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Available energy of the air in solar chimneys and the possibility of its ground-level concentration

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Abstract

Solar chimneys are defined as low temperature solar thermal power plants, which use the atmospheric air as a working fluid, where only one part of the thermodynamic cycle within the plant is utilized. The available work potential that atmospheric air acquires while passing through the collector has been determined and analyzed. The dependence of the work potential on the air flowing into the air collector from the heat gained inside the collector, air humidity and atmospheric pressure as a function of elevation are determined. Various collector types using dry and humid air have been analyzed. The influence of various chimney heights on the air work potential are established. The possibly higher utilization factors of the available hot air work potential without the use of high solid chimneys are discussed. It has been shown that the vortex motion flowing downstream of the turbine can be maintained under pressure and can possibly take over the role of the solid structure chimney. Thus, a part of the available energy potential acquired in the collector would be used to maintain the vortex flow in the air column above the ground-level turbine. Basic conditions for the maintenance of such a vortex flow are described and compared to the tornado phenomenon.

Keywords: Solar chimney; Available energy; Vortex

1. Introduction

Solar thermal power plants can be classified by their characteristics and placed into two categories: high and low temperature power plants, depending on their temperature level.

High temperature solar power plants collect direct solar radiation by means of solar concentrators and use a closed thermodynamic process, where the whole process takes place within the plant itself. These plants are characterized by relatively high efficiency, and unfortunately, by high capital costs. They also have high operational costs, which are in large part due to measures which are used to compensate for the short and long time fluctuations of the solar radiation input.

Low temperature power plants, which are typically utilized, are hydro and wind powered plants, where the cycle of the working fluid is kept predominantly in the free atmosphere. Capital costs per power unit are also relatively high for such plants since the work potential,

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Nomenclature

A	irradiated collector surface (m^2)	u	mean circular velocity of GVC-shell (m/s)
C_p	specific heat air capacity (J/kg K)	u_c	air speed at the turbine outlet (m/s)
e_{coll}	exergy (maximum technically work output, availability) of air at the collector outlet (J/kg)	v_a	air volume in the atmosphere (m^3/kg)
$e_{coll\,tech}$	technically feasible part of exergy (J/kg)	v_{coll}	volume of the collector air (m^3/kg)
$e^{net}_{coll\,tech}$	net technically feasible (part of) exergy (J/kg)	z	height (m)
e_{H_c}	maximal net work output for solid chimney (J/kg)	α	effective absorption coefficient of the collector
g	gravitation acceleration (m/s^2)	β	convective heat transfer coefficient (W/m^2 K)
G	density of overall sun radiation (W/m^2)	δ	thickness of GVC shell (m)
h	specific enthalpy (J/kg)	Δp_c	pressure differences at the bottom of the chimney of the height H (Pa)
h_{coll}	air enthalpy with the collector outlet (J/kg)	Δp_r	radial pressure difference (Pa)
h_0	specific enthalpy of the collector air in thermodynamic equilibrium with atmosphere (J/kg)	Δp_{u_c}	pressure drop equivalent to kinetic energy at the chimney inlet (Pa)
H_{max}	maximum height reached by the collector air (m)	Δt_{coll}	increase of air temperature in the collector (°C)
H_c	chimney height (m)	η_{buoy}	efficiency of buoyancy energy conversion
m	mass air flow (kg/s)	η^t_{buoy}	theoretical efficiency of buoyancy energy conversion
p_a	atmospheric pressure (Pa)	η^{rel}_c	relative efficiency of the chimney
p_{coll}	pressure at the collector outlet (Pa)	η_c	theoretical efficiency of the chimney (i.e. of the Brayton cycle implemented by the chimney)
p_0	collector air pressure in equilibrium with the atmosphere (at $H = H_{max}$) (Pa)	η_{coll}	collector efficiency
P	turbine power (W)	η_t	turbine efficiency
R	mean radius of GVC shell (m)	ϕ_{coll}	relative humidity collector outlet (%)
s_0	air entropy in equilibrium with the environment (J/kg K)	ρ	mean density of GVC shell (kg/m^3)
T_0	environment temperature (K)	ρ_a	density of atmospheric air (kg/m^3)
		ρ_c	air density at chimney inlet (kg/m^3)

which is spontaneously created in the atmosphere, is not concentrated.

