Thermodynamique

Diagramme de Clapeyron et diagramme entropique

Richard Mollier, 1863 - 1935

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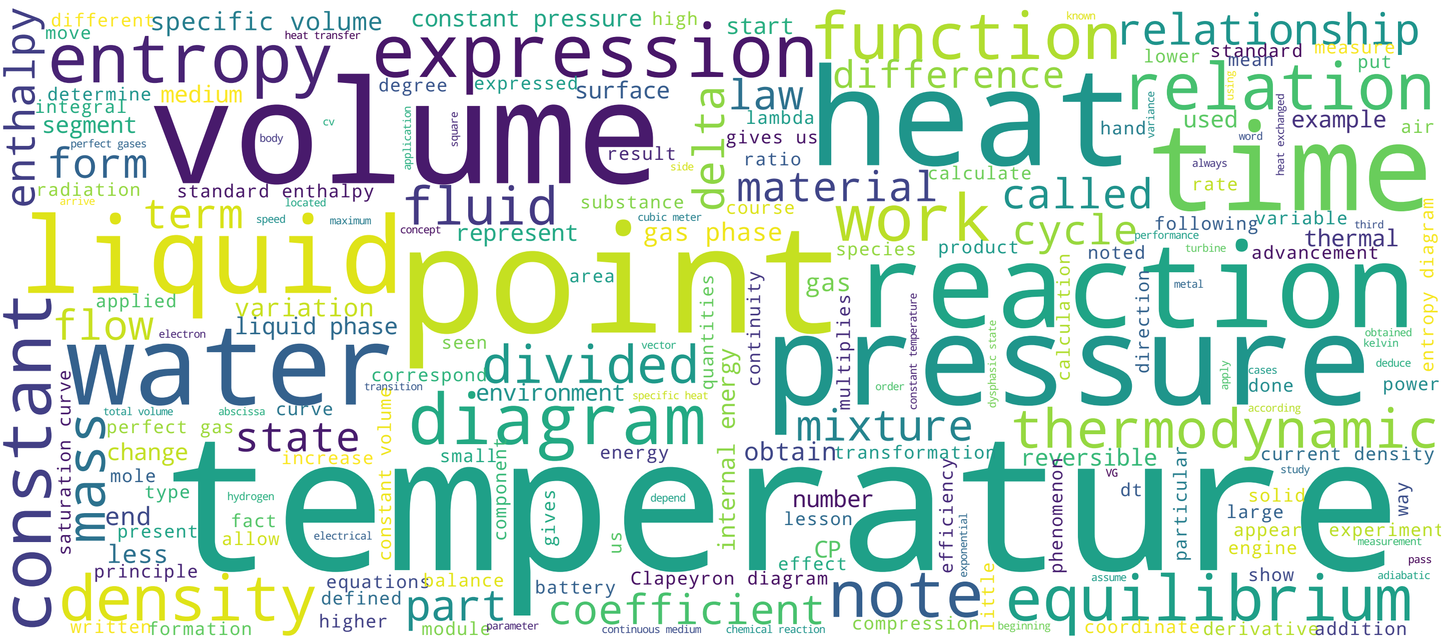
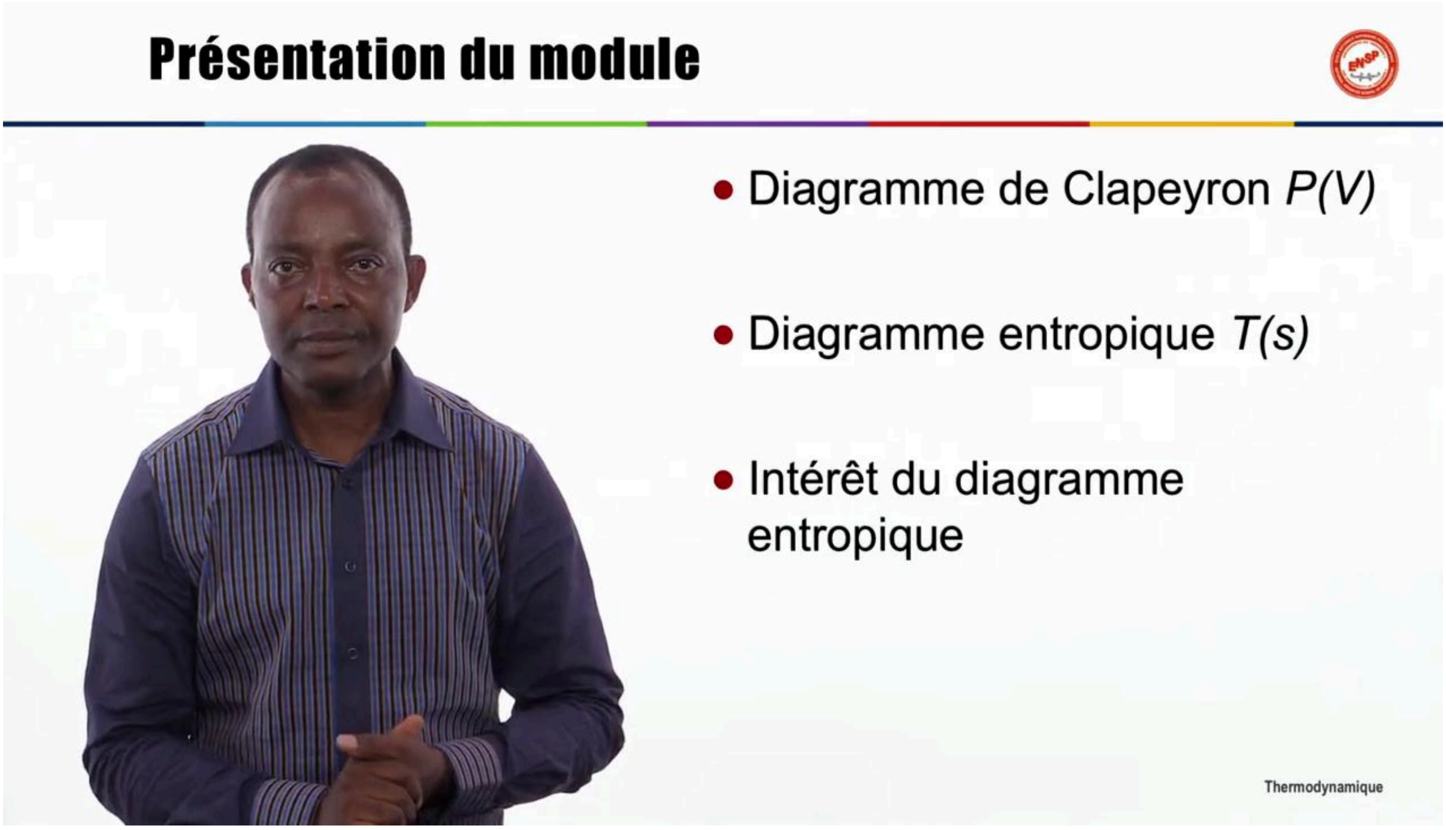


