Design and Evaluation Of Solar Thermal Compressor

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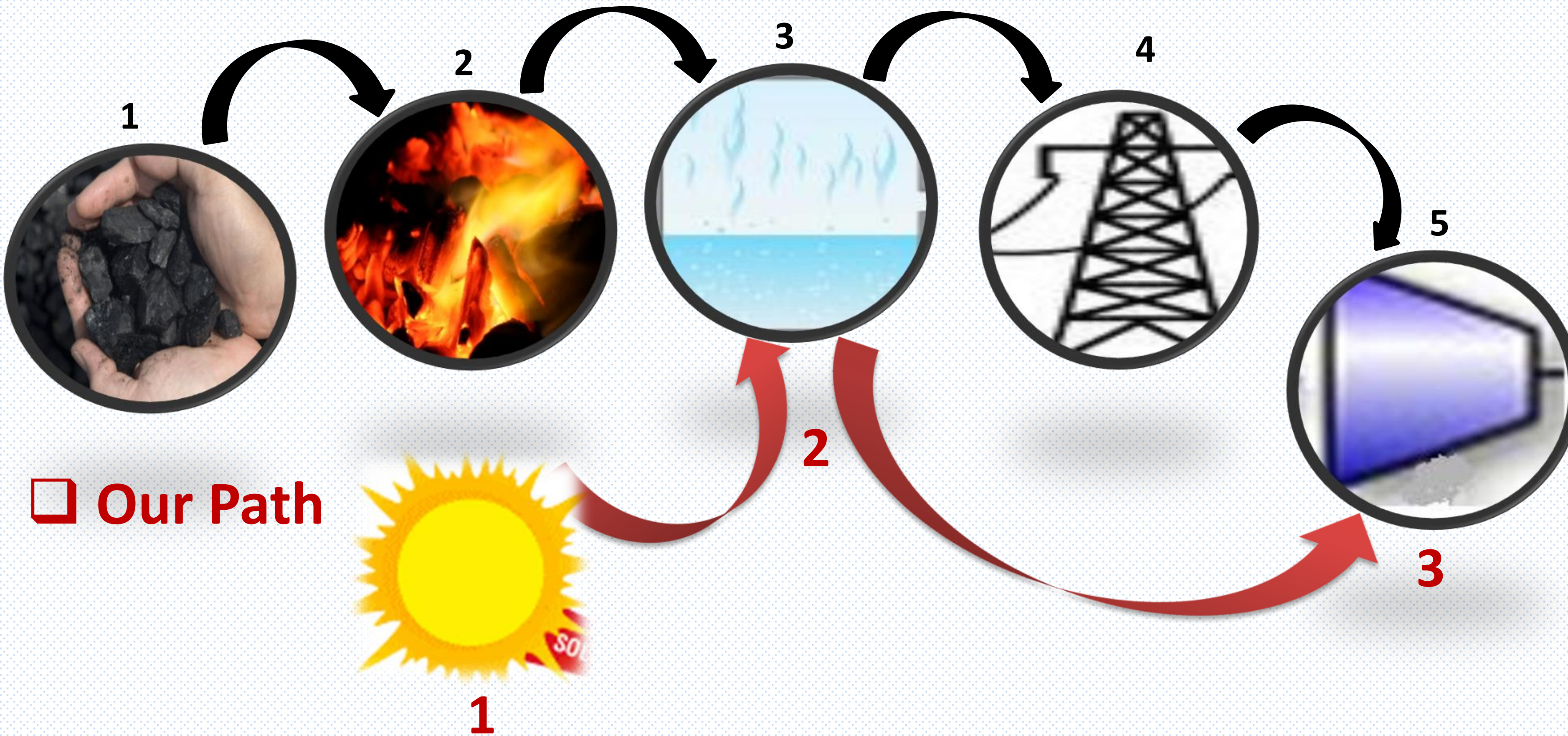
Motivation