Solar thermal power plants based on solar chimneys (SC) by its characteristics are more similar to low temperature power plants. A survey of the technical characteristics, costs and environmental impacts of diverse solar power plants, as well as the survey of world regions of different solar radiation levels was given earlier by Trieb et al. (1997).

Power plants using solar chimneys have not been built yet, but the operating and design characteristics of such plants have been tested on the prototype which was built in Manzanares, Spain. Data regarding the structure and operating capabilities of this prototype were given by Haaf et al. (1983) and Haaf (1984). Profitability analysis of SC power plants, based on the experience acquired by the plant prototype with regard to the operating capabilities were described by Schlaich (1995). Schlaich has shown that SC plants are presently competitive for global radiation in excess of 1950 kWh/m^2 per year. Areas of such radiation levels comprise a great part of Africa, the near East, southwestern Asia including a considerable part of India, a large part of Australia, as well as parts of North and South America. At the price of electricity per kWh, as assessed by Schlaich (1995), SC plants could cope with the long distance transfer losses of generated electric power, e.g. between the Sahara and Central Europe, and have the potential to become one of the global energy sources.

The principles of operation and performance characteristics of a typical SC power plant are described along with a cross-sectional view, based on the power plant project described by Schlaich (1995).

In Fig. 1, the ground is denoted by A, the glass roof (single-layered and in the higher air temperature zone double-layered) of the solar air collector is marked by B, "chimney" marked by C, in which air (heated in the air collector) is drawn by the buoyancy force and D denotes the block of air turbines together with a generator set at the basement of the chimney. The chimney,

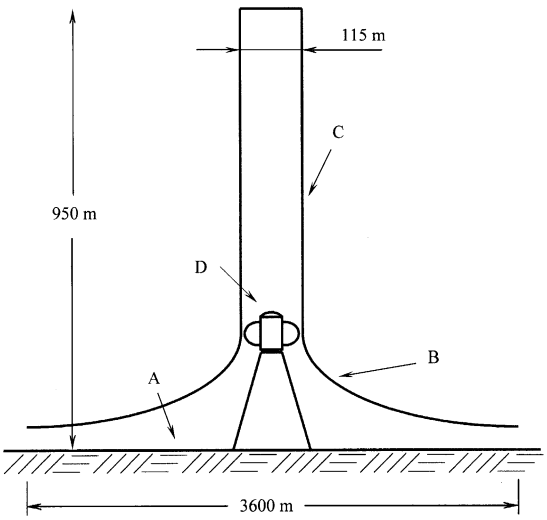

Fig. 1. Cross-section of SC power plant with 100 MW nominal power. A—ground, B—glass roof, C—"chimney", D—air turbine.

as shown in Fig. 1, is 950 m high and 115 m in diameter. The incidental solar radiation of 2300 kWh/m^2 per year was considered nominal. In the nominal case, air temperature in the air collector is increased by about 36 °C, the collector efficiency amounts to $\eta_{coll} = 0.53$, the turbine pressure drop is assumed to be about 900 Pa, the total friction loss of the collector at the chimney's outlet amounts to 80 Pa, the kinetic energy loss at the chimney's outlet amounts to 120 Pa (at the air velocity of 15 m/s). It was anticipated that 10% of the total power generated would be gained by the accumulated ground heat. Adiabatic processes in the turbine and "chimney" are part of the Brayton cycle. In this cycle, the collector air rises through the turbine and chimney into the atmosphere in the presence of the gravitational field. The overall SC power plant efficiency was assessed to be 1.3%. In our case, the process taking place in the turbine differs considerably from the process in the wind turbine, where the pressure drop of 900 Pa, from kinetic energy utilization of 60%, corresponds to a wind speed of about 200 km/h.

Although requiring high global radiation and capital costs, SC power plants would also provide some important benefits, like a long service lifetime lasting several decades, the application of technology allowing utilization of local materials and human resources, as well as the utilization of a solar collector area at the periphery as a greenhouse and/or dryer.

2. Available energy of the collector air

A standard thermodynamic analysis of solar chimneys was given by Schlaich (1995) and Gannon and Backstrom (2000). By use of the optimal thermodynamic process, for given dimensions of solar collectors and chimney height, the maximum obtainable thermal power is determined by relation

$$P_t = GA_{coll}\eta_{coll}\eta_c\eta_t \tag{1}$$

Here G is instantaneous global solar radiation falling upon the unit area (W/m^2), A_{coll} is the collector area (m^2), η_{coll} is the solar air collector efficiency, η_c is the efficiency based on the ideal Brayton cycle, where its thermodynamic parameters are determined by the height of the chimney and temperatures at the collector inlet and outlet, and η_t is the turbine efficiency.