Video

EPFL

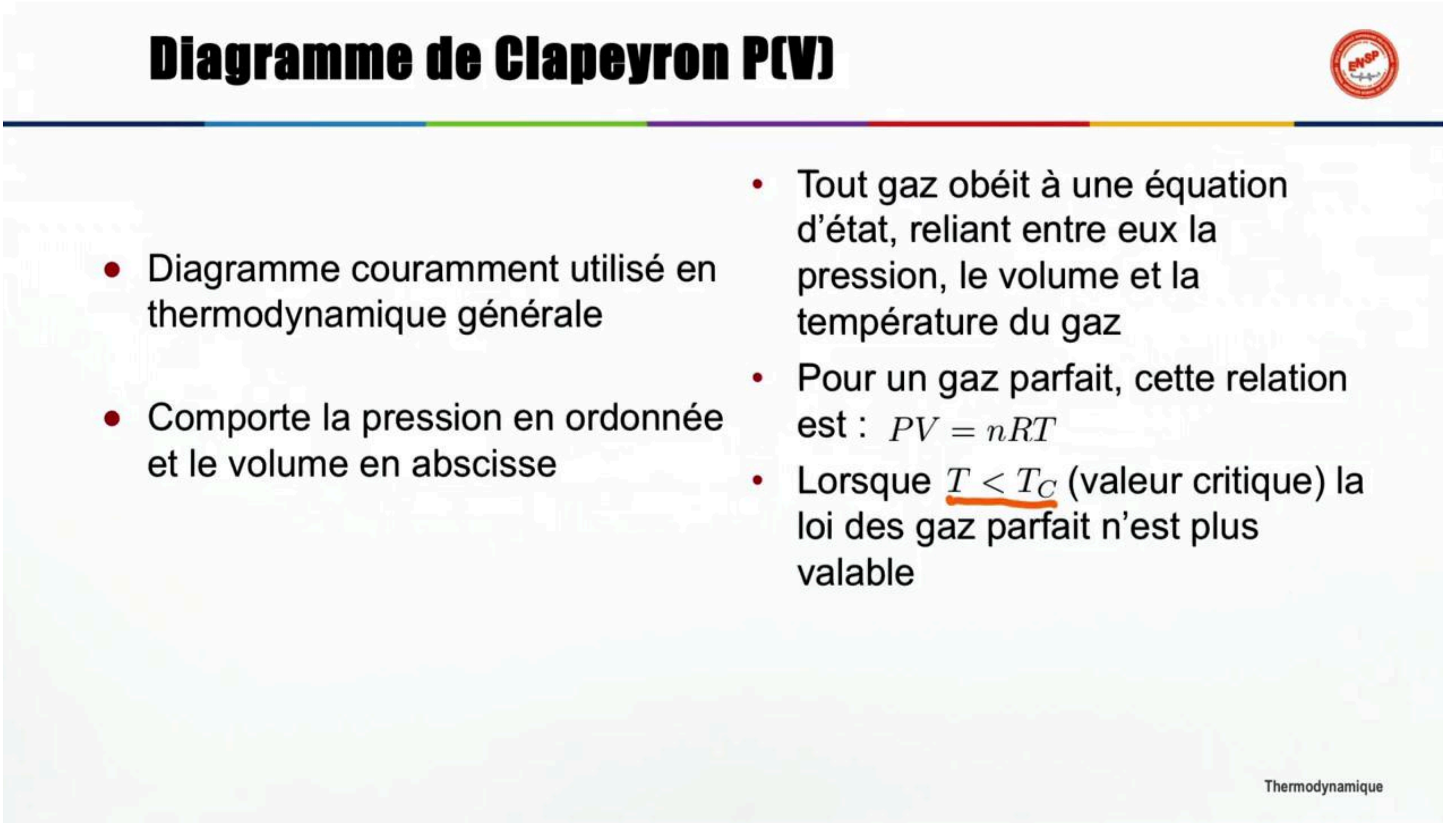


Hello to all, I am happy to see you once again in addition to the thermodynamics course coordinated by the School Federal Polytechnic of Lausanne and related to fluids. The geology module covers on the Clapeyron diagram and the entropy diagram. Immediately look at the summary of this module. In this video, we will bring our attention on the network of other terms that form the Clapeyron diagram and we will define the type of saturating steam. We will then look at the network of curves that forms the diagram entropy before identifying the practical interest of the diagrams.

Notes

Summary

0m 04s



Let's start with the Clapeyron diagram of such a game that this is the diagram commonly used in general thermodynamics. It has a coordinate system with the volume on the abscissa and the pressure on the ordinate. We already know that all gas, whether it is perfect or not, obeys an equation of state linking between them the pressure, the volume and the temperature of the gas. For a perfect gas, this relation is written. PV is equal to n ft, but here it is the pressure v the volume n. The number of mol R represents the constant of perfect gases and the temperature. When the gas temperature D is less than a certain critical value, it is. The law of perfect gases is no longer valid.

