Experimental data for hot water tank experimental analysis with using phase change materials (PCM) in HDPE containers is presented.

Two datasets are uploaded:

1) The cooling data for the system without PCM
2) The cooling data for the system with PCM with melting point of 55 °C

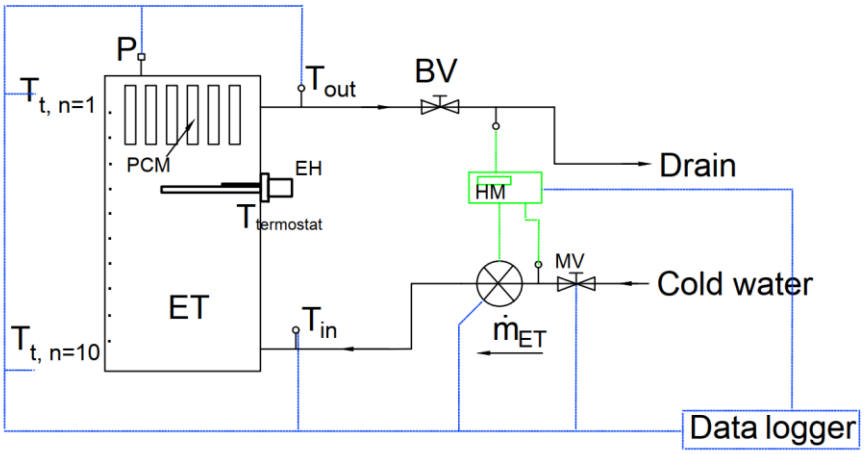

Fig. 1. Diagram for cooling experiments with cold water

Description of the experimental system (Fig.1.) is given below.

Hydraulic system

Before the cooling, ET is heated to the starting temperature by use of electric heater (EH). EH is equipped with a thermostat to heat until the setpoint. Once the cooling is initiated, cold water temperature and the flow rate are measured at the inlet. Data logger reads the flow measurement and sends a signal to a motorized valve (MV) which adjusts the flow according to the setpoint. At the outlet at the beginning of the experiment, balancing valve (BV) is adjusted to achieve pressure balance in the tank, where pressure does not increase or decrease. At the top of the tank pressure transmitter (P) is installed for monitoring purposes. The tank is equipped with a safety pressure relief valve set at 3 bars. Kamstrup Multical 602 energy meter is used with analogue 4-20 mA output to log the flowrate.

Cold water is supplied by the building cold water supply. The supply pressure varies, but the expansion tank installed before the experimental set-up smoothens out the variations. The resulting variations in pressure can change the flowrate, therefore MV is used to adjust the flow rate. Initially only BV was used in place of MV, however, it was found to be too manual labour intensive, therefore an automatic solution was required.

Automatic control was realized by use of valve Danfoss VRB2 with motorized head Danfoss AME435. The AME435 accepts 0-10 V DC control signal. Data logging is done by Campbell CR1000 and Campbell AM32. To have 0-10 V control signal, Campbell SDM-AO4A, which can control 4 analog outputs, is used. The control is realized by measuring flowrate every 10 seconds and the measured value is compared to the target value. If flowrate offset is larger than 20 l/h, then the correction voltage is 200 mV. If offset is smaller than 20 l/h, then the correction voltage is 50 mV.

Data logging and measurement system

Data logger Campbell CR1000 is used to save the data with 1 min interval. At the side of the tank, 10 K type thermocouples are inserted in copper wells. Before the insertion, a thermal compound is injected into the wells, to create a better contact between the well and the thermocouple. Inlet and outlet temperatures are measured by K type thermocouples 1 m before and after tank. The PCM temperature is measured by inserting K type thermocouple from the top of the tank through the lid, and it is placed within a container. Container with thermocouple is placed in the middle between the rest of the containers. The plug of the container with T_PCM temperature sensor is sealed.

Pressure is measured at the top of the tank at the inlet at the top. Pressure sensor used is BD Sensors 17.600 G-100.

