

COST ANALYSIS OF LARCH BARK COATINGS FOR FLOORING TILES

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Abstract:

A manufacturing system involves several production steps with inputs and outputs of material flow at different stages all over value stream. This work presents a method to estimate the fabrication costs of 3mm larch bark based coatings for floorings. The article describes an empirical study involving all the production steps required to manufacture a composite board based on wood biomass that can substitute a cork coating for tiling. For a small production capacity and a medium density level of 600kg/m³, the findings indicate that the total costs can vary from 10.6 to 13.4 €/m². These prices are 13 to 25% higher compared to the value of classical cork coatings, but is also the difference between small to large production capacity.

Key words: cost analysis; larch bark; cork; composites; biomass; flooring tiles.

INTRODUCTION

One of the main three requirements for a material, apart from the appropriate technical properties and workability is the economic efficiency (Ashby 1999). By developing a new material or product, the manufacturing cost is a basic factor that gives a key information about its potential use in a specific application.

In the material selection process, cost is an essential criterion. Valuable components are usually not weighed by establishing a target cost. The decision about material selection is an adjustment between cost and performance (Jahan & Edwards 2013) and an environmental friendly solution will reduce the carbon footprint of the final product (Ajusree & Jenson 2019).

The selection of materials for multi-layer floorings requires to scrutinize elements as wear layer, carrier board, overlay paper and surface finishing (Tudor et al. 2018). An efficient way to optimize the manufacturing costs is to substitute one product with an alternative one (Berk & Berk 2000), more convenient and sustainable (Jahan & Edwards 2013). An alternative to granulated cork for the coatings of multi-layered floorings (Gil 2007) is a thin board made of fine tree bark particles (Tudor et al. 2018).

Cork is a particular tree bark (from *Quercus suber*), a strategic material (Pereira 2007), used in various applications (Gil 2007) and one of the most sustainable raw materials in the world (Gil 2015). Larch (*Larix decidua* Mill.) bark cannot replace completely cork (Tudor et al. 2018), but to a certain extent is a convenient option. Bark price is much lower (Medved et al. 2019) and involves no embedded energy costs as cork (Rehfeld 2011). The bark biomass can be used for different categories of products (Dooley et al. 2013) instead of burning (Pasztoy et al. 2016). Several possibilities of bark utilization (Feng et al. 2013, Jansone et al. 2017) are described in Fig. 1.

In the context of resources sparsity and reduced energy consumption, the superior use of a by-product of the wood industry, namely tree bark, can offer a sustainable alternative for added-value application in wear layers for floorings (Tudor et al. 2018).

The goal of this study was to replace the cork based coating for floorings with 3mm layer made out of cork and to calculate the manufacturing costs. The costs were estimated per 1m² of flooring tile with larch bark coating, considering a small production of 5,000m²/year, in an existing pilot plant with a manufacturing line redesigned for the new product.

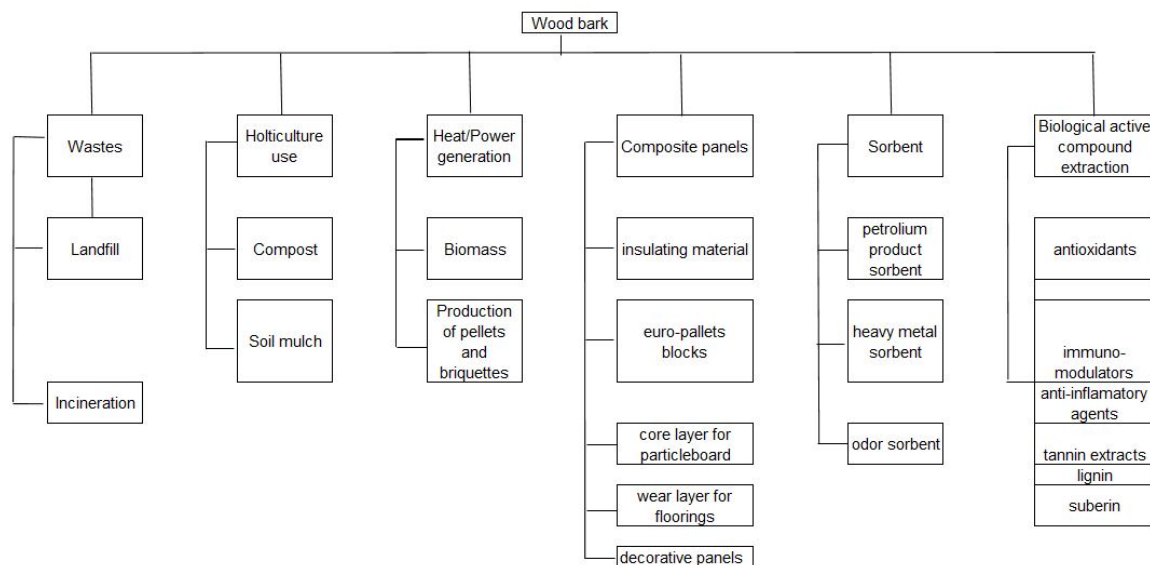


Fig. 1.
Possibilities of bark utilization (after Feng et al. 2013, Jansone et al. 2017).

