The American Journal of Engineering and Technology
ISSN 2689-0984 | Open Access

TYPE Original Research
PAGE NO. 151-153
DOI 10.37547/tajet/Volume07Issue05-13

Heat exchange of granular-fibrous materials in a fluidized bed with superimposition of hot coolant jets

Sheraliyeva Ozoda Anvarovna

Associate Professor, Tashkent Institute of Chemical Technologies, Uzbekistan

Nigmatjonov Samugjon Karimjononovich

Associate Professor, Tashkent Institute of Chemical Technologies, Uzbekistan

Nurmuhamesov Khabibulla Sadulayevich

Professor, Tashkent Institute of Chemical Technologies, Uzbekistan

OPEN ACCESS

SUBMITTED 18 March 2025
ACCEPTED 14 April 2025
PUBLISHED 16 May 2025
VOLUME Vol.07 Issue05 2025

CITATION

Sheraliyeva Ozoda Anvarovna, Nigmatjonov Samugjon Karimjononovich, & Nurmuhamesov Khabibulla Sadulayevich. (2025). Heat exchange of granular-fibrous materials in a fluidized bed with superimposition of hot coolant jets. The American Journal of Engineering and Technology, 7(05), 151–153. https://doi.org/10.37547/tajet/Volume07Issue05-13

Abstract: In this article, the process of heat exchange between granular-fibrous materials in a pseudo-liquefied layer formed by the flow of liquid or gas is scientifically and technically covered. Based on the temperature difference between heat carriers (hot water, steam, gas) and materials, the efficiency of this process is ensured by the free movement of the heat carrier in the layer, the expansion of surfaces, as well as intensive convection. The focus is on parameters such as heat transfer coefficient, temperature gradient, heat capacity of the material and flow rate. The possibilities of process analysis through mathematical modeling (Fourier, Navy-Stokes equations) and experimental methods are also considered.

Keywords: Heat exchange, liquefied layer, granular-fibrous materials, heat carrier, convection, heat capacity, temperature gradient, modeling, Fourier, Navy-Stokes.

Introduction: Heat exchange between granular-fibrous materials in a layer diluted (falsely liquefied) with hot and coolant flows is one of the important and complex sections of the thermal technique. This process is widely used, especially in modern industries — chemical, energy, food, pharmaceutical, building materials production and many other industries. In such technological processes, the process of heat exchange plays an important role in order to obtain a target product, save energy or effectively use thermal energy.

A dilute layer is such a technological state in which a high-speed flow of liquid or gas is passed under solid particles (such as sand, granular or fibrous materials). In this case, the particles begin to move as if they had lost their weight, creating an effect similar to that of them floating in a liquid. This layer is therefore known as the” pseudo-liquefied layer". This situation greatly intensifies the processes of heat and mass exchange, since the surface of contact between the heat carrier and the particles and the dynamics of movement increase.

Granular-fibrous materials, on the other hand, combine two types of physical structures: the first is spherical or irregularly shaped granules, while the second is fibrous or filamentous. The presence of these two different structures in one layer increases the complexity of the heat transfer process. Fibers increase the surface area, but they can be slower to transfer heat. Granules, on the other hand, can absorb or transmit heat more quickly. As a result, materials with different densities, heat capacity, thermal conductivity and heat dissipation rates are simultaneously involved in the heat exchange process.

The process of heat exchange is usually carried out through hot or cold heat carriers — such as steam, hot water, cold air or other gases—. When these currents collide with particles or pass between them, heat is given or obtained due to the temperature difference. In particular, convective heat exchange is at a high level because of the High freedom of movement of the heat carrier in the pseudo-liquefied layer.

A pseudo-liquefied layer is a technologically complex but highly efficient system in which solid particles, either granular or fibrous materials, are passed underneath at a high rate of fluid or gas flow. As a result of this flow, the particles come into a state as if they had lost their weight and begin to move freely, like substances floating in a liquid. The state of the layer formed in this way is called "pseudo-liquefied" because this state shows the same behavior as classical liquids, but it is actually a layer made up of solid particles. In the scientific literature, this system is referred to by the name "fluidized bed" (a term derived from English).

One of the most important advantages of a pseudo-liquefied layer is the very intensive nature of heat and mass exchange processes due to the mobility of the particles in the layer. It is widely used, especially in the chemical industry, in catalytic processes, drying, roasting, granulating, washing, synthesizing or many other technological processes where rapid transfer of heat from one substance to another is necessary. It is also used effectively in the energy sector, such as activated charcoal, waste recycling, heat exchange reactors.

Another important aspect in the process of heat exchange in a dilute layer is the dynamics of movement of particles in the layer and the mobility of different materials relative to each other. Especially when granular and fibrous materials are present in the same layer, due to their different density, shape, size, and thermal conductivity, the thermal distribution in the layer may not be the same. This causes temperature fluctuations in local zones within the layer.

