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Technical note

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Changing the colour of European Hybrid Walnut by means of digital printing

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Abstract - In terms of market, the colour of Walnut timber and veneer is the one from *Juglans Regia* L.. That colour is darker than the one from Hybrid European Walnut . This fact is a barrier for market success of Hybrid European Walnut plantations. There are different methods for modifying the colour such as vaporising, dyeing, thermal modification, etc. Digital printing is an innovative technology that can be used for changing the colour of wooden surfaces. Using transparent inks makes possible to maintain the grain and figure while the colour is modified. In addition to this, digital printing makes possible not just to apply a flat colour but a texture. The review details the colour coordinates allowing that transformation under a certain printing device. It also explains further opportunities of that technology.

Keywords - digital printing, colour modification, European Hybrid Walnut.

Introduction

One of the challenges that timber and veneer products made with young Hybrid Walnut suffer is that they are too light coloured and too unsaturated. For that reason, they do not look as Walnut products. Therefore, the market price of Hybrid Walnut products is lower, and using this species as a source of material becomes unfeasible in economic terms.

In order to overcome this challenge, two industrial Companies (Seistag and Losan) have worked on colour modification of wooden products such as veneer and timber. The collaboration was possible thanks to Woodnat Project, which is an Innovation Action under H2020 that has been supported by REA (GA- 728086). The research focuses on changing the natural colour to reach a new colour that fits to the standard likes of the market. This paper provides an overview of that research and shows the results and methodology for digitally printed wooden surfaces carried out by Seistag.

Figure 1 - Sliced logs after the vaporising process.

In order to dark the natural wood of young Hybrid Walnuts, during Period 1 of Woodnat Project it was studied the process of vaporising. The vaporising process applied to hybrid Walnut is based on the values traditionally applied to vaporizing beech. This process is applied to the logs provided by a partner Company. Those logs were sliced to produce veneer after the vaporising (Fig. 1).

According to the experiences developed by Losan, the vaporising process contributes to: *(i)* improve the technical quality of the veneer for the slicing process and, *(ii)* change the colour of the material reaching a darker and warmer tone. Nevertheless, the colour change due to vaporising does not reach the target of Walnut Regia colour which is the standard in the current market.

Considering those results, two independent research lines have been carried out during Period 2 of Woodnat Project. On one hand, Losan continued to study the colour modification using dyeing. On the other hand, Seistag worked with the same aim, but using digital printing.

In addition to this work of adding colour, both Companies enlarged the focus of the study to consider the opposite process, which is reducing the saturation. This action transforms the original col-

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Figure 2 - Color modification obtained by the described processes.

our of the wood into a grey surface, which is also a valuable decorative effect for the current market (Fig. 2). Both processes, dyeing and digital printing, share the definition of the challenge: reaching a certain target colour by means of modifying the natural colour. Therefore, colour coordinates modification is the basis for both researches. Nevertheless, each process is developed under different circumstances. The modification of colour based on dyes takes advantage of the CIELab coordinates of selected dyes. After the selection, those dyes oght to formulated considering their interaction. Meanwhile, the colour modification by means of digital printing uses four standard inks, which are combined in a well-known colour space (CMYK) in order to fill the gap between the original colour and the targeted one.

In addition to the technical difference both technologies provide different opportunities:

(i) Dyeing changes the inside of the wood while digital printing works on its surface, this means that dyed veneers can be sanded while digitally printed cannot; *(ii)* Dyeing makes possible a complex interaction with the different chemical nature of each part of the wood, so more complex final colours are possible. Meanwhile, digital printing interaction is just a transparency, which is a simpler effect in terms of colour, but more complex in terms of grain; *(iii)* Digital printing can add different colour in different places while dyeing adds the same colour for all the surface of the wood. Due to this issue, dyed veneer is suitable for higher accuracy, while digitally printed veneers makes possible gimmicky effects.

Method

Colour modification

Transforming young wood from Hybrid Walnut into old Walnut Regia by means of digital printing included a two-step research. *(i)* The first to be done is calibrating the change of colour for the average tone of wood. The result of this process is a plain tone to be printed in order to change light coloured Walnut into dark Walnut (Pastore et al. 2004) *(ii)* Later, a complex colour map with sapwood, grains and different changes can be added to the flat colour. By means of this, the printing is not a mere varnish layer over the wood, but a complex effect of transparency that visually melts with the wood surface.

