

PAPER • OPEN ACCESS

Production Technology of Heat-Insulating Material on the Basis of Woodworking Waste

To cite this article: V Rudskikh *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **753** 052011

View the [article online](#) for updates and enhancements.

Production Technology of Heat-Insulating Material on the Basis of Woodworking Waste

V Rudskikh¹, V Pukhova¹, A Bobrik¹

¹Civil Engineering Institute, Siberian Federal University, 660041, Krasnoyarsk, 82 Svobodny Ave., buildings No. 23-24, Russia

E-mail: vitos2604@inbox.ru

Abstract. The creation of new thermal insulation materials in the conditions of critical rise in the cost of energy resources is due to the energy saving policy. The most important characteristics of such materials are energy efficiency and effectiveness and environmental friendliness. Scientists of the Siberian Federal University developed a thermal insulation material based on waste wood processing industry. A distinctive feature of the proposed material is cavitation processing of raw materials. The production technology is the following: wood waste as part of the aqueous suspension go through cavitation treatment with the help of a high-speed mixing plant, then the suspension is kept in room conditions for a day, after that the raw material is subjected to hot pressing. As a result of such sequence of technological actions we get the competitive heat-insulating material on heat engineering qualities close to analogues, but with much lower prime cost of its production. Another important feature of this material is the ability to control its final qualities, depending on the mode and duration of cavitation processing.

1. Introduction

Modern trends in the development of recycling technologies involve the use of waste, which is determined by the necessity to reduce the anthropogenic load and is an economically reasonable solution from the point of view of resource saving. One of the areas of recycling is the use of waste wood processing industry to produce construction products and materials. Before obtaining the necessary building material, the sawdust is preprocessed to improve the technical characteristics of the future product. The result of the production process is a new thermal insulation material from woodworking waste.

2. Literature review

Trends of ecologization of production and development of recycling technologies were considered in works of domestic and foreign authors (V. N. Ignatiev [1], E. N. Abanina, A. V. Popkov [2], T. V. Malysheva, A. I. Shinkevich [3], A. P. Mogirev, Yu. A. Armless [4], G. S. Sagdeev, G. R. Patrakova [5], Khudyakova, G. I., D. A. Danilova [6], M. I. Shahidul, M. L. Malcolm [7], A. Kharazipour, U. Kues [8], I. Jijin, P. Rinitha [9], T. S. Thandavamoorthy [10] H. Binici, S. Amany [11], N. Phonphuak, P. Chindaprasirt [12]), the analysis of their works allows to conclude that recycling technologies are paid much attention in the modern world, that is connected with the large-scale environmental pollution caused by the enterprises of the industry. Possible ways of using waste wood processing industry have become the subject of research by many scientists, experts, technologists. For example,



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

in their work G. I. Khudyakova, D. A. Danilova [6] proposed the use of wood waste as an energy resource, while other authors (T. S. Thandavamoorthy [10], N. Phonphuak, P. Chindaprasirt [12] G. Viruthagiri, S. N. Nareshananda [13], E. Bwayo, S. K. Obwoya [14] S. Abdulhadi [15], I. N. Chelysheva, N. P. Carpenters [16]) considered the use of wood waste as aggregate for composite concrete and refractory bricks. Colleagues from the Siberian Federal University S. I. Vasiliev, and V. M. Melkozerov suggested to use wood filler for insulation secondarily soils, and many of the authors (H. Binici, S. Amany [11] A. A. Lucas, N. P. Lukutsova [17], M. V. Shelepen [18], A. N. Ivanikov, V.-M. [19], T. Li, J. Song [20] F. Asdrubalia, F. D'alessandro [21]) propose to use the wood waste for the production of various composite materials, e.g., corrugated plates [17], a composite material of wood of soft deciduous species [18], plate materials made of pine, sunflower husk, shells of oats, and buckwheat [19]. Article T. Kawasaki, S. Kawai [22] proves that research to create materials of woodworking is held for a long time, and the article of the authors T. Li, M. Zhu [23] about analog glass which is obtained from waste wood, as well as the authors' article Z. Pásztor, T. Horváth [24] on the thermal insulation system made of wood and paper, allows us to judge the impressive success of scientists in the field of application of woodworking waste.

3. Purpose of the study

The initial goal of the research was to create a fundamentally new method for receiving sawdust insulation with high thermal insulation properties, based on the use of hydro thermodynamic cavitation. After receiving the prototypes of the required quality, a technological map for the production of this material was developed, and then an economic study was conducted to determine the cost and assess the profitability of the production of the material on an industrial scale.

4. Technology

During the research, all parameters of the technological process affecting the characteristics and quality of the final product were determined experimentally, as a result, a technological map was developed for the production of thermal insulation material based on cavitation-modified waste of wood processing production.

