Absorption studies of sodium hydroxide solution on finned heat exchanger

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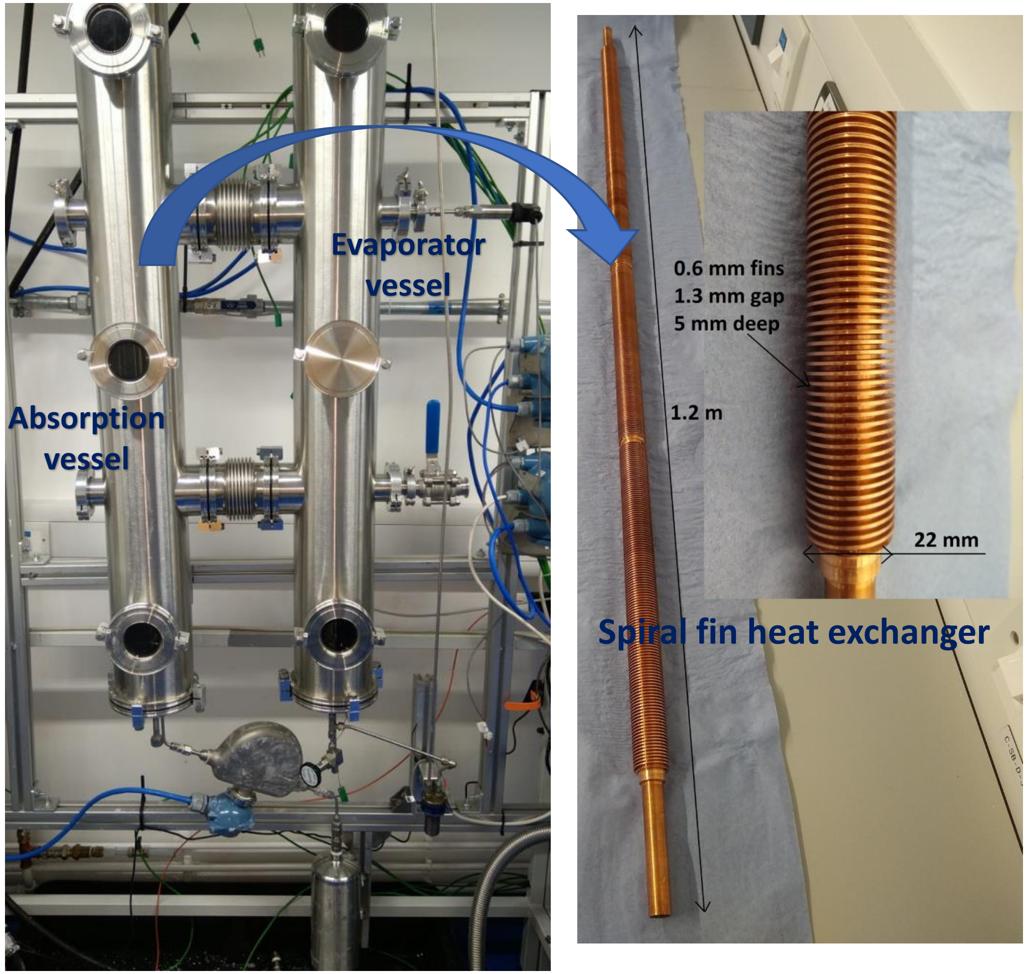
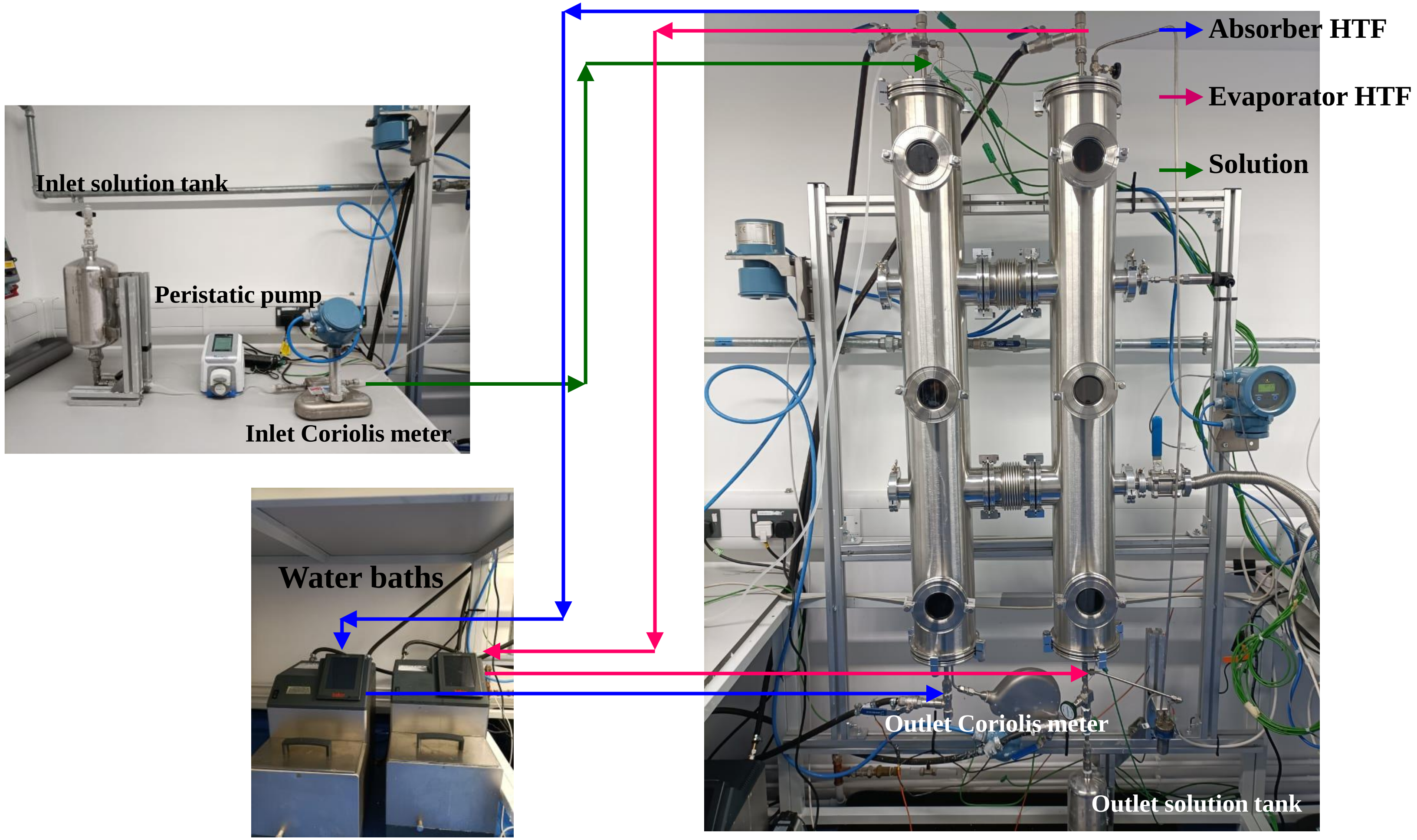
Absorption based thermal storage