Notes

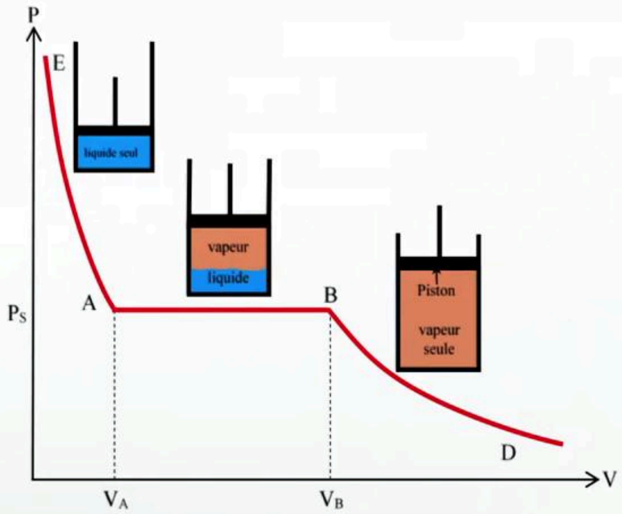
Summary

0m 47s

Diagramme de Clapeyron P(V) - Expérience

- Branche *DB* ~ loi des gaz parfait
- Branche *BA* : formation du liquide à $p = const$
- Branche *AE* : compression du liquide avec forte augmentation de pression et faible variation de volume
- *B* point de rosée
- *A* point d'ébullition

Compression isotherme d'un gaz enfermé dans un récipient



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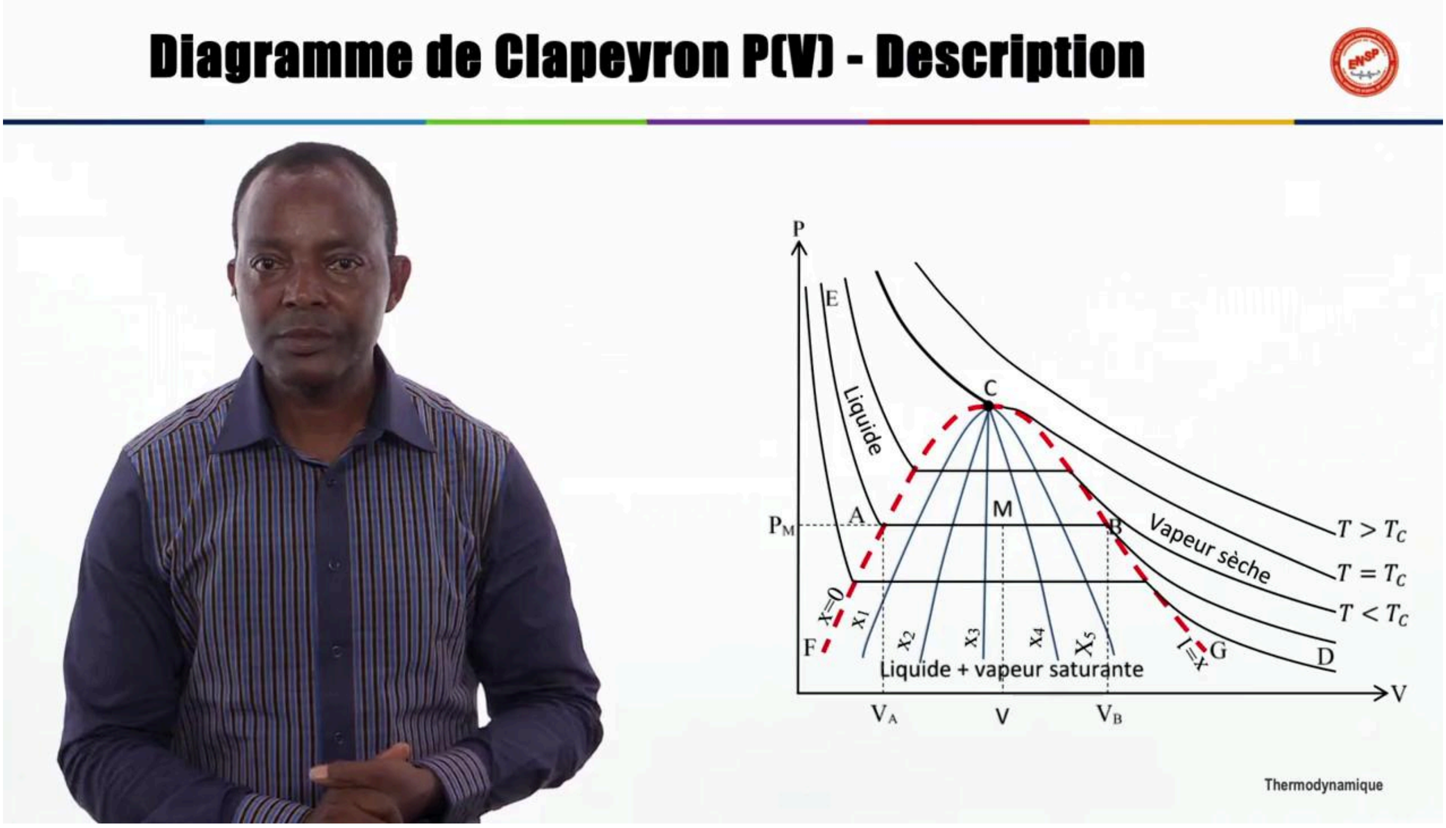
To better understand this, let's go to this experiment. Or a gas enclosed in a container undergoes a dull ISO compression. We have at the beginning a container which contains gas alone. Compression is carried out at constant temperature. The B D branch is essentially subject to the perfect gas law. At point B, we have a beginning of condensation. All along the segment B takes place before the formation of the liquid at constant pressure and there is only liquid at point A. The A branch reflects a compression of the liquid with high pressure increase and volume variation. Point B is known as the point dew point, while the A point corresponds to the boiling point.