The turbine efficiency takes partly into account the non-ideal cycle properties reducing the turbine work by kinetic energy of the air at the turbine outlet, which is approximately equal to one at the chimney outlet.

From a standard theoretical approach based on Eq. (1), one type of hot air utilization was adopted. In general, this type is implemented with a solid chimney, and does not provide an general basis for the analysis of optimum engineering solutions. Our goal was to maximize the output of technical work from the collector air flow, without a predetermined solid chimney. Maximum work, that can be produced by bringing a fluid in equilibrium with the environment is exergy (Bošnjaković, 1965) defined by:

$$e_{coll} = h_{coll} - h_0 + T_0(s_0 - s_{coll}) \tag{2}$$

where "0" denotes the state of the air in a thermodynamic equilibrium with an environment. The environment is usually described as the air at the bottom of the atmosphere. In the case of the SC, the upper layers of the atmosphere can be considered as an indefinite number of environments.

A detailed analysis, based on Eq. (2), in a Mollier h–s diagram is shown in Fig. 2.

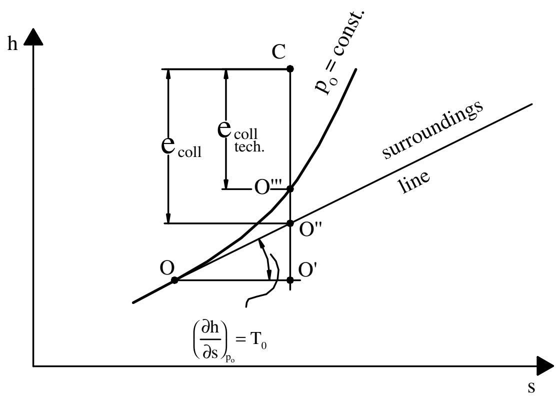

Fig. 2. Exergy end its technically feasible part.

Here C represents the state of air at the collector output, and O represents the state of air in a mechanical and thermal equilibrium with an environment.

In the mechanical equilibrium of the collector and the ambient air exposed to a gravitation field, the collector and ambient air are exerted to the same pressure and force of buoyancy equaling zero. This equilibrium state in Fig. 2 is denoted by O‴. The exergy CO″, as given by Eq. (2) shows maximally available technical work.

One of its mutually equivalent equilibrium transitions could be performed by the adiabatic process CO‴, and followed by the isobar O‴O transition, along with a reversible utilization of the heat quantity $C_p(T_{O'''} - T_0)$. This utilization, for example, could be performed by means of a sequence of Carnot cycles between the isobar of $p = p_0$ and isotherm $T = T_0$. The Carnot cycles would result in additional work O‴O″, and the overall work would equal to $h_{coll} - h_{O''}$. However, any kind of controlled heat exchange above ground level is technically not feasible, and therefore that portion of exergy is also technically not feasible.

Thus, for overall work it follows

$$e_{coll\,tech} = h_{coll} - h_{O'''} \tag{3}$$

Index "tech" is used to denote the technically feasible part of exergy e_{coll}. The specific enthalpy of the collector air at the atmospheric pressure, height H, where the buoyancy force disappears is denoted by $h_{O'''}$. In such a state, the collector air was considered to be in equilibrium with the environment. Although this equilibrium is only mechanical, the ongoing temperature imbalance in this state cannot be technically used. The CO‴ process shown in Fig. 2 is the adiabatic process in the gravitational field. The first law of thermodynamics for the motion of air in a gravitational field gives the following equation, where suffix net indicates technically executed net work:

$$e^{net}_{coll\,tech} = \int_0^H [-v_{coll}(z)\,dp_a - g\,dz] \tag{4}$$

and finally

$$e^{net}_{tech\,coll}(H) = \int_0^H [v_{coll}(z)\rho_a(z) - 1]g\,dz$$
$$= \int_0^H [v_{coll}(z) - v_a(z)]\rho_a(z)g\,dz \tag{5}$$

The same result could be derived even if we did not start from Eq. (3). According to the second law of thermodynamics in which all the reversible processes are mutually equivalent, it is sufficient to calculate the work for one of these processes. Such an imaginary process would be an adiabatic elevation of a unit portion of the collector air under the buoyancy force, whereby directly follows Eq. (5). With a presently unspecified upper endpoint, height H, the integral equation (5) is the resulting equation which shows the maximum technically feasible net work output. In other words, $e^{net}_{tech\,coll}$ is the "height potential" of the collector air.

