

# MEASUREMENT OF SURFACE VOID CONTENT ON BALSA WOOD USING IR THERMOGRAPHY

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## ABSTRACT

This work is aimed at presenting a simple and innovative method for the measurement of surface void content on balsa wood samples, slightly heated using microwaves, applying active IR thermography with a fixed focus microscopy lens. This method involves basic image thresholding to visualise voids, and appears to offer good results, when compared with wood density values. Possibilities and difficulties are also discussed for a future application of the method in an industrial context.

## INTRODUCTION

The wide use of balsa wood in a number of applications requiring lightness and excellent buoyancy suggests the interest of techniques for a fast and reliable density measurement, possibly to be carried out on the conveying line. These properties are obtained with a structure poor in lignin and formed by big cells with very thin walls. In particular, the density of balsa wood is depending on the void content into the structure and in turn, together with grain orientation and woodcutting, affects the mechanical properties of the wood. As a consequence, balsa wood is usually divided into six categories for marketing, depending on its density, going from extra light balsa, with density lower than 0.095, up to extra heavy balsa, with density higher than 0.305 g/cm<sup>3</sup>. However, density may vary in a non-negligible way even in the same batch of balsa sheets: this might lead to accepting/discarding the sheet as suitable for a given use.

Void content is a significant problem in a number of non-metallic, and hence poorly conductive, materials, such as glass fibre reinforced composites, where the presence of porosity is linked with inefficient material moulding and then in turn with mechanical and impact properties [1]. In these materials, a method based on analysis and thresholding of optical microscope images (albeit a destructive one) was applied with some success, allowing measuring void content with accuracy in the order of  $\pm 0.2\%$  [2].

Previous applications of IR thermography to wood have clarified that most serious limitations are its poor thermal conduction and the inherent difficulty of obtaining a reliable measurement of moisture content in the samples [3-4]. In spite of these limitations, the recognition of surface and sub-surface defects proved possible with some accuracy [5]. The availability of microscopic lenses for thermal cameras may enable the observation of surface defects and porosities at a micro-scale, once samples are sufficiently dry, so to overcome the problem of moisture content evaluation.

## EXPERIMENTAL

Ten samples of light balsa (nominal density between 0.096 and 0.160 g/cm<sup>3</sup>) with dimensions 113 x 25.2 x 3.15 mm have been removed from the same batch: the surface of one of these samples is shown magnified in Figure 1. The samples have been subsequently dried out with a slight heating using a MATSUI microwave oven (700 W max. power input) for 2 minutes at medium power.

Immediately after the heating period, the samples have been observed using a Flir SC 3000 thermal imager microscopic lens 26 mm fixed focal distance. In every sample, due to the slight curvature of

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the balsa wood, it was just possible to focus over a squared area of  $\sim 5$  mm side (193 x 193 pixels) smaller than the observed region of 10x7.5 mm and representing the 0.5% of the total area of the samples. The two areas are depicted in Figure 2, and the area inside the black square was solely considered for analysis.

The images have been then treated using commercially available image analysis software (Corel Photo Paint) to provide the pixels histogram on 0-255 colour levels. From the images obtained, it was apparent that the voids appeared coloured in blue. As a consequence, the analysis aimed at measuring the void content, shown on the diagrams appearing on the left in Figure 3, are based on the observation of the typical histogram for the blue channel of the images. These histograms show a number of pixels with a minimal colour level, approaching 0 (no blue in the pixels), then a number of dispersed pixels at some intermediate values (purple shades of the voids) and finally regions of pixels close to the maximum value (blue or nearly blue pixels). The latter were interpreted as being voids. The results of this analysis on three samples are shown on the right in Figure 3.

