Doctoral Thesis

Investigation and development of thermal insulation properties of natural tree bark

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Sopron
2015

Doctoral Thesis

University of West Hungary
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Abstract

The doctoral thesis summarizes the studies on the thermal insulation capacity of bark and development of a new insulation substance. Barks are available in Hungary in large quantities, but they are not widely used as insulation material. After the presentation of general heat insulation and anatomical knowledge, the thesis devoted a large part on the literary review of the bark, since so far the demonstration of the systematic use of the bark is missing in the literature. So my thesis is trying to make up for this gap.

Thermal conductivity properties of both broadleaved and coniferous tree species were studied during the examination. Based on these results, the scopes of the tested species were further narrowed, while we got the best results showing black locust. The effect of compression on the thermal insulation capacity of grained bark was examined, and the different fractions were produced made of grained bark. Furthermore, the heat insulation capacities of bark sheets were investigated until we reached the best result for material combinations. We examined the bark sheets formaldehyde emissions and three broadleaved trees vaper permeability was also determined.

1. Introduction, aim of the research

Nowadays, the importance of improving insulation property of different insulation materials is more and more emphasized. Moreover, several investigations proved that using wood as building material results less CO2 emission with lower energy intake, reusable and thus it is more environment friendly than other building materials.

In Hungary, primary wood processing produces about 600 thousand cubic meters of bark every year. In most cases, with adequate preparation, the insulation capacity of bark chips used mostly as by-product is comparable to that of the commonly used rock and glass wool and foam insulation materials.

In the present research the heat insulation capacity of different chipped coniferous and a broadleaves wood bark was investigated.

2. Materials and methods

In the first part of the work five bark species were measured such as black locust (Robinia pseudoacacia), pannónia poplar (Populus euramericana cv. Pannónia), larch (Larix decidua), spruce (Picea abies) and scots pine (Pinus silvestris). The measurements were done in wet condition and in comparison at 12% water content as well. Based on the results, the group of tested species were further narrowed. The chosen broadleaved timber species are black locust (Robinia pseudoacacia), the poplar clone 'Pannonia' (Populus euramericana cv. Pannonia) and the oak (Quercus robur L.). All three species have especially big bark-to-wood proportion of about 12–20 % based on the diameter of the trunk; however, their barks contains a lot of additional incrustation substances, and therefore are not suitable for mulching. Nevertheless, the high content of incrustation substances provides an advantage with respect to resistance to decay and therefore increases the durability. Based on the best results, the bark of black locust was further investigated.

The change in the thermal conductivity of three broadleaved species was tested with compression method. Acacia showed the best results, therefore different thicknesses of glued sheets of acacia were used to establish the ideal adhesive thickness. Various fractions of the acacia bark were prepared and then compression thermal conductivity tests were carried out. Three fractions were used for preparation of bark sheets. Formaldehyde emission of the bark sheets was also tested. We had the opportunity to investigate the natural vapour permeability of the natural bark of three wood species. Results of these experiments will be analysed and opportunities for further research will be determined.

3. Conclusions

Findings suggest that in addition to the species, the wood moisture content has also a decisive influence on the thermal insulating ability of chips. Our results clearly demonstrate that wood chips produced from the bark of some wood species can be used successfully as insulation material.

The CO2 balance of wood bark is excellent facing other generally used insulation materials. The bark is mainly “byproduct” of wood industry and the bark insulation can be reused on the end of life cycle.

Based on the vapour permeability studies we can say that vapour permeability of natural (acacia) bark is outstanding.

After examining the formaldehyde emission it was determined that this parameter is much lower in the bark sheets than the allowable limit. Thus it can be concluded that the bark has formaldehyde absorption capacity.

4. New scientific results of the PhD thesis:

1. The measurements clearly show the role of moisture content – similarly to the wood – in the insulating ability of bark chips. Because of the high specific heat and good thermal conductivity of the water, the thermal conductivity values of the system is influenced unfavourably. The water fills partly the cell cavities and in the cell wall also provides a better "thermal contact", and the water vapour is able to carry large amount of heat because of its high specific and latent heat. Based on the measured results I determined the percentage of heat transfer coefficient change caused by 1% change in the moisture content. results in a change.

2. Tests were carried out to determine vapour permeability of three species of bark. I found that the bark of the has substantially better vapour permeability than the wood, therefore, more suitable for insulation.