3. Height potential in the standard atmosphere

Regarding the relationship per height for pressure, temperature and air density, the reference atmospheric profile as adopted here, corresponds to the parameters of the International Standard Atmosphere SA-73 or US Standard Atmosphere (NOAA, 1976). It represents mean values at the geographical latitude of 45°, within an average activity of the Sun.

The dependence of pressure and volume on height are shown in Fig. 3 by curve OA. Curves OB and O′C, for the same pressure relationship by altitude OA, represent a distribution of densities at an adiabatic quasi-static elevation of dry air having initial temperatures of 15 °C and 45 °C, respectively (curves OB and O′C). The narrow wedge-shaped hatched area OO′F between the curves OA and O′C represents, according to Eq. (5), the maximally available technical net work of dry air in the standard atmosphere at a ground temperature of 45 °C.

At the intersection of curves OA and O′C (point F), the buoyancy force, in relation to the local atmosphere,

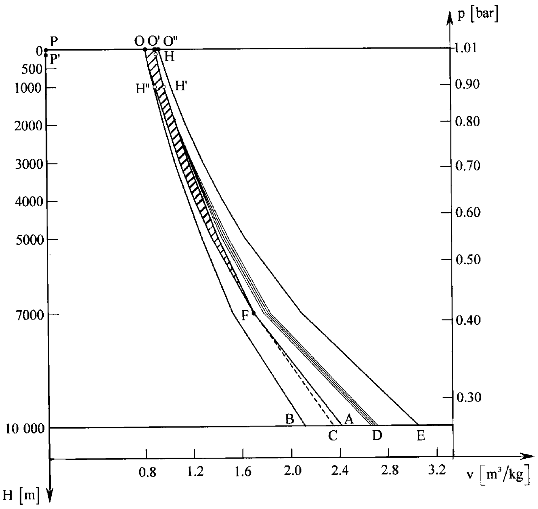

Fig. 3. Standard atmospheric and isentropic specific volume profiles. H,p—height and corresponding standard atmospheric pressure; OA–specific volume in standard atmosphere; OB—isentropic elevation of cold dry air; O′F—isentropic elevation of hot dry air; O′D—isentropic elevations of hot moist air with different relative humidity on the collector inlet; O″E—isentropic elevation of hot air saturated on the collector outlet; PO′HP′P = OO′H′H″O—maximum work net output for chimney height 1000 m.

disappears at the maximal elevation height of $H = H_F = 7000$ m. Thus, point F automatically determines the upper boundary of the integral in Eq. (5). However, in accordance with Fig. 3, the height of an air layer (tropopause), which is the boundary between troposphere and stratosphere, can be taken as a final elevation limit. That specific height can be applied only if there are no other intersections of curves OA and curves of adiabatic elevation of collector air at some of the lower altitudes. Homogeneity of atmospheric temperature above the tropopause is equivalent to the state of intensive air mixing, which destructs any possible residual exergy of the collector air. The elevation of such characteristics is about 10 000 m.

The area beneath the OF curve along the ordinate equals the specific potential energy in the gravitational field at the height H_F, i.e. 68 670 J/kg. To prove it, let us suppose that the fluid is lifted up (with no buoyancy force), so that all the expansion work (area along the ordinate) increases the potential energy. If the collector air expands according to curve O′F, the area between this curve and ordinate is the technically feasible exergy $e_{\text{coll tech}}$; and net work $e^{\text{net}}_{\text{coll tech}}$ equals the hatched area OO′F. By integration of the OO′F area, the height potential (i.e. the net work) of the dry air in a the standard atmosphere having a ground-level temperature of 45 °C could be calculated giving the result of $e^{\text{net}}_{\text{coll tech}} =$ 3735 J/kg. Michaud (1999), who started directly from Eq. (3), obtained similar results in a different way using different calculation parameters.

