UDC 666.973.2:666.972.1

NOILS OF FLAX FIBER AS AN AGGREGATE FOR HEAT-INSULATING PLATES

SERGEY ROMANOVSKIY, NADZEZHDA DAVYDENKO
Polotsk State University, Belarus

Heat-insulating materials on the basis of flax fiber are considered. It was offered to use waste of flax-processing plants – noils flax fiber as a fibrous aggregate for production of a heater. The results of the carried-out testing testify greater efficiency of heat-insulating materials from noils fiber in comparison with heaters on the basis of flax fibers.

It is impossible to call the market of heat-insulating materials underdeveloped – heaters of various groups attract consumers' attention. The most widespread heat-insulating materials are as follows: mineral (glass wool, fibers-based product of working off of blast furnaces, and also rocks), synthetic (received as a result of thermal and chemical processes – for example, polyfoam) and natural materials. The last group is less widespread and respectively less popular with users, though it doesn't give way to recognized materials. And taking into account the increasing requirements to ecological purity of heaters, the use of vegetable raw materials for production of heat-insulating materials is especially urgent. Herewith new heat-insulating materials have to possess a complex of the operational characteristics providing formation of a favorable microclimate of rooms and economy of thermal energy at the operation of buildings. Nowadays natural heaters from hemp, cellulose, cane, pith agglomerate are produced, but flax thermal insulation is one of the best according to its heat and technical indicators [1].

The Belarusian company JSC «AKOTERM FLAKS» offers heat-insulating plates of flax fiber (85%) with a binding component – the conjugate polyester fiber (15%) which is regularly distributed throughout the volume of the plate [2]. This material is optimum for low construction and is used for internal and external warming of walls. The durable natural heat-insulating "breathing" material possesses the following physic-mechanical characteristics: density of 30 kg/m^3, heat conductivity rate of 0,038 Watt/(m·ºC), sound-absorption rate of 0,84 (100 –4000 Hz), vapor permeability rate of 0,4 mg/(m·h·Pa), group of combustibility – G4, service life – 70 years and more.

The heat-insulating plates «Ekoteplin» manufactured in Russia have the following compounds of components: linen fibers are used as filler, natural starch is used as binding, and salts of boron are applied as fire- and bioprotection [3]. The production technology of a heater provides receipt of plates with uniform structure, without the use of synthetic additives. Plates apply both in low construction, and for warming and sound insulation of apartments. The heater of «Ekoteplin» is a hypoallergenic material and is completely safe for health. At the density of 32 kg/m^3, heat conductivity rate is 0,038 Watt/(m·ºC), sound-absorption rate is 0,84, vapor permeability rate is 0,4 mg/(m·h·Pa) at group of combustibility G1. Service life of material is not less than 60 years.

The task of conducting a research of noils of flax fiber as the main component of heat-insulating material is set in the work Samples of a heater were formed from flax noils, and also from mix of fibers and noils of flax at a ratio 80:20. Noils of flax fiber and the mixture of fibers and of noils of flax fiber were used as aggregates in the samples of heaters. Flax fibers up to 90 cm long were used in the research. Noils of flax present themselves departure in the form of short fibers 5–10 cm long, received when carding of the scutched flax. Liquid sodium glass was used as a binder, providing rigidity and durability of heat-insulating material, and also increasing resistance of noils and fibers of flax to burning. The results of the researche are given in table 1.

Table 1 – Physicomechanical characteristics of heat-insulating plates

Composition No.	Expense of components per 1 m^3 (fraction from a unit)			Density, kg/m^3	Heat conduction rate, Watt/(m·ºC)	Durability on compression at 10% of deformation, MPa
	flax fiber	noils flax fiber	liquid sodium glass			
1	0,74	0,19	0,07	70	0,038	0,026
2	-	0,93	0,07	70	0,034	0,025
3	0,65	0,17	0,19	85	0,04	0,032
4	-	0,81	0,19	85	0,035	0,03
5	0,58	0,15	0,27	100	0,043	0,043
6	-	0,73	0,27	100	0,037	0,04

The analysis of the results of compounds 1 and 5 showed that increase in a consumption of liquid sodium glass leads to increase in heat conductivity rate by 0,005 Watt/(m·°C) and durability on compression at 10% of deformation by 65 per cent. Also there is an increase in durability by 60 per cent and heat conductivity rate by

0,003 Watt/(m·°C) at compound 6 in comparison with characteristics of compound 2. The analysis of physico-mechanical characteristics shows that application of noils of flax as an aggregate (compounds 2, 4, 6), instead of mix of fiber and noils of flax (compounds 1, 3, 5), at the identical density of heaters, heat conductivity decreases by 0,004–0,006 Watt/(m °C), and material durability practically doesn't change. When comparing the received results of compounds 2, 4 and 6 with characteristics of the heat-insulating materials "AKOTERM FLAKS" and "Ekoteplin" it was established that at increase in average density of experimental compounds on 40–70 kg/m^3 there is a decrease in heat conductivity rate to 0,034–0,037 Watt/(m·°C), when ensuring durability on compression at 10% of deformation at the level of 0,025–0,04 MPa and group of combustibility G1.