Notes

Summary

1m 43s



This experiment leads us to the description of the Clapeyron diagram.

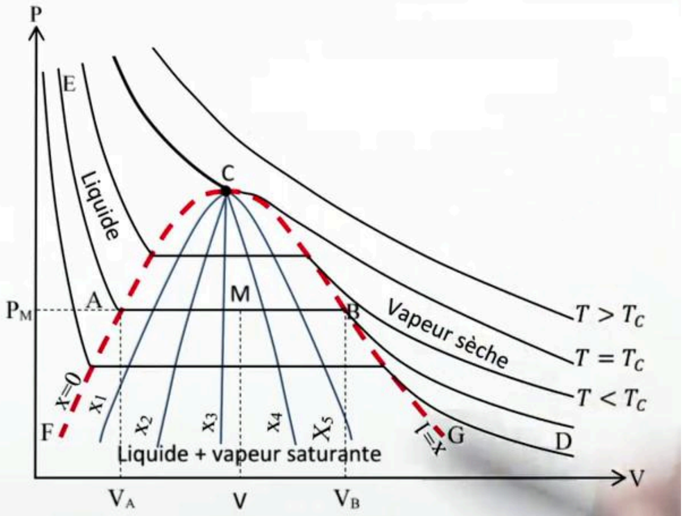
Notes

Summary

2m 47s

Diagramme de Clapeyron P(V) - Description

- C point critique : température critique T_C
- $T = T_C$ partage $p(V)$ en deux parties :
  - Partie inférieure avec états diphasiques $\overline{AB}$ sur $T < T_C$
  - Partie supérieure aux états diphasiques



Thermodynamique

Point C. Ten critical points and at the critical temperature we note. And if the TC authors share the plan P V in two parts, a lower part with a dysphasic state corresponding to segments A and B is located on the other terms and lower than C. Then, a part superior to the dysphasic states.

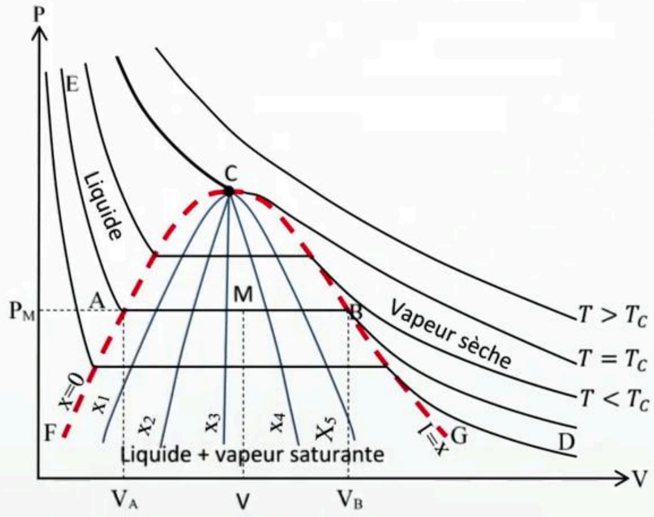
Notes

Summary

2m 52s

Diagramme de Clapeyron P(V) - Description

- *FCG* courbe de saturation délimitant trois zones de réseau d'isothermes :
  - Zone « vapeur sèche »
  - Zone « vapeur saturante »
  - Zone « liquide »



Thermodynamique

The curve f. C. I called the saturation curve. Delineates three areas of the network ten to the end. The dry steam area, the saturated vapor zone and the liquid zone.

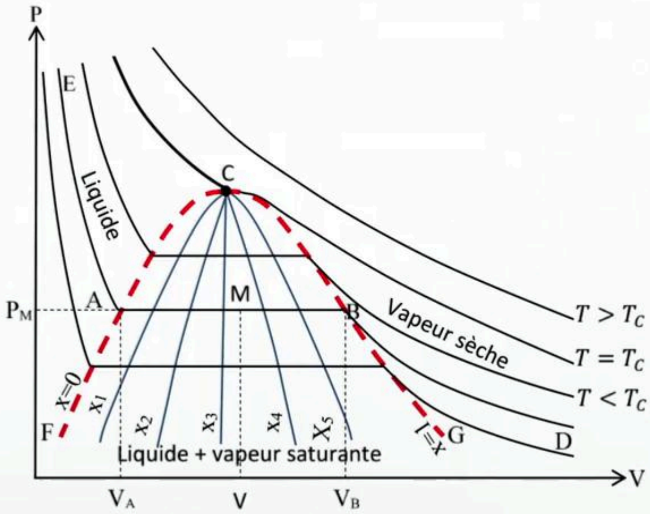
Notes

Summary

3m 28s

Diagramme de Clapeyron P(V) - Description

- $T > T_C$ zone « gaz permanent »
- *FC* branche d'ébullition
- *CG* branche de rosée