4. The role of the solid chimney

The effect of the buoyancy force on a fraction of hot air derives from a pressure difference below and above that fraction of air, which is determined by the surrounding atmosphere. However, if we imagine the elevating air as separate from the surrounding atmosphere by a solid structure chimney of height H_c, the chimney will eliminate pressure differences all along its length, and will keep the hot air separate from the surrounding atmosphere. That way, the chimney will be summing up all elementary pressure differences at its bottom.

The accumulated pressure difference developed with regard to the surrounding atmosphere, amounts to $\Delta p_{H_c} = p_a(0) - p_{\text{coll}}$. That pressure difference is linked to the maximum work output of the collector air in the following way:

$$e_{H_c} = e^{\text{net}}_{\text{coll tech}}(H_c) = \int_0^{H_c} [v_{\text{coll}}(z) - v_a(z)]\rho_a(z) g\,dz = -\int_0^{\Delta p_{H_c}} v_{\text{coll}}(p)\,dp \tag{6}$$

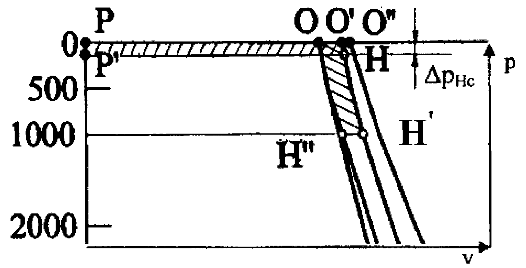

Fig. 3a. Enlarged figure of chimney role in ground-level concentration of the height potential.

In the diagram shown in Fig. 3 and enlarged in Fig. 3aa length OH represents the contour line of zero height for atmospheric and collector air at the bottom of the chimney height of $H_c = 1000$ m, corresponding to the pressure difference of $\Delta p_{H_c} = 1240$ Pa.

Based on Eq. (6), the two areas, PO′HP′ = OO′H′H″ = 912 J/kg as shown in the diagram Fig. 3aa are equally large.

The ratio between of the theoretical work available from the chimney at height H_c, according to Fig. 3 to the heat assumed in the collector can be taken as definition of the chimney's efficiency. It is also possible be to describe the above ratio as a buoyancy conversion efficiency η_{buoy} and to show it as a product with two factors

$$\eta_{\text{buoy}} = \eta^{t}_{\text{buoy}}\eta^{\text{rel}}_{c} \tag{7}$$

where η^{t}_{buoy} and η^{rel}_{c} are theoretical and relative chimney efficiencies, respectively.

The theoretical efficiency is a ratio between the height potential of the collector air and the heat assumed in the collector. The relative chimney efficiency takes into account the limited height of the chimney.

In the particular case $\eta^{t}_{\text{bouy}} = 0.124$ and $\eta^{\text{rel}}_{c} = 0.244$ are obtained, and the buoyancy conversion efficiency of $\eta_{\text{buoy}} = 0.030$ is derived.

Schlaich (1995) and Michaud (1999) for η_{buoy} quoted the approximate equation:

$$\eta_{\text{buoy}} = \frac{H_c g}{c_p T_0} \tag{8}$$

which gives $\eta_{\text{buoy}} = 0.034$. The reasons for the different results as obtained from Eqs. (7) and (8) are that of different reference profiles of atmospheric pressure vs. height, taken earlier by the two authors, and the aberrance of Eq. (8) compared to the more accurate Eq. (7). According to Fig. 3, the buoyancy efficiency is roughly proportional to the chimney height up to $H_{c,\max} = 3000$ m, which already exceeds the technical design possibilities of the solid structure chimney.

In general, considering the height potential utilization, Eq. (8) becomes quite useless. For example for $H_c = 7000$ m, which is the upper elevation height, Eq. (8) shows an error of approximately 100%.

The present analysis shows how to distinguish the calculation of exergy (maximum work output) of the collector air from the net technically feasible potential and separate it from the achievable potential e_{H_c}, if a chimney was used.

5. The impact of humidity on the height potential

The presence of humidity in the collector air would certainly increase its operating potential due to the condensation of moisture, thus slowing down the adiabatic decrease in temperature and speeding up the density decrease of ascending air. The change in air vapor content at its equilibrium adiabatic expansion can be calculated by use of its entropy as a function of the pressure, temperature and humidity. The approximate graphic procedure was suggested by Bošnjaković (1965), and the results obtained for saturated air at the temperature of 45 °C are given by curve O″E in Fig. 3. In such a way, the condensed moisture has been included in the density, as if it had not been separated from the air flow. The technically feasible net part of exergy corresponds now to the area OO″EA, which is substantially larger (10 360 J/kg) than the one for the dry air at the same initial temperature (3735 J/kg). Even in the case of a relatively modest chimney height of 1000 m, the work output availability is about 62% higher, and amounts to 1480 instead of 912 J/kg.