Results

Regarding the first step, changing the colour, the work done includes the following stages: *(i)* Measuring the average starting colour in CIELab by means of a colorimeter (95, 2, 13). In this phase, the method and filters applied to the spectrophotometer are critical for and accurate and meaningful measurement; *(ii)* Measuring the average target colour in the same manner (37, 18, 20); *(iii)* Calculating the colour transformation in CIELab coordinates. In this phase the simple approach of Delta E76 calculation (Euclidean) demonstrated to be precise enough for the purpose as the process starts at a very high value for Delta E ($\Delta = 84, 29$) (Kawasumi et al. 1999); *(iv)* Establishing the printing mode and CMYK coordinates that reproduce the colour neutralization. This work is done by means of iterative experimental tests where the result of each test is measured according to the effective Delta E76 achieved (37, 62, 61, 56). The process stopped when reaching a Delta E of enough accuracy ($\Delta < 5$) (Fig. 3).

For this task, the printing device and inks are

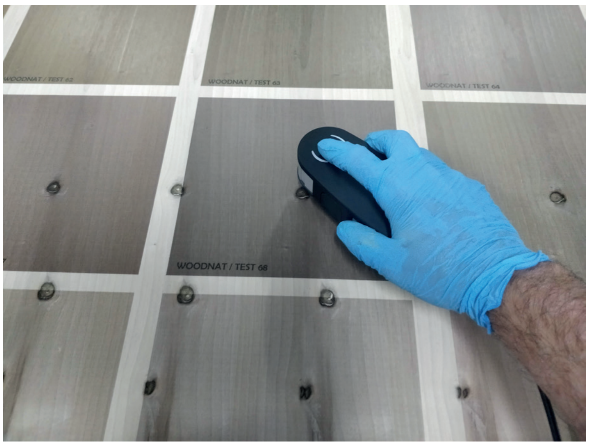

Figure 3 - Measuring the average starting color in CIELlab.

critical to the results as the results refer to that specific device. The device compromises the sum of veneer type, ink, head printers and printing mode. EFI Vutek UVI printer and 3M inks with 4 levels of grey were used during the experimental development.

Figure 4 - Final color modification results.

Figure 5 - Transparent overlap of luminosity added layer.

The above-mentioned method is focused on reaching a target colour of *Regia* Walnut wood, but it can be also applied to reach any other targeted tone as for example a grey surface (62,51,40,30). In this case, the expected result of printing is to reduce the last two values of the targeted CIELab coordinates. The lower their value is the greyish the wood is. Nevertheless, both values should keep in a similar level (ca. ±2) to ensure the absence of any dominant tone such as greenish or blueish.

Further transformation of wood surface by means of digital noise

Once the targeted colour has been reached, the process of adding extra effects might start. Those effects allow: *(i)* to produce a richer colour surface, *(ii)* to speed up the printing process without banding, and *(iii)* to add grain, fibre or figures to the final surface. This process is based on complex maps of colour to modify the average CMYK pattern (Lucassen et al. 2008). (Fig. 4).

In order to achieve the desiderated effect with minimal efforts, the colour modification (a flat colour) is stored in a separated layer while two other layers are added to achieve complexity: *(i)* The first layer is an effect of noise with the form of colour variations along wooden planks. It is added by means of a transparent overlap of colour blending; *(ii)* The second layer is an effect of noise with the form of wooden fibres. Other patterns such as knots or cracks can also be considered. This layer is added by means of a transparent overlap of luminosity, blending between 20 to 35% depending on the pattern (Fig. 5).

Measuring the productivity and the ink consumption per square meter has been an important part of the research. The ink consumption was measured using EFI Software based on the analysis of the images showing a consumption of inks between 3,82 and 13,80 ml/sqm. The timing showed even higher deviations, from 4:10 to 23:37 minutes per square meter. That time depended heavily on the printing

Figure 6 - Final results of Walnut surface modification.

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mode. Adding noise has demonstrated to allow less consumption and higher productivity rates (Donevski et al. 2015) By means of these techniques, the cost of the process has been reduced and a cost-effective technical process to transform the image of the wood surface has been achieved (Fig. 6).

This method for changing the surface of wooden panels has also been used as a creative tool. By means of this, innovative effects such as woodcarving and arabesques have been produced using plain Hybrid Walnut wooden surfaces(Fig. 7).

These results defined a new field of experimentation, a field which does not refer to technical research but to product innovation. It is important to note that this line of development is not constrained to the specific challenge of Hybrid Walnut, as it can also be applied to other species and wooden products increasing the potential impact of the work performed by Seistag.

Conclusions

It has been demonstrated that the technology of digital printing is suitable to transform the original colour of wooden surfaces into a targeted colour.

Within Woodnat Project, Seistag has developed a technical method to perform that transformation with enough accuracy in an easy manner.

Moreover, the company developed technology to speed up the printing process and reduce the consumption of ink by means of overlapping digital noise to reduce the lack of quality, which is associated to low-cost printing.

The market uptake of the technology is currently under evaluation. Good results have already been achieved (stgnature.com).

Aknowledgments

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