Before the experiments, temperature sensors are calibrated in an ice bath (Fig. 2.9.). For each sensor, there is an offset of positive or negative K degrees. This offset is used in Campbell software to provide correction value for each sensor.

Most of the inaccuracies and therefore uncertainties come from metallurgic processes, which result in accuracy from 1 °C to 2 °C. To reduce this error, sensors are calibrated against known reference to obtain offset values.

Another uncertainty comes from the flowmeter. In this set-up, Kamstrup Multical 602 calculator is used with Ultraflow 54 ultrasound sensor. Multical gives rough accuracy of 0.6 %. This makes the overall uncertainty of 0.66 %.

The cold water is supplied from the bottom. The lowest sensor is T_{in} located 100 mm from the bottom of the tank. Then follows T_{10}, T_9 and so on, each 100 mm apart. The top most is T_{out}, located 40 mm from the top of the tank.

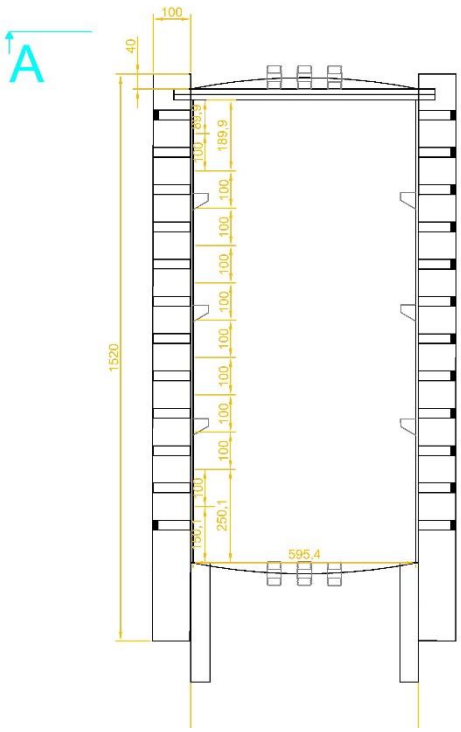

Fig. 2. Temperature sensor respective layer thickness

Type of PCM and melting point

Name	Type	Latent energy, kJ/kg	Specific heat, solid (liquid), kJ/(kg·K)	Melting point, °C	Solidifyng point, °C	Density, solid (liquid), kg/m^3	Thermal conductivity solid (liquid), W/(m·K)
PCM-OM55P	Organic	210	0.73	55	55	840 -)	-

Container size and placement

1.2 litre containers with size 230*305*32 mm. Made out of HDPE. Plugs are glued.

Fig. 3. HDPE container with 1.2 litre volume

Experimental tank

The inlet and outlet are both located on the side of the tank. In the cooling experiment, the inlet of cold water is located 13 cm from the bottom of the tank and outlet 10 cm from the top. Water is the heat transfer fluid.

