# ETD and Thermodynamics

Istvan MAGAI, Ph.D
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## INTRODUCTION

Molecules of the Atmosphere are charged by solar-origin energy and collide with each other. Average velocity of the average molecule exceeds 500 m/s close to the surface of the Earth. Most of the molecules have collisions with other molecules in $6*10^{-5}$ mm distance.[1,2] Effects/forces other than collisions can be regarded as irrelevant on 100 kPa atmospheric pressure. Fig. 1. represents about 1000 $km^3$ of air with $125*10^{15}$ Joule molecular motion energy in it, which is called "stored solar energy".

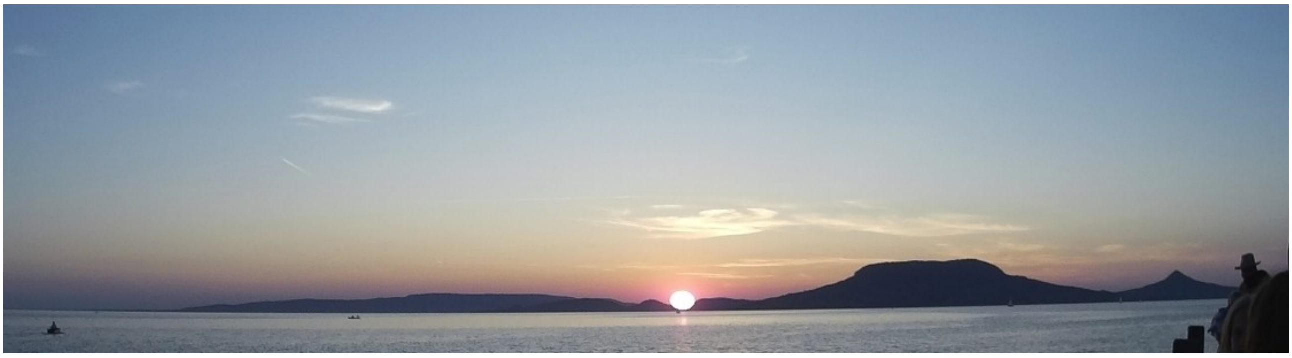


Fig. 1.

The expressions “heat source” or “heat energy” were intentionally omitted because these definitions are based on the continuity of the physical space, on a thermodynamically closed system and irreversible heat transfer.[3,4,5] An important part of the information was ignored during the past one and a half centuries while the observations of the thermodynamically closed systems were applied to opened systems also. Conventional equipartition-based definitions of thermodynamics cannot differentiate between molecules which have interactions with their surroundings. This causes energy additivity problem in a thermodynamic system with fluid flow. Some ideas for opened and flow systems do exist, for example: Lagrange function, Euler continuity equation, Rayleigh flow. The main issue with these ideas is the inability to handle and calculate the shock-time function of the gas molecules in a cooled or decelerated stream or flow. They use empiric corrections to simulate the real effects. The second law of thermodynamics isn't applicable in this case because of the missing principles:[6] **In our cycle spontaneous cooling process, heat transfer point or surface does not exist.**[7]

1 Mean Free Path, Molecular Collisions, Hyperphysics.phy-astr.gsu.edu. Retrieved 2011-11-08.
2 Bohátka S. és Langer G. (2012) Vákuumtechnika, atomki.hu A-M1 1-2-3..pdf 15.p
3 Charles B. Thaxton, Walter L.Bradley, Roger L. Olsen 1997. Az élet eredetének rejtélye. Harmat
4 Louis de Broglie, 1953. The Revolution in Physics. New York: Noonday Press p.14.
5 https://hu.wikipedia.org/wiki/Ekvipartíció-tétel
6 Bihari Péter, BMGE Műszaki termodinamika 2001. 45.p
7 https://en.wikipedia.org/wiki/Thermodynamic_system

The mentioned ideas don't contradict our ideas, but they don't help us building a new one. We need a new approach and some tools of quantum mechanics.

We apply the energy conservation laws when we convert the molecular motion energy to work or electric energy. The collisions of the molecules are effect from or to their surroundings which are used for the extraction of mechanical work.

## LIMITATIONS OF THE BASIC p-V and h-s DIAGRAMS IN A FLOW

The pressure (p) of the p-V diagram has been defined in a closed system. Static and dynamic pressures are changed during the gas deceleration in an opened turbine. Most of the thermodynamics literatures use one kind of "pressure" only while the fluid dynamics applies 2 kind of pressures (static, dynamic) at least using the Bernoulli equation which is the basic energy conservation law of the fluid flow.

