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Air Breathing Engine Theory at the Space Thermostat Presence

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Abstract

The paper presents air breathing engine theory at the Space Thermostat (ST) presence, which fulfilled near Earth space with the temperature T=2.73 K. The ST registration is one of the great achievements in experimental physics and astrophysics during of a few last decades and presents itself the Cosmic Microwave Background (CMB). From the main thermodynamics position we consider the CMB as the additional external ST with the known (no zero) temperature and include into account its influence on aerospace propulsion processes. Any studied natural or technical systems (in particular, any aircraft engine) have closed heat contact with ST and some accompanied energy dissipation on its.

1. Introduction

Some designing complexities of high temperature air breathing engines relate to origin of so-called "unexpected" heat of working process. This additional heat essentially complicates coordination of engine basic components (for a turbojet – a compressor, combustor and turbine, for a high-speed air-breathing engine - an air inlet, combustor, and nozzle). The paper presents a thermodynamically compatible theory of working heat cycle verified by creation experience of high temperature jet engines. It is shown, that at high cycle temperatures impact of combustor heat radiation on the working process and this effect should be accurately taken into account.

The paper is devoted to united conservation laws of mass, momentum and energy for thermal propulsion processes. The united conservation laws are defined by intensive interaction of gaseous medium and thermal radiation. In our modelling a radiate dynamics is described as motion of a continuous lightly movable medium with help of the field functions and the Euler variables. Additional peculiarities of the heat cycle for engines are detail considered. Air-breathing engine processes implement known Brayton's cycle. At sufficiently high temperatures (T~2000 K and above) modern engines require lengthy and costly refining (as typical examples let us give practice of creating TP-400, F-135 and X-51A).

One of the main questions of the paper is nature of entropy. We analyse carefully the first law of conventional thermodynamics and show the difference between quasi-static and dynamic entropy values. Here we begin from quasi-static or dynamic works of finite gas volume and present detail connection of continue medium conservation laws with entropy value. By that only conventional quasi-static entropy is a function of state. In the common case the full dynamic entropy isn't a state function. In this case the entropy nature may be clearly demonstrated and estimated. In particular, entropy growth corresponds to total pressure losses and energy dissipation in ST.

The paper contains typical examples for aircraft engine working process solutions. Also there is shown the ST presence should be included into account in any theoretical analysis (in physics, astrophysics, biophysics, chemistry and so on).

2. Space thermostat

In physics a thermostat is called a greater thermodynamic system, the number of particles which far exceeds the number of particles in a studied system with her in thermal contact [1-9]. In our case as such thermostat (the large thermodynamic system) we take the real cosmic microwave background (CMB) with well-known temperature T_0 = 2.73 K and dark matter (DM) medium with certain massive particles (see below), which are holders and carriers of thermal radiation (and, in particular, CMB). Any smaller size natural or technical system we believe in the thermal contact with the specified space thermostat (ST). The considered ST essentially differs from ordinary Gibbs' thermostat [1, 5-9], in which studied systems are in thermal contact by T >> 2.73 K and have the same temperature.

The registration of the finite temperature T_0=2.73 K in a free space of the Universe should be classified into one of the most impressive experimental results of XX century physics. Firstly this temperature value in the free space was defined in 1933 by E. Regener [10]. In 1956 scientist of the Pulkovo Observatory T.A. Shmaonov has also registered the final temperature in outer space T0 = 4±3 K [11]. In 1965 two American radio astrodomes A. Penzias and R. Wilson opened the final temperature T0 ~ 3 K of outer space, namely, the temperature of CMB [12-14].

The second significant experimental results of XX century is the discovery of Dark Matter (DM) [15-17], which is also called "the hidden mass in the Universe". Now we know that 96% whole matter in our Universe consists of DM. The baryonic substance accounts to only near 4%. There were multiple attempts to describe the nature of DM, but none was successful yet [17]. Here we would like to show only one of the last DM image. Figure1 (on the left) presents the Hubble extreme deep field image of space in the Draco constellation (group of galaxies Abell 2218) [18]. The density of DM for the Draco constellation is shown in fig.1 on the right [19].

