THROTTLING OF GASES AND VAPORS

Throttling of gases and vapors

When the flow of gas (steam) passes through the contracted section formed in a section of pipe, the pressure decreases.

The process of reducing the pressure, as a result of which the kinetic energy is not increased, the technical work is not done, is called ***throttling***.

The throttling occurs: in the valve, flaps, throttle cables and other elements of the valves.

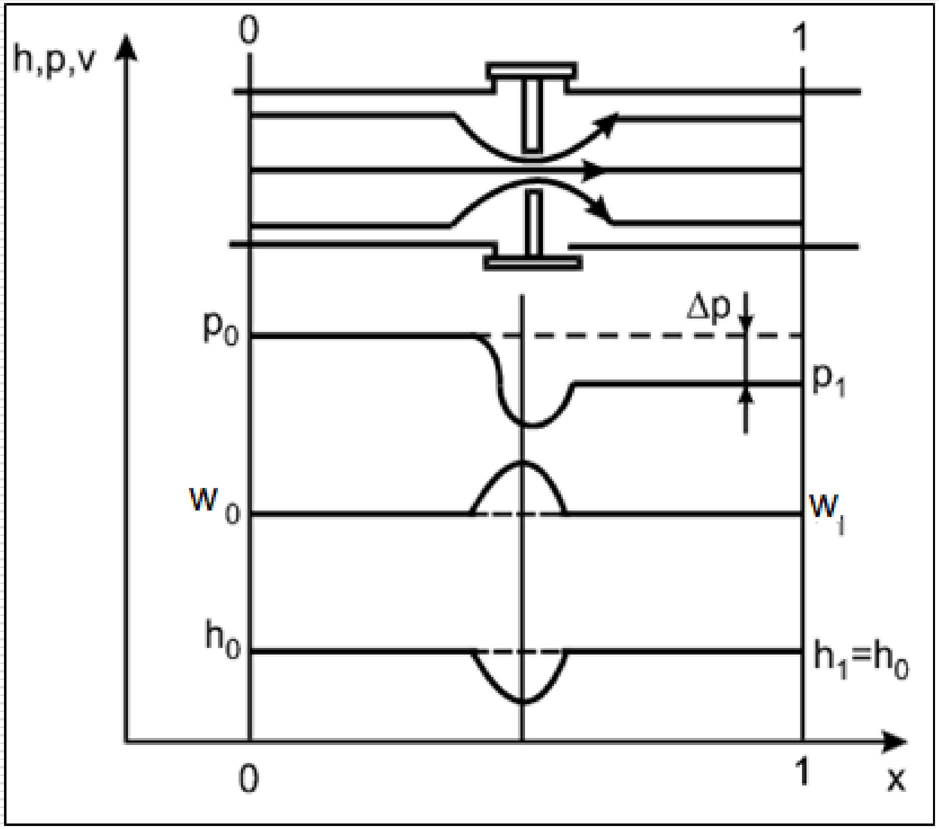
The essence of the process of throttling and the equation of throttling

The pressure drop during throttling by the amount of Δp due to the loss of kinetic energy of the flow due to friction and vortex formation in the local resistance.

This irreversible process occurs in an isolated system (without cause of the heat outside) and so is described by the equation for adiabatic flow:

$$dh = -\frac{dw^2}{2}$$

The equation of throttling



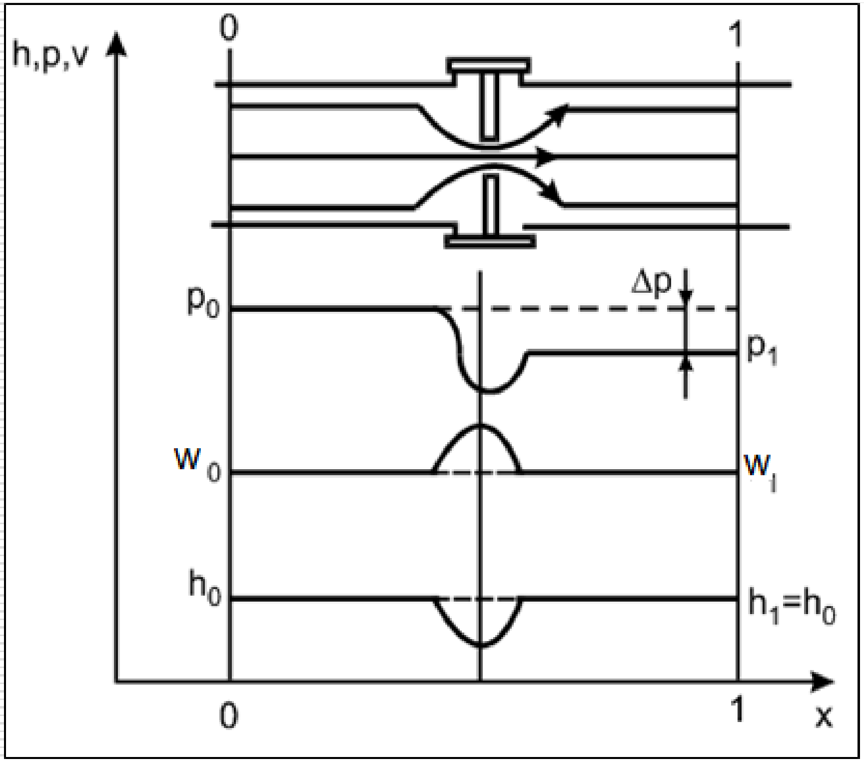
The equation of throttling for the two sections (0 and 1) quite remote from the local resistance:

$$h_0 + \frac{w_0^2}{2} = h_1 + \frac{w_1^2}{2}$$

When the cross section of the channel is the same before and after contraction, it is possible to take $w_0 = w_1$

$$h_0 = h_1 (\Delta h = 0)$$

The change of parameters in the process of throttling

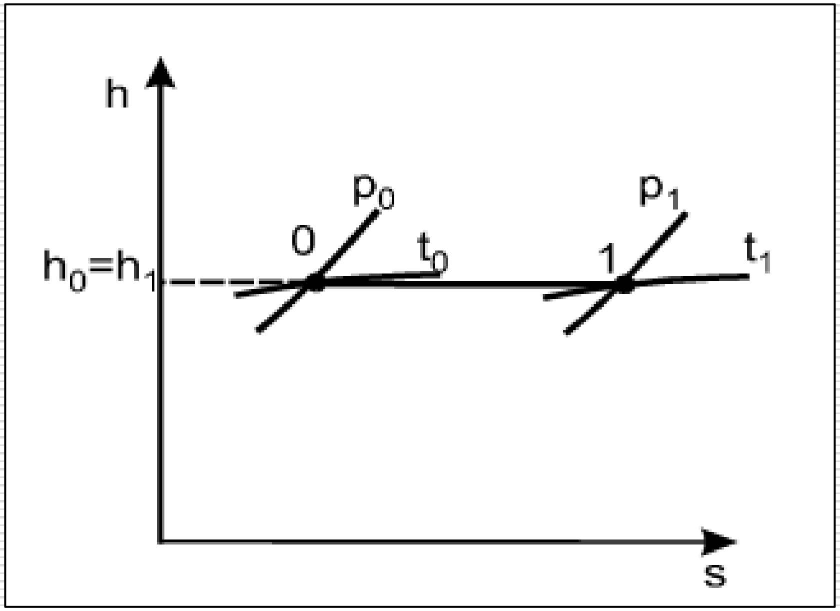


The change of parameters of the gas by throttling

The throttling:
- The pressure ↓ ($p_1 < p_0$)
- The enthalpy constant ($h_0 = h_1$)
- The specific volume ↑ ($s_1 > s_0$)
- The temperature varies differently in different conditions

The throttling process in the *hs*-diagram

The throttling is an isoenthalpic process, which in the hs – diagram is depicted by a straight line h=constant, parallel to the axis of entropy