The volume (V) has been defined in a closed system. The air molecules in a turbine lose velocity (motion energy) and get closer to each-other. This is not a thermodynamic compression process. The result looks like a cooling, but there isn't any cooling process or cooling surface. The right process would be for the turbine if we calculate the effective mass and motion energy of the molecule stream also. The relation of the p and V doesn't enough to define a process function of a fluid flow.

The specific heat (part of the enthalpy and entropy) has been defined in a static material in a closed system. What pressure, temperature and density would be valid for specific heat calculation in a changing stream? Static, dynamic or stagnation? The real energy of the gas stream or flow isn't continual. That consists of the sum of the distributed molecular motion energy parts. That's why equipartition and continuity theory aren't applicable in our case.

Colder working gas can transfer energy to the warmer rotor/blade which would be impossible for the "heat energy". (See second law of thermodynamics) So the gas molecule deceleration is not a heat transfer, but the working gas loses molecular energy, which causes stagnation temperature drop in the outlet. The motion energy decreasing process is not a thermodynamic process. You can't plot it in to a p-V or h-s diagram, because those can't handle the real molecular motion energy changes. We can fix inlet point in a h-s diagram and fix outlet point in another h-s diagram only. The connecting curve doesn't exist in the p-V and h-s relations because the "hardware" has been changed during the process. Some authors use "hybrid" h-s diagrams with empirical corrections for turbines in them, but those are drawings with dashed lines which aren't mathematically defined functions.

Most of the authors use the enthalpy difference of the inlet and the outlet to calculate the power of the turbine, but they can't define the static pressure (temperature, density) process inside of the rotor. The inlet is a closed reservoir, the outlet is another. They use the rotor as a "black box". Most of the literature state: *"There is no change in the static pressure through the rotor of an impulse machine"*, but this isn't a proven fact. As we mentioned above our case is out of the continuity and equipartition theories which are the base of the thermodynamics. Our suggested solution is showed bellow.

## WORK BY GAS MOLECULES

A significant part of the motion energy of the fluid molecules is extractable by deceleration from their surroundings. Most of the turbines' work process are based on this idea in a fluid flow. Specific power is calculated as the velocity of the turbine blade multiplied by the fluid pressure on that surface. This process is theoretically reversible. In practice there is some flow waste, which is calculated later. In case of most turbines the fluid is in contact with the blades for such a short time that we don't calculate with heat transfer. We can extract mechanical work on a blade with colder or warmer fluid as well. The exhausted compressible fluid is colder, but the deceleration isn't a heat transfer. In the followings we will examine compressible gaseous fluids.

The cycle or process of a traditional turbine starts with increasing the pressure in a pressure or energy tank and than accelerate the fluid in a confuser against the lower back pressure. The acceleration is produced by pressure difference as the Bernoulli equation states. After the fluid is accelerated up to local sound speed in the nozzle the moving blade decelerates the flow and extracts the mechanical work. The process is calculated using Newton's first and second laws. The work extraction is reversible. Flow deceleration and work extraction don't generate heat if we use electric generator for energy extraction.

Fig. 2. shows a multistage steam turbine. The red color indicates the high starting overpressure and the blue color indicates the back pressure.

**In case we use a pressure tank with overpressure as the energy source for work extraction, we can talk about a power engine.**

**On the other hand we can talk about a heat engine if we use a pressurized and heated tank as the energy source for work extraction.**

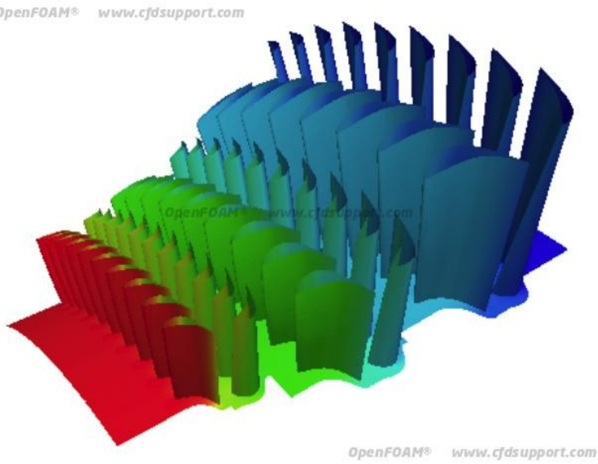



Fig. 2.

