# ACCUMULATORS FOR SOLAR THERMAL ENERGY STORAGE

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## ABSTRACT

This article describes kinds of heat accumulators. Water and gravel accumulators are described. It means that we are interested in advantages, disadvantages and operating features. There is designed an accumulator in the article, which join advantages and uncover disadvantages of those accumulators. Heat convection and conduction are suppressed and temperature potential is spread in layers along the height. This is very important for utilization of heating in the buildings.

## 1 INTRODUCTION

The sun is the source of nearly all energy in the world. We use solar energy in two basic forms. One form is an electrical energy (after PV cell conversion) and the second form is heat energy. The sunshine fluctuates during cycles of day-night, summer-winter etc. The fundamental claim on solar energy efficiency is the necessity of energy storage in electrical and heat accumulators. The problem with solar heating is a need to store solar energy during the day/summer for use at night/in winter or whenever the need arises.

## 2 CLASSICAL ACCUMULATORS

### 2.1 PHYSICAL PRINCIPLE

Water and gravel are traditional materials for solar thermal energy storage. Weight and specific heat capacity give quantity of heat, which is possible to store. Calorimetric equation determines storage capacity of accumulator. We can consider specific heat capacity as constant in our range of temperatures.

$$Q = \int_T mcdT \qquad (1)$$

## 2.2 WATER HEAT STORAGE

In this case water is in a suitable tank. Application of water is in many ways advantageous but they are for low-temperature storage a lot of disadvantages too.

- ✓ the water has the biggest specific capacity of all matters
- ✓ accessible, cheap, ecological
- × unsuitable for low-temperature storage (sizes of accumulators are too big)
- × during heat charging and discharging temperature is shown
- × agitation of water is happening (if accumulator is charged by enough high temperature $\vartheta$, it will fall on middle temperature in the accumulator and during discharging we can not reach original temperature $\vartheta$ again)
- × if we use water heat storage, we will suppose utilization of liquid collector (expensive, more complicated technology and installation in comparison with air collector)

## 2.3 GRAVEL HEAT STORAGE

Gravel accumulators are applied for more days or seasonal storage. Air is heat medium, which warms up in photothermal collector. This way eliminates some disadvantages of previous system.

- ✓ we don't need heat exchangers (water-water, water-air)
- ✓ heat can being kept at lower temperature
- ✓ there is no transmission of heat by convection, there is difference of temperatures among layers
- ✓ transmission by conduction is minimal too (stones touch each other only by edges)
- × low specific heat (too big size of accumulators)