However, by moistening the dry collector air at the temperature of 15 °C in order to get it saturated at the temperature of 45 °C, the solar radiation heat of 200 kJ/kg must be available and allowed to the collector air, which is more than six times in excess of the solar energy needed by dry collector air for the same change of temperature. In comparison, the theoretical buoyancy efficiency of the solar collector filled by dry air amounts to 0.124, whereas for a collector with hot saturated air, it amounts to only 0.050.

Consequently, from the point of view of overall system efficiency, the collector air moisturing up to its saturation level at the collector outlet would not be profitable. On the other hand, the moisture content of the air at the given temperature at the collector inlet should be as high as possible. The results of impact analysis of air humidity at the collector inlet on the change of its specific volume in the course of adiabatic elevation are shown as a bundle of curves O′D in Fig. 3. If relative humidity at the collector inlet increases from 30% to 90%, the curve bundle will slightly separate from the dry air curve O′C. In addition, the intersection point F disappears and looks like a bottleneck in the height potential. A major increase in work potential in raising the air humidity occurs at elevations above 7000 m.

The influence of temperature and relative humidity at the collector outlet on the exergy potential have been additionally analyzed and the results are shown in Fig. 4. The two curves for dry and 18% humid air at the temperature of 40 °C at the collector outlet show the change of air pressure and volume vs. height. The hatched areas between these two curves and reference atmospheric conditions curve SA-73, represent the available net technically feasible part of exergy.

For $t_{coll} = 40\ °C$ and $\phi_{coll} = 0$,
${e_{coll\,tech}}^{net} \approx 2630$ J/kg, end for $t_{coll} = 40\ °C$ and
$\phi_{coll} = 18\%$, $\quad e^{net}_{coll\,tech} \approx 5370$ J/kg

The results obtained from analysis of the air collector height potential by taking into account diverse ways of contributing to overall humidity are summarized as follows:

1. The overall height potential of the dry air in the collector is several times higher than that encountered in "conventional" SC plants using solid chimneys.
2. The height potential will be considerably increased if the air at the collector is moistened. The more humid the collector air, the higher its exergy, but this is accompanied by a decrease in the overall theoretical efficiency.
3. Theoretical efficiency can be increased by use of saturated air at the collector inlet.

Adding water into a collector would decrease its theoretical efficiency, but could contribute to certain gains, e.g. from the simultaneous greenhouse production in the peripheral parts of the collector. In this case the collector

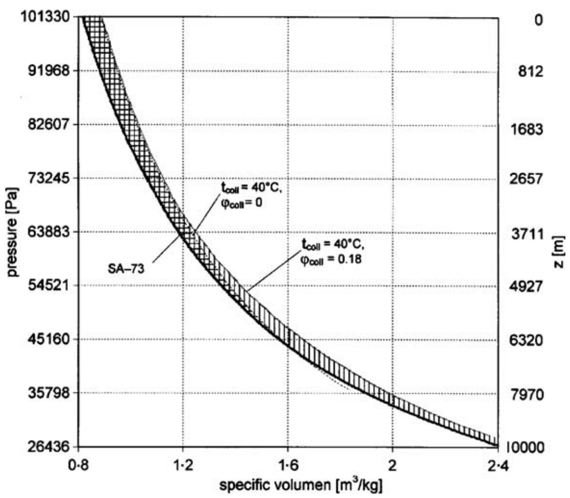

Fig. 4. Influence of air temperature and humidity variation on net technically feasible part of exergy.

peripherals would act as a greenhouse with intensive irrigation, where by tall green vegetation act as a filling for air humidification. At the same time, there would neither be a need for any chemical water treatments, nor would there be any kind of water cleansing having adverse ecological effects. Such SC plants could use some surface bodies of water like lakes and rivers in order to compensate for the evaporated water.

6. The possibility of ground-level concentration of the height potential

According to the results described above, a solid structure chimney can only "reach" a small part of the overall height potential of the collector air. Consequently, such a type of construction cannot be considered satisfactory from a thermodynamic point of view. At the same time, the solid structure SC plant is not appealing when taking into account the construction engineering, safety measures and high investment costs.

