Industrial testing of cork oak wood for veneer and plywood production

Javier Vázquez-Piqué[1]
Arantzazu González-Pérez[1]
Helena Pereira[2]
[1]*Departamento de Ciencias Agroforestales. Escuela Politécnica Superior*
Universidad de Huelva
[2]*Centro de Estudos Florestais, Instituto Superior de Agronomia*
Universidade Técnica de Lisboa

Abstract

The rationale behind this work is to gain further knowledge on the quality and technological properties of cork oak wood for veneer production and to open the possibility of bringing into the market another wood species for high value uses. Nowadays the economics of cork oak forests is mainly focused on cork production.

A total of 23 cork oak trees were harvested in Algarve (Portugal) and processed in one veneer and plywood industrial company (ONTE, Spain). Over 800 m^2 of veneer with 0.6 mm thickness were produced. The industrial testing proved the possibility of producing veneer from cork oak logs using the standard procedures adapted to handle the hardness of this material, namely increasing the duration of the hot water treatment. Most difficulties related to the presence of internal wood defects that decreased operational and product yields. Plywood was also produced with cork oak veneer. Both cork oak veneer and plywood had an excellent aspect and a high aesthetic visual character mainly due to the wide xylem rays that are characteristic of this species. It was also a hard wood and the veneer was very resistant to friction. The veneer characteristics suggest its use for floor components as particularly interesting.

Keywords: plywood, veneer, industrial testing, *Quercus suber*

Introduction

The cork oak (*Quercus suber* L.) is an evergreen oak species spreading in the western part of the Mediterranean area, covering around 2,200,000 ha (Natural Cork Quality Council 2004) in Southern Europe (Portugal, Spain, France and Italy) and North Africa (Morocco, Algeria and Tunisia). The cork oak forests have a high ecological value, growing in poor soils and hot and dry climates, and socio-economical importance mainly based on the production of cork for wine stoppers. The important role of cork oak is at its most in Portugal, the largest producer of cork products in the world, and a country where the cork oak forests cover 8% of the land and 21% of the forested area (D.G.R.F., 2001).

The cork oak stands have been during the last century almost exclusively oriented towards the production of cork. The cork is formed as a continuous outer layer in the bark around the stem and branches (Graça and Pereira 2004) and its removal may be carried out at periodic intervals (i.e. every 9 or 10 years) allowing a sustained production during the tree's lifetime. The research on cork oak has been therefore mainly focused on issues related to cork characterisation and production (e.g. Fortes *et al.*, 2004, Pereira and Tomé, 2004; Vázquez and Pereira, 2005).

The strong dependence of the whole system on cork production can be seen as a problem in two different scenarios:

(1) the increasing introduction of other sealant materials for wine bottling can affect the future of cork stoppers, and hence the economics of the whole system.

(2) forest management techniques for stand regeneration by the cutting of mature trees are scarce since cork is produced during the tree's lifetime and this affects the sustainability of the whole cork oak system.

The possibility of using cork oak wood brings in a further asset to this forest. Nowadays, the use of the wood component of the system is scarce and restricted to the production of less valuable products such as firewood. Very little has been investigated on the wood characteristics of cork oaks. However it is known that the cork oak wood was prized in former times due to its durability and resistance and used extensively in naval construction (i.e. in the 15th and 16th centuries it was a valued wood for hull construction). It is an oak wood with high aesthetic character that has the potential to produce high value sawn components.

An European project is underway addressing the cork oak management for an integrated wood and cork production (site Suberwood) and includes an overall wood characterisation. Anatomical features of cork oak wood have already been reported (Leal *et al.* 2006, Leal *et al.* 2007).

This work aims at gaining further knowledge on the quality and technological properties of cork oak wood in veneer and plywood production by testing it in an industrial environment, therefore opening the possibility to bring into the market another wood species for high value uses. This will also allow to integrate the wood component of the tree into the management of the cork-oak system and to increase its competitiveness as an integrated natural system with a more efficient use of renewable resources.

Experimental

Material

The material consisted in stem logs of cork oak trees harvested in Odelouca (Monchique) in the Algarve region of Portugal, profiting from a trees felling due to a water reservoir construction. This was an important aspect since there is a legal restriction on the harvest of living cork oak trees and therefore collection of wood raw-material is always dependent on the availability of legally authorized fellings and the possibility for selection of stem dimensions is limited.

