INFLUENCE OF THE MINERAL WOOL PRODUCTION TECHNOLOGICAL PARAMETERS AND HUMIDITY ATTACK ON ITS FIBRE FRAGILITY

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ABSTRACT
The influence of the mineral wool production technological parameters and humidity attack on its fibre fragility was investigated.

The investigation results showed that the fragility of the newly produced mineral wool fibre highly depends on the fibre forming air temperature, on the viscosity of the melt and on the fibre′s homogeneity: fragility decreases when the temperature of the fibre forming air and the homogeneity of fibre are increased and the viscosity of melt is decreased. Increasing the fibre forming air temperature from 22 up to 900°C lowers the fibre fragility by two times. The fragility of newly formed inhomogeneous fibre is two or in some cases even three times higher than the fragility of homogenious fiber.

The water vapour attack causes the mineral wool fibre fragility increase. The intensity of the mineral wool fibre fragility increase during water vapour attack is higher in the case of mineral wool having a lower modulus of acidity (M_k). Increasing of the mineral wool fibre inhomogeneity highly influences fragility increase under the water vapour attack.

From the analysis of the investigation results of mineral wool fibre fragility emerged the idea that the value of the fragility of the newly produced mineral wool fibre and the intensity increase of this value under water vapour attack are the most important mineral wool quality characteristics.

1 INTRODUCTION

Mineral wool is one of the most effective thermal insulating materials and is videly used in building constructions. During mineral wool exploitation its fibres are chemicaly attacked by variuos chemical compounds existing in the surrounding environment. They are attacked by mechanical forces as well. In the most cases they are influenced by the bending and pressing forces and by forces of mechanical vibration. The author of this work had established that the wool, produced from slag had crumbled during its 10 year exploitation for in the construction of the spinning factory, but there were no signs of its chemical interaction with water vapour. This proved that the attack of the mecanical forces causing the fragile fibres to rupture may have been one of the main reasons for mineral wool crumbling during its exploitation. Water vapour attack may increase the crumbling speed. However, up to now the fragility of mineral wool fibre has not been investigated and the value of fragility is not used for its quality characterization .

The aim of this work was to investigate the influence of mineral wool production technological parameters on its fibre fragility and the fibre fragility change under water vapour attack.

2 MATERIALS AND INVESTIGATION METHODS

The fragility of the mineral wool fibre produced by laboratorical and industrial ways was investigated.

The mineral wool fibre inhomogeneity was investigated by scanning electron microscopy (equipment Stereoscan S4-10). The etched in 0.5 M HCl fibre surface was investigated. Before the investigation the fibre surface was coated with an ~ 50 Å layer of carbon by its evaporation in a vacuum. The magnification during investigation was x2000 ÷ x5000. The fibre fragility was determined by a method prepared by Keriene [1]. Fibre fragility – the average value of 150 individual fibres′ fragility. Individual fibre fragility was obtained by dividing the maximum bending diameter at which the individual fibre is corrupted, by the fibre′s diameter in the corruption place. The investigation of the influence of mineral wool production technological parameters on its fibre fragility was performed on mineral wool fibres produced by the laboratorical equipment in which pressed air was used for fibre formation. The other investigations were performed on mineral wool fibre produced in the industrial way. The influence of water vapour attack on fibre fragility change was estimated after mineral wool was kept in 98± 2 % humidity at a temperature of 70 °C.

3 RESULTS AND DISCUSSIONS

The results of the investigation of the influence of mineral wool production technological parameters on its fibre fragility are presented in Table 1.

Table 1: The dependancy of mineral wool fibre fragility on the production technological parameters

Sample No	Raw material melting temp. t °C	Viscosity of the melt η, puaz.	Temperature of the fibre forming air, °C	Modulus of mineral wool acidity, M_k	d, μ	Fibre fragility
Slag						
1	1400	6.5	22	0.99	10	58
2	1400	6.5	70	0.99	10	47
3	1400	6.5	70	0.99	6.3	40
Ceramzite dust + cement dust + sand						
4	1450	14	22	1.4	10	66
5	1400	14.3	22	1.4	17.5	91
6	1400	14.3	65	1.4	13	70
7	1400	14.3	500	1,4	9	49
8	1400	14.3	900	1.4	10	44
9	1350	13	500	1.23	14	47
10	1400	10.2	22	1.23	13	71
11	1400	10.2	500	1.23	9	43
12	1450	10	500	1.23	8	41
13	1450	14	500	1.4	8	48
14	1450	16	65	1.5	9	63
15	1450	16	500	1.5	8.5	41
Slag + gabbrodiabaze						
16	1400	10	65	1.4	9	49
17	1400	10	500	1.4	10	47
18	1450	13	22	1.8	9	59
19	1450	13	22	1.8	9	73
20	1450	13	65	1.8	9	51
21	1450	13	500	1.8	8	44