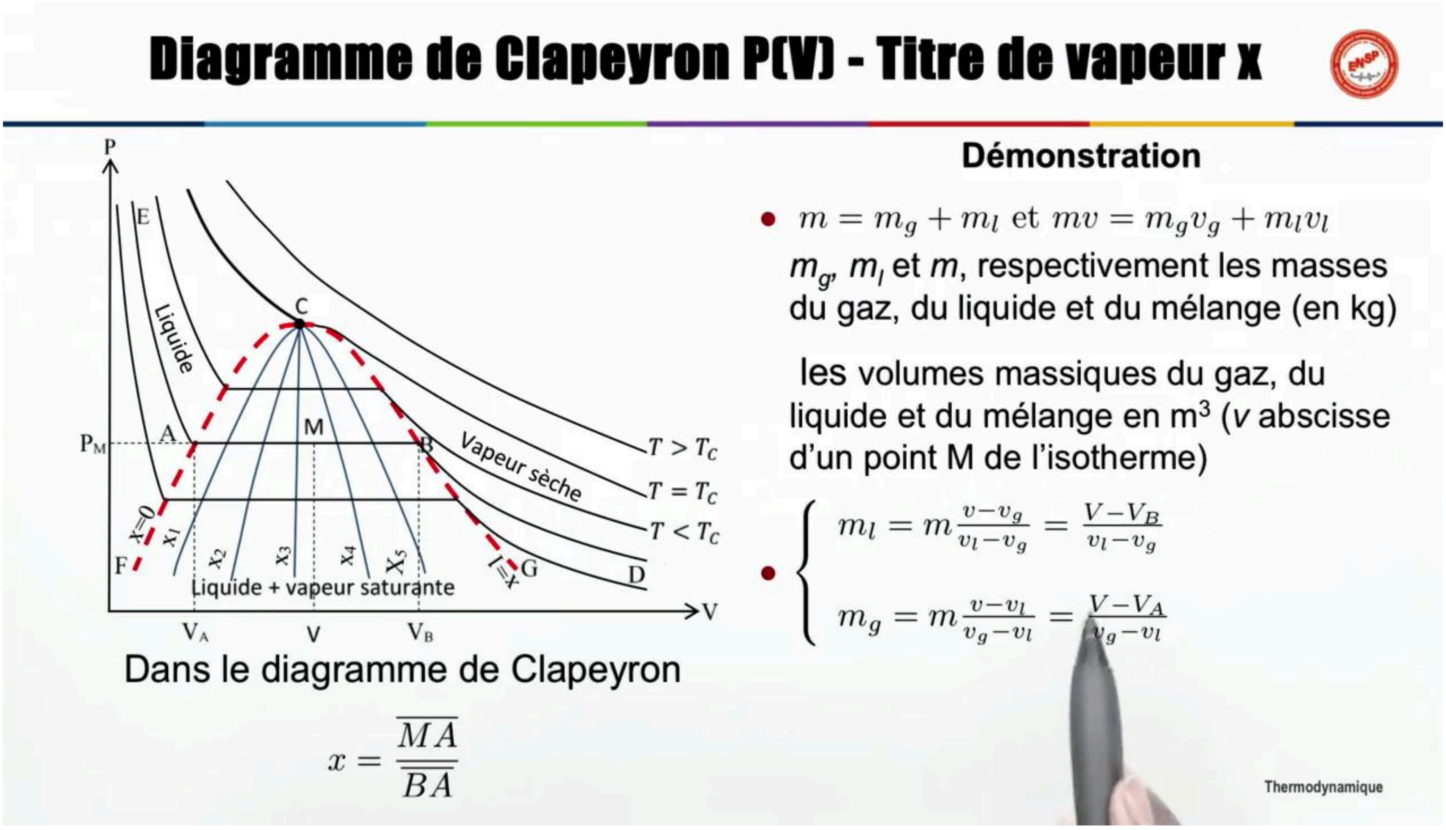
Thermodynamique

The temperature is above. The critical temperature corresponds to the permanent gage zone. The F-branch. C represents the boiling branch and the CG branch corresponds to the dew branch.

Notes

Summary

3m 46s



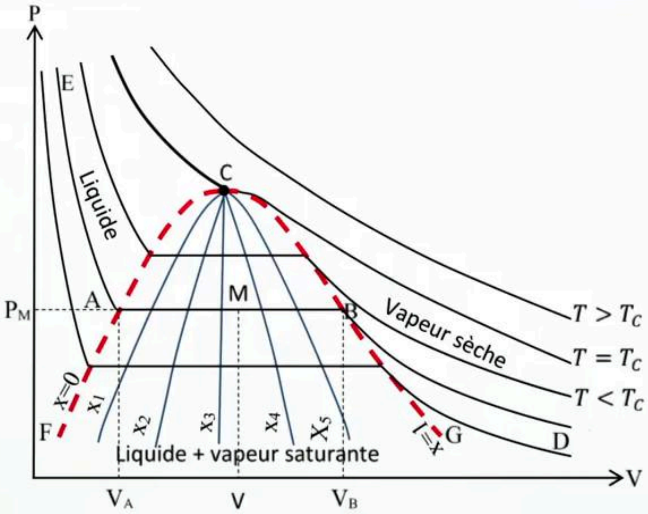
The fluid, a dysphasic state inside the saturation curve, is characterized by the third of vapor x a point M on the segment A B of the Clapeyron diagram as of steam X equal to m a on B A to prove it. We have the mass of the mixture which is equal to the mass in gas phase, plus the mass in liquid phase and the volume of the mixture is equal to the volume in gas phase, plus the volume in liquid phase. Note that mg, L and M represent the masses of the gas, liquid and mixture in kilograms. The mass volume of the gas, liquid and mixture expressed in cubic meters. Kg and noted by V. V being the abscissa of the point M of the heights, then we have. By solving this system of equations, M is equal to M. V. VG over V is the VG which is equal to the total volume, minus the volume at point B divided by the specific volume in liquid phase, minus the specific volume in gas phase. We also have the mass in gas phase which is equal to the mass of the mixture that multiplies the specific volume of the mixture, minus the volume specific volume in liquid phase divided by the specific volume in gas phase, minus the specific volume in liquid phase, which gives us a fine.