The technological map establishes the sequence of technological operations necessary for the manufacture of a single plate of thermal insulation material with a thickness of 15 [mm]. The technological process consists of the following operations: delivery of wood waste, the preparation of components of the slurry, cavitation processing, pouring the slurry into a bale form, exposure of the workpieces under ambient conditions, hot pressing, release of finished plates and delivery to the place of storage. The minimum necessary equipment for such production is a high-speed mixing plant capable of creating a turbulent mode of mixing the suspension, as well as a hot-pressing plant.

The production scheme described in the technological map is semi-automatic. After a risk assessment of the market's launch of new product and opportunities of the enterprises of timber processing complex, it was concluded that at relatively low initial production volumes such ratio of manual and mechanized labor will be optimal from the point of view of the balance between the required investment and the income from the sale of manufactured material. 2-3 people are necessary for producing, thus the main part of works is conducted by machines that allows to reduce influence of the human factor on quality of final production. The volume of material produced will be about 800 [m³] per year.

5. Economy

According to the technological map for the production of thermal insulation material, the cost of its production was calculated. The main cost items were the cost of materials, machines and mechanisms and wages.

Table 1. Production cost of 1 m³ of thermal insulation material.

Cost element name	Sum, (rubles)
Materials, incl.	425.36
Water	6.86
Electricity	418.5
Machines and mechanisms	165.65
Wages	314.60
Measures to reduce the flammability of the material (optional)	149.53
TOTAL (with the flammability of the material G4 / G2)	905.61 / 1055.14

The cost of the suggested insulating material made up 905,61 RUB/m³ for the material group flammability G4 1055,14 RUB/m³ for the material group flammability G2.

To justify the economic efficiency, the comparison of the proposed material with other thermal insulation materials is suggested. It is proposed to calculate the cost of construction of walls using various thermal insulation materials, depending on a particular material and also, we take into account structural and waterproofing elements that make up the wall. The following materials were considered: mineral wool plates, expanded clay gravel, plates of extruded polystyrene, foam concrete blocks, eco-wool, arbolite blocks.

The city of Norilsk, located in the harsh Arctic conditions in the North of the Krasnoyarsk territory, was chosen as the construction site. In accordance with [25], the normalized value of the reduced resistance to heat transfer for Norilsk is 5.26 [m²·°C / W]. Further, taking into account the normalized value of the reduced resistance to heat transfer, as well as the value of the resistance to heat transfer of structural enclosing elements of the walls, the calculation of the necessary thicknesses of thermal insulation elements was carried out.

The results showed that the insulation of the walls of the proposed material is the most cost-effective.

Table 2. Comparison of structural variants of the wall device.

Wall construction	Thickness of layers [mm]	Cost of materials per [m ²]	The cost with installation [m ²]
1.Windscreens	-	30	
2.OSB plate	12	256	
3.Mineral wool board	200	360	
4.Vapor barrier	12	20	1048
5.OSB plate	-	256	
Load-bearing wooden structures	-	126	
1.Brick	120	552	
2.Clay gravel	400	600	2872
3.Claydite-concrete	400	1720	4400

Wall construction	Thickness of layers [mm]	Cost of materials per [m ²]		The cost with installation [m ²]
1.Windscreens	-	30		
2.OSB plate	12	256		
3.Extruded polystyrene	150	638		
4.Vapor barrier	-	20	2922	4450
5.OSB plate	12	256		
Load-bearing wooden structures	-	90		
Solid masonry of foam concrete blocks	800	2200	2200	3400
1.Windscreens	-	30		
2.OSB plate	12	256		
3.Ecowool	175	273		
4.Vapor barrier	-	20	953	2100
5.OSB plate	12	256		
Load-bearing wooden structures	-	108		
Solid masonry of arbolite blocks	500	1950	1950	2500
1.Windscreens	-	30		
2.OSB plate	12	256		
3.Material from waste wood	165	223		
4.Vapor barrier	-	20	893	2000
5.OSB plate	12	256		
Load-bearing wooden structures	-	108		

Evaluation of the effectiveness of the project implementation showed that capital investment (IO) in the amount of 2.1 million rubles discounted payback period (DPP) will be about 5 years, the internal rate of return (IRR) of 19%, the net present value (NPV) – 614,4 thousand rubles, while the horizon of calculation (n) in 6 years.

It should also be noted that the State Duma has adopted a draft law on amendments to the law on mandatory utilization of wood waste, the date of entry into force of which is tentatively designated to the year 2022.

6. Summary

Among the advantages of the material efficiency, environmental friendliness, energy efficiency, low resource demand. Disadvantages-flammability and low strength. A high degree of combustibility can be reduced with the help of flame-retardant impregnations and corrugated foil, and low strength is not a serious disadvantage for the thermal insulation material.

The study showed that with relatively small capital investments, it is possible to offset part of the costs that will arise in woodworking enterprises within the framework of waste disposal activities.

It is supposed to develop fully automatic production lines for the production of material on an industrial scale, however, it is necessary to bring the material to the market and assess the demand. The development of fully automatic production lines is a technically complex task that requires the participation of specialists from various fields, which is advisable only if there is a steady demand for the material.