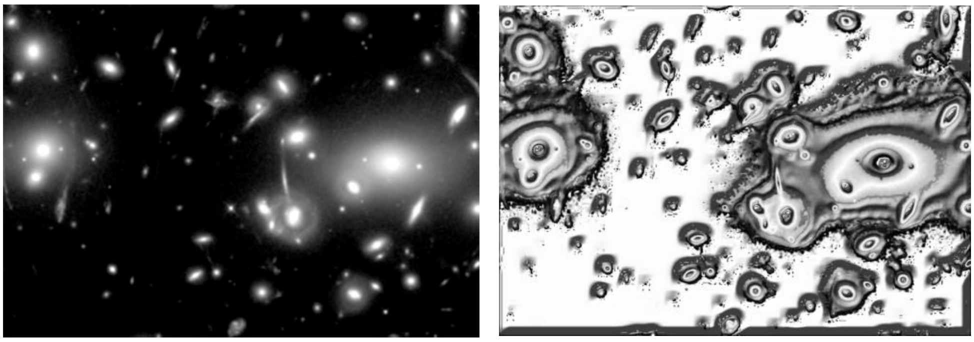

Figure 1. The Hubble Draco constellation image in visible and ultraviolet lights.

Our ST is radiate compressible medium and bearer of electromagnetic waves. Following the [20-28] we believe that the thermal radiation (and, in particular, CMB) behaves like an ideal gas with adiabatic factor $\gamma = 4/3$ and is synonymous in this sense with photon gas. Coming back from some fundamental ideas (first of all, from recommendations by M. Planck, A. Einstein and L. de Broglie) allows us to indicate a correlation linking energy E with mass value m, frequency ν and temperature T

$$E = mc^2 = h\nu = kT, \qquad (1)$$

where c – the light velocity, h and k - the Planck and the Boltzmann constants. The last equality in (1) is the law of evenly distributed energy on freedom degrees [1-4]. Also Eq. (1) follows from Planck's distribution in vicinities of maximum radiation density of absolutely black body and presents itself Wien's displacement law. The relation (1) allows us to define also the vacuum particle mass, when $T \neq 0$. The presence of these nonzero mass particles in physical vacuum was specified in [20-22] and it was identified with massive particles of DM named hidden mass boson (HMB) [21-26]. The same way we propose simulation for the dark energy (DE) [22-28]. To be short, we change the virtual Planck resonators in his derivation of the famous formula for absolutely black body radiation density by real (massive) particles with $m = kT/c^2$ (following from the relations (1)). Also the possibility of radiation (including of electromagnetic waves, similar the virtual Planck resonators) allows us to consider these real HMBs as a classic Hertz's dipoles.

Considering the ST particle concentration n and multiply (1) on n we can write

$$n \cdot mc^2 = n \cdot kT$$

and go to the typical ideal gas state equation

$$p \approx \rho c^2 = nkT. \qquad (2)$$

Here $\rho = n \cdot m$ – density, p – pressure in ST. The relation (2) is one of the mathematical forms of Avogadro's law. Now we show that the recommendations by M. Planck, A. Einstein and L. de Broglie (1) may be considered as another form of Avogadro's law and the classic state equation for perfect gaseous medium (2). The relations (1) and (2) may be used for answers on intrigue question so to what comprises about 96% of content of the Universe (i.e., what and why over 70% of the mass-energy content of the Universe is in form of the unknown vacuum DE, over 20% of the mass is in the form of the mysterious DM).

Get through (1) and (2) refinement more accurate the value for the ST particle mass at a known temperature T_0 = 2.73 K and the perturbation velocity $c = 2.998 \cdot 10^8$ m/s. We have obtained from the simple Boltzmann kinetic theory

$$E=\frac{mv_{av}^2}{2}=\frac{3}{2}kT_0=\frac{3}{2}\frac{R_U}{N_A}T_0=m\frac{3}{2}\frac{R_U}{mN_A}T_0=\frac{3}{2}\frac{m}{\gamma}\gamma RT_0=\frac{3}{2}\frac{m}{\gamma}c^2$$

and

$$m=\gamma kT_0/c^2=5.6\cdot10^{-40}kg=3\cdot10^{-4}eV. \tag{3}$$

We calculate the gas constant R and the specific heat capacity c_v and c_p by $\gamma = 4/3$

$$R=\frac{k}{m}=0.25\cdot10^{17}\frac{\text{J}}{\text{kg K}};\quad c_v=0.75\cdot10^{17}\frac{\text{J}}{\text{kg K}};\quad c_p=R+c_v=1.0\cdot10^{17}\frac{\text{J}}{\text{kg K}}.$$