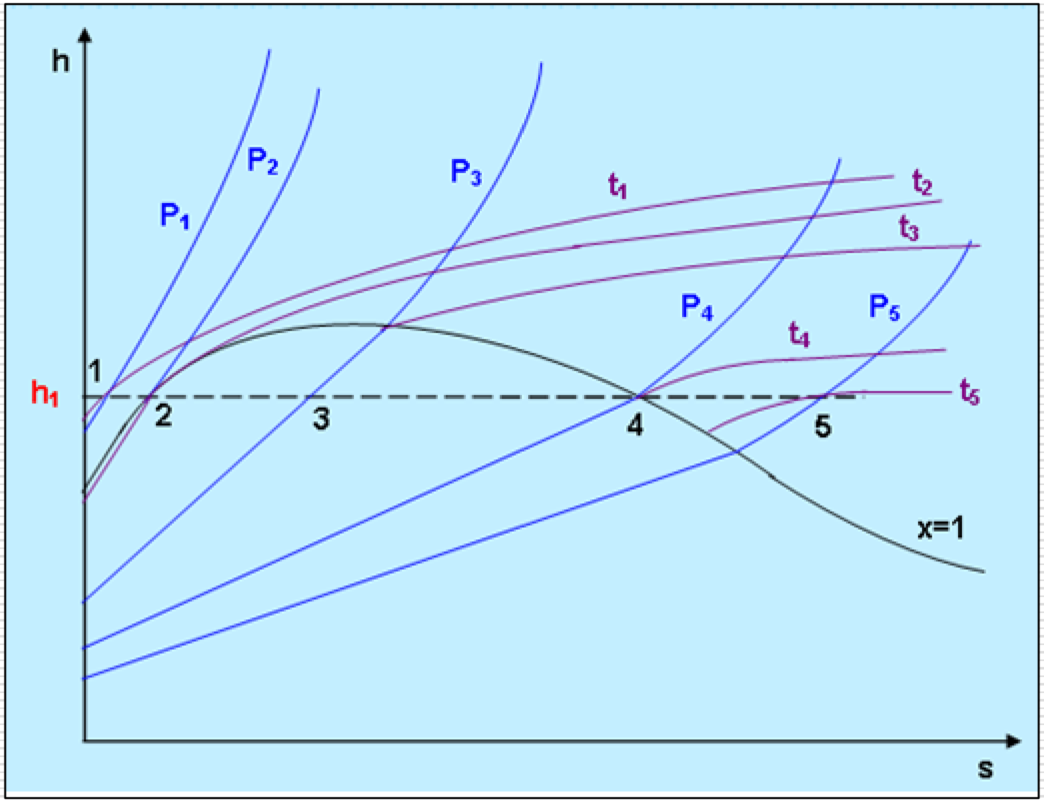
The throttling process in the *hs*-diagram