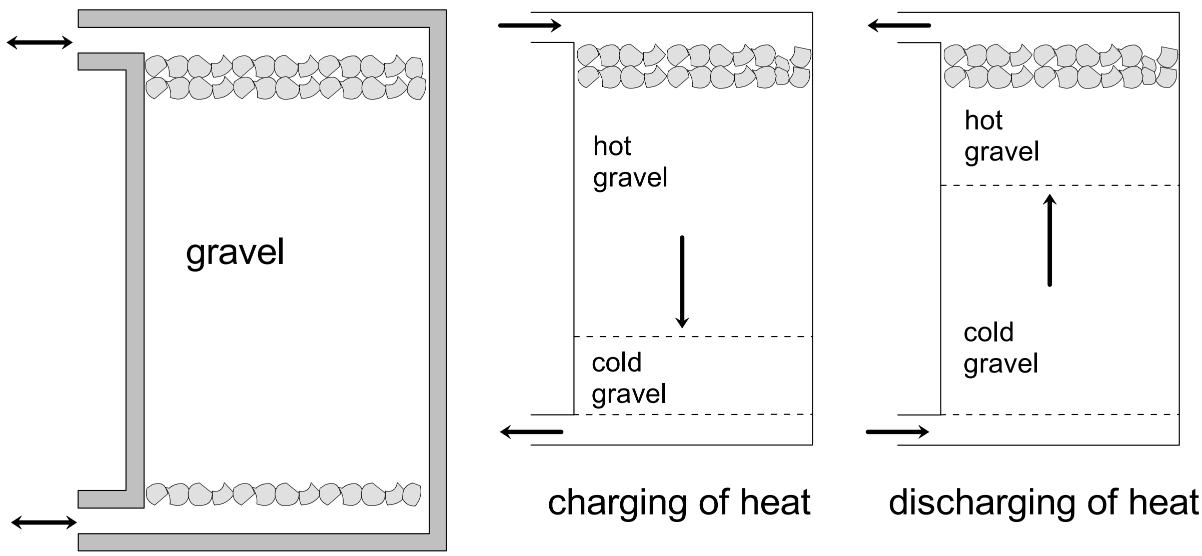


**Fig. 1:** *Schematic illustration of gravel heat accumulator*

# 3 ACCUMULATOR WITH SUPPRESSED CONVECTION AND CONDUCTION

## 3.1 DESIRED FEATURES AND DESIGN OF ACCUMULATOR

Under research project MSM 262200010 and FRVŠ 1600/2004-G1 there was designed and constructed a model of heat accumulator for low-temperature storage in the laboratory of unconventional energy changes in Department of Electrical Power Engineering, FEEC, BUT. The aim of design is to join advantages and uncover disadvantages of water and gravel accumulators. Desired features are:

- ✓ high density of energy storage (small size of accumulator)
- ✓ no transmission of heat by convection and conduction among elements of storage matter
- ✓ charging and discharging at constant temperature
- ✓ ability to exploit PCM (Phase Change Material) as storage matter
- ✓ possibility to use photothermal collectors (cheap, an easier application, less of heat exchangers)
- ✓ cheap, accessible, ecological

The model is conceptually similar to gravel accumulator. The basic different is there are hollow elements (mostly on the plastic basis) instead of stones, which contain matter with much higher heat capability.

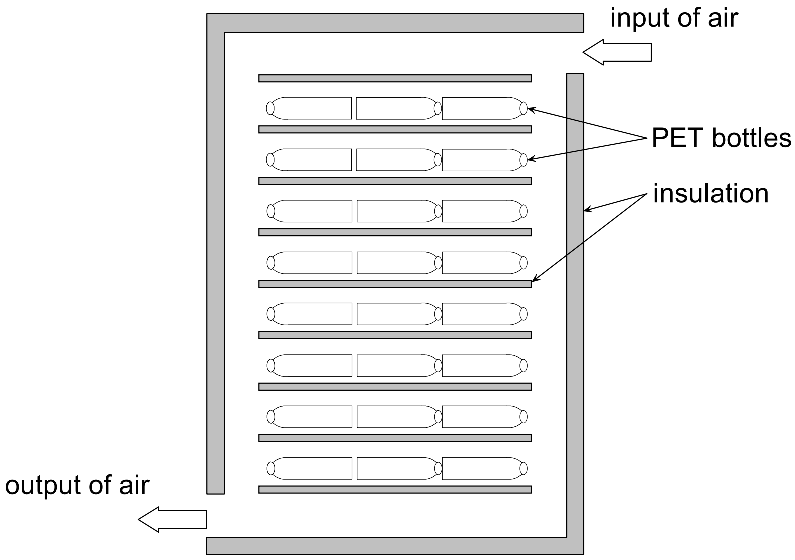


**Fig. 2:** *Schematic illustration of heat accumulator with suppressed heat convection*

The model consists of eight layers (Fig. 2). PET bottles create elements with volume 1 liter. There are 18 PET in each layer, so the total volume of accumulator is 144 liters. Nowadays water is used as storage substance, in the future we suppose to use phase change materials [3]. There is a system of swinging distributing flaps in the vertical ducts. They can direct air to layers, close and isolate layers etc.