The process is also influenced by the chemical properties of the heat carrier, which is injected as a gas or liquid. For example, if a heat-carrying gas contains reactive components, they can chemically react with the material, causing thermal separation or absorption. In these cases, heat exchange takes place not only on a physical basis, but in conjunction with chemical processes, which complicates the model and calculations. At the same time, automated monitoring and control systems for liquefied layers are being used in modern heat exchange systems. Such systems measure temperature, pressure and flow rate in real time, keeping the process in optimal condition. This technology is particularly important in the energy facilities, Petroleum and chemical industries, providing safety and efficiency.

Granular-fibrous materials are special substances used in these processes. They contain particles of two physical properties: the first are granular particles, which are usually spherical or granular, smooth, with a clear center of gravity, and easy to move; the second are fibrous materials that are structurally more complex, brittle, layered, in some cases shaped like fabrics.

The presence of granular and fibrous particles in a mixed state in one layer has a significant effect on the processes of thermal conductivity, temperature distribution and energy exchange. For example, granular particles can absorb and transfer heat faster due to their higher density, while the contact surface with the heat carrier increases due to the greater surface area of the fiber. For this reason, in such complex systems in a pseudo-liquefied layer, the temperature field may not be uniformly distributed, but this simultaneously increases the intensity of the heat and mass exchange process.

For optimal results in these systems, layer height, flow rate, particle diameter, their density, heat capacity, and many other factors are carefully analyzed. Such systems are simulated in many cases on the basis of mathematical models, and advanced control systems are introduced in the process of their control. Thus, the interaction of fake liquefied layer and granular-fiber materials is an important technological solution to ensure high efficiency and energy efficiency in many areas of the industry.

When the heat exchange process is carried out in the presence of granular-fibrous materials and using heat carriers in a liquid or gaseous state, the effectiveness of this process is determined through a number of physical parameters. In particular, this process is mainly based on the temperature difference of hot and cold substances. That is, a hot carrier medium – which can usually be in the form of steam, hot water, or hot gas – and a temperature difference between the granular-fibrous materials in a relatively cold State, this difference causes heat flow to occur.

The presence of a diluted (falsely liquefied) layer makes this process more intensive. The reason is that in this layer, each particle, either granular or fibrous elements, moves relatively freely between them, while through the spaces between them, heat carriers can move with great speed. This action, in turn, expands the contact surface of the heat carrier with the particles and greatly accelerates the process of heat from one particle to another. As a result, the distribution of heat occurs quickly and a stable temperature field can be formed throughout the layer.

There are basic physicochemical factors that determine the effectiveness of heat exchange. One of them is the temperature gradient, which indicates the magnitude of the temperature difference between the heat carrier and the acceptor. The larger the temperature difference, the stronger the heat flux. The next important factor is the coefficient of heat transfer. This indicator depends on the quality of contact, surface and other conditions between the particle and the heat carrier medium. The specific heat capacity of a material, on the other hand, indicates how much energy is required to raise or lower the temperature. In addition, the flow rate of the heat carrier is also of particular importance, which determines at what speed and in what direction the heat carrier moves inside the layer.

Mathematical modeling is widely used for in-depth analysis and management of this process. This typically uses differential equations representing heat transfer processes, such as complex systems such as the Fourier equation (heat dissipation), the Navy-Stokes equations (motion of liquids and gases). With the help of such equations, the temperature distribution in the layer, the interaction of heat flow and gas-liquid flows can be theoretically determined.

In addition, through experimental studies, cases such as fluid motion, convection, thermal radiation (radiation) and transfer of energy through the surface are studied in detail under real conditions. With specialized laboratory equipment, fluid motion and heat transfer mechanisms with temperature sensors, heat flow meters, and high-speed cameras are analyzed visually and digitally. This data, on the other hand, serves as the basis for the design, optimization and efficient management of heat exchange systems in later practical production conditions. Thus, the heat exchange process is analyzed in depth, both theoretically and practically, in a way that is applicable to the needs of the industry.

CONCLUSION

In conclusion, the process of heat exchange in the diluted layer is an integral part of industrial technologies. This process is widely used in fields such as chemistry, energy, pharmaceuticals, ensuring high-efficiency energy transfer between materials and heat carriers. Through an in-depth study of its theoretical and experimental foundations, it will be possible to design modern thermal systems, increase energy efficiency and optimize technological processes.

REFERENCES

Kunii, D., & Levenspiel, O. (1991). Fluidization Engineering (2nd ed.). Butterworth-Heinemann.

Ranjan, S. (2009). "Heat Transfer in Fluidized Beds: A Review". Chemical Engineering Science, 64(13), 2991-3011. https://doi.org/10.1016/j.ces.2009.04.022

Rhodes, M. (2008). Introduction to Particle Technology (2nd ed.). Wiley.

Geldart, D. (1986). "Radial concentration profiles in a fast fluidised bed". Powder Technology, 48(3), 13-22. https://doi.org/10.1016/0032-5910(86)85002-1

Choi, S., & Lee, S. (2017). "Influence of pipeline modeling in stability analysis for severe slugging". Chemical Engineering Science, 157, 187-198. https://doi.org/10.1016/j.ces.2016.12.004