MATERIAL AND METHODS

Manufacturing of larch bark wear layers

The larch bark was collected at Graggaber local sawmill (Unternberg, Austria). The bark planks were ground by means of a four-shaft shredder RS40 with a mesh of 30mm at Untha Co. (Kuchl, Austria). Subsequently the bark particles were dried at 60°C and 200 to 250 mbar in a vacuum kiln dryer Brunner-Hildebrand High VAC-S, HV-S1 from 65% to 9% moisture content.

After the material was crushed in a four-shaft shredder (RS40), was repeatedly screened according to EN 15149-1:2011 with sieve shaker Retsch AS 200, to obtain particles the spectrum 0.5-2.5mm and 2.5-4mm.

The larch bark was bonded with 10% urea formaldehyde type Preferé 10F102 (MetaDynea Krems, Austria) and pressed for five minutes at a temperature of 180°C with Höfer HLOP 280 hydraulic press. After conditioning at 20°C and 65% relative air humidity, until constant mass was reached, the larch bark wear layers were sent to Tilo Co. (Lohnsburg, Austria). At site, the 3mm bark coatings were industrially pressed for 30 minutes with a 7mm HDF carrier board and counteracting paper (120g/mm²) using Folcolit PVAc adhesive (Follmann&Co., Minden, Germany), then sanded (0.1mm sanding off) and lacquered with Twist Plus (Tilo, Lohnsburg, Austria) acryl finish (gloss level 18) with film thickness of 65µm, resulting in 10mm sandwich boards. It is to mention that the calculation of manufacturing costs presented in this paper covers only the production of the 3mm larch bark wear layers for floorings.

The production steps (Fig. 2) were carried out under realistic conditions and the larch bark was used in the same form as it had been obtained after debarking in sawmills.

Estimation of manufacturing costs

This work attempts to estimate the manufacturing cost of flooring tiles consisting of multi-layered panels with wear layer made of larch bark.

Cost analysis (Fig. 3) was performed according to technical cost modelling approach of (Segovia et al. 2015) after (Wakeman & Månson 2004) where all resources utilized in the manufacturing process of the boards are considered (variables and fixed costs).