The cork oak stand was a low-density uneven-aged forest and the trees were in cork production. A total of 23 trees were harvested and the stem up to the bough bifurcation was taken as a log. The logs had a mean length of 1.9 m and mean diameter of 0.48 m, with minimum values of 1.2 m and 0.31 m respectively. Only 4 logs had a length above 2.44 m. All the selected trees had already been debarked.

Industrial production of veneer

The industrial processing of the cork oak logs raw material for veneer production by slicing has been undertaken in the industrial veneer unit of ONTE (Lugo, Spain). It was the first time cork oak was processed industrially into veneer and the corresponding operational conditions were adapted from the usual procedures but using the equipment, labour and general flow sheet of the unit (Figure 1).

The preparation of logs for veneer cutting started with an initial classification according to size and form, followed by the mechanical debarking of the logs, that eliminated the bark and evened the stem. The clean logs were squared in rectangular tangential sections to optimise the pool volume for the steaming treatment and to facilitate the subsequent cutting.

A so-called steaming of the logs was made by immersion in a hot water (70-80ºC) pool during 26-32 hours for the wood softening prior to cutting. The logs were extracted from the steaming pool immediately before the veneer cutting operation, to prevent moisture and temperature losses. Any bark or stem irregularities were corrected manually to avoid damages to the cutting blade.

The veneer sheets were cut with a vertical plane type equipment with a thickness of 0.6 mm. The log was fixed to the stone bench by one of the flat sides (previously squared) and the cutting blade moved up and down. The blade was sharpened whenever notches occurred that affected the quality of the cut.

The veneer sheets were dried by passing between rollers in a hot air flow at 180ºC during 2,5 min. After drying, the veneer sheets were cut with a guillotine in a rectangular shape and defective parts were eliminated. The veneer was let to rest for 15 days for moisture content stabilisation.

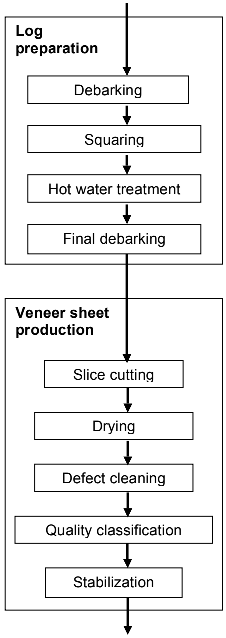

Figure 1. Flow chart for veneer production

Industrial testing in plywood

The performance of cork oak wood veneer for plywood production was tested in the same industrial unit using their usual procedures.

The raw veneer sheets were cut into a rectangular shape with high precision by laser cutting, since they have to adjust perfectly to form a larger veneer sheet to cover the board surface. The test was done in boards of 1220x610 mm instead of the standard board sizes of 2440x1220 and 2000x1000 mm due to the small dimensions of the cork oak veneer. The joining was done by stitching together side by side the veneer pieces with a glue filament.

The plywood board was covered with glue on both sides and the veneer sheets were pressed during 1.5 min at high pressure and 100ºC. Occasional fissures in the cork oak veneer were corrected manually using wood paste.

Surface smoothing with removal of glue residues was made by sanding sequentially with of 180 and 240 grain sand paper.

Several plywood boards were varnished manually.

Results and discussion

A total amount of over 800 m^2 of veneer with 0.6 mm thickness was produced from cork oak logs using the usual industrial process. The cork oak wood veneer production process had no industrial problems in itself. Cork oak was the hardest wood that this company had ever worked with, but the blade was able to perform the cutting without any particular problem and the other operations could also be applied.

The hot water treatment of the logs was carried out for 26-32 h. Although some species do not need this treatment, most require this so-called steaming to soften the wood in order to decrease the energy needed for the sheet cutting in the veneer machine, and the blade wear.

Steaming time will depend of the type of wood, temperature and stem diameter. In this case, the technical staff from the company recommended an increase of the steaming process up to 72 hours (70-80º C) in order to improve the performance of the cutting.

The overall yield obtained for the veneer cutting was 20-50 cuts/min. The veneer sheet drying was carried out at 180ºC air temperature with a yield of 10-20 m of veneer/min. The cork oak veneer did not bring any problems in the drying process and no fissures were produced or colour alterations.