3. It was found that the thermal conductivity of the bark varies depending on the particle size. The fine grain bark gave the best results. It was also concluded that the fraction analysis is essential to making the bark sheets, because the bark powder having smaller particle size than 1mm has a negative effect on sticking.

4. After examining the formaldehyde emission it was determined that this parameter is much lower in the bark sheets than in other particleboards. Formaldehyde is present in bark sheets in in much lower amount than the permissible content described in the standard.

5. I developed an insulating cover, which has a similar thermal insulation values than the currently used general insulation products.

Publications

Publications in scientific journals written in Hungarian:

1. **RONYECZ, I. – PÁSZTORY, Z. (2015): A tölgy, a nyár és az akác kérgének hőszigetelő képessége (Heat insulation capacity of oak, poplar and black locust bark), Faipar 63:(2) pp. 24-28. (2015)**

2. **RONYECZ, I. – PÁSZTORY, Z. (2013): Természetes állapotú tölgyfakéreg hőszigetelési tulajdonságainak vizsgálata, Tavaszi szél konferenciakötet, ISBN 978-963-89560-2-6, Budapest**

3. **RONYECZ, I. – MOHÁCSI, K. – PÁSZTORY, Z. (2012): Néhány hazai fafaj kérgének hőszigetelő képessége, Faipar – A faipar műszaki tudományos folyóirata, LX. évf. 1. szám 16-21. oldal**

Publications in edited scientific journals written in foreign language:

4. **RONYECZ, I. – PÁSZTORY, Z. (2013): The Thermal Insulation Capacity of Tree Bark, Acta Silvatica & Lignaria Hungarica, Volume 9., 111-117**

5. PÁSZTORY, Z. – BÖRCSÖK, Z. – RONYECZ, I. – MOHÁCSI, K. – MOLNÁR, S. (2014): Oven dry Density of Sessile Oak, Turkey Oak and Hornbeam in different region of Mecsek Mountain, Wood Resarch, 59 (2): 2014; 683-694

Desktop publishing, publishing details:

6. **PÁSZTORY, Z. (szerk.), MOHÁCSINÉ RONYECZ, I. (tech. szerk.) (2015): Fában a jövő: Természetes alapú szigetelő anyagok fejlesztése, pp 44-47, ISBN 978-963-359-043-0, Nyugat-magyarországi Egyetem Kiadó**

Publications in scientific journals written in Hungarian:

7. **RONYECZ, I. (2013): Az építőanyag hatása a környezetre, Magyar Asztalos 2013/12. szám**
8. **RONYECZ, I. – MOHÁCSI, K. (2013): Hőszigetelés – ez csak természetes, Gerendaházak, ISSN 1787-62X, VIII/1. szám**
9. **RONYECZ, I. (2013): Kéregből szigetelést? Gerendaházak, ISSN 1787-62X, VIII/4. szám**
10. **RONYECZ, I. (2011): Faház kontra CO_2, Gerendaházak – Rönk, gerenda és könnyűszerkezet, VI. évf. 2. szám 11. oldal**

Publications in electronic written in Hungarian:

11. **RONYECZ, I. (2013): Hőszigetelés – ahogy elkezdődött, Fatáj- online szaklap**
12. **RONYECZ, I. (2013): Természetes fakéreg hasznosítása, Egyetemi honlapon megjelent tanulmány**
13. RONYECZ, I. – MOHÁCSI, K. (2013): A hengeresfa nedvességtartalmi mintavételezése során felmerülő hibalehetőségek, Egyetemi honlapon megjelent tanulmány
14. RONYECZ, I. (2009): Nanotechnológia a papír újrahasznosításában, FATÁJ - online szaklap, Sopron 2009. június 16.

Publications in conference proceedings written in foreign language:

15. **RONYECZ, I. – PÁSZTORY Z. (2012): Thermal insulation capacity of chipped oak bark in different compress**ion level, **The International Academy Of Wood Science (IAWS), Zvolen**
16. RONYECZ, I. – PÁSZTORY Z. (2013): Development of new heat insulation system, Resarchers & Producers V – 4, pp 4-9
17. PÁSZTORY Z. - RONYECZ, I. (2013): Moisture effect to the thermal conductivity, Annuel Meeting of International Academy of Wood Science 2013 (IAWS), Nanjing

Publications in conference proceedings written in Hungarian:

18. RONYECZ, I. (2009): Nanotechnológia a papír újrahasznosításában, XXIX. Országos Tudományos Diákköri Konferencia, Agrártudományi szekció, Erdészeti és Faipari tagozat, Gödöllő, 2009. április 6-8.,

19. RONYECZ, I. – MOHÁCSI, K. (2011): Kéregből szigetelést? XXX. Országos Tudományos Diákköri Konferencia, Agrártudományi szekció, Erdészeti és Faipari tagozat, Keszthely

20. RONYECZ, I. (2011): Természetes fa és kéreg anyagok hőszigetelési tulajdonságainak vizsgálata és fejlesztése, Doktorandusz konferencia kiadvány

21. RONYECZ, I. (2012): Természetes fa és kéreg anyagok hőszigetelési tulajdonságainak vizsgálata és fejlesztése, Doktorandusz konferencia kiadvány

22. RONYECZ, I. (2013): Természetes fakéreg anyagok hőszigetelési tulajdonságainak vizsgálata és fejlesztése, Doktorandusz konferencia kiadvány

23. MOHÁCSINÉ RONYECZ, I. – PÁSZTORY Z. (2014): Természetes állapotú tölgyfakéreg hőszigetelési tulajdonságainak vizsgálata, Lignocellulózok energetikai hasznosításának műszaki vonatkozásai, ISBN 978-963-334-190-2

Poster presentations written in foreign language:

24. RONYECZ, I. – MOHÁCSI, K. – PÁSZTORY, Z. (2014): Errors of Sampling Based Moisture Contect Measurment of Wood, SWST International Convention, Sustainable Resources and Technology for Forest Products, Zvolen

Presentations:

25. RONYECZ, I. (2007): Nanotechnológia a papír újrahasznosításában, Tudományos Diákköri Konferencia, 1. hely, Sopron

26. RONYECZ, I. (2008): Nanotechnológia a papír újrahasznosításában, Tudományos Diákköri Konferencia, 2. hely, Sopron

27. RONYECZ, I. (2009): Nanotechnológia a papír újrahasznosításában, XXIX. Országos Tudományos Diákköri Konferencia, Agrártudományi szekció, Erdészeti és Faipari tagozat, Gödöllő

28. RONYECZ, I. – MOHÁCSI, K. (2010): Kéregből szigetelést? Tudományos Diákköri Konferencia, 3. hely, Sopron

29. RONYECZ, I. (2011): Természetes fa és kéreg anyagok hőszigetelési tulajdonságainak vizsgálata és fejlesztése, Doktorandusz konferencia, Sopron

30. RONYECZ, I. – MOHÁCSI, K. (2011): Kéregből szigetelést? XXX. Országos Tudományos Diákköri Konferencia, Agrártudományi szekció, Erdészeti és Faipari tagozat, Keszthely

31. **RONYECZ, I. (2012): Természetes fa és kéreg anyagok hőszigetelési tulajdonságainak vizsgálata és fejlesztése, Doktorandusz konferencia, Sopron**

32. **RONYECZ, I. – PÁSZTORY Z. (2012): Thermal insulation capacity of chipped oak bark in different compression level,** The International Academy Of Wood Science (IAWS), **Zvolen**

33. **RONYECZ, I. – PÁSZTORY Z. (2013): Természetes állapotú tölgyfakéreg hőszigetelési tulajdonságainak vizsgálata, Tavaszi szél konferencia, Sopron**

34. TOLVAJ, L. - RONYECZ, I. – PÁSZTORY Z. (2013): Környezettudatos anyagok, TÁMOP nyitókonferencia

35. **RONYECZ, I. (2013): Természetes fakéreg anyagok hőszigetelési tulajdonságainak vizsgálata és fejlesztése, Doktorandusz konferencia, Sopron**

36. RONYECZ, I. – PÁSZTORY Z. (2013): Development of new heat insulation system – Mirrorpanel implementation, Resarchers & Producers V - 4, Sopron

Utility model:

37. *PÁSZTORY, Z. – RONYECZ, I.* (2010): Többrétegű hőszigetelő panel, Használati mintaoltalom, lajstromszám: P 1000 190

38. *MOHÁCSI, K. – KANTÓ, Z. – RONYECZ, I. – PÁSZTORY, Z.* (2013): Mintaforgács zsákkal ellátott faforgács mennyiség szelektáló adapter, Használati mintaoltalmi bejelentés