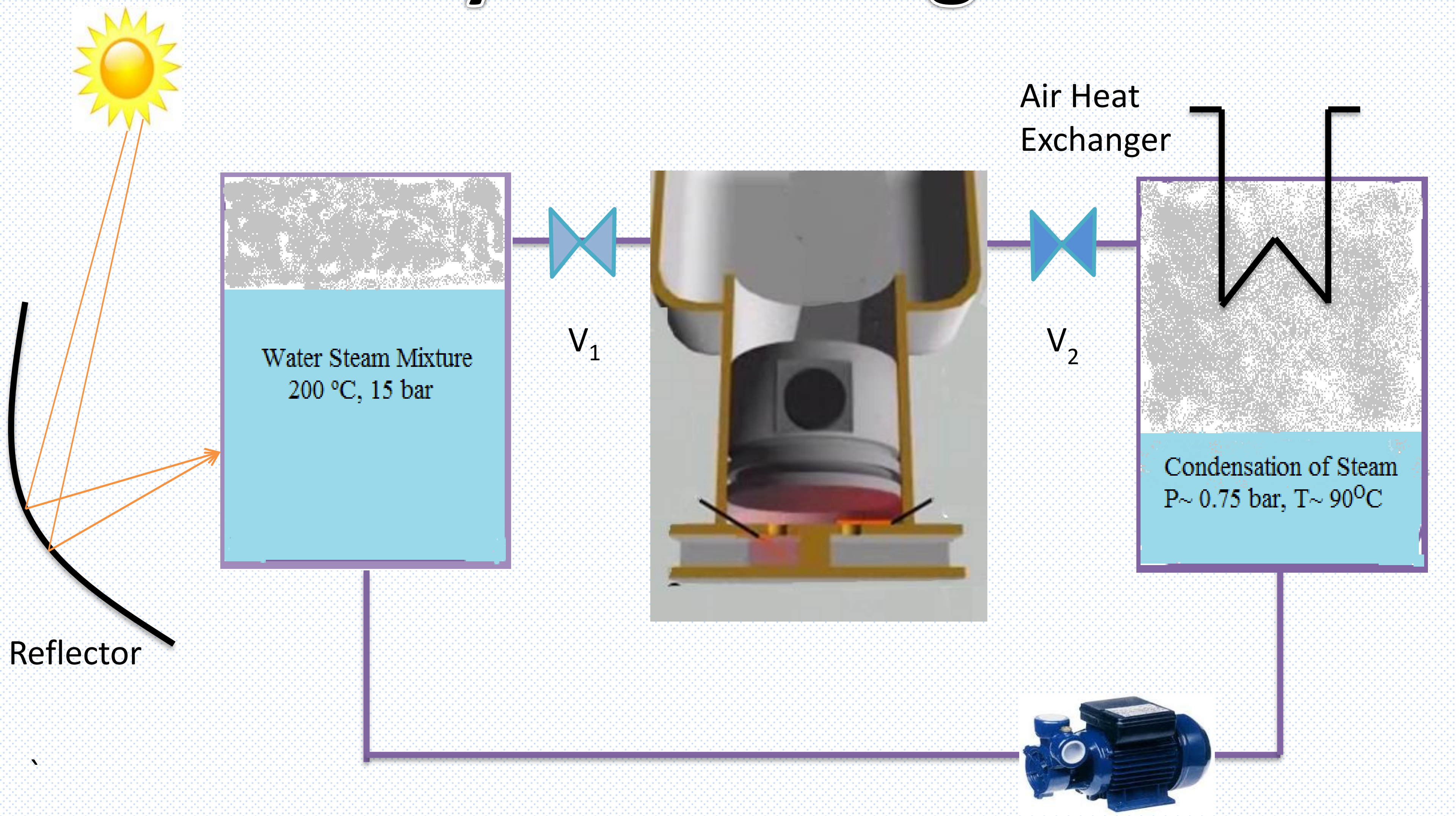
- Conventional Path

- Our Path

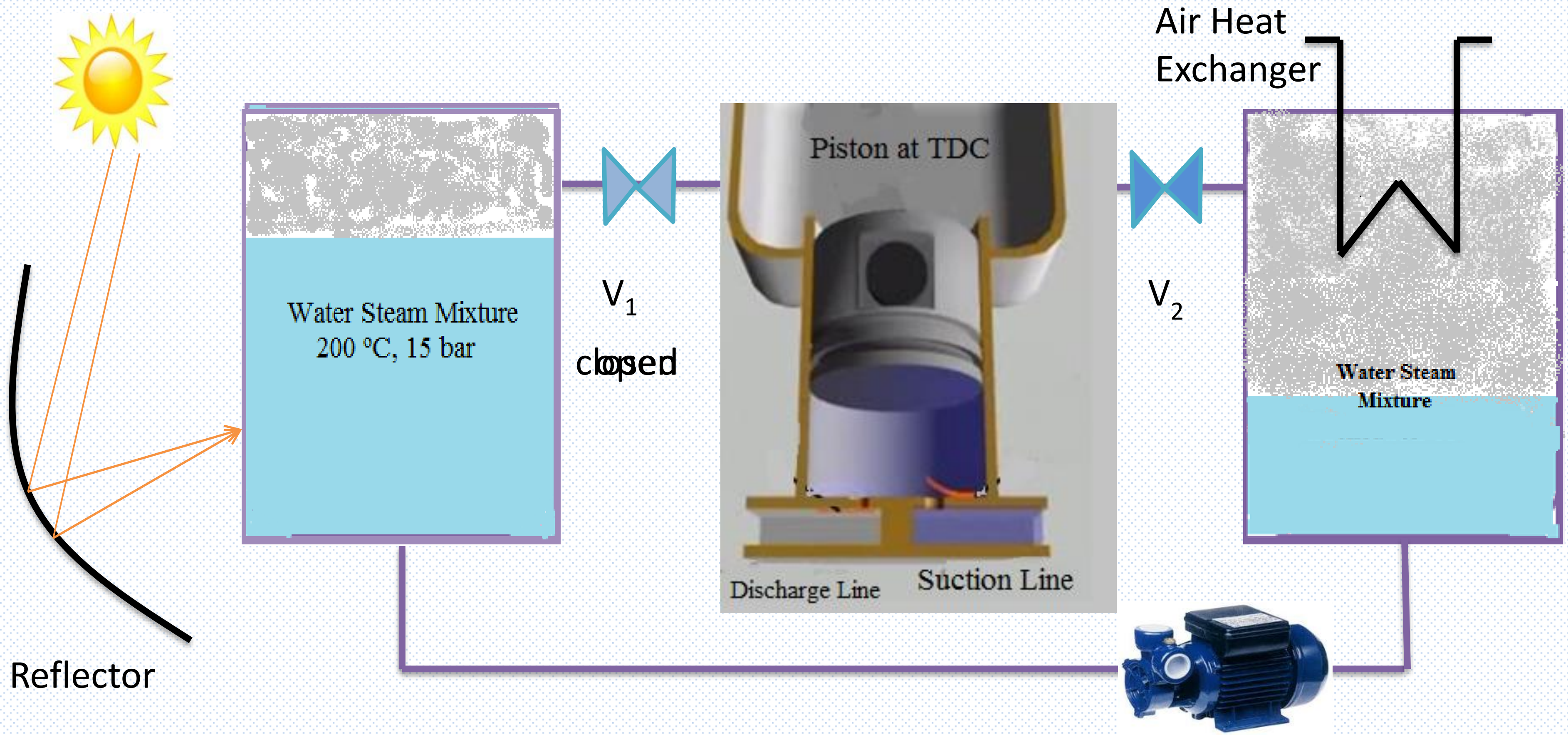


It can run without electricity

System Design



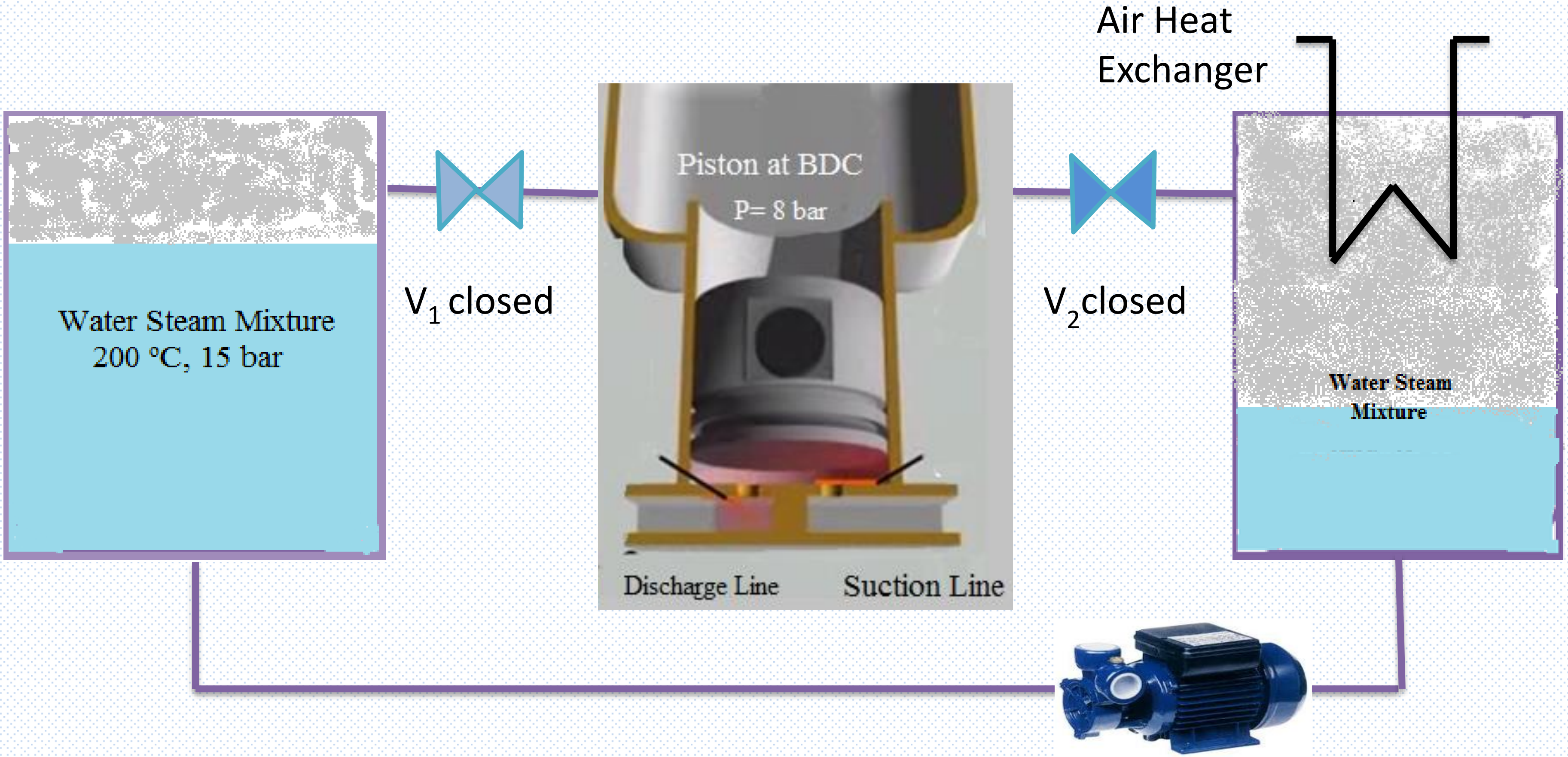
Thermodynamic Cycle Step 1