The features of throttling for ideal and real gases

The throttling **for an ideal gas** $u=u(T)$, $h=h(T)$ => $T_0=T_1$

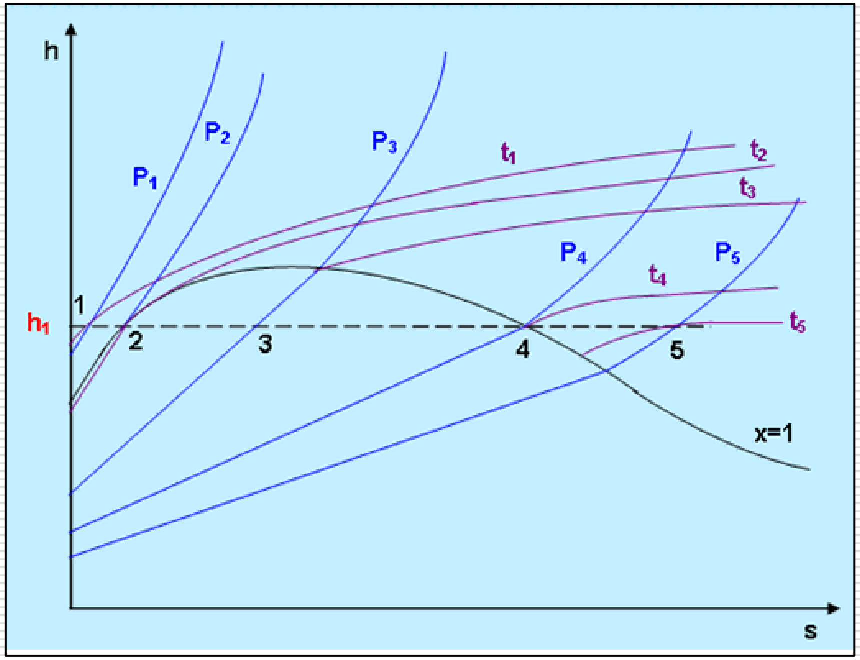
For **a real gas**, whose internal energy depends on volume, $u=u(v,T)$, despite the fact that while throttling $\Delta h=0$, $\Delta u\neq 0$, and hence, и $\Delta T\neq 0$, ($T_0\neq T_1$), i.e. the throttling for a real gas is accompanied by a change in its temperature due to heat capacity changes.

The Joule-Thomson Effect



Points 1 to 5 indicated the possible initial and final states of water vapor during throttling

The Joule-Thomson Effect



Consistently throttling the superheated steam from state 1 with p_1 the steam generated in the states:

- 2 – dry saturated steam with p_2;
- 3 – wet saturated steam with p_3;
- 4 – dry saturated steam with p_4;
- 5 –superheated steam with p_5.

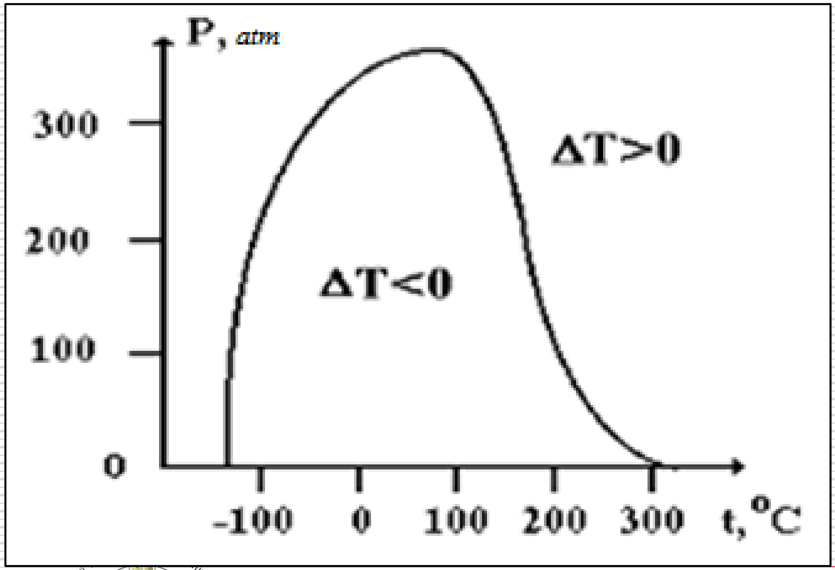
All these processes are accompanied by temperature decrease.

This process is called ***the Joule – Thompson Effect***, in honor of the scientists who discovered it.

The concept of temperature inversion

To effect Joule – Thompson introduced the concept of *temperature inversion*.

This is the temperature Ti, at which the difference ΔTi, passing through zero value changes its sign.



The set points of temperature inversion in the pT – diagram is called the curve of inversion

The practical use of the throttling process

To change the parameters of process steam in accordance with the characteristics of industrial equipment often have to lower the parameters in power plants.

Reduction-cooling installation used for this purpose.

Here are the throttling of steam in the control valves and lowering the temperature by injecting in it the cooling water.