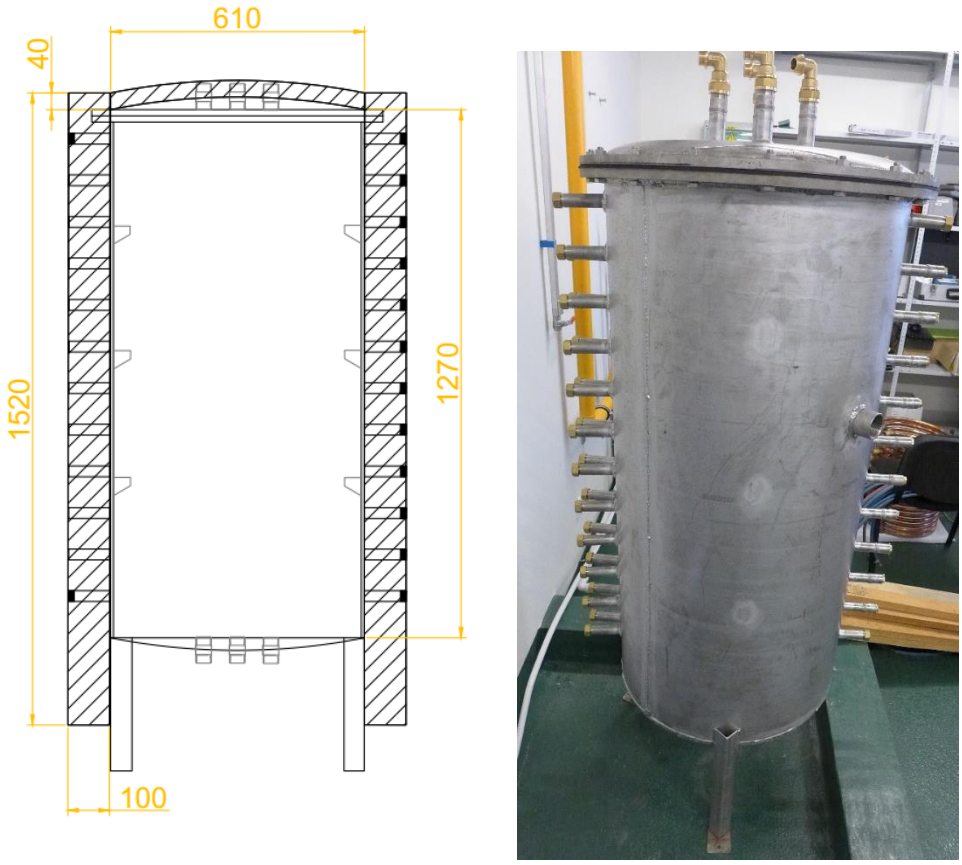

Fig. 4. Experimental tank (ET) schematic and picture (with insulation removed)

Parameter	Value	Unit
Tank height	1.26	m
Tank volume	353	liters
Outside diameter	0.60	m
Outside surface area	1.88	m^2
Top/bottom surface area	0.28	m^2
Total surface area	2.45	m^2
Tank material	Stainless steel	-
Tank wall thickness	3	mm
Stainless steel thermal conductivity	7	W/(m·K)
Side insulation type	Rock wool	-
Side insulation thickness	100	mm
Side insulation thermal conductivity	0.042	W/(m·K)
Top insulation type	K-Flex	-
Top insulation thickness	50	mm
Top insulation thermal conductivity	0.04	W/(m·K)
Calculated:		
Ratio of side wall area	0.769	-
Ratio of top wall area	0.115	-
Ratio of bottom wall area	0.115	-
U value for sides	0.42	$W/(m^2 \cdot K)$

U value for top	0.80	$W/(m^2 \cdot K)$
U value for bottom	24.76	$W/(m^2 \cdot K)$
U total (weighted)	3.27	$W/(m^2 \cdot K)$

Experimental description

The flow rate is 600 l/h and cold water inlet temperature around 10 °C. The initial temperature of the tank is 65 °C and it is cooled by the cold water until it reaches the temperature of cold water.

For the experiment with PCM, 21 containers with PCM with melting point of 55 °C are placed vertically in top portion of the tank. The rest of the procedure is the same as for the experiment with only water.

The cooling data for the system without PCM

The tank is fully mixed at the start of the experiment and starting from the bottom layers the cooling rapidly takes place within the layers in a very stratified manner. Cold water temperature at the start is slightly elevated due to water standing still and being heated up by the environment, however, within the first minutes reaches stable temperature around 10 °C. The experiment length is 78 min.

The cooling data for the system with PCM

Initial few minutes the flowrate fluctuates due to the manual opening of cold water valve and adjustment speed of the automatic valve. The temperature of PCM starts to decrease 4 minutes after the temperature of water at the level of PCM (T_1) has started decreasing. This is due to the thermal resistance of the HDPE container. The PCM phase change process takes place in the temperature range of 53-54 °C. In this range, the phase change process takes 11 minutes.