The results presented in Table 1 prove that at a constant melt’s temperature the increase of the fibre forming air temperature causes a decrease in fibre fragility, despite the raw materials composition (compare fragility values of fibre samples No 1 and No 2; Nos 5, 6, 7, 8; Nos 19, 20, 21). How much the fragility is decreased when the fibre forming air temperature is increased depends on the melt’s viscosity: the fragility decrease is higher in the case of more viscoseous melt from which fibre is formed (compare fragility values of fibre samples No 5 and No 7 with those of No 10 and No 11). When the composition of the raw materials and the fibre forming air temperature are kept constant the fibre fragility value is decreased when the melt′s viscosity is decreased (compare the fragility values of fibre samples Nos 7, 11, 12, 13). The dependancy between the values of fibre fragility and its average diameter has not been established. When the parameters of fibre production from the same composition of raw materials are changed in a way causing a decrease in the fibre average diameter the fibre fragility is decreased (compare the fragility values of fibre samples Nos 9, 11, 12). Otherwise, the fragility values of fibre having the same or very close values of average diameter, produced from different raw materials or using different technological parameters, may be different (compare the fragility values of fibre samples No 1 with No 2; No 14 with No 15; No 20 with No 21).

The fragility of 10 different samples of mineral wool fibre produced in the industrial way was estimated. The raw materials used for the mineral wool production, types of the melting furnaces, fibre forming methods, as well as M_k, the average diameters of the mineral wool fibre and the fragility values of each sample are presented in Table 2.

Table 2: The characteristics of the mineral wool produced in the industrial way

Sample No	Raw materials	Type of melting furnace	Fibre forming method	M_k	d, μ	Fibre fragility
1_{ind}	Liquid slag	Bath furnace	Centrifugation + blowing	0.92	8.5	57
2_{ind}	Liquid slag + basalt	Cupola furnace	Centrifugation + blowing	1.00	7.7	69
3_{ind}	Liquid slag + basalt + broken glass	Cupola furnace	Multiroller centrifugation	1.11	7.7	79
4_{ind}	Liquid slag	Bath furnace	Centrifugation + blowing	1.00	8.3	56
5_{ind}	Silicamanganese slag + basalt	Cupola furnace	Centrifugation + blowing	1.40	7.3	113
6_{ind}	Silicamanganese slag + lime stone + basalt	Cupola furnace	Centrifugation + blowing	1.57	7.2	55
7_{ind}	Marl	Bath furnace	Draw plate + blowing	1.76	9.5	49
8_{ind}	Dolomite + gabrodiabaz	Bath furnace	Multiroller centrifugation	2.35	2.7	35
9_{ind}	Ceramsite + cement dust + sand	Bath furnace	Multiroller centrifugation	1.39	8.1	44
10_{ind}	Dolomite + gravel + basalt	Cupola furnace	Centrifugation + blowing	1.22	8.1	56

In Fig. 1 the scanning electron microscope photographs of the surface of the etched by 0.5 M HCl mineral wool fibres of samples 1_{ind} – 8_{ind}, characterized in Table 2 are presented.

The results, presented in Table 2 and Fig. 1, prove that the increased inhomogeneity of mineral wool fibre causes increase in its fibre fragility: the value of the fragility of the