The main problems were related with the quality and dimensions of the raw material. In the log batch only 17% of the logs had a length over 2.44 m, which is the standard plywood board length. At present log lengths of approximately 2 m will be the characteristic available raw-material from mature cork oaks in cork production as a result of the past cork oak forest management practices. In fact, for an easier cork extraction and an increase of debarkable area, the cork oak silviculture has formely advised to enhance low tree branching and the typical shape of a cork oak in full cork production shows a thick and short tree stem, branching with 2 or 3 main boughs (Pereira and Tomé, 2004). The more recent practices have favoured denser stands and higher branching, and therefore it can be expected that better dimensions of cork oak logs will be available in the future.

Another problem related to log quality since most of the logs (78% of the total) presented internal defects consisting in small pockets of hard tissues that seriously affected the quality of the veneer sheet. These irregularities produced notches in the blade that grated the wood surface, and affected the quality of the following veneer sheets. When this occurred the machine had to be stopped to sharpen the blade and this decreased the productivity of the whole process. More research is needed to find out the origin of such defects. It is however probable that at least some of the defects result from a tree response to occasional cambium wounding during the cork extraction process resulting into the formation of sclerified cell aggregates. However the defects in stem regions formed before the first cork extraction will not have that origin and more information is needed in relation to knot formation and characteristics in the cork oak. The presence of defects on the veneer surface also required their elimination when the rectangular sheets were cut, therefore decreasing yields and clean veneer dimensions.

Beyond these problems, the appearance of the product was excellent and presented an interesting visual character mainly due to the wide xylem rays that are characteristic of this species (Leal *et al.*, 2007). The colour was a light brown and uniform across the surface. It was also a hard wood and the veneer was very resistant to friction.

The veneer can be used in different ways, for production of plywood, floor components or craftsmanship and marquetry. The characteristics of the cork oak veneer (small pieces, frequent defects, resistance to friction) indicate that it has interesting possibilities for floor components for which natural appearance and even some wood defects have an added value. The dimensions of raw material are not a real problem since only comparatively small pieces are required for these floor components.

The industrial testing for use of cork oak veneer in plywood was also achieved using the standard procedures of the unit. The laser cutting and glue stitching of the clean pieces ran without any problems. After the high pressure and temperature pressing of the cork oak veneer onto the plywood board, some occasional fissures occurred. This defect could be corrected with good results using wood paste and following the mill practice, but further testing should optimise the combination of time, pressure and temperature for the plywood veneer gluing.

The standard varnishing of the finished cork oak plywood had no operational problems and the finished problem presented an excellent aesthetically value.

Conclusions

The industrial testing proved the possibility of producing veneer from cork oak logs using the standard procedures adapted to handle the hardness of this material, namely increasing the duration of the hot water treatment. Most difficulties related to the presence of internal wood defects that decreased operational and product yields. Plywood was also produced with cork oak veneer. Both cork oak veneer and plywood had an excellent aspect and a high aesthetic value. The veneer characteristics suggest its use for floor components as particularly interesting.

References

D.G.R.F. 2001. Direcção Geral das Florestas website - www.dgf.min-agricultura.pt.

Fortes M.A., M. E. Rosa, and H. Pereira. 2004. A Cortiça. IST Press, Lisboa

Graça J., and H. Pereira. 2004. The periderm development in Quercus suber. IAWA J 25(3): 325-335.

Leal, S., V. B. Sousa, and H. Pereira. 2006. Within and between-tree variation in the biometry of wood rays and fibres in cork oak (*Quercus suber* L.). Wood Science and technology, 40(7): 585-597.

Leal, S., V. B. Sousa, and H. Pereira. 2007. Radial variation of vessel size and distribution in cork oak wood (*Quercus suber* L.). Wood Science and technology, 41(4): 339-350.

Natural Cork Quality Council, 2004. website - www.corkqc.com.

Pereira, H., and M. Tomé. 2004. Cork Oak. In: Burley, J., Evans, J., Youngquist, J.A. (eds) Encyclopaedia of forest sciences. Academic Press, pp 613-620.

SUBERWOOD website. http://www.suberwood.com.

Vázquez,J., Pereira,H., 2005. Mixed models to estimate tree oven-dried cork weight in Central and Southern Portugal. For. Ecol. Manage. 213, 117-132.