Notes

Summary

4m 05s

Diagramme de Clapeyron P(V) - Titre de vapeur x



Dans le diagramme de Clapeyron

$$x = \frac{\overline{MA}}{\overline{BA}}$$

Démonstration

- $m = m_g + m_l$ et $mv = m_g v_g + m_l v_l$

m_g, m_l et m, respectivement les masses du gaz, du liquide et du mélange (en kg)

les volumes massiques du gaz, du liquide et du mélange en m^3 (v abscisse d'un point M de l'isotherme)

- $$\begin{cases} m_l = m\frac{v - v_g}{v_l - v_g} = \frac{V - V_B}{v_l - v_g} \\ m_g = m\frac{v - v_l}{v_g - v_l} = \frac{V - V_A}{v_g - v_l} \end{cases}$$

- D'où

$$x = \frac{m_g}{m} = \frac{V - V_A}{mv_g - mv_l} = \frac{V - V_A}{V_B - V_A} = \frac{\overline{MA}}{\overline{BA}}$$

Thermodynamique

The total volume, minus the volume at point a divided by the specific volume gas phase, minus the specific volume in liquid phase. Note that V. And expressed per cubic meter and PTV expressed in cubic meters per kilogram. Then, going back to the definition of the title, namely X is equal to M on M. We deduce that X is equal to at a large V, i.e. the volume of the mixture minus the volume at point a divided by m vg, i.e. the volume in gas phase, minus the volume in phase liquid, which gives the total volume, minus the volume at point a divided by by the volume at point B, minus the volume at point A. This gives the segment M H divided by the segment B1.

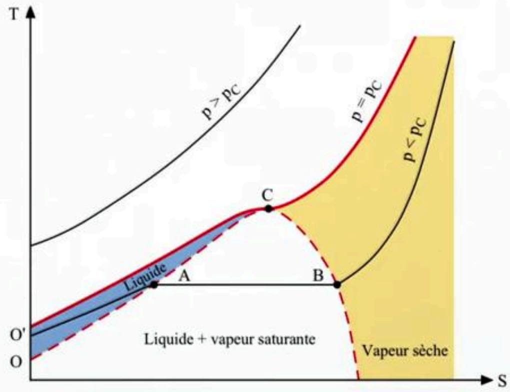
Notes

Summary

5m 54s

Diagramme entropique T(s)

- Température *T* en ordonnée
- Entropie spécifique *s* en abscisse
- Image du diagramme *p(V)* dans le système de coordonnées *T(s)*



Thermodynamique

Finally, we note that the Clapeyron diagram is not used in the calculations of industrial projects. TS entropy diagrams of hts or lock p refrigeration related words of H are preferable because they have the energy quantity HTS. These quantities allow of course a lighter calculation of work and heat and load. Now we move on to the topic diagrams in these diagrams with one coordinate system with the temperature and on the ordinate and the specific entropy s on the abscissa. It is neither more nor less than the image of the Clapeyron P diagram.

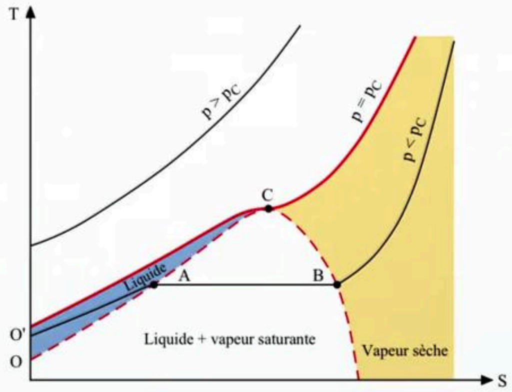
Notes

Summary

6m 50s

Diagramme entropique T(s) - Description

- *Forme des isobares*
  - *OO'* : compression adiabatique de p_0 à $p < p_c$ (compression avec peu d'effet sur la température)
  - *O'A* : chauffage du liquide à pression constante (branche pratiquement confondue avec la courbe de saturation)



Par convention $s_0=0$ (détermination d'entropie définie à une constante additive près)

Thermodynamique

V in the coordinate system ts describing these entropy diagrams specifically characterized by the isobaric network. Examining the form at, the segment or price corresponds to an adiabatic compression from p0 to pressure below the critical pressure. So note that compression has little effect on temperature. From prime to. We have a heating system that is at constant pressure. This branch with A premiums is almost identical to the saturation cut.

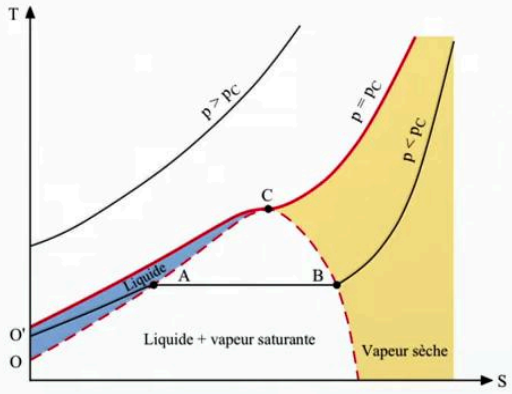
Notes

Summary

7m 49s

Diagramme entropique T(s) - Description

- *AB* : chauffage isobare et isotherme entrainant le changement d'état liquide-vapeur ; $T_A = T_B = T_e(P)$



Par convention $s_0=0$ (détermination d'entropie définie à une constante additive près)

Thermodynamique

Recalling us, we said that a liquid was a little as specified in segment A, B represents isobaric heating and ISO term by maintaining the change of state liquid vapor at temperature and A is equal to TB and corresponds to the temperature of boiling at pressure P between point A and B in rise.

Notes

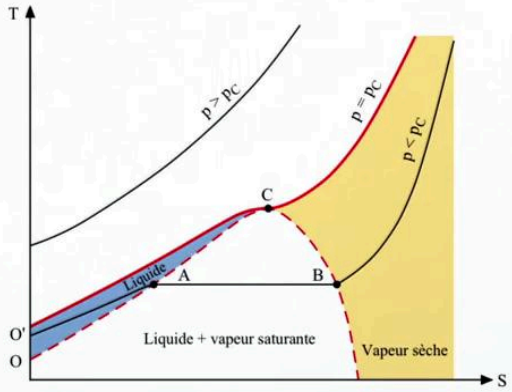
Summary

8m 33s

Diagramme entropique T(s) - Description

- *AB* : chauffage isobare et isotherme entrainant le changement d'état liquide-vapeur ; $T_A = T_B = T_e(P)$
- Entre *A* et *B*, on montre comme plus haut que tout point M est en état diphasique de titre :

$$x = \frac{s_M - s_A}{s_B - s_A}$$



Par convention $s_0=0$ (détermination d'entropie définie à une constante additive près)

Thermodynamique

As we have done above, any point M located on the segment A B and a physical state of the securities X is equal to the difference between point M and point A, divided by the difference in entropy between point B and point A beyond point B.

