SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF MECHANICAL ENGINEERING

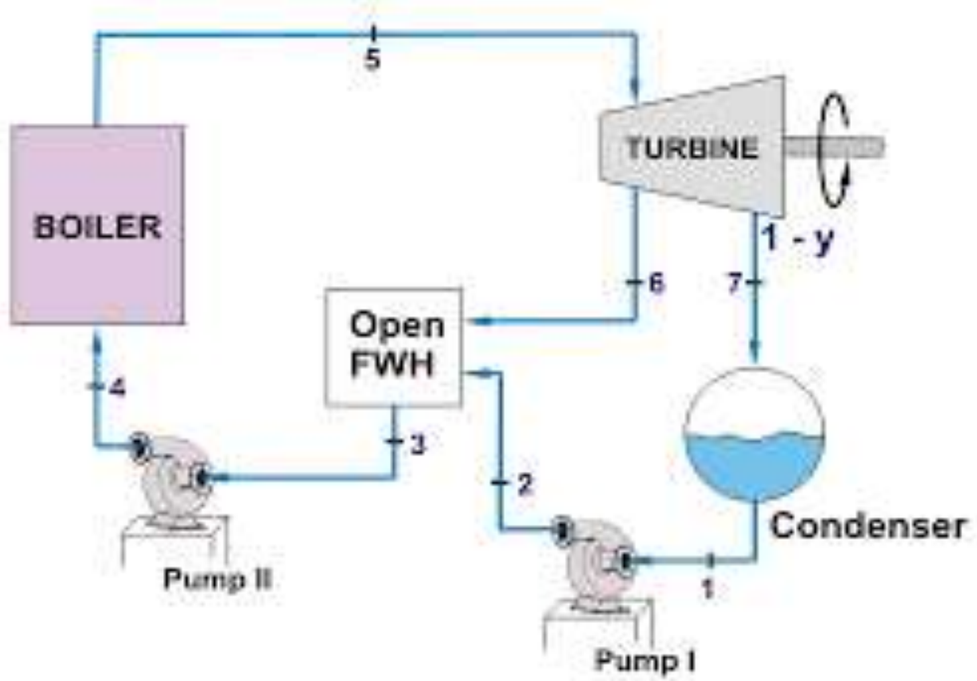
ENGINEERING THERMODYNAMICS

UNIT 4 – STEAM POWER CYCLES

TOPIC –RANKINE WITH REGENERATIVE CYCLE

K.Prakash,
ASP/ Mechanical Engg.,
SNS College of Technology,
Coimbatore - 35

Introduction to Regenerative cycle



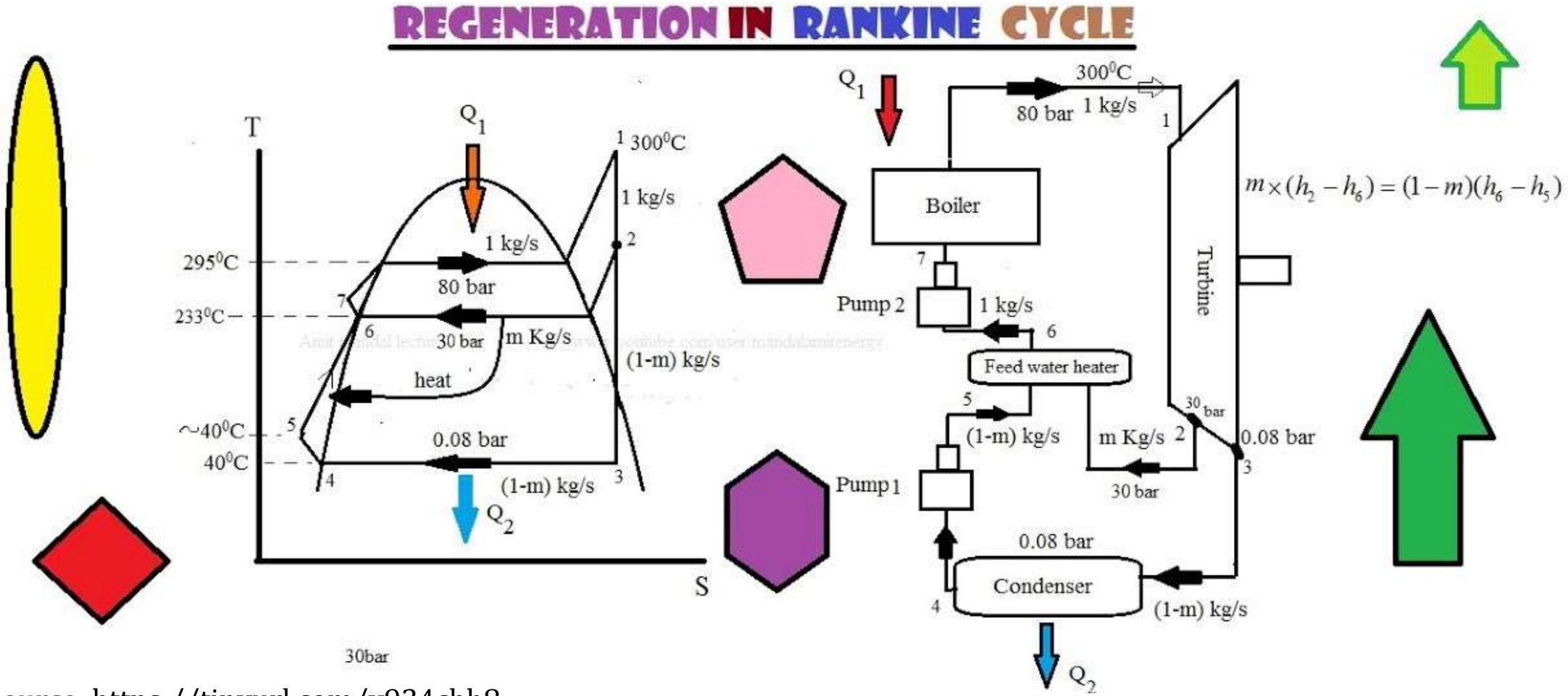
Source : **electrical4u.com**

It is process in which steam is extracted at several locations of the turbine

Why Regenerative cycle?

- To reduce the heat loss from the Condenser
- To save the fuel consumption
- Cost effective
- To reduce the pollution

Schematic Diagram



Source :https://tinyurl.com/y934cbh8

Assessment -1

1. The steam extracted at several locations at the turbine is called
   a) Dry steam
   b) Wet steam
   c) Bled Steam
   d) Superheated steam
2. Identify the place where maximum heat rejection takesplace
   a) Boiler
   b) Condenser
   c) Turbine
   d) Pump

Assessment -1(Contd..)

3. For every 9°C temperature rise in the feed water, 1% of _____ will be saved.

a) energy consumption

b) fuel consumption

c) Turbine work

d) pump work

4. The place where bled steam and condensate is mixed is called

a) Turbine

b) Condenser

c) Feed water heater

d) Pump

Processes involved

- Process 1-2 , 2-3 Isentropic expansion [Turbine]
- Process 3-4 Constant pressure heat rejection [Condenser]
- Process 4-5 and 6-7 Isentropic compression in Pump1 and Pump2
- Process 7-1 Constant pressure heat addition [Boiler]

Working Principle

- High pressure and high temperature passes through the [*Turbine*]
- The steam extracted several locations(*Bled Steam*) before entering to the condenser
- Only less amount of steam passes through the condenser(*less amount* heat released)
- condensate and Bled steam is directly mixed in *feed water heater*
- Thus feedwater (*to boiler*) temperature increases

Working principle