- Step I) a) Heating in vessel 1 to attain 200° C, 15 bar

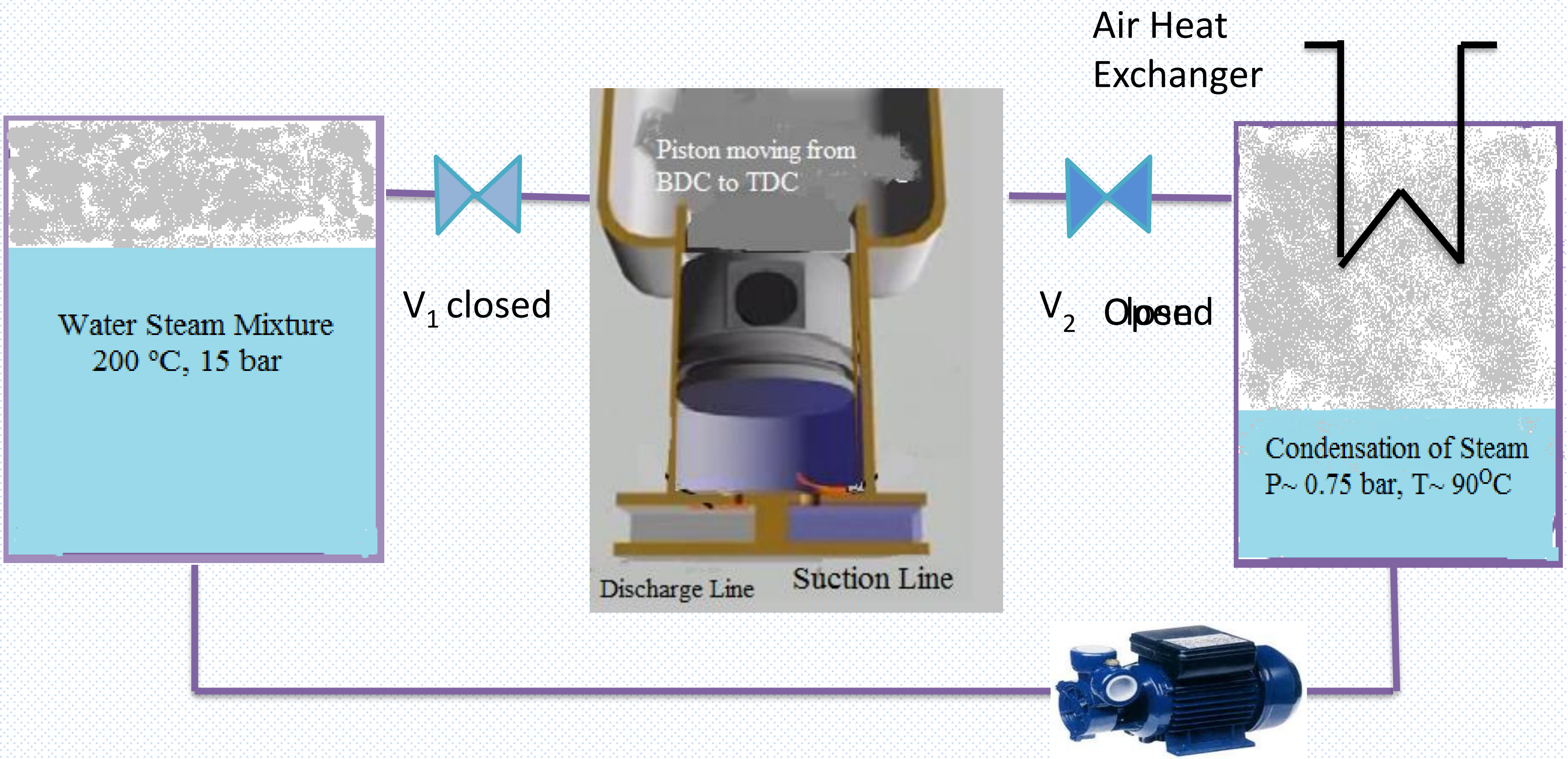
  b) On reaching (a) valve V1 will open, allowing steam to pass to vessel 2, builds P= 15 bar, piston does not moves till then.

