BPT-201 (semester II)

Topic: Regenerative Cooling and Liquefaction of Helium gas

Dr Neelam Srivastava

Department of Physics (MMV Section)

Banaras Hindu University

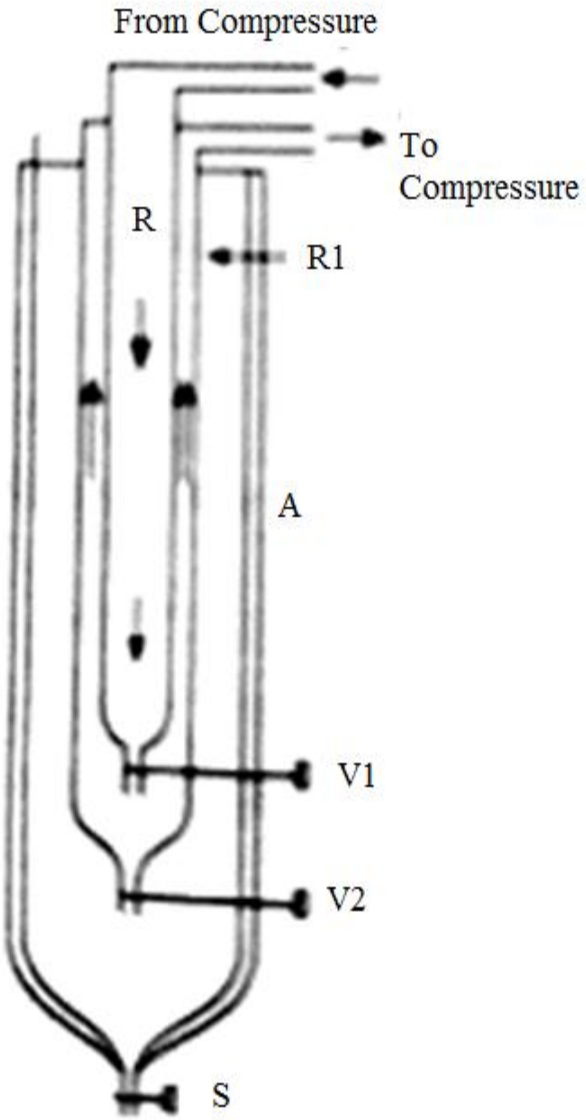
neelamsrivastava_bhu@yahoo.co.in

neel@bhu.ac.in

What is the use of regenerative cooling

- For liquefaction of a gas, gas should be cooled down upto its critical temperature T_c.
- For many gases the Tc is quite low and hence their liquefaction needs pre-cooling.
- As in JT expansion we have seen that cooling of a gas can be done through expansion
- Although this also requires the initial temperature to be less than T_i
- But $T_c = \frac{4T_i}{27}$
- i.e. $T_i > T_c$ Hence it is much easier to achieve T_i by other means.

The ΔT depends upon the initial temperature.
Hence a process of regenerative cooling has been designed.
The sketch of the apparatus is shown in figure
Where in chamber R gas from compressor
Enters and it throttles via valve V_1
This chamber R is surrounded by chamber R_1
Hence, the gas coming out of valve V_1 ,
which has temperature lower than the initial temperature, passes through R_1, cools the gas in chamber R.
Now when gas in chamber R reaches to valve V1, it has lower initial temperature (than what it was having in previous cycle and after throttling ΔT is much larger.



- This cycle is repeated for many times
- After every cycle ΔT is greater than the previous cycle and hence cooling effect is regenerated via circulating the cooled gas around the gas chamber R.
- After certain number of repetition of cycle the temperature of gas is lower enough for liquefaction of gas
- The liquefied gas gets collected in chamber A.
- From where through valve S it can be taken out.

Liquefaction of Helium

- Value of critical temperature and inversion temperature of He gas is very low

  Tc=5.28K and Ti=35K.

- Hence liquefaction of He was not easy.
- Since its inversion temperature is also very low, use the regenerative cooling process was also not possible until the liquid hydrogen came to reality.
- Value of critical temperature and inversion temperature of H_2 are Tc=33K and Ti=193K.
- In 1898 Dewar got success in liquefying the H_2 and ten years after that in 1908 scientist Onnes got success in liquefying the He gas.

