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Heatengine of molecular action

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Heat engines are used more than two centuries [1]. Almost all of them are thermodynamic action engines working by changing of thermodynamic parameters of gas – temperature, volume and pressure [2]. The main disadvantage of thermodynamic engine is that temperature difference is necessary. In result thermodynamic heat engine converts to electricity not heat itself but chemical energy of burned fuel. Today the problem of fuel deficiency is actual so we need a head engine working on heat of surrounding environment.

It is known [2] that laws of thermodynamics do not works in systems with very small number of particles as far as in systems where molecular motion is not chaotic like Maxwell's demon. Examples of small number of particle systems are Brownian [3] and single-atomic [4] heat engines. This engines works today and they convert heat to electricity without temperature difference. This paper is devoted to system where molecular motion is not fully chaotic – molecular action heat engine. In this system all the thermodynamic parameters of gas are unchanged, but character of molecular motion is under external influence.

To understand the principle of molecular action heat engine let's consider a rarified gas xenon between two horizontal metallic plates (see fig.1). At room temperature xenon molecules are classical objects [5].

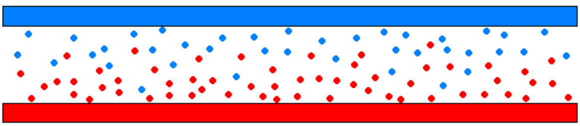

Figure 1. Xenon molecules between metal plates

It is known [2] that heat energy of gas is energy of it's molecular motion. When molecules are fast gas is hot. When molecules are slow gas is cold. It is also known [2] that when hot gas contacts with cold solid body gas gives heat to solid. When gas is colder than solid gas takes heat from solid. Gas takes heat from solid means that gas molecules before interaction with solid have lower average energy than after interaction with solid. So system on fig. 1 achieves thermal equilibrium when temperatures of gas, top plate and bottom plate are equal.

Now let's consider system on fig. 1 placed in very strong gravitation. Moving from top plate to bottom plate molecules of rarified gas accelerates and their average energy increases. If we want that average energy of molecules before and after interaction with bottom plate remains the same temperature of bottom plate must be higher than temperature of top plate. If we calculate an acceleration of falling molecules and slowing down of rising molecules we find that heat equilibrium will be achieved when top plate is colder than bottom plate on ΔT_{gs} from equation (3).

$$\Delta T_{gs} = \frac{2mgh}{3k} \quad (3),$$

where m – the mass of xenon molecule, that is equal to $2{,}2 \cdot 10^{-25}$ kg,
h – distance between plate, m,
g – gravity, m/s^2,
k – Boltzmann constant, that is equal to $1{,}38 \cdot 10^{-23}$ J/K,
ΔT_{gs} – gravitational shift of thermal equilibrium.

Our theoretical analyses [6] of system on fig. 1 showed that observation of gravitational shift of thermal equilibrium is possible when the gravity is higher than 100 000 g. In other case heat transfer between plates provided by radiation eliminates temperature difference created by molecular motion heat transfer. It was also shown that xenon is the most appropriate gas for this study.

Numerical simulation of molecular motion shows that shift of thermal equilibrium present in normal gases as far as in rarified gases. Numerical simulation also shows that thermal equilibrium is present in artificial gravity created by centrifuge where Coriolis force is present together with centrifugal gravity. This feature gives us a possibility to develop a molecular action heat engine by the scheme showed on fig. 2.

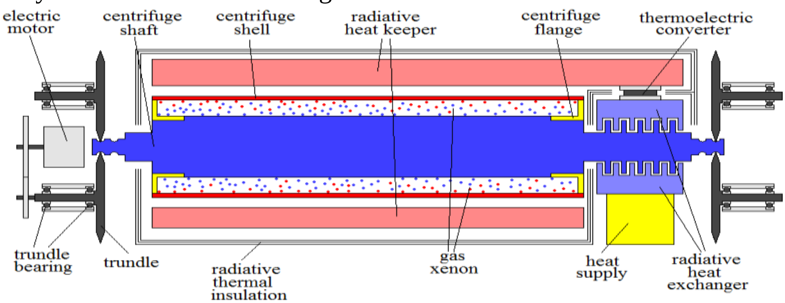

Figure 2. Schematic cross-section of engine

The centrifuge with xenon gas rotates with high angular speed in special suspension consisting of eight trundles. All the system is placed in high vacuum.

Rotation of centrifuge creates a centrifugal gravity in gas layer. By the effect of shift of thermal equilibrium shell of centrifuge became hot and shaft of centrifuge became cold. Cold shaft and hot shell of rotating centrifuge exchange heat with static parts of engine by radiation heat transfer. To increase a surface of radiation heat transfer there are edges on centrifuge shaft as far as on corresponding static part. The thermoelectric converter placed between hot and cold static parts of engine.

If suspension is ideal and vacuum is absolute centrifuge will rotate perpetually because of law of conservation of angular momentum. But in real life electric motor must some times switch on to accelerate centrifuge. A some part of energy generated by thermoelectric converter must be used for it. Conversion of heat to electricity leads to cooling of all the parts of engine. To avoid overcooling and stopping of engine there is heat supply that takes heat from outside.

May be in some future this type of engine will help us to generate electricity from surrounding heat instead of heat burned fuel. This can play important role in saving fuel resources.

References

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