- NaOH-H_2O pair studied for domestic heating applications.
- Absorption performance is evaluated over spiral finned heat exchangers.
- The setup is being scaled to provide a discharge power of up to 8kW.



Absorber HTF
Evaporator HTF
Solution
Inlet solution tank
Peristatic pump
Inlet Coriolis meter
Water baths
Outlet Coriolis meter
Outlet solution tank

Results and conclusions

Parametric study of heat exchanger with fin height 3mm

Impact of varying cooling water inlet temperature

Case	Solution flow rate (g/min)	Cooling water inlet temperature(°C)	Heating power	Solution outlet concentration
1	5.8	21.3	150.7	30%
2	7.5	25.4	99.0	37%
3	6.5	29.6	69.9	39%

Impact of varying solution flow rate

Case	Solution flow rate (g/min)	Heating power	Solution outlet concentration	Average solution temperature (°C)
2	5.7	80.7	36%	34.4
	7.5	99.0	37%	36.4
	9	61.1	42%	32.3

- A temperature lift of 10°C is seen to be optimal.
- A storage density of 1900-2250 MJ/m^3 is evaluated.

Parametric study of heat exchanger with fin height 3mm (contd.)

Impact of varying evaporator temperature

Evaporator temperature (°C)	Solution flow rate (g/min)	Cooling water inlet temperature(°C)	Heating power (W)	Solution outlet concentration
20	6.2	27.9	141.4	31%
15.5	6.8	25.0	151.8	31%
11	6.0	21.3	150.7	31%
7	5.7	17.8	124.4	32%

- Performance drops for evaporator temperature lower than 10 deg.C.
- Lower absorption uptake limit results in lower kinetics.

