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GREEN FIBER BOTTLE: TOWARDS A SUISTANABLE PACKAGE

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Abstract: The Green Fiber Bottle is a fully biodegradable bottle made from molded paper pulp. Its development depends on the establishment of the manufacturing technology. Impulse drying, an innovative way of drying, has the potential to improve significantly the manufacturing process of the Green Fiber Bottle, towards a sustainable packaging.

1 INTRODUCTION

The ambition of the Green Fiber Bottle (GFB) project is to manufacture a fully biodegradable bottle. Carlsberg Group has collaborated with EcoXpac (a Danish SME) to package beer in this bottle (Figure 1).

The GFB will replace plastic and glass bottles, thus reducing their impact on the environment, especially the oceans. For example, the life span of a plastic bottle in the ocean is 500 years, and during its degradation, the plastic is reduced to micro pieces, which can cause the starvation of several marine animals. The new bottle is made from molded paper pulp, which is a renewable resource. The bottle could thus be left to biodegrade in nature or enter a recycle system, along with other paper-based product.

Figure 1: Illustrative image of the Green Fiber Bottle (GFB).

In order to contain the liquid, the bottle has an inner coating barrier. The latest solution proposed is to coat the inner walls with silicon dioxide, which is not biodegradable but rather environmentally inert.

To reduce the environmental footprint and enhance the sustainability of the bottle, the manufacturing technology has to offer the possibility of significant energy savings. Molded pulp products are made from wood fibers dispersed in water, and then they are formed, drained and dried. A relatively large quantity of resources (i.e. energy and time) is consumed during the drying process. It is in this process stage that an innovative way of drying the products can be exploited by using the concept of impulse drying. Via this technology, the wet pulp is dried in seconds. In this work, in order to optimize the molded pulp drying process, the effects on the dryness of two variables are investigated: process time and temperature.

2 IMPULSE DRYING

Impulse drying is an advance drying technique in which water is removed from a wet paper web by the combination of mechanical pressure and intense heat. It was introduced in the beginning of the 1980s, and it attracted considerable interest from the paper industry as a means of reducing energy consumption in the drying process. Despite over thirty years of research, this technology has never been applied in the paper industry due to various runnability problems affecting the paper quality.

In this process, the wet web is exposed to pressures ranging from 10 bar to 50 bar and to hot surface temperatures typically between 120 °C to 300 °C. At these conditions, the wet web is dried in few seconds [1]. Enhanced liquid water removal is the key to energy savings in impulse drying.

The application of the impulse drying concept for the manufacture of molded pulp products, such as the GFB, was only recently reported [2].

1.1 Test rig and drying performances

A laboratory-molding machine that exploit the impulse drying concept was designed and developed at EcoXpac A/S (Denmark). The machine is capable of press drying a preformed pulp disk of Ø200 mm with a grammage of about 500 g/m^2. Process steps are as follows:

1. The chamber, in which the wet pulp disk is placed, is pressurized at 20 bar.
2. A hot surface is put in contact with one side of the disk and the temperature (**Temperature [°C]**) is kept constant for a certain time (**Contact time [s]**).
3. Pressure is suddenly released from the chamber and vacuum is applied for a certain time (**Vacuum time [s]**).

The influence of the process parameters (highlighted in bold) on the final dryness of the paper disks were investigated by means of design of experiments. Dryness was calculated as follows:

$$Dryness = \frac{m_{bone\ dry\ disk}}{m_{dry\ disk}}\% \quad \textbf{(1)}$$

3 RESULTS

3.1 Drying performances

An experimental plan was designed and performed, in which the factors under investigation and the corresponding levels are reported in Table 1. The experiments were replicated three times, which resulted in 81 data sets.

Table 1: Factors and levels under investigation.

Factors	Levels
Contact time [s]	2, 6, 10
Vacuum time [s]	2, 6, 10
Temperature [°C]	130, 160, 190

In Figure 2, for the sake of simplicity, contact time and vacuum time were summed up together under the name **t [s]**.

Figure 3, instead, depicts what are the contributions to the final dryness of the various process parameters. It is clear that the temperature is the most influential, followed by the contact time. Vacuum time, instead, appears to be uninfluential. This is because the large drop in pressure (from 20 bar to atmospheric pressure) is far more significant than the application of vacuum, which gives a drop in pressure of just 0.8 bar.