Thermodynamic Cycle Step 2



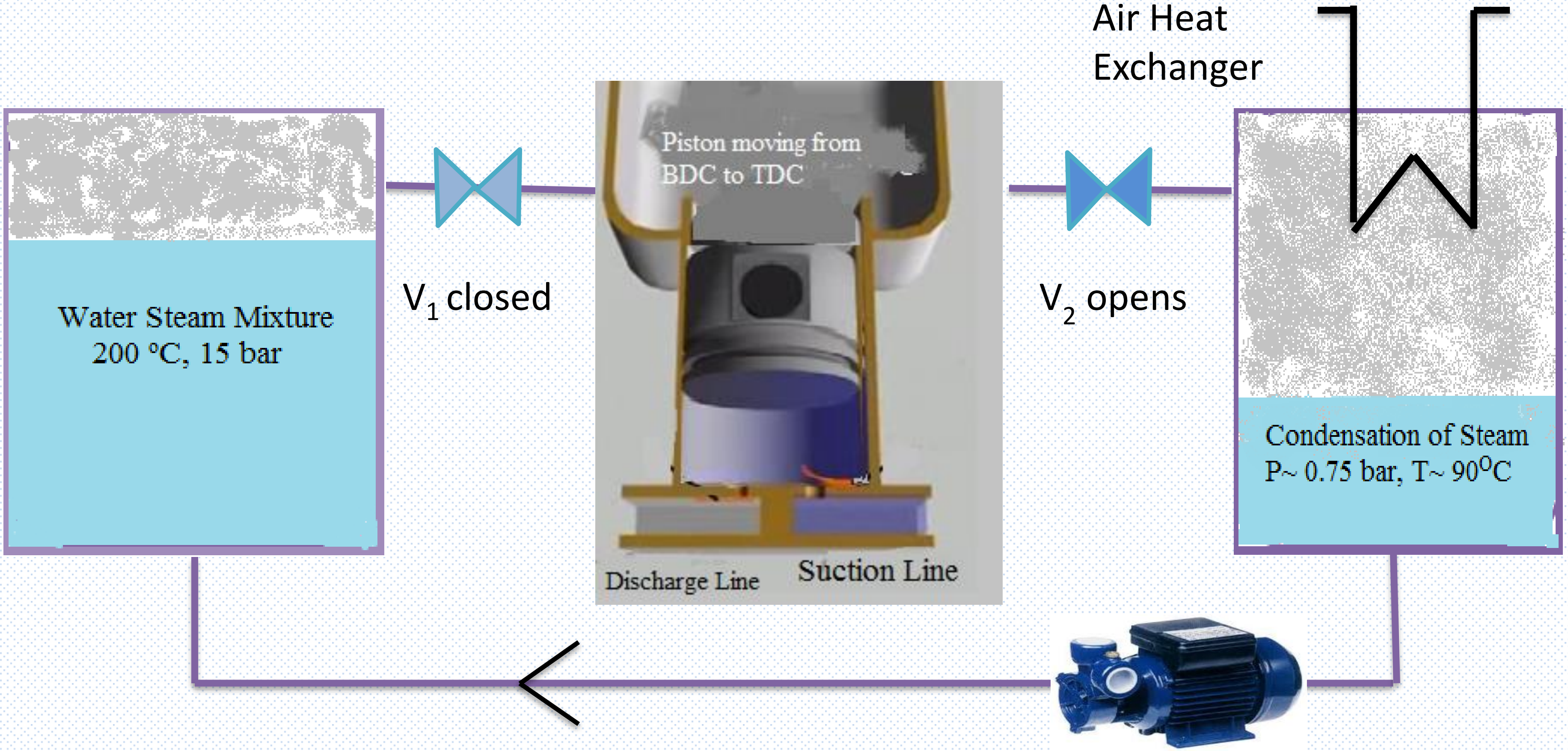
- Step II) V_1 closes; Steam works on piston, isentropic expansion, Final P= 8 bar (assuming volume doubling)

Thermodynamic Cycle Step 3



- Step III)
  - a) Valve V_2 opens, steam moves to vessel 2.
  - b) Steam is condensed to P= 0.75 bar, T= 90 °C. Suction Valve opens to make fluid enter from suction line.