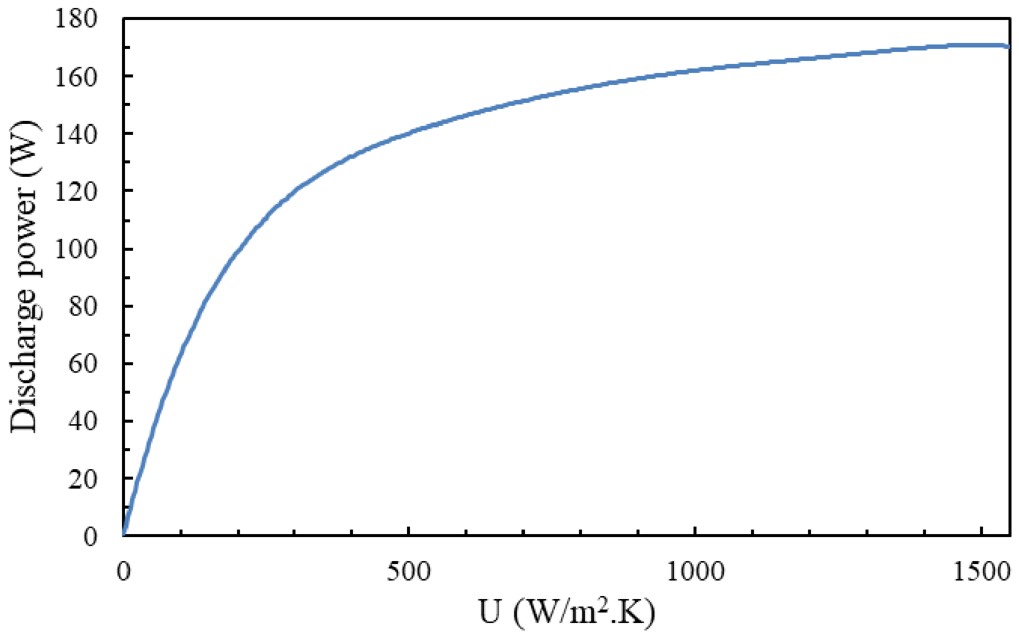
Heat and mass transfer analysis

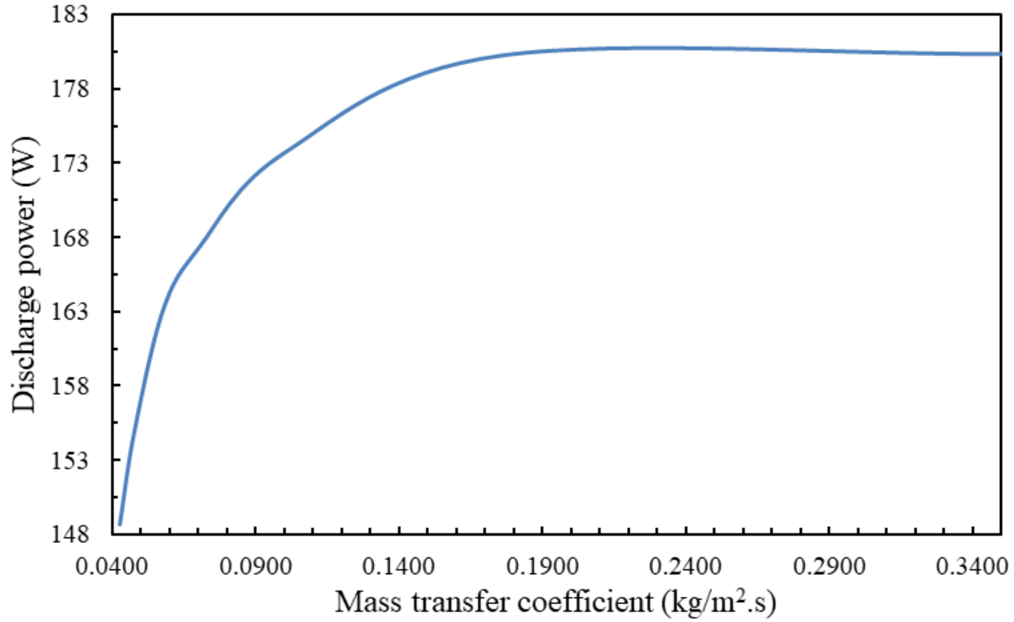
$$\dot{m}_{htf} \times 4.18 \times \left(T_{htf,out} - T_{htf,in}\right) = UA \frac{\left(T_{htf,out} - T_{s,in}\right) - \left(T_{htf,in} - T_{s,out}\right)}{\log\left(\frac{\left(T_{htf,out} - T_{s,in}\right)}{\left(T_{htf,in} - T_{s,out}\right)}\right)} = \dot{m}_s\left(h_{in} + \left(\frac{X_{in}}{X_{out}} - 1\right)h_v - \frac{X_{in}}{X_{out}}h_{out}\right)$$

$$\dot{m}_s\left(\frac{X_{in}}{X_{out}} - 1\right) = kA\frac{\left(X_{in} - X_{eq,in}\right) + \left(X_{out} - X_{eq,out}\right)}{2}$$

A lumped parameter analysis is considered for studying the impact of heat and mass transfer coefficients

