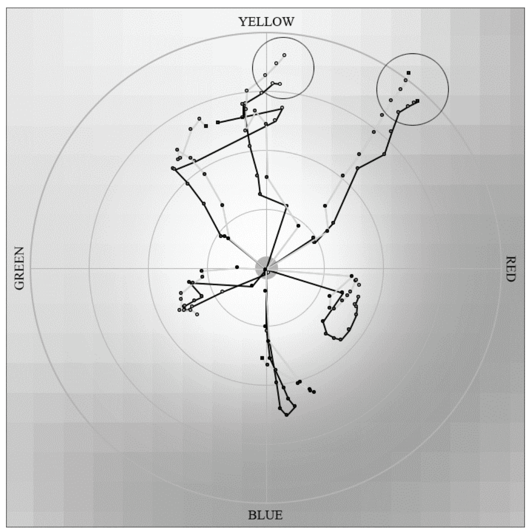
G = green, B = blue; Y = yellow, R = red

3. RESULTS

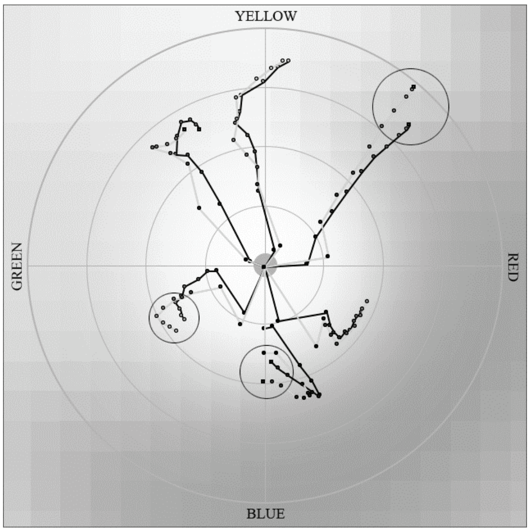
As it can be seen from Table 1. the mean error of around ΔE 6 is the highest for spruce board, but it is also interesting to note that the spruce board has the highest minimum error of ΔE 1,9 and smallest maximum error of ΔE 9,9. This indicates that the entire color amount after varnishing changed linearly which is nicely shown on the Diagram 1c. However blue tones slightly went to green after varnishing which can be seen on Figure 4c. and the saturation of red color increased which can be seen on Figure 3a. The smallest mean error of around ΔE 4 is for MDF board although Diagram 1b. shows desaturation of green and blue tones before varnishing. That indicates that MDF board has great absorption properties and that the green and blue tones merged with the surface. Use of varnish not just increased the saturation of these colors but also the saturation of yellow color and desaturation of red which can be seen on Figure 2b; and Figure 4b. indicates that red went to yellow. It is noticeable on the Figure 4a. that the saturation of red color on chipboard after varnishing fall drastically which also indicates the maximum error of high ΔE 15,2. This is indicated also by Figure 1a. and Figure 1b. where we can see from bottom view the missing area in $a+$ zone which indicates the red color. It can be seen on Diagram 1. and Figure 4. that all colors go slightly to yellow after varnishing therefor it's complementary color suffer the most, the blue one.



(a)



(b)



(c)

Fig. 4. *Color gamut in 2D before varnishing (shown as dark gray line) and after varnishing (shown as light gray line) for (a) chipboard, (b) MDF board and (c) spruce board*

4. FUTURE WORK

The most problematic ambient for this kind of printing would be in places with high concentrations of vapor (like kitchen). It would be very interesting to see how the color is reacting in these surroundings and also to measure how much different lights influence on print aging.

5. CONCLUSION

If the printed wood would be using as part of furniture in houses, like kitchen fronts or wardrobe doors, the varnishing would be very important. Not only that would be protecting printed ink or preventing mechanical damages it would be also facilitate cleaning and maintaining. But it is very important that the quality of color reproduction printed on wood surface would not be decreased after varnishing. Using the equation for color difference CIEDE2000 the results showed that the differences exist but with MDF boards the results were much better. The problem is with subtract itself. Wood surface has a yellowish tone and varnish stimulate it more. That is the main problem for blue tones, because blue color does not contain yellow (blue and yellow are complementary colors). After varnishing print looks slightly blurred and warm (from yellow tones) what would be great for art reproduction. Sharp edges would slightly loose their sharpness. The best results of printed wood were on natural surface like spruce board in our case. The best fact is that all these kinds of wood surface are in mass production therefor the price is optimal, and this kind of finishing wouldn't cost more than the standard painting and varnishing. And this way, enabled by new technologies, mass production goods could be upgrade to satisfied personalized customer demands.

Although this is just an idea for now, customers enjoy the possibility of designing their own kitchen fronts. It gives them opportunity to avoid the monotony and standardization and to express themselves in the new way. The power is in giving life to their own ideas in their household. They also like the ability just to reface their old fronts instead of replacing the whole kitchen. Modern way of living demands frequent changes in all life aspects, which also include furniture, and this new technology enables changes in fast and cheap solution.

5. REFERENCES

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