It should be stressed that the thermal radiation has the classic state equation

$$p=\rho RT,\quad p=(\gamma-1)\rho e,\quad e=c_vT. \tag{4}$$

The ST particles (3) are the sub-atomic (non-baryonic) material particles moving "almost" free in all directions at different velocities. One half of particles have positive charge and other half has negative identical in its value electrical charge [20-24]. Besides, pairs of the oppositely charged particles form the classic Hertz dipoles, which have with translational, rotary and oscillatory degree of freedom. Proceeding from the appreciations of mass and charge for proton and electron [22] we obtain a liner size of the dipole $l = 7\cdot10^{-20}$ m and its charge $q = 10^{-28}$ C. The value of the electric dipole moment $p = q\cdot l = 7\cdot10^{-48}$ C·m. In spite of its miniature size we consider that all known properties of electric dipoles are retained. Thus the medium as a whole is quasi-neutral; however there are so-called "collective" processes possible, such as a local concentration of positive and negative electrical charges. Each particle interacts with others by means of electromagnetic and gravitational field and by elastic collisions.

Dimensional analysis in the presence of a characteristic charge allows getting two character values: frequency (similar as Langmuir frequency in plasma) and the Debye radius of screening [22]. Within the framework of considered approximation one can formulate specific equation system similar the gas dynamics model with electric charge presence, as the two fluid hydrodynamic plasma models (see below).

From the energy law we can estimate initial pressure p0 and density ρ0 for the ST by the temperature T_0=2.73 K. For steady volume Ω with boundary Γ the energy law is written

$$\frac{\partial}{\partial t}\iiint\limits_{\Omega}\rho e\,d\omega=-\iint\limits_{\Gamma}\vec{S}\cdot\vec{n}\,d\gamma$$

or in differential form

$$\frac{\partial\rho e}{\partial t}=-div\vec{S}.$$

We integrate this equation for the 1D case from the initial data with T=0 and p=0 to data T_0=2.73 K and p_0, when for unit volume with T=0 on the left and T =T_0 on the right boundaries and obtain

$$\rho_0e_0=\frac{p_0D}{\gamma-1}=\sigma T_0^4,$$

where $D=\Delta x/\Delta t$. For the case with D=1 (for a single volume with Δx=1 and Δt=1) we have

$$p_0=(\gamma-1)\sigma T_0^4=10^{-6}\ \text{Pa},$$

$$\rho_0=p_0/RT_0=1.46\cdot10^{-23}\ \text{kg/m}^3.$$

The presented values p_0, ρ_0 and T_0 show the radiation component parameters in free cosmic vacuum. Also, for adiabatic process in a radiation medium one may be obtained

$$\frac{p}{p_0}=\left(\frac{T}{T_0}\right)^{\frac{\gamma}{\gamma-1}}.$$

The adiabatic compression to temperature T=1500 K, 1700 K, 1900 K and 2100 K gives p=1, 1.5, 2.3 and 3.5 atmospheres. These addition pressures should include into account in physics practice applications (for thermo physics, aero physics and so on).

3. Engine thermodynamics

Engine thermodynamics is the first of applied branch, which should been revised at the ST presence with temperature T_0 = 2.73 K. Any natural or technical system in the Earth conditions operates usually by $T>>T_0$ and some part of its energy is dissipating in ST. Below we show a mathematical way for descripting of mentioned dissipation of thermal and mechanical energies. First of all we rewrite the thermodynamics quasi stationary laws to dynamic form.

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With a view to limiting visibility there is chosen the simplest way of explanation. The first main equation of mechanical thermal quasi stationary theory by R. Clausius (the equation number (IV) in [29]) is written

$$\delta Q = d\varepsilon + \delta W = d\varepsilon + pdV. \tag{5}$$

The amount of heat δQ supplied to the gas volume is equal in quasi stationary approach to the internal energy dε plus the amount of work *δW=pdV* done by the volume on its surroundings. At the ST presence the amount of heat δQ includes the part of heat dissipated in the considered thermostat. There is presented more detail the right part of the relation (5).