Rather often in operating process heat-insulating materials can be in conditions of the increased humidity of air or be exposed to moistening as a result of violation of a integrity and leakages of a covering of a roof or the ventilated facades [4]. For ensuring durability of heat-insulating materials in such service conditions, first of all, it is necessary to provide the water resistance of liquid sodium glass as the binding heater component. On this purpose, the study of liquid sodium glass in water resistance according to methodology described in [5] was additionally carried out. Solubility of binding was determined by a drying method with the use of flannel fabric. Samples of flannel fabric with the size of 100×100 mm impregnated with liquid sodium glass, dried up in a drying cabinet at a temperature of 80–110 °C. On reaching constant weight samples cooled and immersed in the container with water with a temperature of 20 ± 5 °C. 2 hours later flannel samples with a binder were taken from capacity. To remove the surplus of water the fabric was hung in a free state for 30 minutes. Then the samples of flannel were placed in a drying cabinet and on reaching constant weight the fabric was weighed. Further the samples were immersed in the container with water again, dried up and weighed. The number of experiments was defined by the constancy of mass the three consistently dried up flannel samples. Change of mass of samples was expressed as a percentage. Before and after soaking and drying determined a relative indicator of solubility by the size of change of mass of the impregnated flannel samples binding and the insoluble rest (water resistance). The received samples were tested 1 day later, after t full drying. Liquid sodium glass without additives after the first cycle was exposed to considerable dissolution, and the insoluble rest on weight made 24%. After the second cycle of tests the firm phase of liquid glass wasn't recorded.

During the tests for water resistance 8% of additive of lime and plaster from the mass of binding was used, replacing liquid sodium glass. In the course of hashing the binder with additives lime was added first, and gypsum was the second to be added. Adding of 16% of Ca (OH) 2 + CaSO4 led to the formation of 99% of the insoluble rest after 4 cycles of tests.

The influence of additives on heat conductivity and durability on compression at 10% of deformation of heat-insulating plates was also investigated. Table 2 shows data on the effect of lime and gypsum on physical and mechanical properties of the insulation.

Table 2 – Physico-mechanical characteristics of heat-insulating plates

Composition No.	Expense of components on 1 m^3 in shares from unit				Density, kg/m^3	Heat conduction rate, Watt/(m·°C)	Durability on compression at 10% of deformation, MPa
	noils flax fiber	liquid sodium glass	lime	gypsum			
1	0,84	0,16	-	-	92	0,035	0,028
2	0,84	0,134	0,013	0,013	92	0,035	0,028
3	0,72	0,28	-	-	102	0,037	0,041
4	0,72	0,0236	0,022	0,022	102	0,037	0,041

As the results of the experiments show, there were no recorded changes of values of density, heat conductivity and durability on compression at 10% of deformation after adding lime and plaster (compounds 2, 4). Thus, the use of additives not only doesn't worsen physico-mechanical indicators of a heater, but also provides the water resistance of liquid sodium glass and as a result durability of heat-insulating material increases.

Conclusions. The conducted researches confirmed the possibility of use of noils of flax fiber for the production of effective heat-insulating material. The heater on the basis of this filler including liquid sodium glass is environmentally friendly and safe for people. Additives like lime and plaster in quantity of 8% of the mass of the binder contribute to the increase in water resistance of liquid sodium glass up to 99%. At the identical density of samples the indicators of heat conductivity rate, durability on compression at 10% of deformation are identical with the characteristics of compounds without additives.

In comparison with the existing heat-insulating materials on the basis of flax fiber the developed heater has a lower coefficient of heat conductivity of 0,034–0,037 Watt/(m·°C) and belongs to the group of combustibility G1. Unlike analogs, the developed heat-insulating material has durability at 10% of deformation of 0,025-

0,04 MPas, which allows to expand its use, including warming of the ventilated facades and roofs, and the arrangement of termoshuba.

The use of noils of flax fiber for the production of heat-insulating materials solves a problem of utilization of vegetable waste of a flax-processing and expands the nomenclature of natural effective heaters.

REFERENCES

1. Льняной утеплитель: обзор натуральных утеплителей из льна [Электронный ресурс] / Remontami. – Режим доступа: http://remontami.ru/lnyanoj-uteplitel-obzor-naturalnyh-uteplitelej-iz-lna/. – Дата доступа: 25.01.2017.
2. Акотерм флакс [Электронный ресурс] / АКОТЕРМ. – Режим доступа: http://akoterm.by/ru_RU/льняная-теплоизоляция/. – Дата доступа: 25.01.2017.
3. Экотеплин – льняной утеплитель [Электронный ресурс] / ЭКОПЛАНЕТА. – Режим доступа: http://www.ekoplaneta.su/eco_shop/for_in/ekoteplin/. – Дата доступа: 25.01.2017.
4. Давыденко, Н.В. Теплоизоляционные плиты на основе отходов растениеводства и неорганического вяжущего : дис. … канд. техн. наук : 05.23.05 / Н.В. Давыденко. – Новополоцк, 2015. – 121 с.
5. Повышение водостойкости жидкого стекла, применяемого в качестве вяжущего при производстве теплоизоляционных костросоломенных плит / Н.В. Давыденко, А.А. Бакатович // Вестн. Полоц. гос. ун-та. Сер. F, Прикладные науки. – 2015. – № 8. – С. 71–75.