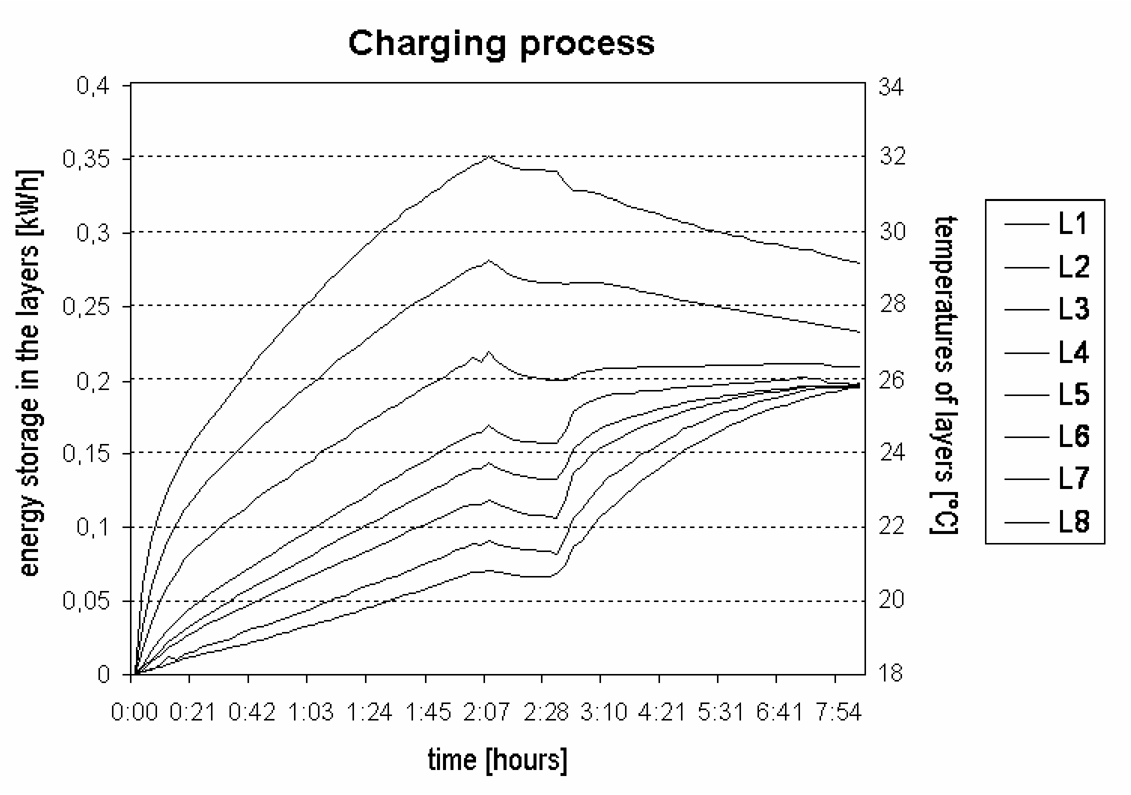


**Fig. 3:** *Layers charging process of accumulator*

Figure 4 shows the charging process of heat accumulators. Accumulator was charged by warm air of 42 °C. After two hours the charging was stopped and swinging distributing flaps were closed and layers isolated. In 30 minutes we restored charging, but with the air of temperature 26 °C. At this moment we can see the advantage of that accumulator. Because there is no transmission of heat by convection and conduction among layers the temperature potential is kept and spread along the height. The air of 26 °C does not flow through each layer like in the first part of charging process, because we would chill warm layers and loose temperature potential. By the help of flaps we put the flow of air to the layer, which has a little bit lower temperature.

The parts of model are measured in detail. We measure temperatures of air flow, distribution of temperatures in the each layer, air flows etc. We calculate energy and power balances in the model of accumulator.

## 4 CONCLUSION

There is designed an accumulator in the article, which combines features of water and gravel accumulators. There are described its advantages against traditional ways of heat storage. This accumulator is used and measured in the laboratory of unconventional energy changes in Department of Electrical Power Engineering. Energy and power balance are calculates. In future water will change for PCM in bottles.

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