Thermodynamic Cycle Step 4



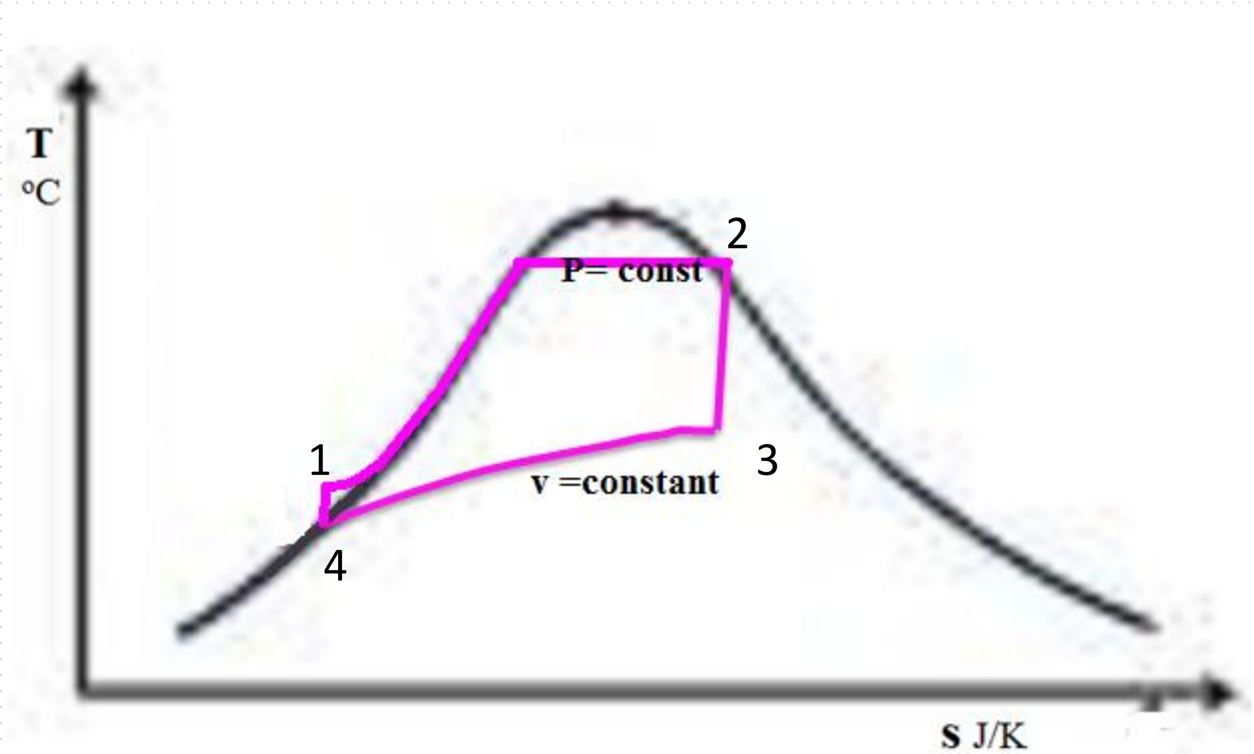
` • Step IV) Electric Pump, pumps back the water from P ~ 0.75 bar to P = 15 bar, isentropically

Thermodynamic Cycle

- This model has been developed by the concept of Steam Engine and Reciprocating Compressor.

- We have planned to operate this on this thermodynamic Cycle (ideal case)-

1-2)	Isobaric heat addition
2-3)	Isentropic expansion in piston
3-4)	Isochoric heat removal
4-1)	Isentropic compression in pump