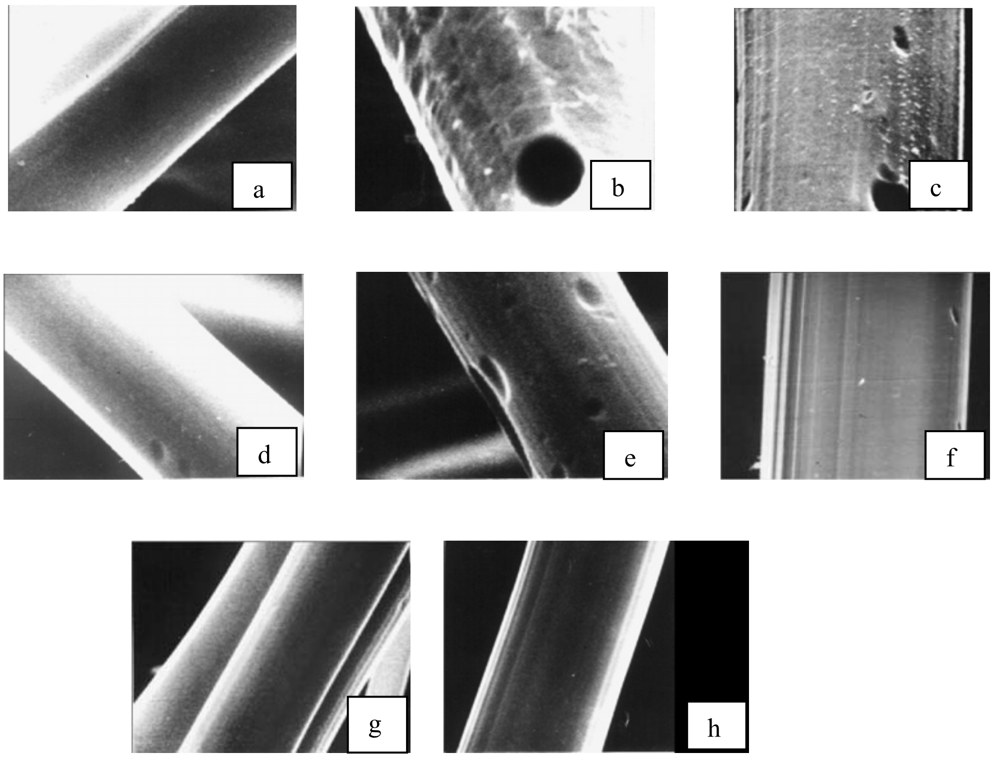

Fig. 1. The scanning electron microscope photograghs of the newly produced in the industrial way mineral wool fibres etched 0.5 M HCl. Magnification x3000. a – 1_{ind}, b- 2_{ind}, c – 3_{ind}, d – 4_{ind}, e – 5_{ind}, f – 6_{ind}, g – 7_{ind}, h – 8_{ind}.

mineral wool fibres of the sample No 1_{ind} and No 4_{ind}, produced from the same liquid slag which was used for the producing of the samples No 2_{ind} and No 3_{ind}, but without using any additives, is lower than the fragility of the inhomogeneous fibres of the samples No 2_{ind} and No 3_{ind}, produced from the same liquid slag but using unsutable additives and a type of raw materials melting furnace that caused increased of inhomogeneity. The same can be said about the fragility of fibres samples No 5_{ind} and No 6_{ind} : the increased fibre inhomogeneity caused their increased fragility.

The results of the fibre fragility change under water vapour attack during mineral wool keeping in 98 ± 2% humidity at 70 °C are presented in Table 3.

The analysis of the results presented in Table 3 show that the water vapour attack caused the fibre fragility increase. The fragility is increased when the mineral wool M_k is decreased and the fibre inhomogeneity is decreased. The fragility increase is even intensive in the case of water vapour attack on the inhomogeneous fibres.

The influence of water and water vapour attack on the change of the surface and the mechanical cheracteristics of the glass and glass fibres have been investigated in numerous works; among them, in work of Keriene [2]. In the work of Keriene [2] it was estimated that water vapour chemically interacts with mineral wool fibre and as a result the fibre surface structure is changed.

Table 3. The change of the mineral wool fiber fragility under the water vapour attack

Sample No	M_k	Duration of the attack, h	Fragility
1_{ind}	0.92	0	57
		6	133*
		24	288**
		72	Fibre very fragile
2_{ind}	1.00	0	69
		6	162*
		24	172**
		72	Fibre very fragile
3_{ind}	1.11	0	79
		6	225*
		24	250**
		72	Fibre very fragile
9_{ind}	1.39	0	44
		6	542
		24	58
		72	126
10_{ind}	1.22	0	56
		6	82
		24	136
		72	160*

* there were no long fibres ** only small number of fibres were suitable for testing

In this work the conclusion, based on the investigation results and analysis of works in the area of investogation of glass surface change under water attack, was made that the reason for the fibre surface structure change is the interruption of the chemical bonds and leaching of Na, K, Ca, Mg from the fibre surface under water vapour attack. The intensity of the fibre surface structure change increased when the mineral wool M_k was decreased. The results of Keriene [2] agree with the results of the recent investigations of Koenderik [3], who showed that the alkaline earth sodium silicate glasses were leached under the water attack.

The fibre structure change under water vapour attack was not the only reason why the fibre fragility increased. Another not less important reason why the mineral wool fibre fragility increased was the growth of microcracks which occured during the fibre formation. For this reason the inhomogeneuos fibres were extremely unstable during the water vapour attack. Water vapour influences on the glass cracks grow. There are the conclusions of Yoshida [4], Takeda [5] and many other authors, including the authors of works which were recently analysed by Gy [6].

The results of this work show that the reason for high fragility value of the newly produced mineral wool fibre may be the low fibre forming air temperature (samples No 5 and No 10) or high fibre inhomogeneity (samples No 2_{ind}, No 3_{ind}, No5_{ind}).

The rate of cooling of the fibre surface layer during the fibre formation is faster than the rate of cooling of the fibre inner layer. The difference in these rates is increases when the fibre forming air is decreased. With the increasing difference in these rates, difference of the viscosity values of the fibre surface layer and the inner layer increases and causes an increase in the number microcracks formed on the fibre surface and an increase in fibre fragility.

The forming of the fibre inhomogeneities causes the stress to apear in the interface of the different phases existing in the fibre. This is the reason for fracture increase.

Based on analysis of the results of all investigations done in this work, it has been concluded, that the value of the fragility of the newly produced mineral wool fibre and the intensity of the fragility increase during water vapour attack are very important mineral wool fibre quality characteristics, which evaluate the optimality of raw material composition choice and production technological parameters as well as a mineral wool fibre resistance to water vapour attack.

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