SUMMARY

LifeCycle artificial mineral fibre insulating materials (KMF)

Optimization of material flows in the life cycle of building products made of artificial mineral fibre insulating materials

1. Introduction

In recent decades, the climate protection targets have led to a continuous increase in the requirements for the structural thermal insulation of buildings. Insulation materials have therefore increasingly been used to minimise energy requirements. Due to its properties with regard to fire, heat and sound insulation, mineral wool is used in almost all building constructions of heat-transfer building envelopes and interior fittings as well as for insulating components of technical building equipment, so that today's market share in the total insulation market is approx. 54%.

It can be assumed that about 160 thousand tons of mineral wool are landfilled as waste every year. The amount will grow continuously over the next 50 years.

There are currently no recycling processes that can guarantee a quantitatively relevant return of the mineral wool to the production process.

In the LifeCycle KMF research project, a completely closed recycling cycle for mineral wool - starting with dismantling, through processing, packaging and transport to recycling in the manufacturing process - was systematically developed and general requirements and boundary conditions were defined.

2. Subject of the research

In the course of the research project, the current life cycle of building products made of mineral wool was analyzed in a first step. In particular, the focus of the analysis of the currently applied mineral wool-related material system has been placed on production, application in buildings, waste generation and disposal in order to be able to define the requirements for the development of a completely closed recycling cycle. In the following, the building substance investigation, the selective dismantling, the collection, processing and transport processes as well as the return into the production cycle were examined in more detail in order to enable a high recycling rate.

2.1 Investigation of building substance

The sooner a distinction is made between glass wool and rock wool and between - suspected of having a carcinogenic effect - drawn ("new") and not drawn ("old") wool in the recycling process, the more efficiently the necessary effort in the recycling process can be controlled. It is recommended to carry out an inventory using a cadastre on the building site and to identify the mineral wool e.g. by building files or chemical analyses. X-ray fluorescence analysis and near infrared spectroscopy - confirmed by first experiments - can also be used to distinguish between stone and glass wool. If research into the analysis of mineral wool using near-infrared spectroscopy is continued, it will be possible in future to carry out the analysis in situ at low cost using hand-held measuring instruments.

2.2 Selective deconstruction

In order to minimize impurities in the material flow of mineral wool, which can lead to considerable consequences for treatment and preparation processes, selective deconstruction is an option. The quality of the material flow varies depending on the installation situation and product characteristics and is partly associated with contamination of the mineral wool to be separated, such as by plaster, ceramic aprons, but also metal screws and plastic dowel sleeves, as well as the glass fibre reinforcement fabric.

As a rule, a very good separation cut of the mineral wool can be achieved for roofs and non-load-bearing inner walls. In the case of exterior walls - apart from curtain-type ventilated claddings and curtain walls - a higher degree of contamination is to be expected. In particular, the removal of glued and dowelled ETICS proves to be costly when using impact dowels with metallic nails and screw or set dowels with additional dowelling through the fabric.

It is not possible to dismantle filling bricks in a single type. These must first be completely dismantled, i.e. as a mixture of insulating material, plaster and masonry, and then fed to a processing plant. The same applies to the insulation of aggregates for technical building equipment and similar components.

When handling mineral wool, dust release should be avoided as far as possible. Especially in the case of "old" mineral wool, it will only be possible to dismantle small parts using hand tools.

2.3 Transport, collection and preparation

Reclaimed mineral wool is transported in dustproof packaging. It is advisable to use BigBags, which must be marked accordingly, especially for "old" mineral wool.

Due to the relatively low georeferenced mineral wool volume to be expected, collection and handling nodes are necessary in the transport system. It is expected that the mineral wool volume to be reduced will more than double in the next 30 years. At present, it is advisable to integrate transport to the manufacturer into the disposal infrastructure for construction waste provided by the waste management industry. Depending on the catchment area of the collection and storage areas, buffer times can be expected, as the utilisation of the means of transport must be maximised from an economic and ecological point of view. A conceivable compression of the mineral wool waste to maximise the utilisation of the means of transport can be economical, depending on the length of the disposal route and the amount of waste, due to the presses to be provided. With the compression plants currently available, it is not economical to compress the waste for transport over distances of less than 85 km (cf. Fig. 2).

Currently in Germany, due to the return of mineral wool, a central processing plant would be required for both rock wool and glass wool - preferably in the vicinity of a manufacturing plant.

Starting from recycled mineral wool waste, which is compressed, technological steps are taken to remove the impurities and to feed the material back into the manufacturing process. First, the transport packaging is removed and the mineral wool bale is milled. The mineral wool is then shredded and separated from metals, plastic parts and films to be separated and mineral fractions.

Shredder plants with additional upstream and downstream technologies appear to be suitable for conveying mineral wool flakes and separating impurities. The technology, which can rely on process technologies from the textile industry, should be tested for application in a pilot plant.

Mineral wool filled bricks should be collected separately and separated in a proven separate process.

2.4 Return to the manufacturing process

Within the scope of the research project, the feedback into the manufacturing process based on the production of rock wool in the cupola furnace was investigated.

For the production of rock wool, coke and natural gas are used as fuels, as are natural rocks (e.g. basalt, diabase and dolomite) and mineral-bound shaped bricks as starting materials. Shaped bricks are pressed bodies of ground mineral wool and cement as a binding agent, in which currently between approx. 10% and a maximum of approx. 40% by mass of ground rock wool waste can be incorporated.

With an increase in the recycling rate, a higher proportion of recycled material is required. The tests in the research project proved that a recyclate content of 75 % by mass is possible while retaining the current technological concept. Both common Portland cements with high early strength and geopolymer binders are suitable as binders. Depending on the contamination and the chemical composition of the recycled mineral wool, additional recipe blocks may be required in addition to the recycled bricks in order to achieve a free-drawn recipe for the new product.

2.5 Economic and life cycle assessment

Within the scope of the research project, the economic efficiency of returning rock wool to the production process was investigated in comparison to landfilling. The recycling scenarios selected in the study are already economically better than the most cost-effective landfill (lowest landfill price determined in the study: 60 €/t or 74.09 €/t with transport). Under the assumptions considered, regional processing plants have no economic advantages compared to on-site processing, as additional loading and unloading processes as well as storage costs are incurred. The savings in raw material costs on the part of the manufacturer are below the costs to be estimated for acceptance and processing.

Furthermore, an ecological assessment of the production and disposal phase was carried out on the basis of the environmental impacts of global warming potential (GWP), ozone depletion potential (ODP), acidification potential (AP), eutrophication potential (EP), ozone formation potential (POCP), non-renewable primary energy (PENRT) and renewable (PERT) (cf. Fig. 4).

With five environmental impacts (EP, POCP, AP, PENRT, PE), recycling performs better than landfilling. For the other three indicators examined (GWP, ODP, PERT), however, recycling proves to be an ecologically worse option.

3. Conclusion

With the study presented, general requirements for a recycling process could be worked out and a recycling process could be shown that a volume-relevant recycling of artificial mineral fibre insulating materials into the production process could be guaranteed.

In order to close the cycle in practice, further research must be carried out using pilot plants, in particular with regard to process engineering, and various obstacles must be removed. From an economic point of view, recycling appears economical and can be controlled by monetary incentive systems.

The question of the ecological benefits, on the other hand, must be answered according to the focus on the environmental impacts investigated and other influencing factors (e.g. environmental impact of landfills).

Key data

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total costs: 232.866,85 €

Share of federal subsidy: 103,250.60 €

Project duration: 2014 - 2019