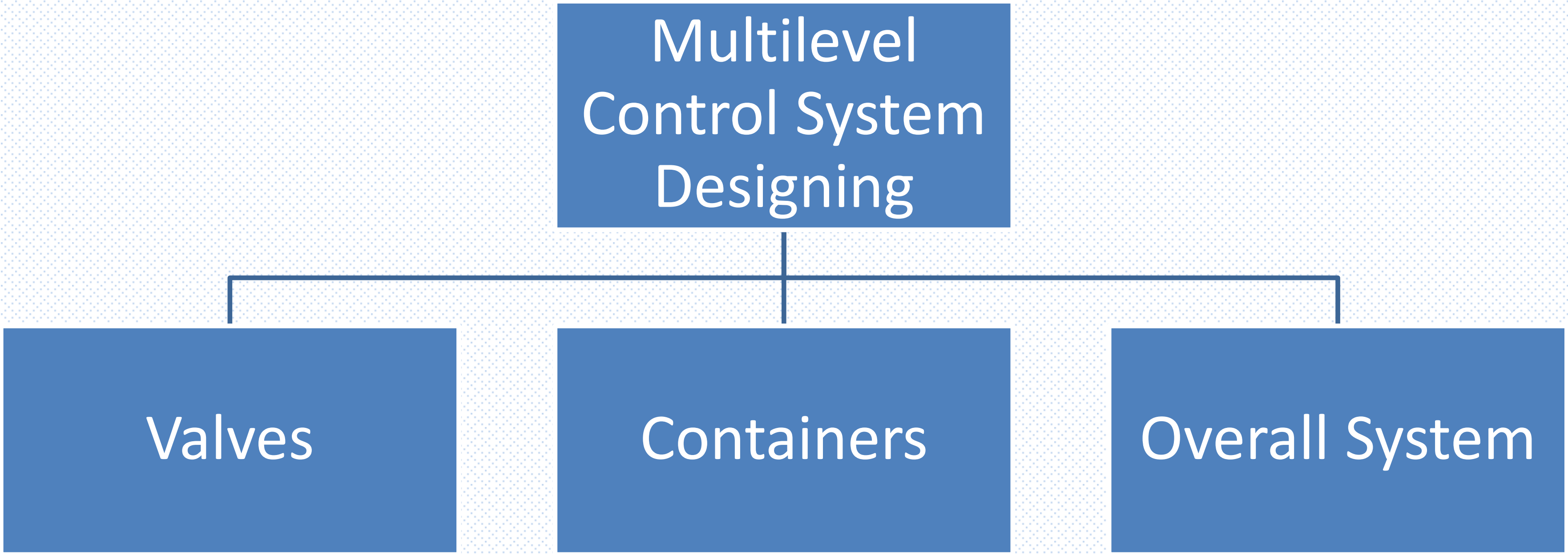


System Highlights

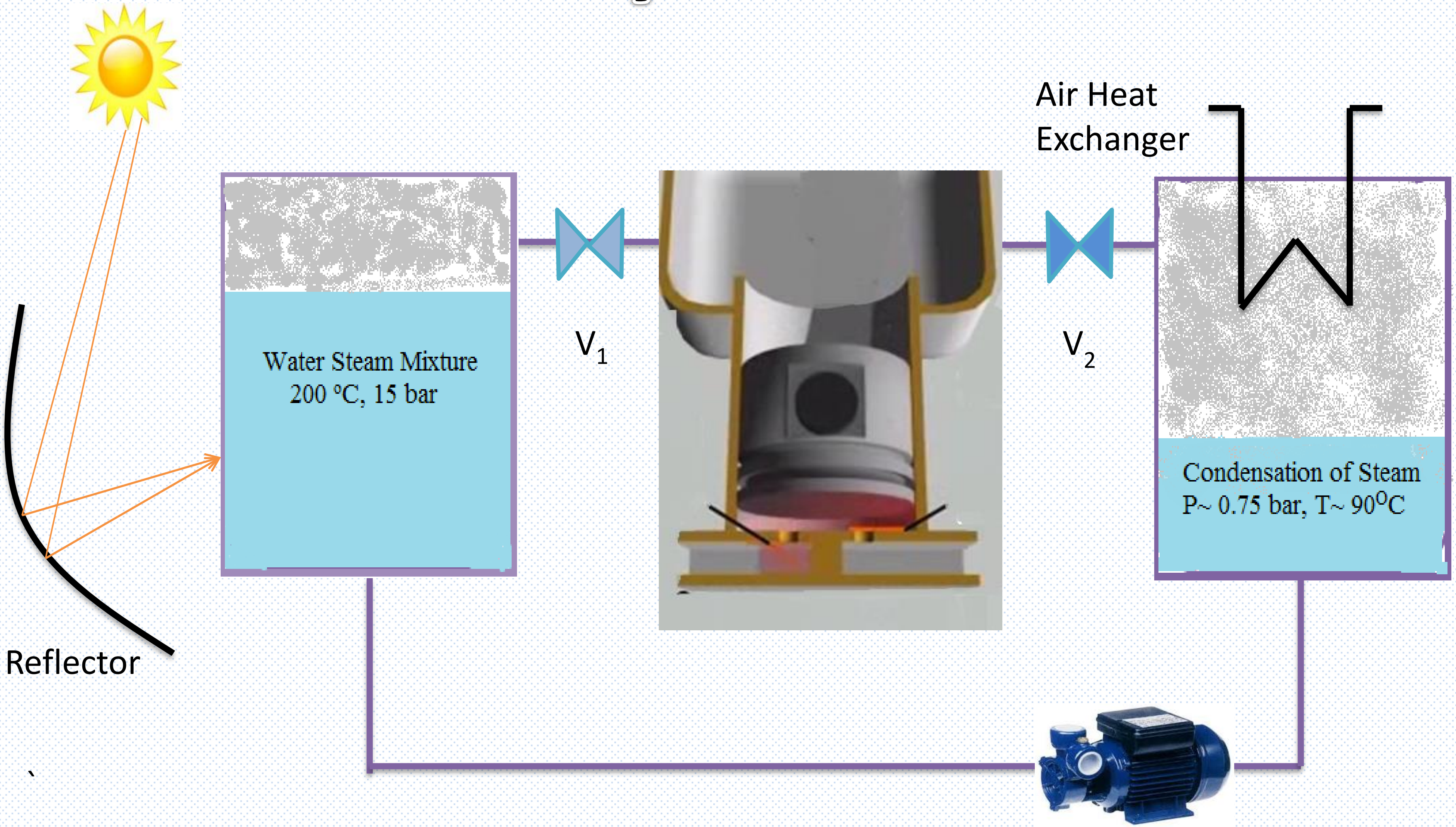
- Electrical Input to Pump is 2-3 % of mechanical work extracted.
- Expected net efficiency of system 10-15 %
- Challenges-
  - Non Uniformity.
  - Cant be readily used in industries.

Can play extremely crucial role in Domestic Appliances

Control System Designing

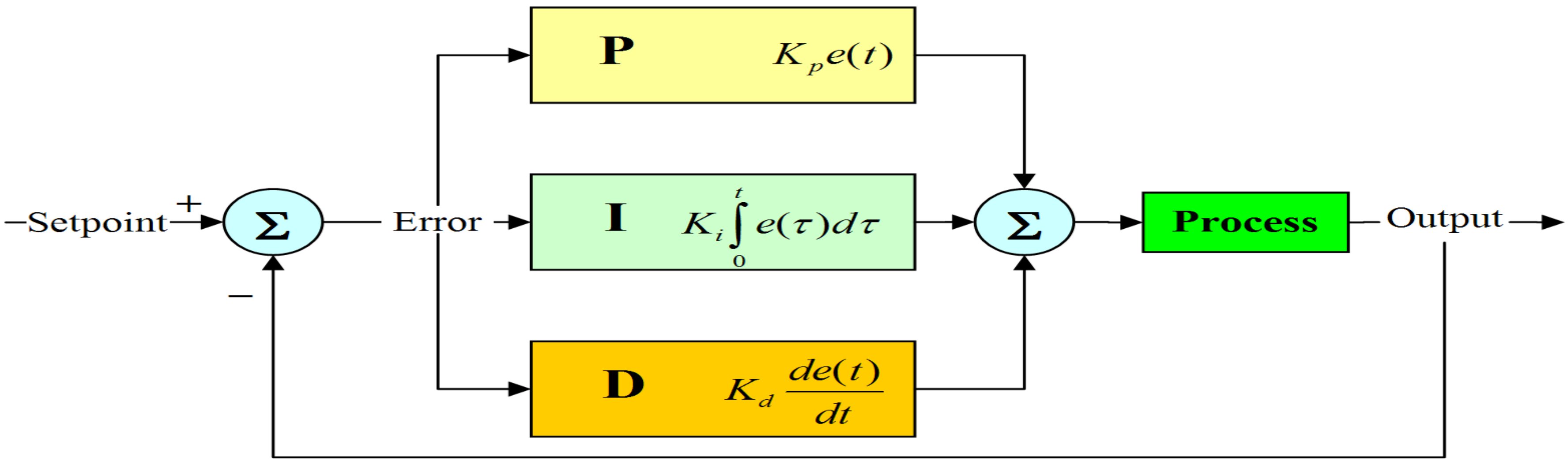


System



Air Heat
Exchanger
Water Steam Mixture
200 °C, 15 bar
V_1
V_2
Condensation of Steam
P~ 0.75 bar, T~ 90^{O}C
Reflector