References

- [1] Ignatiev V N 2017 Ecologization of production *Prospects for development in the 21st century, Modern aspects of the economy* **11** pp 18-21
- [2] Abanina E N, Popkova V A 2017 Ecologization of production in the Russian Federation: implementation mechanism *experience of foreign countries Eurasian law journal* **5** pp 288-291
- [3] Malysheva T V, Shinkevich A I 2017 Economic aspects of ecologization of industrial production *journal of NGIEI* **8** pp 129-141
- [4] Mogirev A P, Bezrukikh J A, Medvedev S O 2015 the Processing of wood wastes of timber industry complex as a factor of sustainable natural resources management *Engineering journal of don* **2** ID 3011
- [5] Sagdeev G S, Patrakova G R 2014 Processing of production wastes and consumption with the use of their resource potential *Vestnik Kazanskogo technological University* **6** vol 17 pp 194-198
- [6] Khudyakova G I, Danilova D A and Khasanov R R 2017 The use of urban wood waste as an energy resource *IOP Conf. Series: Earth and Environmental Science* **72** ID 012026
- [7] Shahidul M I, Malcolm M L, Mohammed S J Hashmi 2018 Waste Resources Recycling in Achieving Economic and Environmental Sustainability: Review on Wood Waste Industry *Reference Module in Materials Science and Materials Engineering* pp 1-10
- [8] Kharazipour A, Kües U 2007 Recycling of Wood Composites and Solid Wood Products, Wood production, wood technology, and biotechnological impacts *Universitätsverlag Göttingen* pp 509-533
- [9] Jijin I, Rinitha P 2016 Effective Recycling and Use of Wood Carving Waste in Wood Industry *IOSR Journal of Mechanical and Civil Engineering* pp 20-30
- [10] Thandavamoorthy T S 2015 Wood waste as coarse aggregate in the production of concrete *European Journal of Environmental and Civil Engineering* **2** pp 125-141
- [11] Binici H, Amany S, Sohail H 2016 Thermal, sound and radiation properties of insulation materials made with sawdust, wheat, sunflower, ashes of corn stalks and egg white *European Journal of Engineering and Technology* **4** pp 11-17
- [12] Phonphuak H, Chindapasirt P 2015 Types of waste, properties, and durability of pore-forming waste-based fired masonry bricks *Eco-Efficient Masonry Bricks and Blocks. Design, Properties and Durability* Woodhead Publishing pp 103-127
- [13] Viruthagiri G, Nareshananda S N, Shanmugam N 2013 Analysis of Insulating Fire Bricks from Mixtures of Clays with Sawdust Addition *Indian Journal of Applied Research* **3** 469-473
- [14] Bwayo E, Obwoya S K 2014 Coefficient of Thermal Diffusivity of Insulation Brick Developed from Sawdust and Clays *Journal of Ceramics* ID 861726
- [15] Abdulhadi S 2017 Study of thermal insulation and some mechanical properties for hybrid composites (cement – wood sawdust) *International Journal of Computation and Applied Sciences* **3** pp 212-216
- [16] Chelysheva I N, Plotnikov N P, Afanasieva N A 2017 Improvement of technology for obtaining wood composite materials *Forest Bulletin* **5** pp 75-82
- [17] Lucas A A, Lukutsova N P 2014 Corrugated cardboard plate – effective heat-insulation material *Building materials* **10** pp 24-27
- [18] Shelepen M V 2017 Composite materials from the wood of soft hardwoods *Innovations in construction* **1** pp 171-175
- [19] Pankov A N, Baushev O S, Volodkova M V 2015 Composite building materials from wastes of agriculture and woodworking industry *Biotechnology and society in the XXI century* pp 115-118
- [20] Li T, Song J, Zhao X, Yang Z, Pastel G, Xu S, Jia C, Dai J, Chen C, Gong A, Jiang F, Yao Y, Fan T, Yang B, Wagberg L, Yang R, Hu L 2018 Anisotropic, lightweight, strong, and super thermally insulating nanowood with naturally aligned nanocellulose *Science Advances* **4** ID 3724

- [21] Asdrubalia F, D'Alessandro F, Schiavoni S 2015 A review of unconventional sustainable building insulation materials *Sustainable Materials and Technologies* **4** pp 1-17
- [22] Kawasaki T, Kawai S 2006 Thermal insulation properties of wood-based sandwich panel for use as structural insulated walls and floors *Journal of Wood Science* **52** pp 75-83
- [23] Li T, Zhu M, Yang Z, Song J, Dai J, Yao Y, Luo W, Pastel G, Yang B, Hu L 2016 Wood Composite as an Energy Efficient Building Material: Guided Sunlight Transmittance and Effective Thermal Insulation *Advanced Energy Materials* **6** ID 1601122
- [24] Pásztor Z, Horváth T, Glass S V, Zelinka S L 2016 Thermal Insulation System Made of Wood and Paper for Use in Residential Construction *Forest Products Journal* **65** pp 352-357
- [25] SP 50.13330.2012 Thermal protection of buildings Updated version of SNiP 23-02-2003 Ministry of regional development of Russia