We consider the finite gas volume ω(t) with the boundary γ(t). The gas pressure p on the surface element dγ produces the work

$$\delta W = \iint\limits_{\gamma(t)} \delta n p d\gamma, \tag{6}$$

where δn – the boundary shift on an external normal direction. Corresponding power can be written

$$\frac{\delta W}{\delta t} = \iint\limits_{\gamma(t)} \frac{\delta n}{\delta t} p d\gamma = \iint\limits_{\gamma(t)} p\vec{u}\cdot\vec{n} d\gamma. \tag{7}$$

At mechanical equilibrium of gas volume in a quasi-stationary case with p=const (or for thermodynamically reversible processes, see later) the work δW using (6) is rewritten

$$\delta W = p\iint\limits_{\gamma(t)} \delta n d\gamma = pdV. \tag{8}$$

In the common dynamic case with a variable pressure the presented power from (6) is written

$$\frac{\delta W}{\delta t} = \iint\limits_{\gamma(t)} p\vec{u}\cdot\vec{n} d\gamma = \iiint\limits_{\omega(t)} div(p\vec{u}) d\omega. \tag{9}$$

The first law of thermodynamics is presented usually in conventional simple relation (5). Here δW presents only the quasi-static kind of work (8). In this case the second law of thermodynamics has the typical form

$$\delta Q = TdS_s = d\varepsilon + pdV, \tag{10}$$

giving the "quasi-static" kind of entropy dSs . The relation (10) is rewritten

$$\frac{\delta Q}{\delta t} = T\frac{dS_s}{dt} = \frac{d\varepsilon}{dt} + p\frac{dV}{dt}. \tag{11}$$

We should emphasis only the "quasi-static" entropy Ss is the state function with the integrate factor 1/T

$$\frac{dS_s}{dt} = \frac{d}{dt}(c_v \ln T + R\ln V) = \frac{d}{dt}\left[c_v \ln(p/\rho^{\kappa})\right]. \tag{12}$$

Also only in this case we have possibility considering the thermodynamics potentials as the Helmholtz free energy and the Gibbs free energy.

In the dynamic case for a gas volume instead of value dε in (5), (10) – (12) we should use the common specific energy changing d(ε+q2/2), including specific kinetic energy q2/2, and the power of pressure forces (9). The first law of real thermodynamics for the dynamic case should be written as

$$\frac{\delta Q}{\delta t} = T\frac{dS_d}{dt} = \frac{d(\varepsilon + \frac{q^2}{2})}{dt} + \frac{1}{\rho} div(p\vec{u}). \tag{13}$$

From relations (13) for a smooth solution one can obtain

$$\frac{\delta Q}{\delta t} = T\frac{dS_d}{dt} = \frac{d\varepsilon}{dt} + p\frac{dV}{dt} + \frac{d(q^2/2)}{dt} + \frac{\vec{u}}{\rho}\nabla p. \tag{14}$$

Two last terms in (14) determine the total pressure losses [30-31].

If there is no pressure losses for smooth solutions (for thermodynamically reversible processes with quasi stationary work (8)), we can use ("work-kinetic energy theorem")

$$\frac{dq^2/2}{dt} + \frac{1}{\rho}\vec{u}\nabla p = 0, \tag{15}$$

and have the complete equivalence of equations (14) and (12). The relation (15) follows from the impulse equation by multiplying it by the velocity vector $\vec{u}$ (q-module of the velocity vector)

$$\frac{d\vec{u}}{dt} = -\frac{1}{\rho} grad\ p. \tag{16}$$

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However, when there is pressure losses (in the shock wave or on the heat adding to a moving volume) the equations (6) and (12) do not run (we should include into account total pressure losses and use the relation (13) as the first thermodynamics law). The relations (13) or (14) express the dissipation of mechanical energy on the ST level. It was considered the first by W. Thomson [32].

Here very important to emphasis following item only relation (16) may be presented in the conservation law form for associating nonlinear equation of evolutions [33, 34]. The relation (15) can't be presented in the conservation law form and hasn't evolution features.

3. Engine aerodynamics

At the beginning we consider integral modelling of the ST presence and radiation losses on its level. Radiate heat transfer simulation usually requires the solution of radiate transfer equation, which depends on spacial, directional and spectral variables. We consider two approaches for radiate heat loads estimation: simple enough integral and detail differential simulations. In integral estimation the radiate heat loads in the ST level depend on temperature's fourth power. The energy conservation law for radiate gas medium has additional term

$$\frac{d}{dt}\iiint_{\omega(t)} \rho(\frac{1}{2}q^2+\varepsilon)d\omega = -\iint_{\gamma(t)} (p\vec{u}+\vec{S})\vec{n}d\gamma + \iiint_{\omega(t)} \rho Q' d\omega. \tag{17}$$

The integral value of radiation flux S in the right hand side (17) may be estimated by the Stephan – Boltzmann law (e.g., $S = \varepsilon\sigma T^4$, $\sigma = 5.67\cdot10^{-8}$ Wt/m^{2}K^4 and ε takes into account the degree of blackness of the emitting surface part). The analyses of the common value $p\vec{u}+\vec{S}$ shows for u ~ 1 m/s gets Δp ~ ΔS and for ΔS ~ 1 MW/m^2 the value Δp may have near a few atmosphere (see above).

