International Refereed Journal of Engineering and Science (IRJES)
ISSN (Online) 2319-183X, (Print) 2319-1821
Volume 9, Issue 5 (May 2020), PP. 33-40

Building Structures with Internal Heat Source - Heat Insulating Panels with Active Regulation of Heat Transition

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Abstract: *The technical solution of thermal heat insulating panels with active regulation of heat transition was described in the European patent specification number EP 2 572 057 B1 published in the Bulletin of the European Patent Office 2014/42, 15.10.2014. Author of the invention - the technical solution is Associate prof. Ing. Daniel Kalús, PhD. Technology applies to the invention of heat-insulating panel with active thermal protection and its heat transition regulation used in panel buildings, new or existing ones being renovated. The construction mentioned above is a part of prefabricated light external cladding which together with low-temperature heating and high-temperature cooling systems creates indoor environment. The energy source is usually renewable. The invention falls within the area of building industry.*

Keywords: *Heat insulating panel with active regulation of heat transition, building structures with internal energy source, active thermal protection, thermal barrier, low-temperature heating and high-temperature cooling.*

Date of Submission: 08-11-2020 Date of acceptance: 23-11-2020

I. INTRODUCTION

Usually, the principle of energy saving building design consists of building constructions with massive thermal insulation layers. The property of the structure is defined by the thermal resistance R (m^2K/W), i.e. coefficient of heat transition U (W/m^2K) in accordance with the STN 73 0540 standard. The energy systems used for heating, ventilation and cooling, mainly use renewable energy sources, out of which, the solar thermal and photovoltaic ones, ambient energy and geothermic energy are the most apllied.

There are various technical solutions with suitable thermal-technical properties, e.g. panels of shell structure, where the space between the concrete and the „shell" is filled with thermal insulation, e.g. foam material. The disadvantage of such panel construction is possible corrosion of metal joints in the inner-space where, during winter,t he temperature might fall below the dew point and cause long lasting moisture.

Even the construction of prefabricated panels with thermal insulation applied to the concrete panel during its production might be problematic. Systems are also known as thermal insulation panels applied as a lightweight cladding to the supporting structure.

II. STATE-OF-ART

The active heat protection system has already been applied in some buildings and has brought qualitatively new dimension in to the field of energy saving buildings and their structure. Active heat/thermal protection utilizes so called, internal energy source, the energy system integrated in to the zone between the static part and heat insulation the building construction in a form of low-temperature heat transitioning material. The heat is gained from captured and cumulated solar and geothermic energy and transfered to the building constructions, as seen in the Fig. 1. This active heat protection system can be i mplemented eather to the exterior part of the wall or interior one. The captured heat can be distributed via pipe or flexible tubing system which is attached to the wall and covered with plaster, thermal insulation and „topping" plaster. The system can be used for new, as well as, the existing buildings.