Notes

Summary

8m 56s

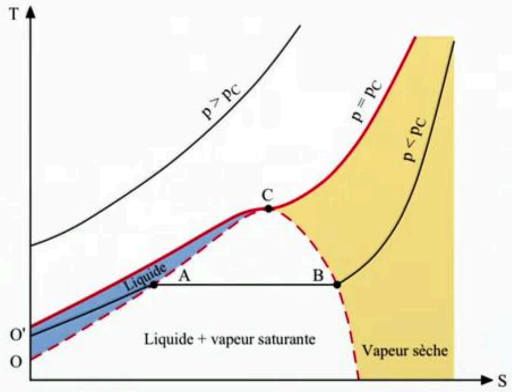
Diagramme entropique T(s) - Description

- Au-delà de point B : chauffage d'une vapeur sèche à pression constante

$$ds = \frac{\delta Q_p}{T} = \frac{C_p dT}{T} \quad \text{et}$$

$$T = Ke^{\left(\frac{s}{C_p}\right)}$$

Si C_p indépendant de T



Par convention $s_0=0$ (détermination d'entropie définie à une constante additive près)

Thermodynamique

We have a dry steam heating at constant pressure. We write in this case that DMS is equal to Delta Kuiper Suter which is equal to C. Pdt Suter S. It is the occupied delta entropy, it is the variation of heats and if the temperature is CP and the heat capacity at constant pressure. If we assume that CP does not vary with of the temperature, we can integrate this equation differential and we obtain an exponential case of s cp. We have in the exponential range of Isobares. In the area will pass h.

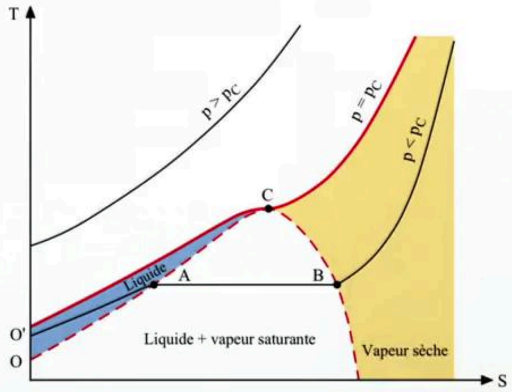
Notes

Summary

9m 16s

Diagramme entropique T(s) - Description

- $p = p_C$, tangente à la courbe de saturation au point C
- Pour $p > p_C$, isobares sans point d'intersection avec la courbe de saturation



Par convention $s_0=0$ (détermination d'entropie définie à une constante additive près)