Impact of heat and mass transfer coefficients





The performance is limited by mass transfer resistance of the solution film

Performance analysis of heat exchanger with fin height 6.35mm

Performance with preheating section

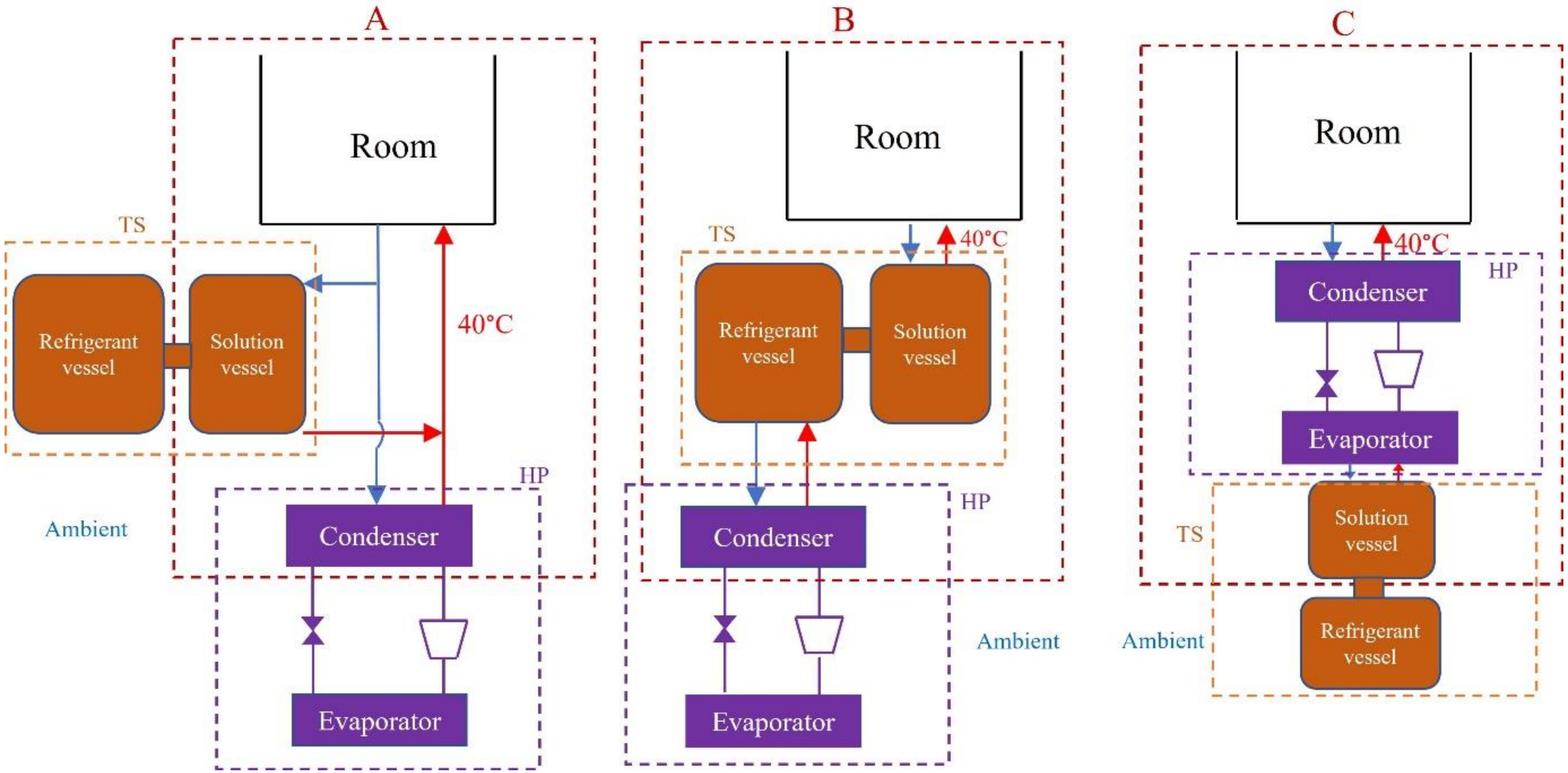
Evaporator temperature (°C)	Solution flow rate (g/min)	Cooling water inlet temperature (°C)	Discharge power (W)	Solution outlet concentration
20	6.7	28.0	127.5	36%
15.9	6.5	25.1	120.3	36%
10.5	6.0	20.5	123.6	35%

Performance without preheating section

Evaporator temperature (°C)	Solution flow rate (g/min)	Cooling water inlet temperature (°C)	Discharge power (W)	Solution outlet concentration
20	8	28.0	138.6	36%

- Preheating section reduces discharge power with no reduction in energy density.
- Tube fins without preheating section are considered for scaling up the absorption heat exchanger.

Discharging cycle



Way further

Impact analysis with 1-Octanol surfactant

1-Octanol concentration (ppm)	Solution flow rate (g/min)	Cooling water inlet temperature (°C)	Discharge power (W)	Solution outlet concentration
100	5.6	28.0	115.3	35%
300	6.5	25.1	107.3	36%
500	6.0	20.5	88.2	37%

- Octanol is seen to reduce the absorption capability of NaOH and not recommended.
- Further work includes the performance analysis with 2-Ethyl-1-Hexanol surfactant.
- Performance studies are to be carried on a scaled rig of around 8kW discharge power capacity with 60 concentric tubular finned heat exchangers.