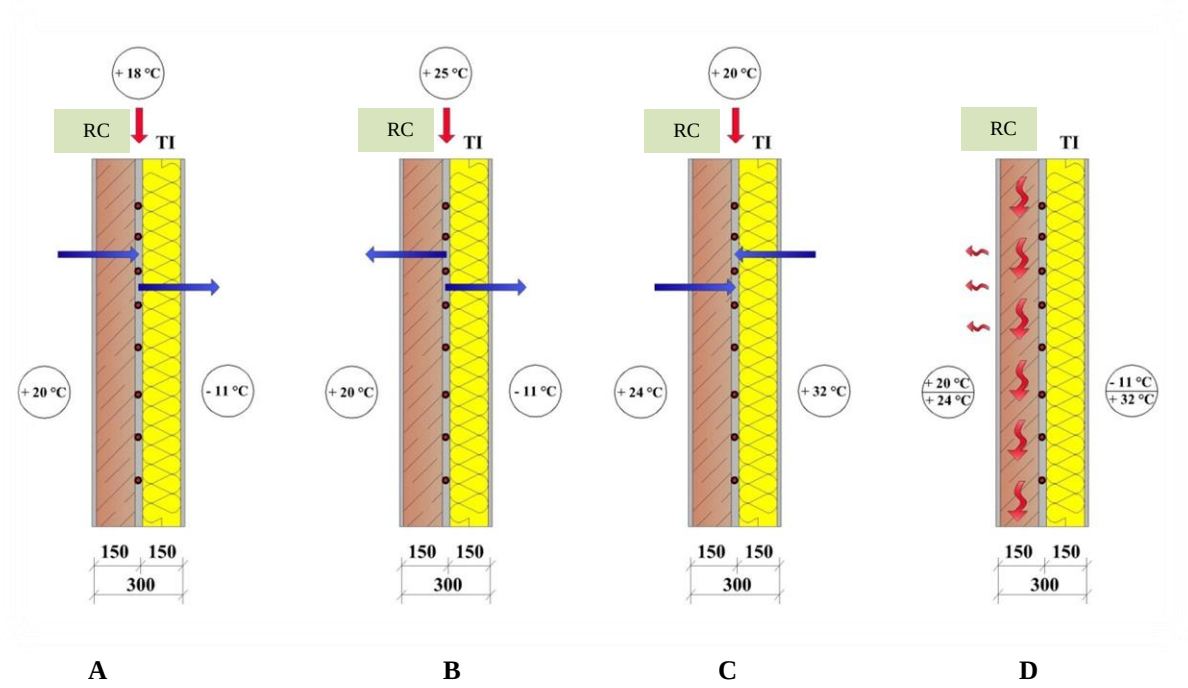

Fig.1. The multiple-function character of ATP (WATER base) [author: Kalús, D.]
RC – reinforced concrete, TI – thermal insulation
A - Thermal barrier, B – Heating, C – Cooling, D - Heat/cold accumulation

The **A**ctive **T**hermal **P**rotection (**ATP**) system based on active control of heat transfer, by changing the temperature at the interface of supporting and thermal insulation part of building envelope, Fig. 1, can fulfill the function of several "energy systems". For instance, it can have a function of thermal barrier, low-temperature heating, high-temperature cooling and heat /cold accumulation in the load-bearing part of building structures. Under certain conditions, it can also have a function of heat recovery and / or energy collection from surrounding environment.

ATP is currently applied in two ways. The first method is applied to the exterior wall. The attached pipe system, distributing a low-temperature heat medium, is covered with a leveling plaster, glued thermal insulation and all layers are covered with surface (“toping”) facade plaster. This application can be used for new buildings but also existing ones which already have thermal insulation, Fig.2, [2], [3], [6].

The second method is by means of load-bearing panels in the form of lost formwork (mostly polystyrene) in which active thermal protection is stored and usually their interior is usually filled with a cast concrete mixture only after installation on the construction site. In the next stage, the concrete must harden and reach the required strength (approx. 28 days). We call such construction technology the so-called "Wet construction process". This applies only to new buildings, Fig.3 and Fig. 4, [2], [3], [6].

So far, there are only few buildings with applied active thermal protection built in the world. There are some universities focusing to this topic, for instance, the Technical University of Warsaw [11], Opole [10] and Gdańsk [10]. Professor Zhu Q.Y., Xu X.H. *, Yu J.H., from the Technical University of Science and Technology in China, is addressing this issue, and have developed a simplified dynamic thermal model of pipes built into the building envelope in the frequency domain by the finite element method [9]. In Luxembourg, buildings with active thermal protection have been built since the 1990s. Doctor Edmunt Krecké from Luxembourg deals with the issue of a system with active thermal protection and is the author of several patent solutions in this area [6].

Fig. 2. Family house in the village of Tomášov with a solar roof [author - Kalús, D.]