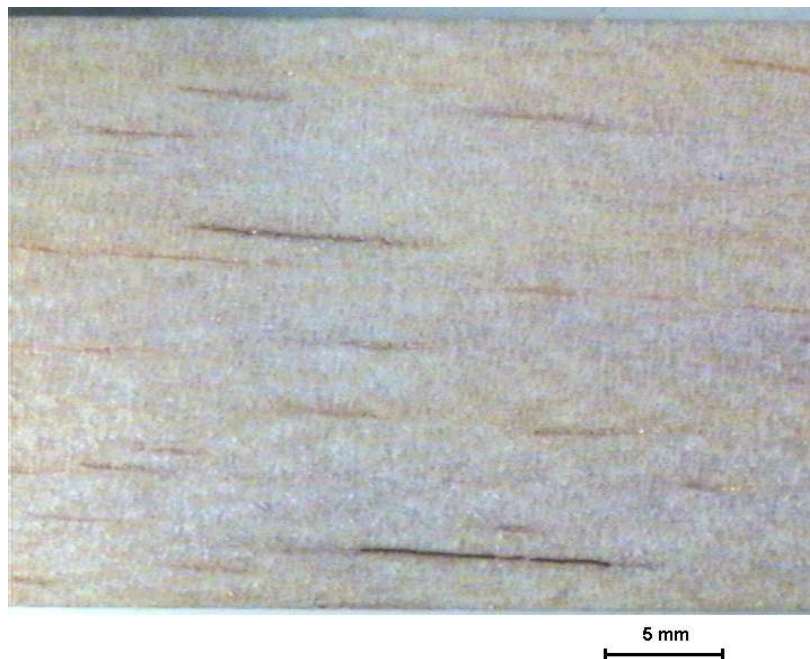


Figure 1 Surface of a balsa wood specimen

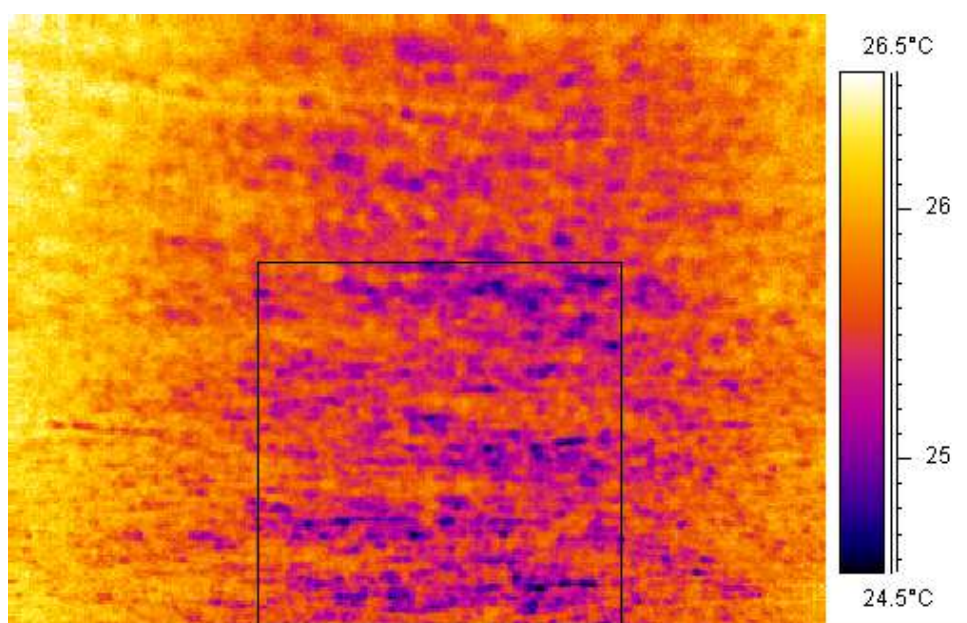


Figure 2 Area imaged and (in black square) area considered for analysis

## RESULTS AND DISCUSSION

The void content measurement was easily carried out from the histograms in Figure 3, where the “deep blue” pixels, whose histogram bars have been painted in red, appear to be clearly separated from the rest of the image pixels for all the samples analysed. In addition, the values obtained on the focused area appear to approximately correspond to the density values, as measured from the weight and volume of the samples, in Table 1. The density appears to be considerably higher in the sample *a.*, which shows a much lower void content, and then not much different between samples *b.* and *c.*, the latter having a slightly higher void content and consequently a slightly lower density.

Preliminary results are promising for future work. These suggest that, differently from what shown in the analysis carried out on composites, where data appeared to be very scattered and required a sound and time consuming statistical analysis [2], in the case of balsa the observation of a small part of a sample can still provide indications on void content, confirmed by density. This was attributed to the limited variations in colour observed in the samples. However, the possibility of generalised and reliable measurements of void content in balsa needs to be obviously confirmed by imaging some larger and more representative areas.

As a whole, these results confirm the possibility of using IR thermography also for different purposes including e.g., damage characterisation, on balsa wood. In particular, the more promising indications provided would concern the following aspects:

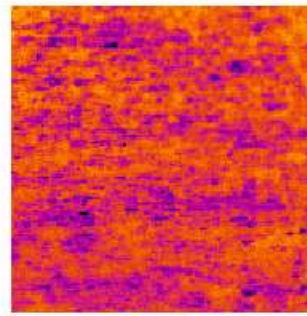
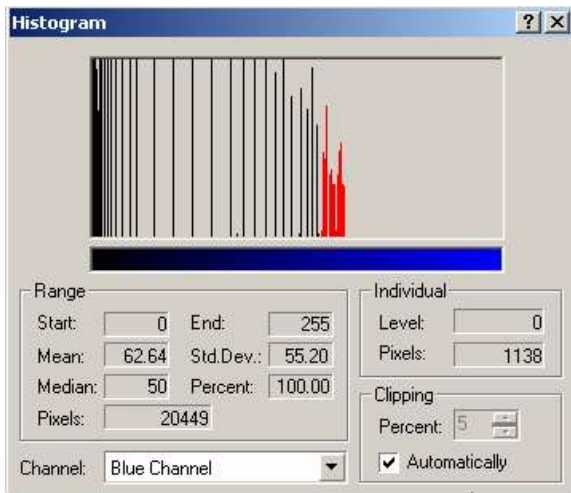
- A slight microwave heating provides balsa wood drying at a level sufficient to yield an acceptable thermal imaging contrast
- The level of temperature and microwave exposure of the samples is extremely unlikely to generate any damage on the material surface
- The observation of samples is possible under normal lighting with incandescence lamps, a characteristic which is important for a possible industrial application

## CONCLUSIONS

A simple and fast method for void content measurement on balsa wood, based on image analysis from micro-focused thermograms, is presented. The preliminary results show that the values obtained on a small area of the samples correspond quite well to the average density measured by weighing the samples. This would appear promising for a possible application of this method for quality discrimination in a go-no go philosophy on balsa wood, and more in general, suggest the possibility of a wider use of IR thermography on this material.

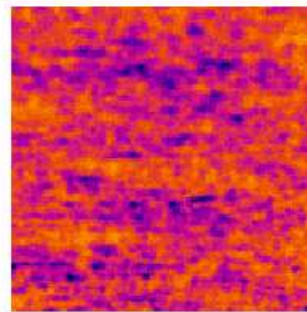
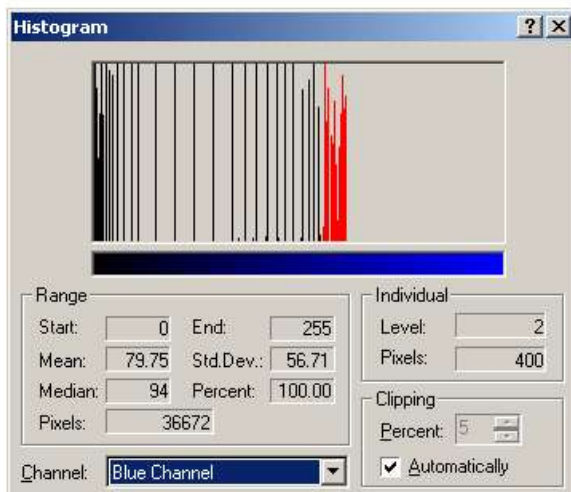
## REFERENCES

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3. Ludwig, N, Redaelli V, Rosina E, Augelli F, Moisture detection in wood and plaster by IR thermography, *Infrared Physics & Technology* **46**, 2004, pp. 161-166.
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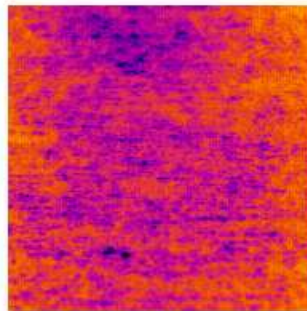
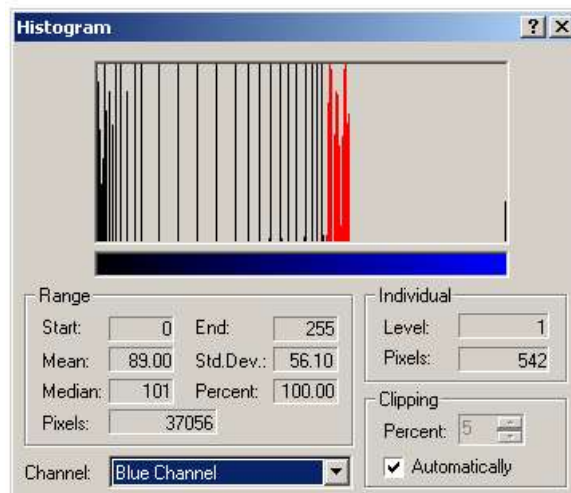
a

12.5% voids



b

20.8% voids



c

22.9% voids

Figure 3 Image analysis and void content of three samples measured by active thermography

| Samples | Density |
|---------|---------|
| a       | 0.18    |
| b       | 0.138   |
| c       | 0.129   |

Table 1 Density values measured by weighing the samples ( $\text{g}/\text{cm}^3$ )