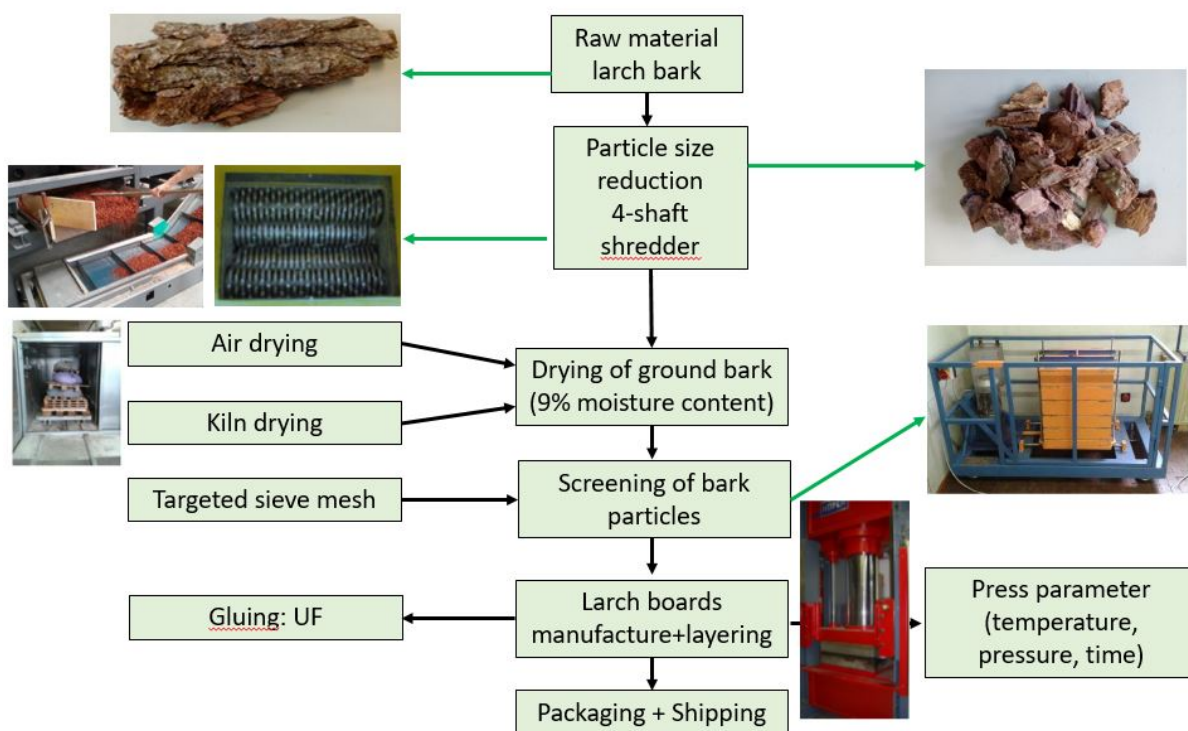


Fig. 2.

Visualization of the pilot plant process steps for the wear layer for floorings based on larch bark.

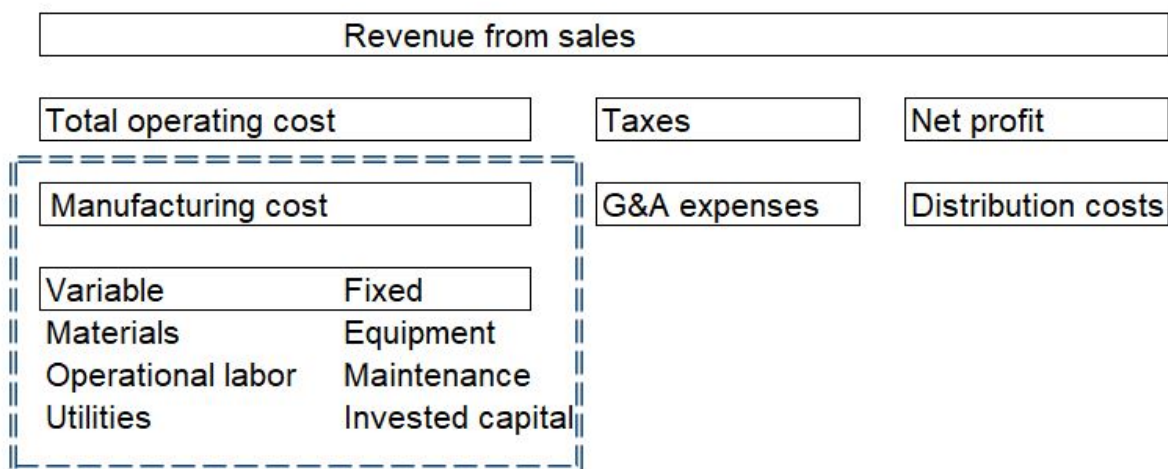


Fig. 3.

Approach for estimation of manufacturing cost (selected within blue dashed frame) of multi-layered boards with larch bark coating (after Segovia et al. 2015).

Variable costs are directly dependent on production and include the cost of materials (coating layer - larch bark, substrate board - HDF, adhesives etc.) and utilities (e.g. electricity). Variable costs also include processing costs (operational labour) of each stage of the manufacturing process including shredding, drying, fractioning, bark particles gluing, pressing, bonding (multi-layered board), sanding and lacquering, cutting to size and packaging. Fixed costs include generally equipment, maintenance and invested capital, which are not dependent on production (Fig. 3).

The manufacturing cost was estimated per m² of flooring tile with larch bark coating, considering a small production of 5,000m²/year, in an existing pilot plant with a manufacturing line redesigned for the new product. The variable costs were divided into material costs and processing costs for 2019 for a site running in a German language speaking country. The costs of UF adhesive for the bark gluing were approximated at 400 €/t and was calculated for 26,4 €/m³. The costs of manufacturing steps of the 3mm wear layer made of

larch bark were calculated based on information provided by project partners companies. Because some of the costs are confidential, only the production steps within blue dashed line from Fig.4 will be considered.