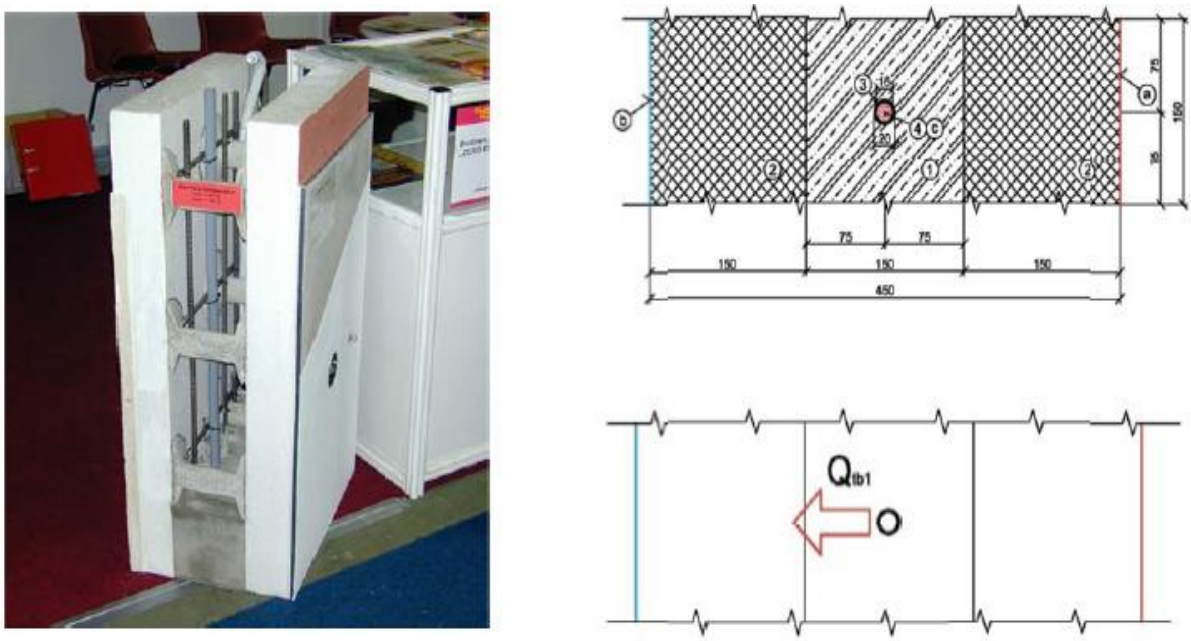

Fig. 3. Single-pipe wall energy system with ATP [2], [6]

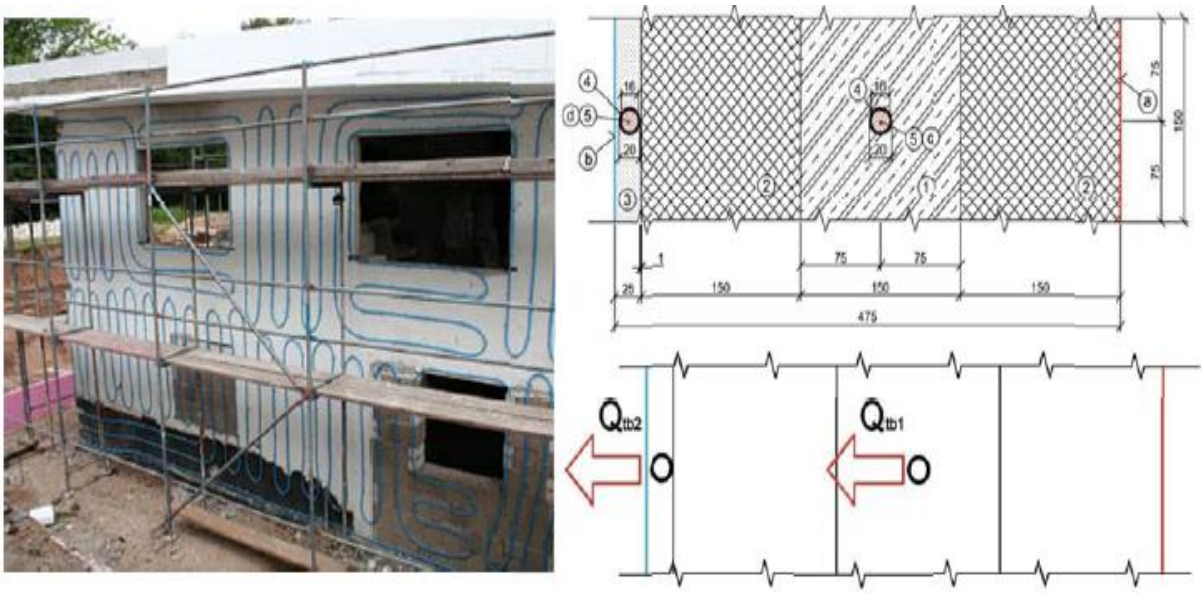

Fig. 4. Two-pipe wall energy system with ATP [2], [6]

Family houses with an active thermal protection system are being built to a greater extent, mainly in Germany, Portugal, Spain, Belgium, Spain, Japan, Saudi Arabia and Japan. Several apartment buildings, office buildings and hotels were built with similar technology as well. In Slovakia, family houses with the active thermal protection system are located in Ivanka pri Dunaji, Tomášov, Svederník [13], Dunajská Streda and Miloslavov [12].

