Investigations on heat transfer mechanisms in layered composites based on aluminosilicates and natural fibers

Growing requirements for energy efficiency in buildings and fire safety are driving the search for new materials. The objectives of the European Green Deal and the Fit for 55 package are also important. The response to these challenges was the development of a layered composite with a geopolymer matrix and insulation made of natural fibers. This solution is an alternative to systems based on cement and synthetic insulation, thus fitting in with the concept of a low-carbon economy. It also reduces the carbon footprint and makes use of renewable and waste materials. At the same time, it increases the durability and fire resistance of the partition. The thesis assumed that the inorganic structure of the geopolymer would effectively protect natural fibers from thermal degradation and improve fire safety. It was also assumed that the appropriate design of the multilayer system would increase the insulation efficiency without increasing the amount of insulation. The thesis examined the physicochemical and granulometric properties of geopolymerization precursors, determined the conditions for synthesis and the method of layer formation and reinforcement distribution. The properties of natural fibers were examined and the thermal and mechanical parameters of the composites were determined. The influence of layer configuration on effective thermal conductivity was analyzed. It was shown that dividing the same amount of insulation into several thinner layers does not increase effective thermal conductivity despite the greater number of interlayer boundaries. This phenomenon is related to the contact resistance paradox and has been confirmed in laboratory tests. An LCA environmental analysis and an economic analysis were performed for the final variants. The results indicate favorable ecological potential at moderately higher costs compared to the simplest traditional solutions. It was shown that alkaline activators have the greatest impact on the carbon footprint, which indicates directions for further optimization of the composition. The main objective of the work has been achieved, although the thesis has only been partially confirmed. The work is application-oriented and provides a basis for further research. A patent application is also planned for a solution involving the construction of a wall in an alternating pattern with the simultaneous introduction of continuous layers of fiber insulation during the construction phase. The scope of the work was fully completed in accordance with the accepted research assumptions.