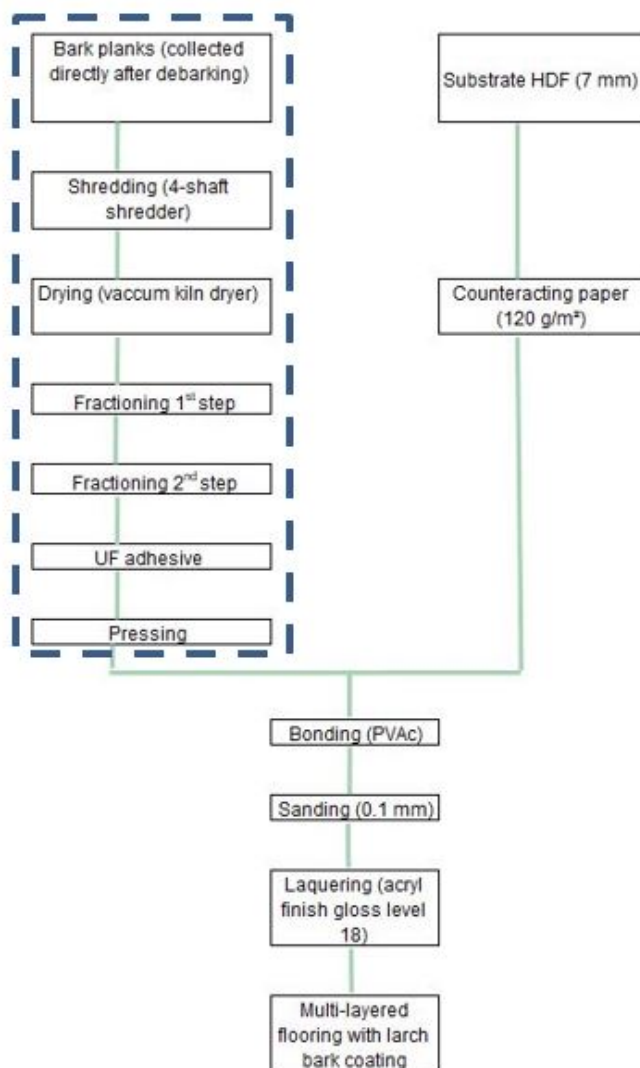


Fig. 4.
Manufacturing process of multi-layered boards with larch bark coating.

The price of the larch bark was estimated to 144.75 €/m³. The preparation of the larch bark costs about 80 €/m³. It was assumed that for the production of the 3mm larch bark coating will be one person employed, that will receive the loan for m³ product at the level of salaries for Central Europe, namely 176,8 €/m³. The loss factor for material was estimated at 9.65. The energy costs were calculated at a level of 160 €/m³. Due to the confidentiality of the contractual terms, the detailed prices would not be revealed. The distribution costs were estimated at 35.35 €/m³ and other costs at 10 €/m³. The risk costs were approximated at 0.75 €/m³.

RESULTS

The total estimated manufacturing costs of the multi-layered flooring tiles with larch bark coat-ings ranged from 10.6 to 13.4 €/m², in case of a yearly production of 5,000m² in a small-scale production plant. The 3mm wear layer of larch bark represents approximatively 13-25% of estimated costs (1.4-3.4 €/m²), in case of a board with a density of 600kg/m³. Assuming that an additional risk factor is included in the price estimation, the manufacturing cost is between 2.15 and 4.15 €/m².

When the density decreases at 500kg/m³, the manufacturing cost for the coating ranged between 0.9 and 2.1 €/m². When the density increases at 700kg/m³, the manufacturing cost can be predicted from 2.2 to 5.4 €/m², which means it is up to 19 to 29% higher than the commercial cork covering/sheet.

According to the information delivered from a reliable producer, industrial partner of this re-search, the price of a commercial flooring tile with wear layer made of agglomerated cork is estimated at 10-11 €/m², where 8-12% represents the cost of the thin layer of cork.

The manufacturing cost of the new product, 3mm wear layers of larch bark is 13 to 25% higher than the cork coating, because it was assumed a small production capacity of 5000m²/year. When the production changes from small scale to a medium size company, the manufacturing cost decreases significantly and the price of the wear layer of larch bark will be more convenient compared to cork coating.

CONCLUSION

At this stage, the manufacturing cost of the larch bark coating cannot provide a bench-mark to compete with the cork layer. Very important issues when the manufacturing cost is calculated are the production capacity, the quality of the larch bark (with or without foreign matter, e.g. earth, sand, stones), the quality (fresh or partially rotten), grain size influenced by moisture content, temperature, freshness but also the type and amount of the adhesive. In case of an established production capacity of flooring tiles (which runs in Central Europe), at least 500,000m²/year can be calculated. The investment in an adapted production line should be also take into consideration, together with the degree of amortisation and the production flow. This research showed that bark from larch, as an underutilized material, could be considered as a raw material for the flooring industry. By integrating wood bark and other similar by-products of the woodworking industry the concept of cascading use of wood (Mair & Stern 2017) will be enlarged and maybe will help to integrate it within circular economy (Fan et al. 2019).

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