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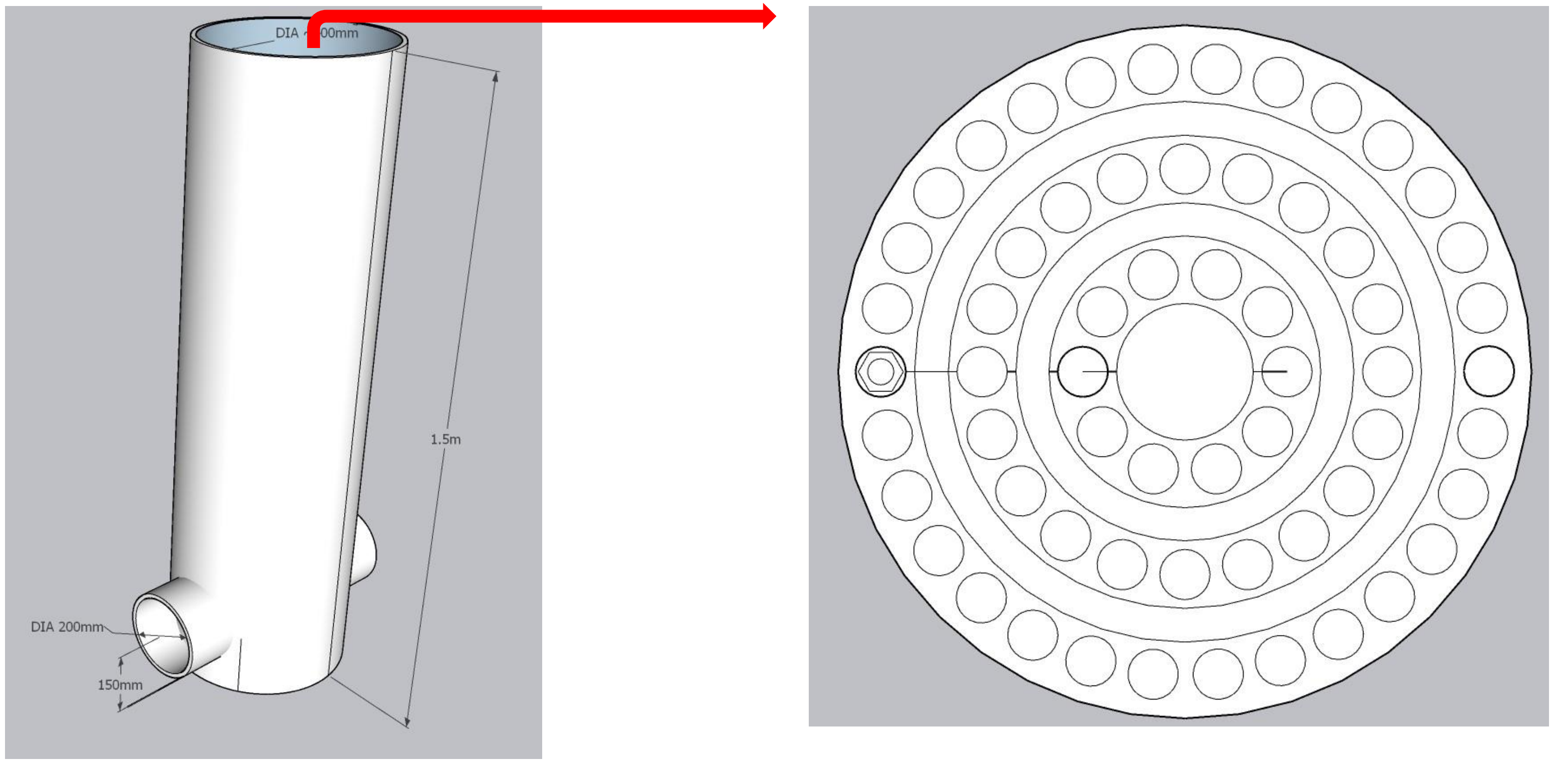

60 finned tubes are arranged in 3 rows with gaps for vapor diffusion