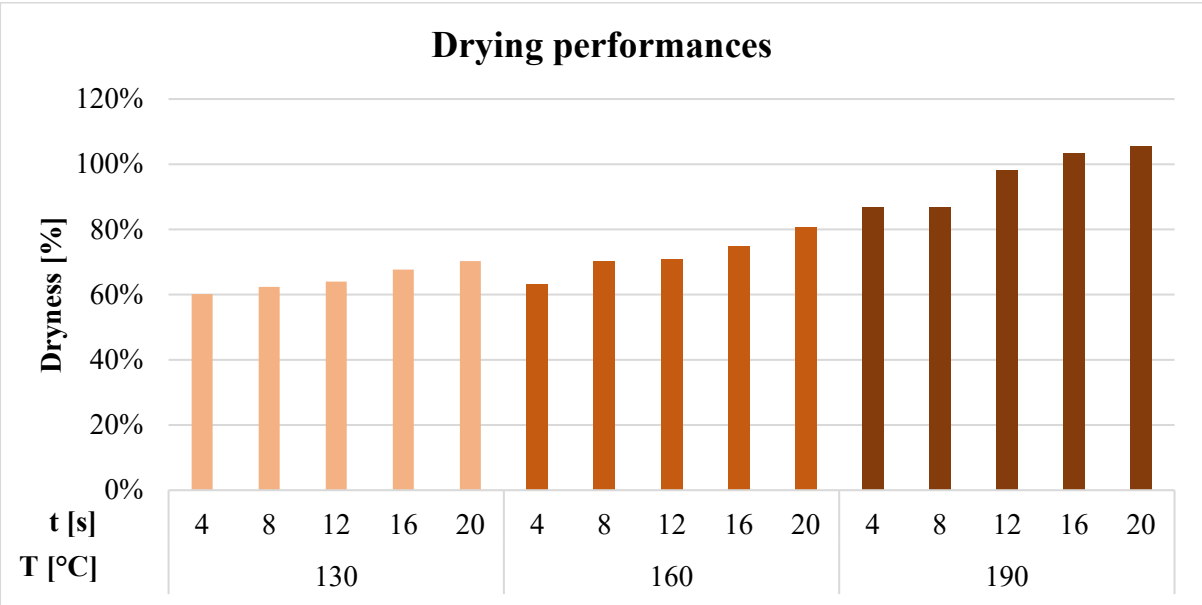

Figure 2: Drying performances.

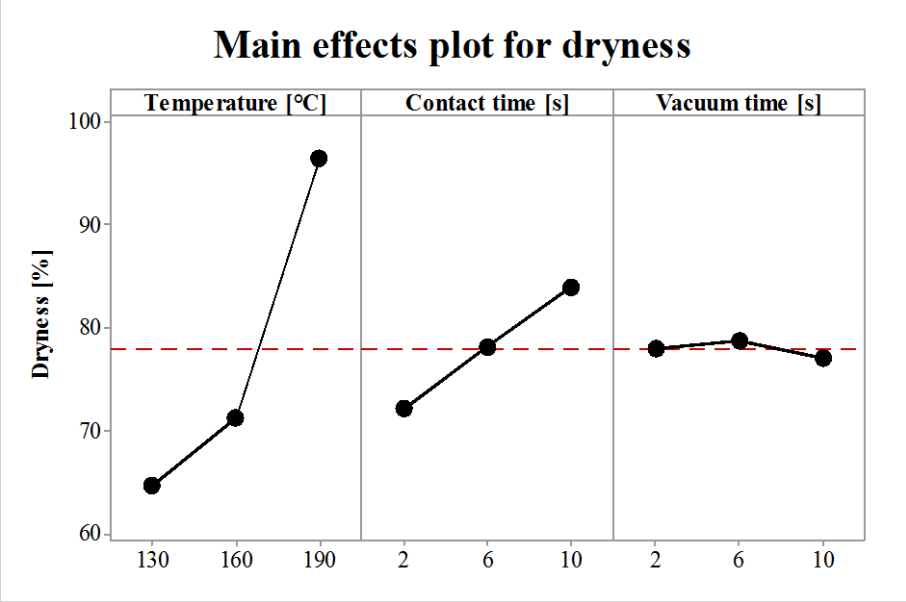

Figure 3: Main effects plot for dryness.

4 CONCLUSIONS

Impulse drying has the potential to improve significantly the manufacturing process of molded pulp products. The large water removal combined with quick run time speak volumes to the capability of impulse drying technology for molded pulp products.

5 ACKNOWLEDGEMENT

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