The important estimation is the radiation influence in a burning process. For the simplicity we consider a heat addition dq and radiation dS in a cylinder tube. The energy value for two sections 1 and 2 has balance

$$\varepsilon_2 + p_2/\rho_2 + q_2^2/2 = \varepsilon_1 + p_1/\rho_1 + q_1^2/2 + dq - dS\,.$$

The mass and impulse conservation laws get the Michelson straight line relation [35,36]

$$m^2 = (p_2 - p_1)/(1/\rho_1 - 1/\rho_2)$$

and its tilt in the (p,1/ρ) plane (fig.2).

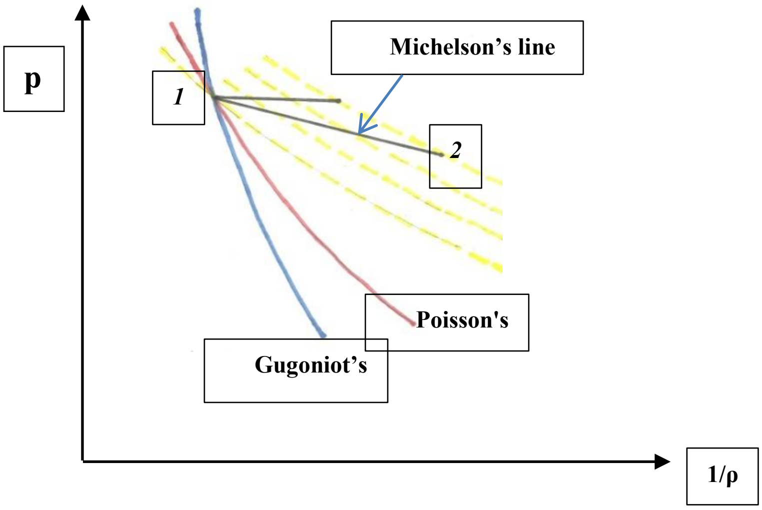

Figure 2. The Michelson line 1 - 2 in the (p,1/ρ) plane; Gugoniot's and Poisson's adiabatic lines.

The burning process in our case goes to the Michelson straight line 1 - 2 in the (p, 1/ρ) plane and has total pressure losses. The process for p = const presents only in an ideal case. For including into account radiation losses a using numerical simulation should apply the energy equation (17).

Further we present the common conservation laws system for the case of the ST presence as the two components model of a gaseous and radiation medium. There are used the index g for gas and the index f for radiation components of medium (for example, for densities ρ_g and ρ_f). For the one velocity model the values of velocity

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components u, v, w at the axis x, y, z are the same for each medium components. The integral conservation laws are presented as [37] for the volume ω(t) with the boundary γ(t)

$$\frac{d}{dt}\iiint\limits_{\omega(t)} \rho_k d\omega = \iiint\limits_{\omega(t)} q_k d\omega,$$

$$\frac{d}{dt}\iiint\limits_{\omega(t)} \rho_k \vec{u} d\omega = -\iint\limits_{\gamma(t)} p_k \vec{n} d\gamma + \iiint\limits_{\omega(t)} \vec{r}_k d\omega \qquad k = g, f \qquad (18)$$

$$\frac{d}{dt}\iiint\limits_{\omega(t)} \rho_k (\frac{1}{2}q^2 + \varepsilon_k) d\omega = -\iint\limits_{\gamma(t)} p_k \vec{u}\cdot\vec{n} d\gamma + \iint\limits_{\gamma(t)} K_k gradT_k \cdot \vec{n} d\gamma + \iiint\limits_{\omega(t)} L_k d\omega.$$

Here q^2 - the square of the velocity vector and

$$L_g = C_{gf}(T_f - T_g) + Q'_g \, , \; L_f = C_{gf}(T_g - T_f) + Q'_f \, .$$

Energy conservation laws are written for heat transfer gas and radiation components (the second terms in the right side of these equations, K_g and K_f correspondently thermo transfer coefficients for gas and radiation parts). The last terms in the right side of initial energy equations describe an energy exchange between gas and radiation parts (the space thermostat). The terms Q_g and Q_f are an additional energy souses, which include into account energy exchange channels (for example, in the case chemical reactions).