**If we utilize the molecular motion energy of the static air to generate mechanical work, we can talk about an Energy Transformer Device.**

## ENERGY TRANSFORMER DEVICE (ETD)

The molecules of the flowing gas produce a special effect during the entropy reduction, which is the result of the deceleration by the turbine. The average collision distance between the molecules has decreased because of their motion energy reduction. **The motion energy reduction would reduce the static pressure, but because the molecules get closer to each other more collisions occur more frequently on the same surface which increases the static and stagnation pressure.** This effect can only be investigated with the tools of quantum mechanics. This is hidden from traditional thermodynamics which is based on the equipartition theorem.

Fig. 3. shows a test equipment with Venturi pipe and a special axial turbine in it. The left bottom conical nozzle contains the decreasing cross section for the flow acceleration, which is produced by

the collisions of the surrounding molecules. The molecules which are accelerated to the local sonic speed in the throat  generate mechanical work on the turbine and they are partly decelerated. The partly decelerated molecules are fully decelerated in the diffuser cone and flow  out to the open air. Without the turbine we would only have a Venturi pipe. During the test of the Venturi pipe we measured 59 kPa static pressure in the smallest cross section when the pressure difference was 12 kPa before and after the Venturi pipe.  These tests are identical to the ones they  use in regular practice .[8]

The Venturi pipe with the inbuilt special turbine (WO 2017/103632 and HU-P1800202) is called ENERGY TRANSFORMER DEVICE. For the process to start a generator is utilized as a starter motor supplied from an outside battery or tank and produces low static pressure before the turbine. The extractable energy or power is proportional to the 3rd exponent of the flow velocity. The waste-energy covering need is proportional to the 2nd and 1st exponents of the flow velocity.[9] These two power-velocity functions cross each-other at the balance point. The starting process is terminated if the RPM of the turbine overruns the balance point. On a higher RPM than the balance point the turbine accelerates until the flow speed

Fig. 3.

reaches the local sound speed in the narrowest cross section. Above the balance point the turbine can be braked by the torque which is generated by the extracted electricity. **The temperature of the exhausted air working fluid is decreased but this isn't the result of any heat transfer. It is the result of the reversible breaking process.** Firstly in the ETD process the motion energy of the gas molecules accelerates the other molecules by shocks toward to the lower static pressure area. This is adiabatic and isentropic process in the nozzle as the Bernoulli equation states.

After the nozzle the turbine partly decelerates the flow and extracts mechanical work through the generator. The turbine reduces the entropy of the gas as well. The diffuser decelerates the flow with an adiabatic process after the turbine and guide the gas out to the ambient air. **The origin of the extracted electric energy is the molecular motion energy reduction.** The motion energy reduction caused a decrease in temperature but it is not the result of a cooling process, because there isn't any heat transfer point, surface or process installed. We produce cooler air than the ambient, but without cooling. This process is different from cooling cycles because the work direction is the

8 Tamás Lajos, BME, ARA Lecture_Notes_Fluid_Mechanics/3U_resz.pdf

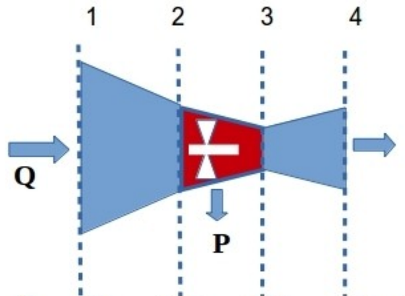
9 https://uzh.ch/cmsssl/physic/dam/jcr..._e.pdf, Fluid friction in liquids, p3.

opposite: We extract mechanical work and don't import it from the surroundings.

R = 287 (J/kgK)
γ = Cp/Cv = 1,4
Cp = 1000 (J/kgK)

## DETAILED DESCRIPTION

The equation $1/2mv^2 = 3/2k_BT$ defines the relationship between the *m* molecule mass, *v* average velocity of the thermal motion, $k_B$ Boltzmann-constant and *T* absolute (kinetic) temperature. The changes in the kinetic energy of the molecules are proportional to the changes in the absolute temperature. We apply the $\beta = v_3^2 / v_2^2$ rate of velocity quadrats which is equal to the changes of the molecular kinetic energy as well, where $v_2$ is the entering velocity and $v_3$ is the final velocity of the flow in the turbine. The change of the free path between collisions causes the changes of a specific volume which is proportional to the $\beta^3$.




| | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| $P_0$ | 100 | 100 | 102 | 102 | (kPa) |
| $P_{st}$ | 100 | 60 | 78 | 102 | (kPa) |
| $T_0$ | 293 | 293 | 230 | 230 | (K) |
| $T_{st}$ | 293 | 253 | 213 | 230 | (K) |
| v | 10 | 283 | 200 | 7 | (m/s) |
| ρ | 1,19 | 0,83 | 1,39 | 1,68 | (kg/m³) |
| Q = | 4400 | (m³/h) | | | |
| P = | 91,0 | (kW) | | | |
| $\Delta T_0$ = | 63 | (K) | | | |

Fig. 4.

The change of density is calculated by equation (1.1):

$$\frac{\rho_3}{\rho_2} = \beta^{-3} \qquad (1.1)$$

The mean free path of the molecules[10],[11] has decreased by $T_3/T_2 = v_3^2/v_2^2 = \beta$ rate of square velocities. The number of collisions increased by the $\beta^{-2}$ function on the reference surface. **Molecules collide $\beta^{-1/2}$ times more frequently on the given velocity because they move on shorter distances.** The rise of the static pressure depends on the $\beta$ rate of square velocity, $\beta^{-2}$ rate of the number of collisions and the $\beta^{-1/2}$ rate of booster functions. The $p_{s2}$ static pressure is calculated with the equation (1.2) by multiplying the $p_{s3}$ static pressure and the three $\beta$ functions above:

$$p_{s3} = \beta\, \beta^{-2}\, \beta^{-1/2}\, p_{s2} = \beta^{-3/2}\, p_{s2} \qquad (1.2)$$

**This "Beta function" ($\beta^{-3/2}$) will be important for turbine design**, because it gives more accurate result than the enthalpy and specific heat based calculations ever could. Our calculation with Beta function doesn't need empiric factors and corrections to define the changes of the static and stagnation pressure, temperature, density.

A calculation example is shown on Fig. 4. (detailed calculation can be found on this web page: www.magai.eu)

Working fluid: dry, ideal air with static temperature 293 K and static pressure 100 kPa. We use adiabatic and isentropic processes.

10 Mean Free Path, Molecular Collisions, Hyperphysics.phy-astr.gsu.edu. Retrieved 2011-11-08.
11 Bohátka S. és Langer G. (2012) Vákuumtechnika, atomki.hu A-M1 1-2-3..pdf 15.p

The Q shows the 4400 $m^3$/h ambient air intake at point 1 with 10 m/s velocity. The air is accelerated until point 2 up to 283 m/s and the static temperature decreases to 253 K. The turbine decreases the flow speed with 50 % efficiency between point 2 and 3. The diffuser decelerates the flow to 7 m/s from 200 m/s velocity between point 3 and 4. The air flows out to the surroundings at point 4 with 230 K stagnation temperature and 102 kPa stagnation pressure. **The theoretical power of the ETD is P=91 kW.** The air flowing out **is colder by 63 K** than the intake was at point 1.

**The volume of the 91 kW ETD with 300 mm diameter turbine is less than 110 liters.**

The predicted effective power is about 50-60% of the theoretically calculated power. In theory there isn't any limitation to increase the nominal power. As an example a 10 MW theoretical ETD would need a 1.3 m diameter axial turbine with 3000 1/min RPM.

**The air which is "warmed" by the Sun is accessible for both mobile or power station applications. There isn't any need for air storage or transport, because we have it everywhere. Also the operation of the ETD doesn't pollute the environment. The cold air exhaust needs considering locally only. The ETD doesn't increase global warming. The ETD doesn't use fossil fuel. The ETD is not inflammable, but it is cheap and simple.**

From 1000 $km^3$ air 20.7 TWh energy is extractable in one theoretical step by the ETD which is shown on Fig. 1. This energy is the half of the molecular motion energy in that amount of air and this energy is the 46 % of the Hungarian 2017. annual electric consumption.

## AFTERWORD

We produced and tested several turbines, impellers, nozzles from our small budget. Most of them has been broken or damaged. Some of the turbines exploded because of the uncontrollably high RPM. We need professionals to support our project. We know, that the idea of the ETD may seem "unbelievable" for some engineers at first, but physics and reality are on our side. We continue to work on this project because it means more than just business for us, it is a mission.

For further information please check our web page: **www.magai.eu**