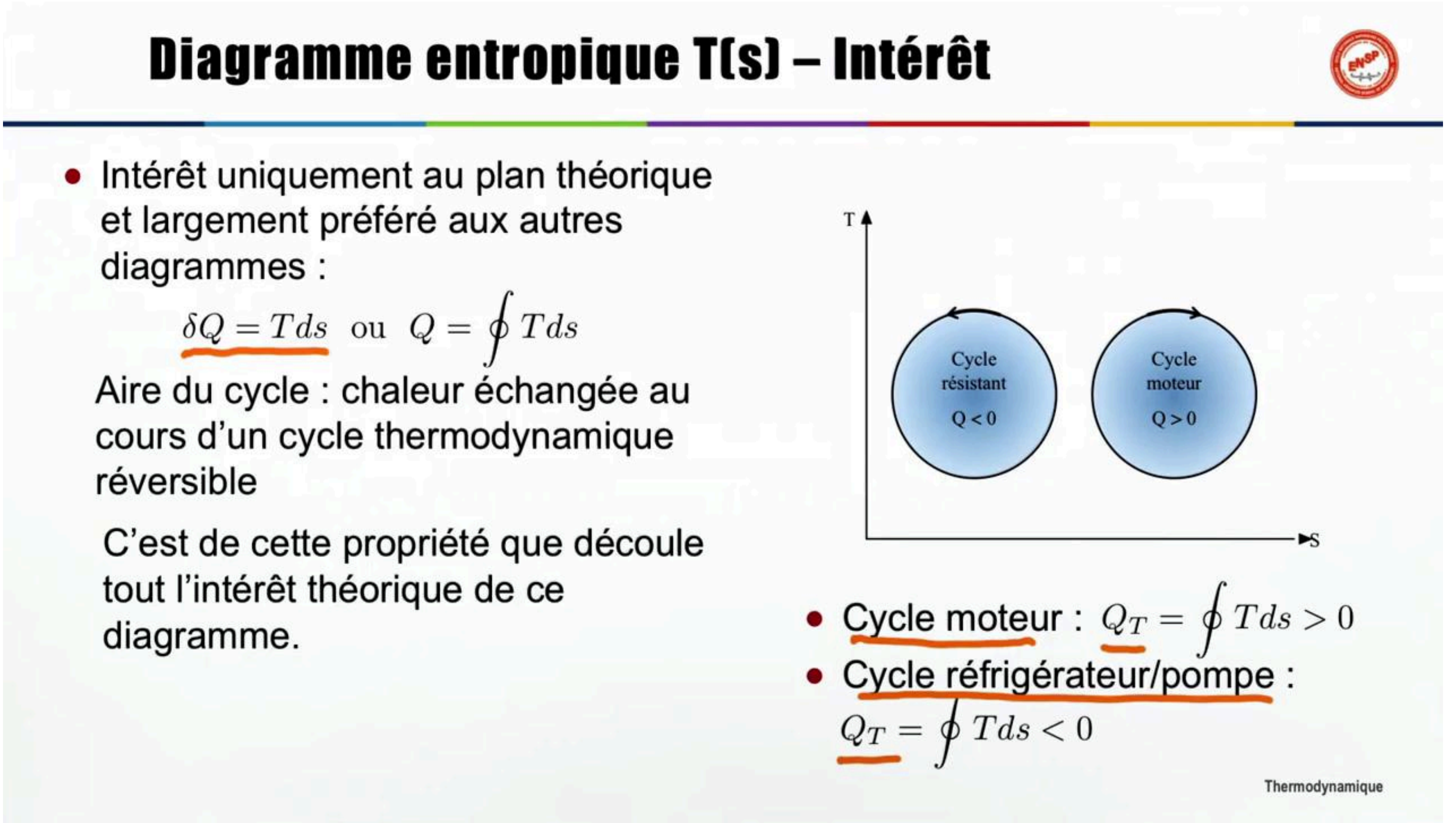
Thermodynamique

Lise Aubert. Critical PC is a genre with a saturation curve. To the point, it is. When the pressure p is higher than lower, the OBAs are without intersection point with the saturation curve.

Notes

Summary

10m 00s

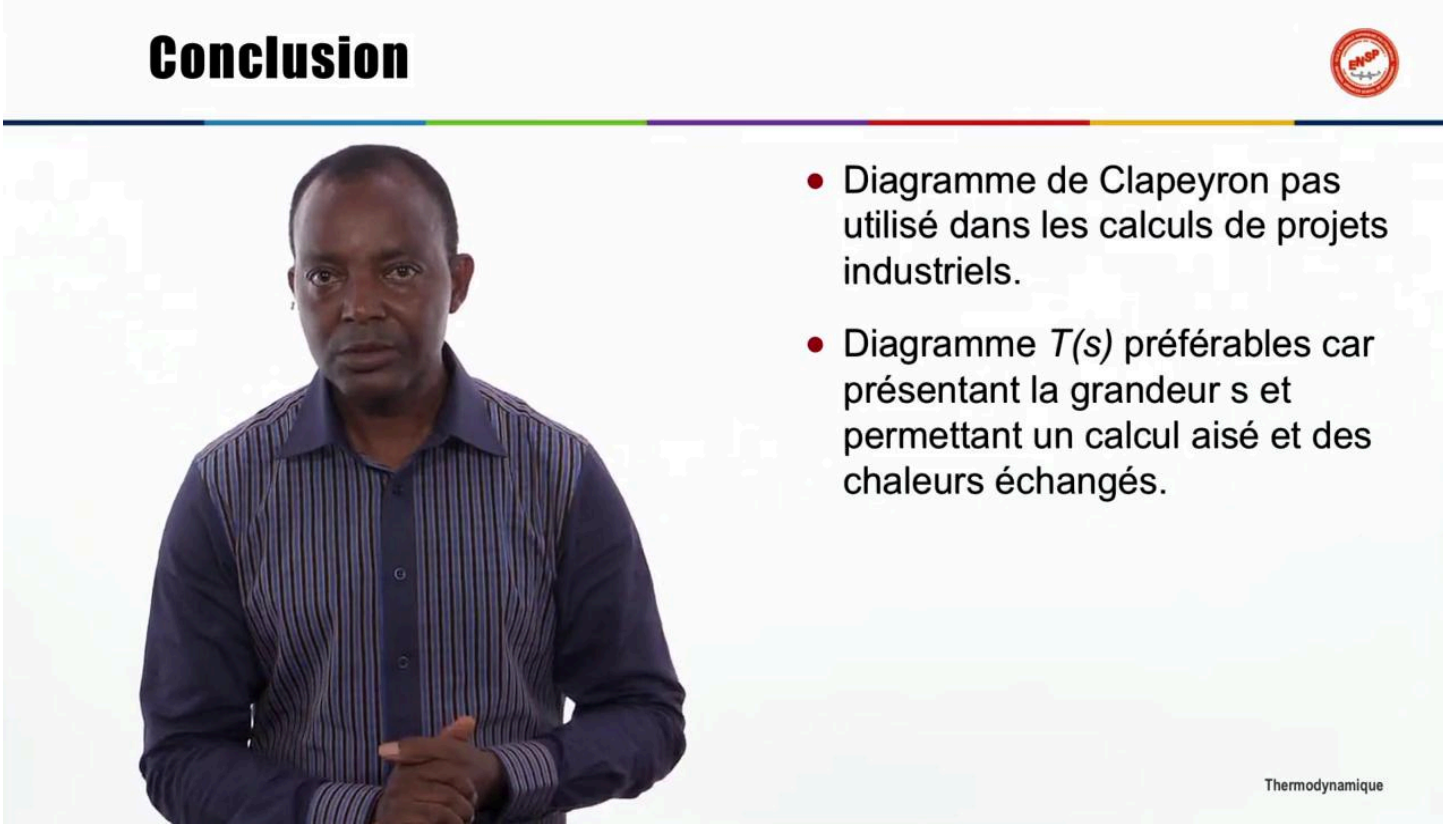


Passing inside the diagram a topic. We will note that the interest of these diagrams is only at the theoretical level. From this point of view, it is largely preferred to other diagrams. You have a delta effect more equal to T DST, is the temperature S and the entropy Q is the heat exchanged. By integrating, we equal the integral over the TDS cycle. In other words, the heat exchanged during a cycle The reversible thermodynamic area is simply the area of the cycle. It is from this property that all the theoretical interest of these diagrams derives. If we consider thus as author, we will have this heat which will be positive. And if we consider a refrigeration cycle or a heat pump, we will have this heat which will be negative. In these diagrams, we see that for a moped, the traffic was in the direction clockwise, while the refrigeration cycle is also clockwise. not very resistant to traffic, went in a clockwise direction.

Notes

Summary

10m 22s



Two things to remember at the end of this module. First, we note that the diagram of Clapeyron is mainly used in the lower part of thermodynamics. Next, we will note that the entropy diagram is preferable to other diagrams for its interest theoretical, in this case the calculation of heats in a thermodynamic cycle. Call soon.

Notes

Summary

11m 34s