We obtain the summary laws as composition of equations (18)

$$\frac{d}{dt}\iiint\limits_{\omega(t)} \rho d\omega = \iiint\limits_{\omega(t)} q d\omega,$$

$$\frac{d}{dt}\iiint\limits_{\omega(t)} \rho\vec{u} d\omega = -\iint\limits_{\gamma(t)} p\vec{n} d\gamma + \iiint\limits_{\omega(t)} \vec{r} d\omega, \qquad (19)$$

$$\frac{d}{dt}\iiint\limits_{\omega(t)} \rho\left(\frac{1}{2}q^2 + \varepsilon\right) d\omega = -\iint\limits_{\gamma(t)} p\vec{u}\cdot\vec{n} d\gamma + \iint\limits_{\gamma(t)} W d\gamma + \iiint\limits_{\omega(t)} Q d\omega.$$

In (19) we use

$$\rho = \rho_g + \rho_f, p = p_g + p_f, \varepsilon = \rho_g / \rho \cdot \varepsilon_g + \rho_f / \rho \cdot \varepsilon_f, \qquad (20)$$

$$W = K_g gradT_g + K_f gradT_f, Q = Q_g + Q_k.$$

The system (19) is closing by the state equations:

$$\varepsilon_k = \varepsilon_k(\rho_k, T_k), \, p_k = p_k(\rho_k, T_k), k = g, f \, .$$

Further we present practice applications of our typical simulations for internal aero physics internal and external problems on the base of the system (19). All additional details of our simulation may be found [38-40].

4. Applications

For practical problems there are shown working processes in air breathing high temperature engines. Thermo aerodynamic calculations of high temperature engines demand detail description of whole working process, including heat addition and radiation losses into ST in combustors and other component of propulsion systems. Some basic complexities of designing high temperature air-breathing engines relate to origin of so-called "unexpected" heat of working process [41-44]. This additional heat essentially complicates coordination of engine basic components (for a turbojet – compressor, combustor and turbine, for a high-speed jet engine - air inlet, isolator, combustor, and nozzle). In our simulations we include into account "unexpected" heat as radiate heat and heat transfer to ST using system (19).

Propulsion combustion chambers with temperatures above 3000 K, scramjet chambers with temperatures near 2500 K and other jet engine combustors with temperatures near 2000 K are strongly influenced by radiate heat transfer. Radiate heat loads depend on temperature’s fourth power [45,46]. Radiate heat transfer simulation usually requires the solution of radiate transfer equation, which depends on special, directional and spectral variables. Examples such type modeling were realized for combustion chambers in [45,46] have good enough progress. At the same time the practice realization of scramjet propulsion has great difficulties. One of these reasons is a highly detrimental operation mode called unstart [47-50].

Using our theoretical model we would like to explain the similar unstart mode, which don’t allow us to realize supersonic burning in scramjet with positive thrust. This operation is the unstart mode, when radiation and shocks (pseudo-shocks system) are destroying supersonic flow in combustor channel. Figure 3 presents typical results this mode simulation and shows Mach number and pressure counter lines inside channel without burning (a) and with burning (b). In the last mode heat addition destroys supersonic burning and shock wave system is located in the inlet zone.

