III. Phase change cycles (Rankine)

1. Rankine cycle

The Rankine cycle is an ideal thermodynamic cycle of a heat engine that utilizes a phase change. It is the fundamental operating cycle of steam power plants (Fig. 1). At constant pressure, it converts some of the heat into mechanical work. Heat is supplied from outside to a closed loop, which usually uses water (in liquid and vapor phases) as the working fluid. The working fluid of the Rankine cycle undergoes a phase change from liquid phase to vapor phase and vice versa.

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2. Fonctioning

It consists of (Fig. 1):

1–2: adiabatic and reversible pumping in the pump, from a saturated liquid state 1

2–3: isobaric heat exchange in the boiler until the state of saturated steam 3

3–4:adiabatic expansion and reversible in the turbine

4–1: heat exchange isobaric in the condenser.

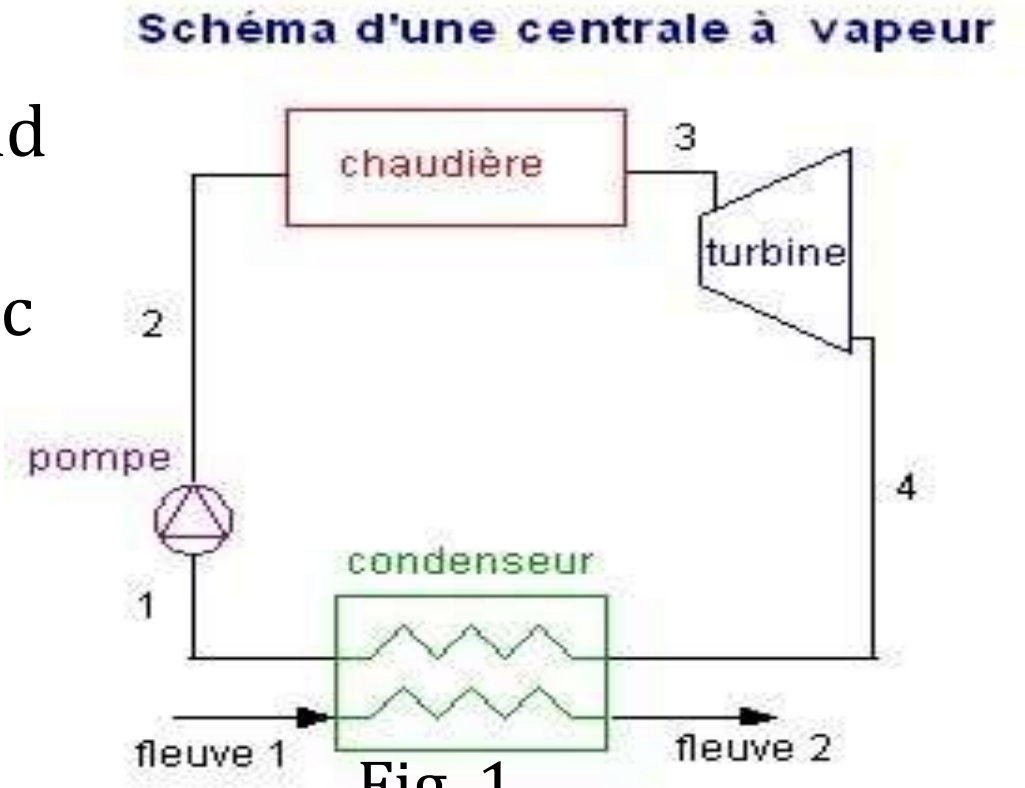

Fig. 1

III. Phase change cycles (Rankine)

A variation is the Hirn cycle in which the steam is superheated before being expanded. It is this variant that is used in power plants. Neglecting variations in kinetic and potential energy, the heat received by the fluid is represented by the area a–2–2'–3–b–a
and the heat given upAt the condenser
is shownBy the area a–1–4–b–a
(Fig. 2).The cycle includes two
isobars and two adiabatic.

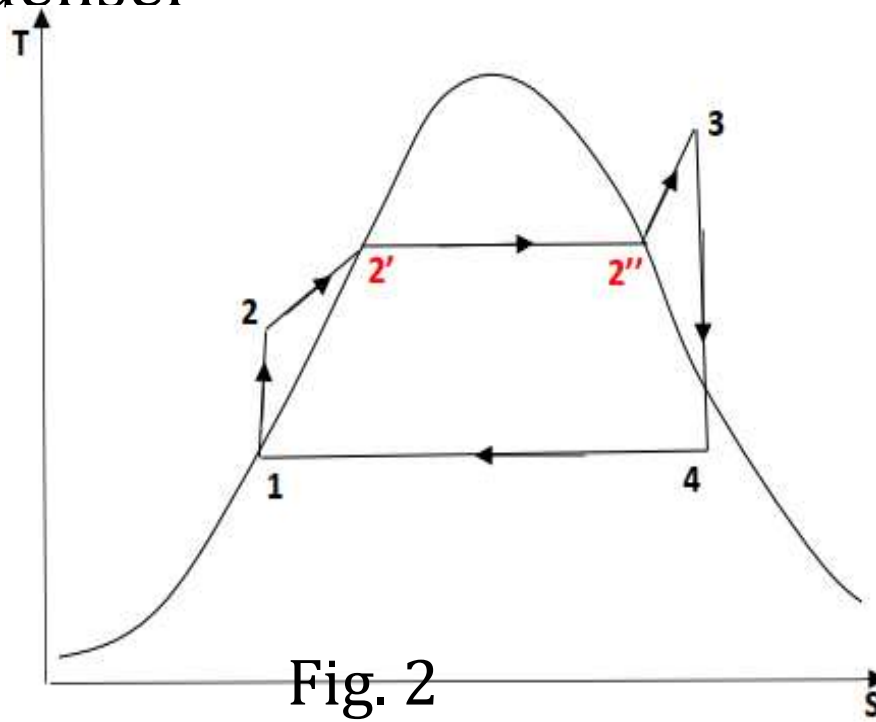

Fig. 2

III. Phase change cycles (Rankine)

3. Energy balance

- The change in enthalpy for one cycle per unit mass

$\Delta H=Q+W$

-Isentropic compression in the pump

- $Wp=h2-h1$

-Isobaric heating which is a vaporization in the boiler

$Qb=h3-h2$

- Isentropic expansion in the turbine

- $Wt=h4-h3$

-Isobaric liquefaction cooling in Condenser

-$Q1=h1-h4$

The use of thermodynamic tables and diagrams is necessary for the calculation of the intermediate states 2' and2''