Control System Designing

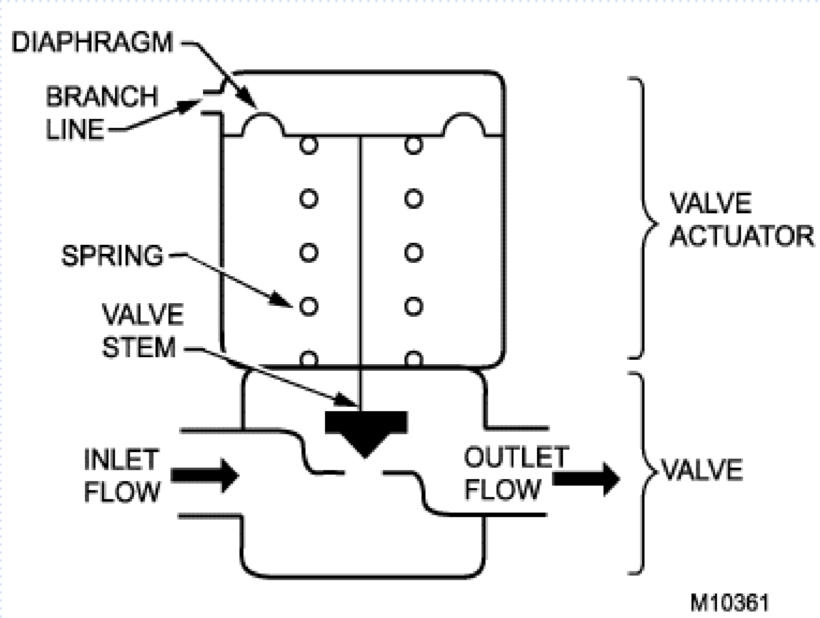


- Transient analysis - reduce settling time.
- Steady State analysis – minimize steady state error.
- Root Locus, Nyquist and Bode Plot for calculating Kp, Ki & Kd.
- As feedback we will take pressure.

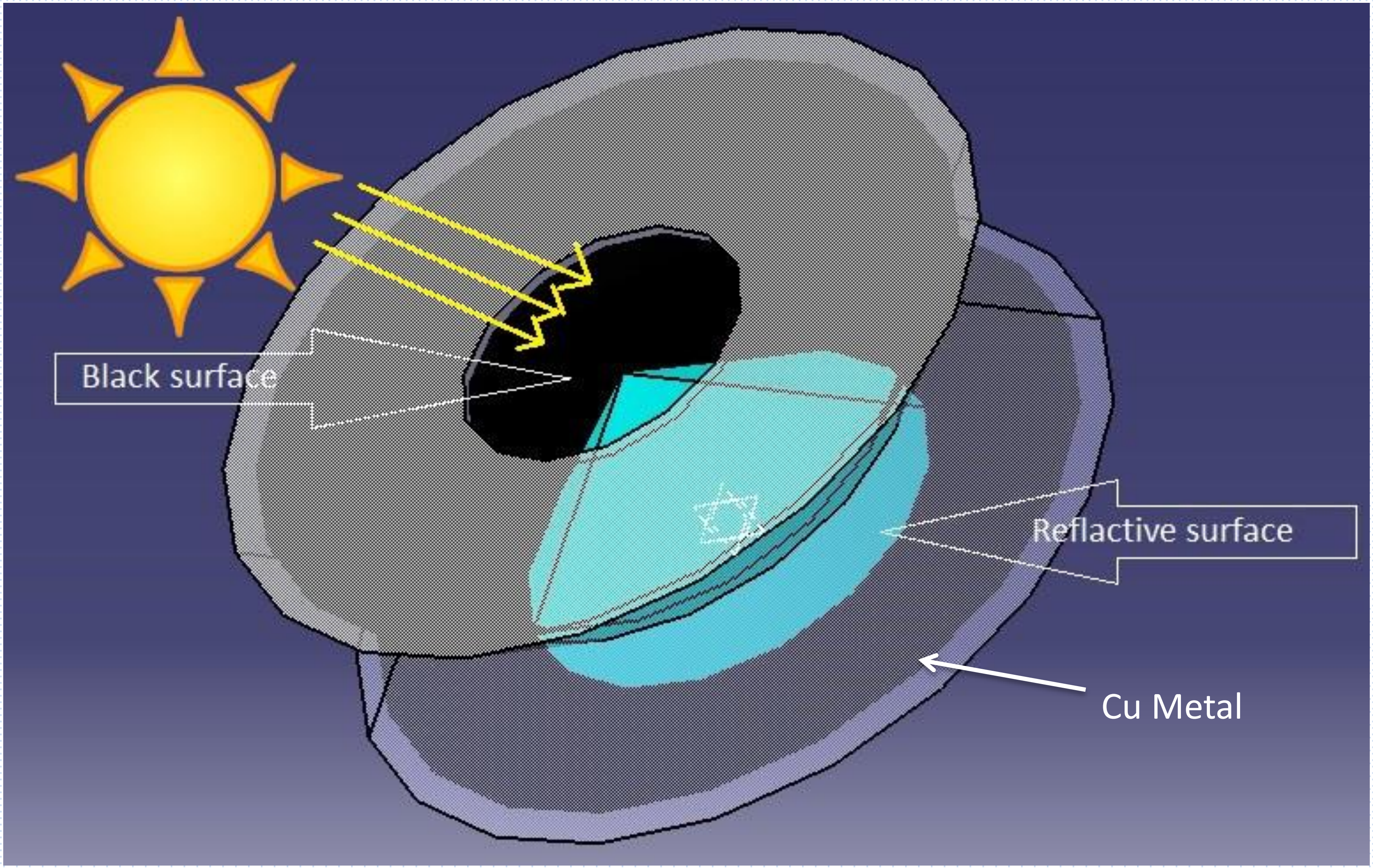
Control System Designing (Valves)

- Pneumatic Valves with Actuator (figure shown below) - To control flow rate of fluid between containers.