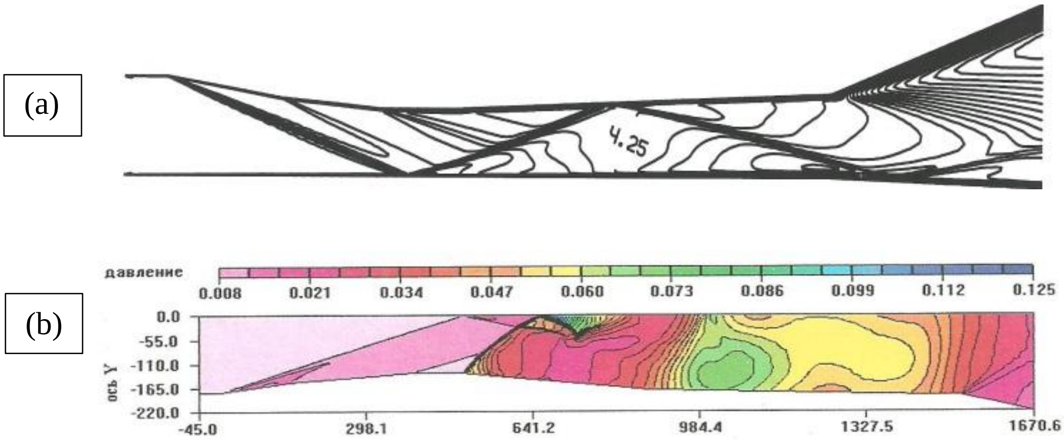

Figure 3. Mach number lines without burning (a) and pressure counter lines with burning on unstart mode (b) inside high speed channel.

Our simulation (19), (20) is relevant to high-class models based on real 3D geometry of aircraft engine flow path [38-40]. They are also based on three-dimensional (3D), quasi-three-dimensional (two-dimensional (2D) and one-dimensional (1D) approaches. The models can be applied either in isolated turbo machinery components or in entire flow passage. All approaches are closely connected among themselves. Together they form the dynamic system for efficiency analysis of entire flow path. This method of working process modeling considers all main features of working process (viscous and radiation losses, various steam properties, fuel addition and combustion, cooled air bleed and blow out, leakage from flow path, rotor and stator thermal dilatation, air humidity, rotor inertia and so on). Steady and transient modes of turbine operation could be simulated via these models. The direct problem for specified flow path is being solved from the position of internal aerothermodynamics.

The typical examples of investigation of steady and unsteady working modes of the bypass gas turbine engines are shown in fig.4, 5. These engines were investigated in detail experimentally. Both the whole engines and their engine cores were tested. Different design and off-design working points were numerically studied and compared with the test results. The experiments demonstrated significant discrepancy between the tested and design engine parameters for a number of working points. Figure 4 presents the flow structure in the high pressure compressor on design (a) and off-design (b) working modes. In the off-design mode we can see widely spread separation zone near the hub of the compressor (b). For compensation it we should open the high pressure turbine vane throat on 1.5° and obtain the design regime. These design and computational results were obtained with including of additional “unexpected” radiation losses in the main combustion chamber.

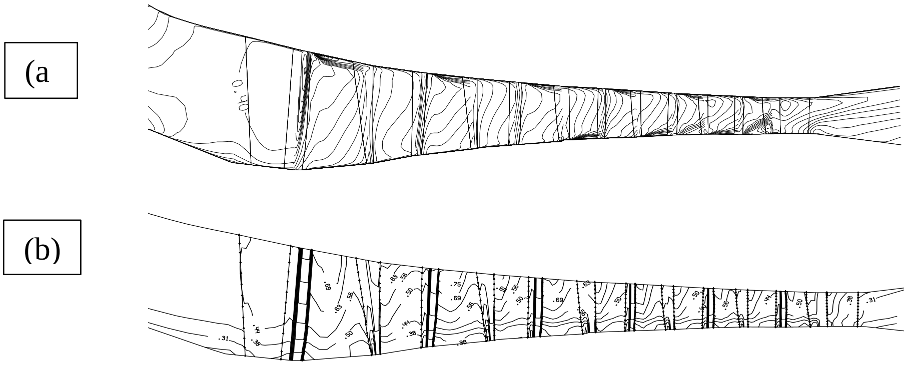

Figure 4. Design (a) and off-design (b) working modes in high pressure compressor.

Now we present simulation of whole flow passages for bypass gas turbine engine with afterburning trust 80 kN.

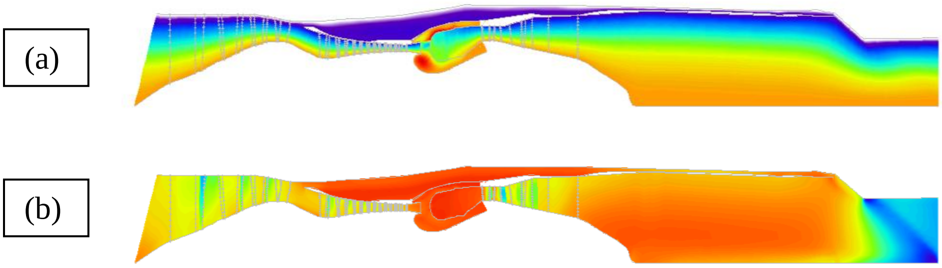

Figure 5. Streamlines (a) and Mach number (b) counter distributions in whole flow passage of multi regime engine.