Active use of renewable energy by means of a pipe system in a massive absorber (single-pipe wall energy system), Fig. 5, in combination with high-temperature heating, low-temperature cooling (two-pipe wall energy system), Fig. 6, offers a technical solution for self-supporting panels from RIEDER in Austria [7].

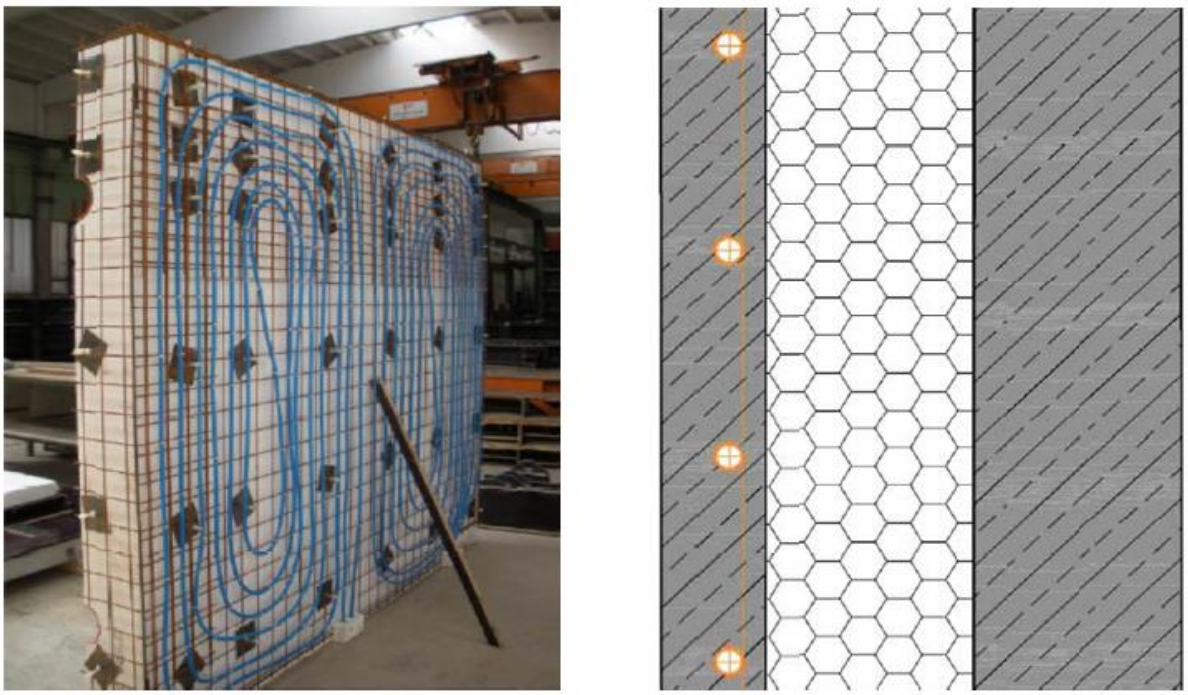

Fig. 5. Single-pipe wall energy system with massive absorber [7]

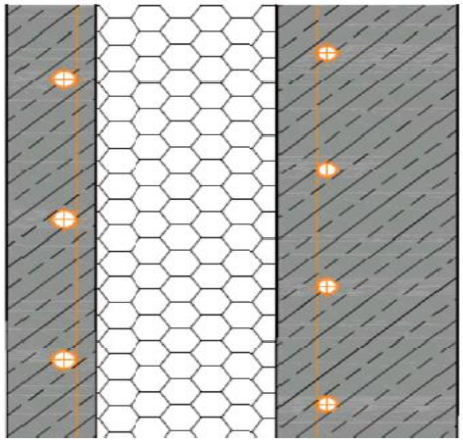

Fig.6. Two-pipe wall energy system with massive absorber and large-area wall low-temperature heating / high-temperature cooling [7]