- Controlling variables for actuator signal - Pressure, Temperature and flow rate . We will add new variables as the design develops further.



Design of the device that measures solar heat flux



Heat Flux Measuring Device
Aim

1. Design flux measuring device for more than one sun condition. (capacity till 100 kW)
2. Plot the curves of temperature vs time of radiation exposure
3. Calculation of incident heat flux where area through which radiation is coming is known.

We know energy equation is-

$$\overset{o}{E}_{in}+\overset{o}{E}_{g}-\overset{o}{E}_{out}=\overset{o}{E}_{st}$$

Here assumptions are-

$$\overset{o}{E}_{g}=0$$

$$\overset{o}{E}_{out}=loss$$

$$and$$

$$\overset{0}{E}_{st}=\overset{o}{m}C_{p}\Delta T$$

Here Cp is varying with temperature change.

Losses are of two types here-

Reflective losses(when rays are going back out)

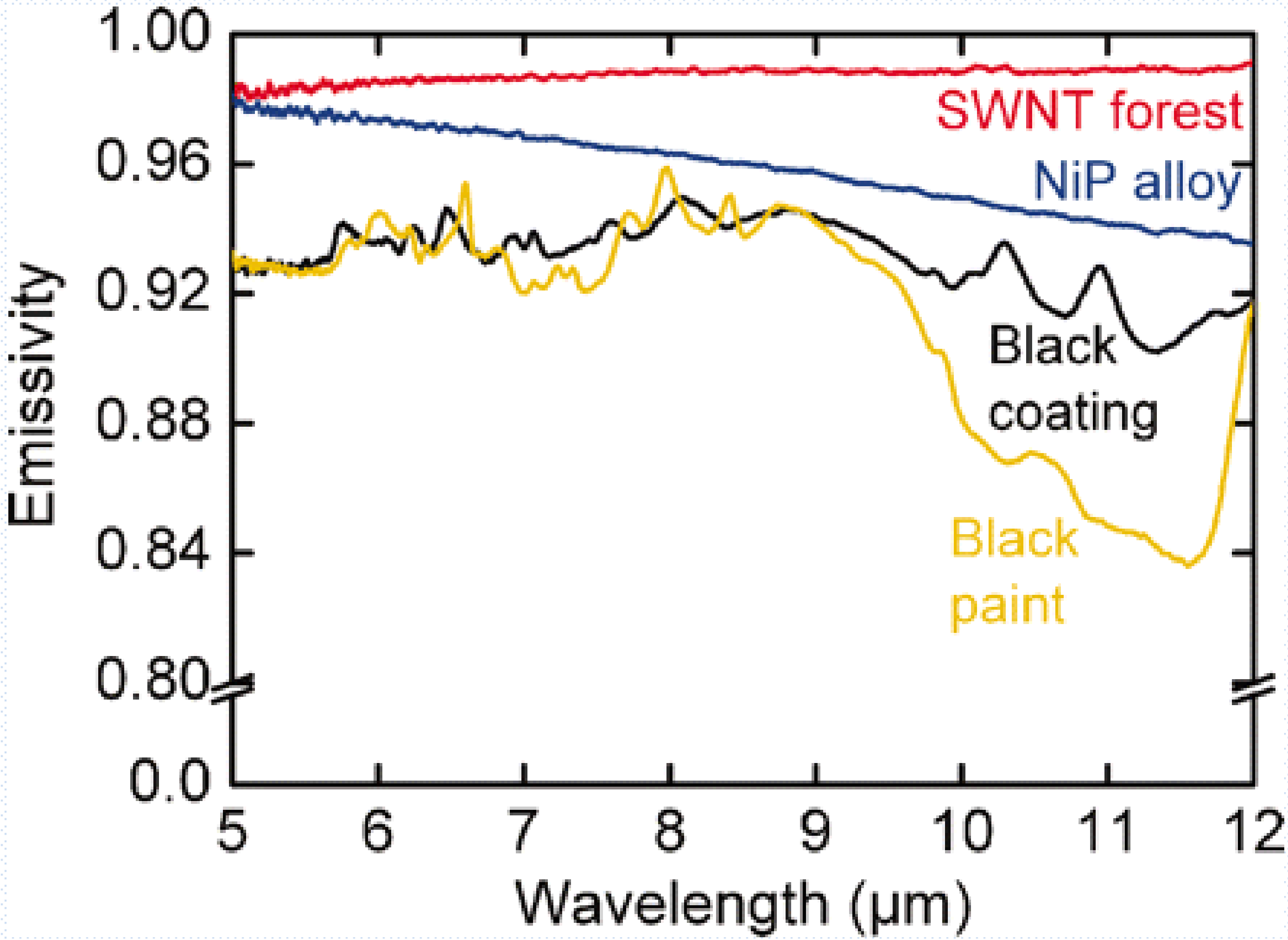
Convective losses(due to outside air)

Design

- We are using Cu as device material as Cu has high conductivity and can get uniform temperature earliest.
- Reflected beam is a diffused beam. So to minimize view angle and to increase the area of absorption we are curving the walls in a way that we get maximum efficiency.
- Black body material is another important aspect for this experiment
- Insulation is key factor to reduce convective losses.

following are the description of some black body materials-

Materials for black body



Thank You!!!

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