Figure 5 illustrates streamlines and Mach number counter distributions in whole flow passage of multi regime engine with bypass ratio 0.17 and the 3 stages fan, 6 stages high pressure compressor, annular main combustor, one stage high and low pressure turbines and afterburner. Additional pressure losses in main combustors demands very accurate determination high pressure turbine cross section and correlation of power for compressor driving. Here we have the decreased flow capacity of the compressor and led finally to increased turbine inlet temperatures.

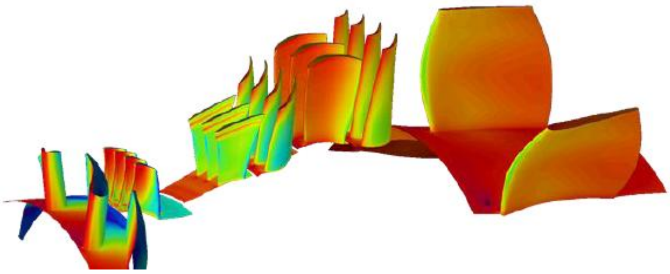

Figure 6. Flow field in one stage high pressure turbine, two stage low pressure turbine and exit channel.

Flow field in one stage high pressure turbine, two stage low pressure turbine is shown in fig.6. Here the core flow capacity essentially depends on radiation influence. For compensation additional thermal losses the common pressure ratio in compressors had been increased on 7%.

4. Some related issues

At the last part of the paper a few related issues are considered. The presence of ST requires some revision of the methodology of phenomenological and statistical thermodynamics. As there was mentioned above our ST essentially differs from ordinary Gibbs' thermostat [1], in which studied systems are in thermal contact by T >> 2.73 K and have the same temperature. We should revise Gibbs' statistical thermodynamics for opened system with outlet temperature T_0=2.73.

Looking at some consequences of the ST influence the question of applicability of the Noether theorem [51] should be analyzed. As we know the every differentiable symmetry of the action of a physical system has a corresponding conservation law. By Noether's theorem the symmetries of translations in space and time get to the conservation laws of momentum and energy within this system, respectively. Noether's theorem takes place only for dissipative less isolate systems. In our case with the ST we have no possibility to use Noether's theorem. The same situation takes place with the Lagrangian and the Hamiltonian mechanics.

There is used as the standard language of the particle physics to express in terms of Lagrangians [52, 53]. To give the flavour of the general theorem, a version of the Noether theorem for continuous fields in four dimensional space – time has been given. The requirement of invariance of the Lagrangian for local gauge transformations is the original principle of all modern physics theories of a microcosm. The gauge transformation is rotation at arbitrary angles around the same axis in the Minkovsky 4-space. Here we have local time's arrow decline and rotation. It is one of the great differences between propulsion and modern physics. We should include into account some principal limitations of the Lagrangian formalism and quantum field theories, which connect with time's arrow (real time's arrow has no

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possibility to decline at any side and twisting). The propulsion physics has only the "one-way direction" arrow of time (without any rotation).

Real physics is based on the principle of Galileo's relativity (invariance) and Newton's laws of motion. Some items of modern theoretical physics base on the Noether theorem, the formalism by Lagrange and Hamilton and Lorentz' invariance. The Noether theorem, the formalism by Lagrange and Hamilton can't by right in such type cases of opened systems with the ST presence. Therefore the particle and gauge theories should be reviewed.

Conclusions

Any studied natural or technical systems (in particular, any aircraft engine) have closed heat contact with ST and some accompanied energy dissipation on its. By that we have additional thermal radiation losses into ST.

The thermal radiation should be included into account in the design process stage for real coordination of different components of high temperature air breathing engines.

United conservation laws of mass, impulse and energy are the base of air breathing engine working process simulation (including additional thermal radiation losses into ST).

The entropy growth shows value of dissipate energy and total pressure losses.

The entropy growth ensures time's arrow "one –way" direction (the second law of thermodynamics).

The ST presence should be included into account in any theoretical analysis (in physics, astrophysics, biophysics, chemistry and so on).

The Noether theorem, the formalism by Lagrange and Hamilton can't by right in such type cases of opened systems with the ST presence.

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