A=container having He gas

B=compressor to compress the gas

Coming in cyclic process

LH_2 Flask= flask having liquid H_2

P=compressor to bring H_2 vapor from flask K and create pressure in LH_2 flask so that liquid H_2 rises in Flask K

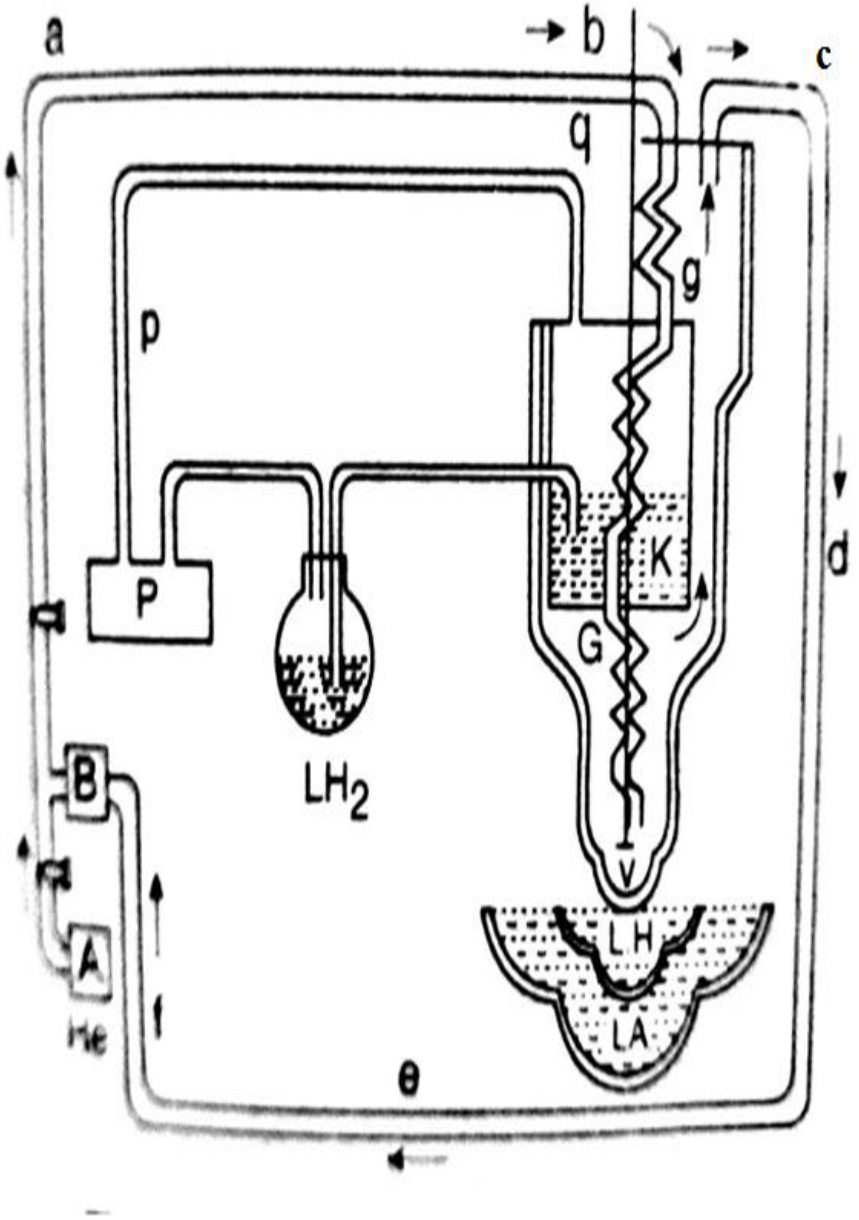
K== flask having liquid H_2 and the spiral tube through which He gases passes before throttling process

G= container where throttling process Takes place

V=valve where throttling takes place.

LH and LA= containers having liquid H_2 and liquid air to maintain the temperature of surrounding of whole chamber where throttling process is taking place

Apparatus for liquefaction of Helium gas



- To use the regenerative process for liquefaction of He, liquid H_2 is used to bring the initial temperature of He gas below its inversion temperature.
- As shown in previous slide gas passes through the spiral pipe around which there is a chamber K filled with liquid H_2
- In chamber K liquid H_2 is vaporized under reduced pressure by pump p and compression part of 'P' applies pressure in flask LH_2.
- Because of increased pressure in flask an amount of liquid H_2 rises and goes to flask K.
- In this way temperature in the chamber K is maintained at certain level

- Helium gas initially starts flowing from chamber A
- It follows the path a to b where it goes in spiral pipe which is in contact with liquid H_2 in chamber K
- Its temperature decreases below its Ti and hence during the throttling process in chamber G its temperature decreases further.
- This gas through 'g' enters in a pipe and follows path c-d-e-f and reaches to compressor 'B' where it is compressed again and after which the complete process.
- After certain number of repetition the temperature of gas is low enough and liquefaction takes place.