III. HEAT INSULATING PANEL WITH ACTIVE REGULATION OF HEAT TRANSITION

Classic contact façade thermal insulation systems - thermal insulation panels, for example based on polystyrene plates or mineral wool boards without active heat transfer control (active thermal protection), are characterized by the fact that their thermal resistance depends directly on the thickness of the thermal insulation. Their function is only to create the packaging structure of the building. They can not actively respond to the immediate changes in outdoor temperature. They do not have the function of providing heating, cooling and ventilation of the building, [1], [2], [3], [6], [7].

The shortcomings mentioned above of existing systems of heat insulating panels constructions without active heat regulation with respect to limited function, higher operating costs of the building and saving of primary sources of energy lead to the possibility to solve this problem by appropriate technological means.

The result of this effort are variants of the construction of thermal insulation panels with active heat transfer control (active thermal protection - ATO) according to the invention described in the European patent specification EP 2 572 057 B1, [1]. These are built-in pipe systems in the building constructions, to which a heat transfer medium (water, air) with a modified temperature (it is thus a matter of creating a combined building-energy system is supplied. Fig. 7 presents a photo of a prototype thermal insulation panel with active heat transfer control/ milled grooves in expanded polystyrene foam, and Fig. 8 shows an alternative of a prototype mineral wool panel.

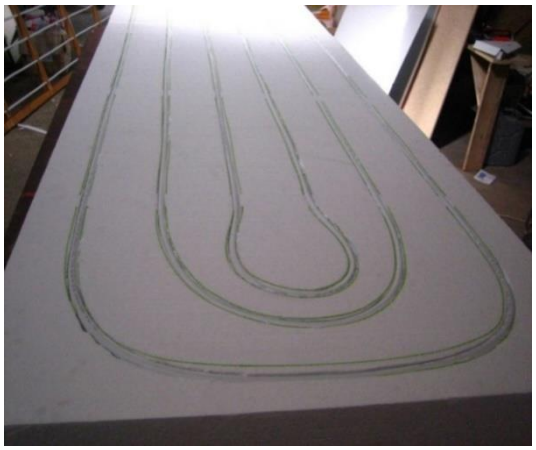

FIG.7 Prototype of a panel with ATP, expanded polystyrene, dimensions 2000 x 1000 x 100 mm (heat transfer medium WATER) [author Kalús]

Fig.8. Prototype of thermal insulation panel ATP - supporting frame - mineral wool, dimensions 2000 x 1000 x 100 mm (heat transfer medium WATER) [author - Kalús, D.]

The heat insulating panels with ATP have a wide range of application. Not only new buildings, but also reconstructions are concerned. The idea of unification of the production is supported by the fact that majority of apartment houses in Slovakia, in Central and Eastern Europe are not yet insulated. Elaboration of prototypal documentation with layouts for the respective types of panel apartment buildings could significantly contribute to mass production of the panels with ATP. For this purpose, thermal insulation panels with active heat transfer, heat-carrying substance water should be used, Fig. 9.

