

JAPANESE KNOTWEED, A USEFUL MATERIAL FOR GRAPHIC PRODUCTS

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Abstract: *Eco-design is an approach to designing products with special consideration for the environmental impacts of the product during its whole lifecycle. To design packaging, it is important to seek for new packaging materials that are sustainable, recyclable and if possible also biodegradable. One of such materials is cardboard, made from fibers obtained from Japanese knotweed. The goal of our research was to make innovative graphic products from this material. First, the characteristics of cardboard were determined and afterwards sustainable graphic products were designed.*

Keywords: *cardboard, eco-design, packaging*

INTRODUCTION

Eco-design is an approach to designing products with special consideration for the environmental impacts of the product during its whole lifecycle and is becoming a core design concept in packaging [1]. The main purpose of packaging is to contain and protect the packed items from their point of production through to the point of use. The challenge is to do so by optimizing the use of materials, water and energy, minimizing waste and maximizing the recovery of used packaging [2]. The sustainable packaging design principles of effective, efficient, cyclic, and safe should be consider [3]. For packaging with short-life span is even more important to focus on material choice, to use materials from renewable sources that are recyclable or compostable, and design for maximum sustainability and recoverability [1, 4]. The project »APPLAUSE – from harmful to useful with citizens' led activities« addresses unsolved questions with regard to invasive non-native plant species in terms of the zero-waste approach and circular economy. At present, these plants are composted or incinerated, though they could be utilized for other useful purposes, such as raw material for wooden products, paper and graphic products [5]. As invasive plant species represent a more or less rich source of cellulose fibers, in the project Applause, several plants were explored, among them Japanese knotweed. Just like other cities Ljubljana is also faced with significant Japanese knotweed overgrowth, a plant on the list of hundred most invasive non-native species worldwide [6]. It is a fast-growing and strong clump-forming perennial, with tall, dense annual stems. Stem growth is renewed each year from the stout, deeply-penetrating rhizomes in sum. In summer, dense stands of tall bamboo-like canes grow to 2.1 m tall (Fig. 1a). [7]



a



b

Figure 1: Japanese knotweed (a) and harvested steam (b)

In the research program novel sustainable materials are used for production of more eco-friendly products. In our study we have analyzed some properties of cardboard made from the Japanese knotweed and designed a sustainable graphic products from it.

EXPERIMENTAL

Materials

The cardboard was made from a mixture of wood fibers (hardwood/softwood) and Japanese knotweed fibers, which were obtained from the stem of the plant (Fig. 1b) using a sulfate process of delignification (Fig. 2a). Pulp was prepared using a Hollander beater (Fig. 2b). Cardboard with a nominal grammage of 240 g/m² was produced on a pilot paper-making machine at the Pulp and Paper Institute in Ljubljana shown in Figure 2c.

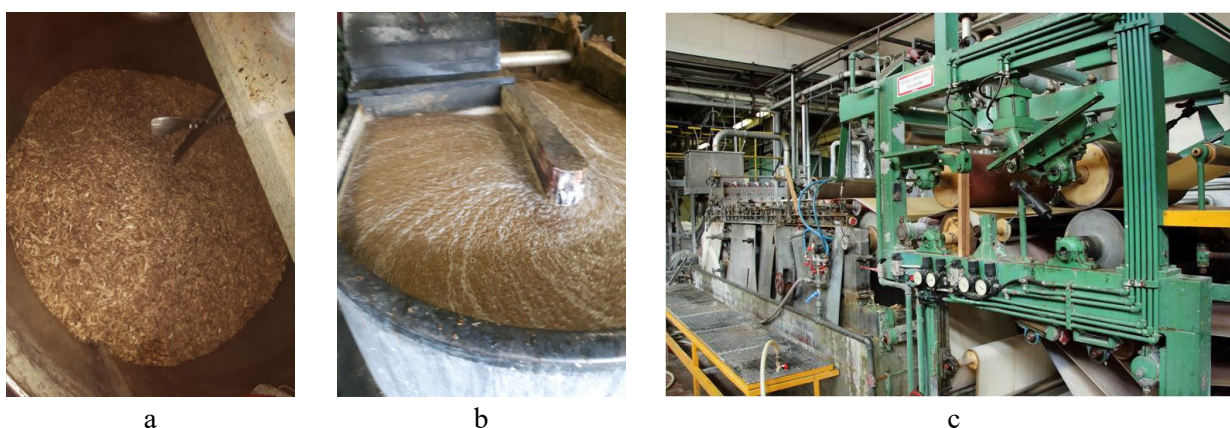


Figure 2: Fiber preparation: delignification (a) beating (b) and paper-making (c)

Methods

Cardboard was tested under standard climate conditions (ISO 187). Among basic properties of cardboard, the basic weight (ISO 536), thickness and bulk (ISO 534) were determined. The surface roughness of cardboard was determined according to ISO 8791-2 with the Bendtsen tester measuring device. Determination of mechanical properties included determination of tensile strength, tensile strain and energy at break, modulus of elasticity (ISO 1924-2), busting strength (ISO 2759), tearing strength by Elmendorf method (ISO 1974), bending stiffness – L&W 15° (ISO 5628) and folding endurance (ISO 5626).

RESULTS AND DISCUSSION

Cardboard properties

In table 1 properties of cardboard made from Japanese knotweed are presented. Analyzed cardboard has compared to commercial ones, higher roughness and natural brownish color with lot of darker specks seen, resulting from plant fiber residues. It is also less compact, more voluminous and less homogeneous, especially in the surface roughness, as indicated from a high coefficient of variation.