- 1% of fuel consumption is saved for every 9°C temperature rise (*feed water*)
- Increases the *overall thermal efficiency*
- Reduces the *fuel consumption.*
- This indirectly helps to reduce *CO_2 emissions*
- Reduces the corrosion at turbine blades (*Increases turbine life*)

Estimation of Thermal efficiency

Turbine work : $W_T = (h_1 - h_2) + (1-m)(h_2 - h_3)$ kJ/kg

Compressor work : $W_P = (h_7 - h_6) + (1-m)(h_5 - h_4)$ kJ/kg

Heat input : $Q_{in} = (h_1 - h_7)$ kJ/kg

Thermal efficiency : $\eta = (W_T - W_P)/Q_{in} \times 100$

Advantages

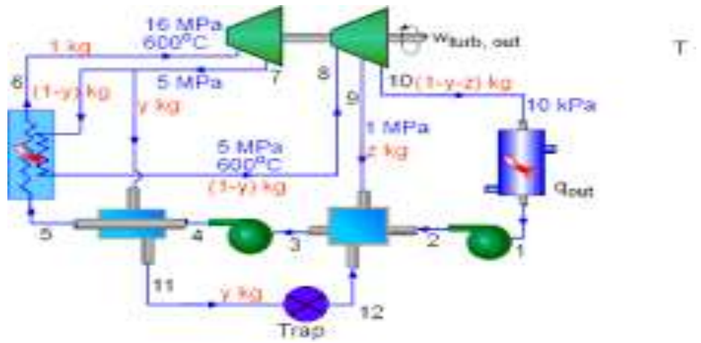
Source :https://www.clarke-energy.com/

- Reduces primary energy cost (fuel cost)
- Improves fuel efficiency

Source : https://science.howstuffworks.com

- Reduces CO_2 emission

Advantages



Source : https://www.ecourses.ou.edu

- Improves overall thermal efficiency (less heat loss at Condenser)

Source : https://tinyurl.com/y7ef2sl9

- Less corrosion at Turbine

Disadvantages

Source :electrical4u.com

- High initial cost for setting up Feedwater heaters

Source : https://blog.miragemachines.com

- High maintenance

Assessment -2 (Problem)

1. In a single heater regenerative cycle, the steam enters the turbine at 30bar,400^{o}C and the exhaust pressure is 0.1 bar. The feed water heater is a direct contact type which operates at 5 bar. Estimate

   i) the efficiency of Rankine with Regenerative cycle.

   ii) Steam rate and Heat rate

References

- Nag. P.K., “Engineering Thermodynamics”, 4th Edition, Tata McGraw-Hill, New Delhi, 2013
- Cengel. Y and M.Boles, "Thermodynamics - An Engineering Approach", 8th Edition, Tata McGraw Hill, 2014
- Moran, Shapiro, Boettner & Bailey "Principles of Engineering Thermodynamics:", Wiley & Sons, 2015
- https://ocw.mit.edu/courses/physics/8-21-the-physics-of-energy-fall-2009/lecture-notes/MIT8_21s09_lec12.pdf
- https://nptel.ac.in/courses/101/104/101104063/