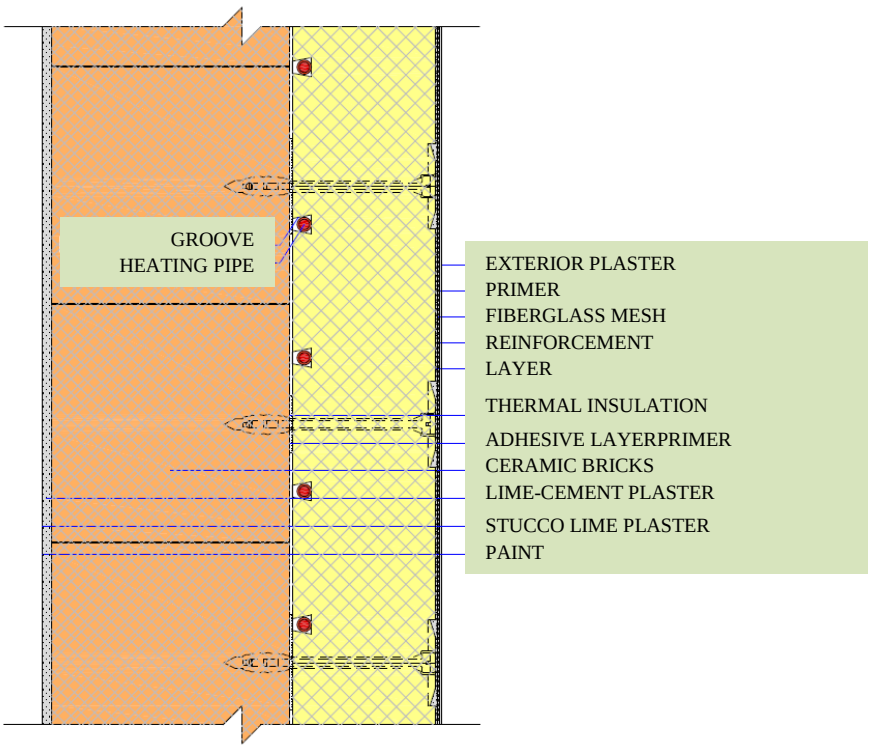

Fig. 9. Application of contact heat insulating panel with active regulation of heat transition carrier WATER [author - Kalús, D.]

The character of low temperature heating applied into the constructions with ATP also designates this system for the application into industrial buildings, commercial premises and other civic amenities, where, besides the traditional heat sources, it is possible to use renewable energy sources and waste heat, e.g. from cooling and freezing installations. The versatility of application to all types of buildings or premises is supported by the possibility to use the ATP panels also with AIR as the heat carrier, Fig. 10. Panels with AIR heat carrier can be manufactured with plastic (metal) air-conditioning ducts with a circular cross-section with the diameter of 50 to 100 mm, integrated into the insulation board.

The combination of ATP and integrated active area represents another possibility to create a compact thermal insulation system. These include thermal insulation panels ATP (WATER or AIR heat transfer medium) with the additional function of an absorber on the exterior side to capture the energy of the environment, Fig.11. This expands the multifunctionality of the building structure and the contact thermal insulation system with ATP. At the same time it reduces the number of operations in the construction of buildings and the implementation of energy systems. The simplicity and technological process of implementation of the combined intelligent façade system remains the same as before, [1].

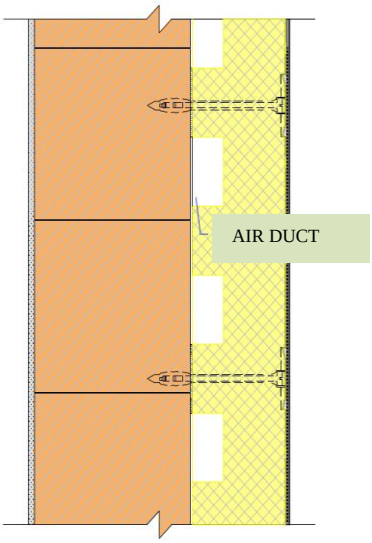

Fig. 10. Application of contact heat insulating panel with active regulation of heat AIR transition carrier [author - Kalús, D.]