Table 1: Basic and mechanical properties of cardboard in mechanical (MD) and cross direction (CD): average value (av. val.) and coefficient of variation (CV%)

	MD av. val. (CV%)	CD av. val. (CV%)
Grammage (g/m ²)	229,8 (1,2%)	
Thickness (mm)	0,335 (1,7%)	
Density (g/cm ³)	685,9 (2,6%)	
Roughness (ml/min)	1480 (18,4%)	1639 (18%)
Tensile strength (kN/m)	10,5 (10,4%)	6,3 (3,5%)
Tensile index (Nm/g)	47,6 (6,5%)	28,5 (2,9%)
Tensile stress (MPa)	31,2 (10,4%)	18,7 (3,5%)
Stretch at break (%)	1,3 (16,5%)	4,9 (7,9%)
Modulus of elasticity (GPa)	3,9 (9,9%)	1,7 (6,5%)
Tensile energy absorption index (mJ/g)	74,1 (15,4%)	222,2 (10,3%)
Tear index (mNm ² /g)	10,9 (4,1%)	11,6 (9,4%)
Bending stiffness (mN m)	18,1 (9,9%)	9,3 (19,3%)
Folding endurance (double fold number)	1852 (26,2%)	215 (38,2%)
Bursting strength (kPa)	335,8 (8,6%)	
Bursting index (kPam ² /g)	1,5 (8,6%)	

Comparison with a commercial cardboard of the same nominal value of the grammage has shown that the mechanical properties of analysed cardboard are somewhat inferior, except of tearing strength and bending stiffness. Bursting strength, tensile strength, tensile stress and energy absorption are lower, though still within acceptable range. The most inferior characteristic of analysed cardboard is folding endurance, with only 215 double folds in cross direction, suggesting very high tendency to cracking and loss of strength at folding. These inferior characteristics must be consider by design of packaging.

Design of graphic products

Packaging

Sustainable packaging needs to be effective to provide functional requirements, efficient in its use of materials, energy and water, cyclic in its use of renewable materials and safe for people and the natural environment. Besides using recyclable, biodegradable printing substrate (cardboard from Japanese knotweed) packaging had to be fit for purpose, with optimizing the volume occupancy, considering the reduce of the use of graphic materials (glue), to design for recycling, reuse and apply eco-design at visual communication.

The construction of the packaging was made in the way to overcame the inferior mechanical properties of the cardboard and to achieve good stability of the box. With the sliding matchbox shape, in addition to simply opening it, we could reinforce the bottom of the box with a double layer (box and outside sleeve). With the interior fitment that was tide to box design we could stabilize the product and further strengthen the box.

For visual design only three colors were used, grey, pink and white, which are part of company's corporate identity. With the cut opening in outside sleeve, other three colors (purple, blue, orange) which are also part of the company's visual identity, and label design are meaningful incorporated. Opening in the sleeve, besides enabling the consumer to see the product, also saves material (cardboard and printing ink) and makes printing process more sustainable. A minimalist graphic design style was used, only elements are lines and concentric circles, the latter made by embossing, as seen from Figure 3.



Figure 3: Packaging made from Japanese knotweed

Bookmark

A bookmark is one of the least demanding graphic products. Modern bookmarks are available in a huge variety of materials in a multitude of designs and styles. Many are made of cardboard and are often used for promotional purposes. In our case the task was to create the bookmark that would promote the Applause project. Among different materials, we chose cardboard from Japanese knotweed, because its mechanical properties especially good tearing strength and bending stiffness, make this material a good choice for producing a bookmark. In graphic design a bilingual text in Slovene in English language, two logos and the graphic element reminiscent of a Japanese knotweed had to be included. A monochrome solution and design based on the steam and leaves of Japanese knotweed was suggested (Fig. 4).

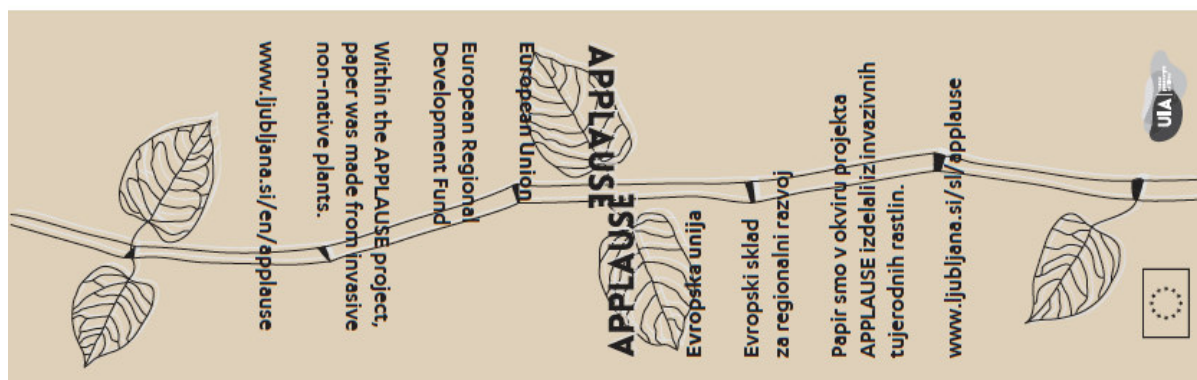


Figure 4: Bookmark made from Japanese knotweed

CONCLUSIONS

Japanese knotweed, one of the most invasive non-native plants in the world, represents a good source of papermaking fibers. With adding up to 40% of Japanese knotweed to wood fibers a natural looking cardboard can be produced. To some extant inferior mechanical properties of cardboard must be taken into account at the design of a graphic product. By aplying eco-design guidelines an uniq, sustainable graphic products can be obtained.

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