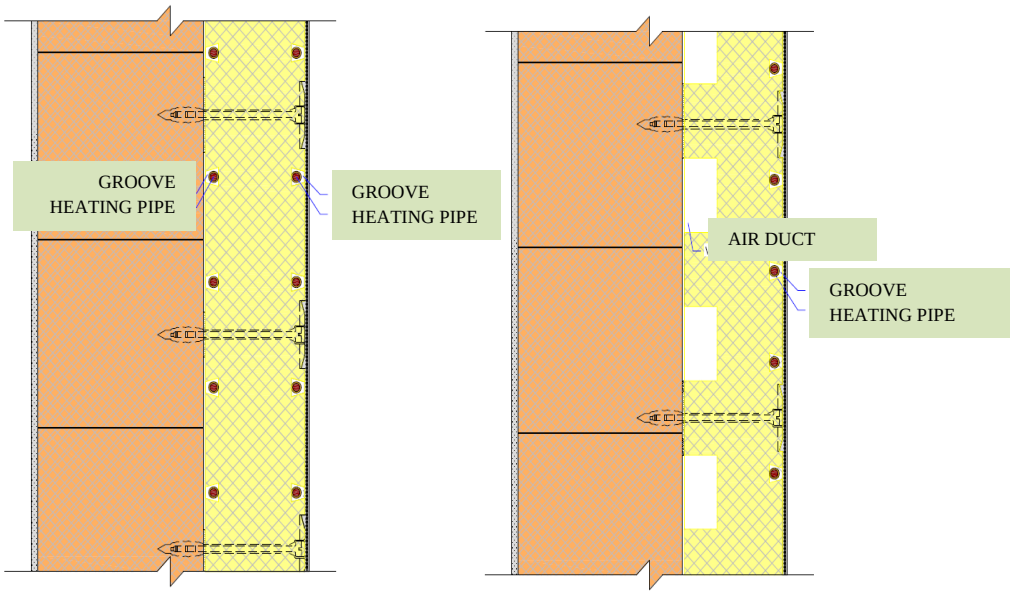

Fig. 11. Application of a contact thermal insulation system using ATO thermal insulation panels with a combined ATO function and a collection register of solar energy or ambient energy [author - Kalús, D.]

IV. CONCLUDING REMARKS

The application of heat insulating panels with active heat control is most suitable for buildings with load-bearing parts of building constructions made of materials with good thermal conductivity and heat accumulation (eg reinforced concrete and solid fired brick). The research of the use of thermal insulation panels with active heat transfer control will be followed by mathematical simulations under various conditions. The research of optimal criteria for the design, calculation and assessment of energy-efficient, cost-effective and environmentally friendly intelligent façade systems are to be conducted. Experimental measurements will also be performed.

REFERENCES

[1]. KALÚS, D.: EUROPEAN PATENT EP 2 572 057 B1: Heat insulating panel with active regulation of heat transition. Date of publication and mention of the grant of the patent: 15.10.2014 In: *Bullettin 2014/42 European Patent Office*, interantional application number: PCT/SK2011/000004, international publication number: WO 2011/146025 (24.11.2011 Gazette 2011/47), 67 p.
[2]. CVÍČELA, M.: Analýza stenových energetických systémov. Dizertačná práca. *Slovenská Technická Univerzita v Bratislave, Stavebná fakulta*, Slovenská republika 2011, 119 s., SVF-13422-17675.
[3]. JANÍK, P.: Optimalizácia energetických systémov s dlhodobou akumuláciou tepla. Dizertačná práca. *Slovenská Technická Univerzita v Bratislave, Stavebná fakulta*, Slovenská republika 2013, 185 s., SvF-13422-16657.
[4]. Q Zhu, X Xu, J Gao, F Xiao: A semi - Dynamic simplified therm model of active pipe embedded building envelope based on frequency finite difference method. In: *International Journal of Thermal Sciences*, 2015 – Elsevier, Vol. 88, pg. 170-179, 2015.
[5]. KRZACZEKA, M., KOWALCZUK, Z.: Thermal Barrier as a technique of indirect heating and cooling for residential buildings. In: *An international journal devoted to investigations of energy use and efficiency in buildings - Energy and Buildings*, 2011 – Elsevier, Vol. 43, pg. 823-837, 2011.
[6]. www.isomax-terrasol.eu
[7]. www.rieder.at
[8]. STN 73 2901 - Zhotovenie vonkajších kontaktných tepelnoizolačných systémov (ETICS).
[9]. STN 06 0892 - Ústredné sálavé vykurovanie so zabetónovanými rúrkami.
[10]. www.po.opole.pl. TU v Opole (2013)
[11]. http://www.eng.pw.edu.pl. TU vo Varšave (2013)
[12]. http://www.stavebne-forum.sk/sk/article/18284/
[13]. ISOMAX. http://www.isomax.sk.

Daniel Kalús, et. al. "Building Structures with Internal Heat Source - Heat Insulating Panels with Active Regulation of Heat Transition." *International Refereed Journal of Engineering and Science (IRJES)*, vol. 09, no. 05, 2020, pp 33-40.