Sections 2, 3, and 5 have dealt with a technically feasible height potential. In these sections we are going to deal with idea concerning on how to use that potential. In order to exploit the potential it should be available at the ground level, which is the only place where turbines can be placed. If we exclude the option of building very high and robust chimneys, another possibility of achieving the ground-level height potential concentration could be by creating a special velocity field above the ground-level plant. The velocity field would have to keep the turbine back pressure lower than the pressure of the surrounding atmosphere, which as a result enables the net turbine work. One could imagine a kind of "inertial bottle" for which maintaining one part of the height potential would be consumed, whereas the remaining part of the available potential could be utilized in the turbine. This type of a "bottle", characterized by a substantial impact of air friction with the ground, was suggested by Michaud (1999) under the name of "vortex". However, he did not take into account the full thermodynamic aspect of the process. The type of plant in which the collector process would be a part of the Brayton cycle in the gravitational field has been suggested by Ninic (2000). In such a plant the role of ground friction is not essential. According to the latter variant an inertial bottle is represented by the vertical vortex column in the gravitation field in whose axis the pressure would be lower than in the surrounding atmosphere at the same elevation. The structure of the "bottle wall" in the vertical cross-section would be complex. The radial pressure difference existing between an external and internal circular wall is in equilibrium with a centrifugal force in accordance to the relation $\Delta p_{\mathrm{r}} = u^2 \rho \delta R^{-1}$.

In the gravitation field radial pressure difference would rise when going downwards from the vortex top and it would be concentrated at the ground level, where the turbines are situated in the ringlike base of such a gravitation vortex column (GVC). The GVC height should be much greater than the height of any solid structure chimney, possibly up to the upper level of the troposphere (refer to points D and E in Fig. 3).

In the crucial evaluation of the GVC concept, a question is posed: is it generally possible to generate and maintain such a circular flow at motion of air with energy dissipation along the vertical boundary layer, which could destroy such a vortex motion much sooner than it could reach the upper layers of the troposphere.

The following was of utmost importance in the physical GVC model which was developed:

- The process taking place in the GVC is primary a thermodynamic phenomenon, and thermodynamic premises of a somewhat wider scope than those dealt Section 2 are necessary for designing a physical and mathematical GVC model.
- Dissipation intensity of the angular momentum into the surrounding atmosphere shall be relatively small, either due to flow stability (laminar flow) on the GVC periphery or due to the induced low intensity radial flow on the periphery, or due to both. In any case there are observations regarding the tornado vortex, which indicate the existence of angular momentum conservation mechanisms.

There is a close analogy between the above described gravitational vortex column and the tornado phenomenon in certain atmospheric conditions. Describing the atmospheric circumstances that correspond to the first of the above quoted prerequisites, the concept of "convective available potential energy" (CAPE) have been introduced in meteorology. The definition of CAPE is identical to the net technically feasible part of exergy. The range of the CAPE criteria calculated on the basis of atmospheric measurements as the first prerequisite for occurrence of a tornado is very broad. Thus Renno and Ingersoll (1996) quotes the CAPE mean value for the tropical belt amounting to 1000 J/kg, and Garner and Thalken (2002) quote that in the operating zone of the developed tornado CAPE amounts from 966 to 6142 J/kg. According to these measurements and the calculations in Section 2, dry air heated to 45 °C would have CAPE (3735 J/kg), which according to the basic criteria would be sufficient for the maintenance of a tornado-like vortex, even with dry air in a standard atmosphere.

7. Conclusion

This article is based on published theoretical tenets and on the key results regarding the evaluation of SC power plants with solid structure chimneys. For maximally available work output, defined as the operating potential of the collector air in the standard atmosphere, it was shown to be considerably larger than that one of theoretically obtained in SC designs with solid chimneys. The impact of air humidity on the increase of the operating potential and efficiency of the whole plant has also been analyzed. Finally, the technical possibility of utilizing the total operating potential was suggested—partly for generation of the turbine work, and partly for the maintenance of the GVC air flow structure above the ground level. Basic assumptions preceding GVC physical modeling were provided. A significant analogy exists between GVC-flow structures and natural tornados thereby playing the role of an almost experimental confirmation that the proposed GVC structure is technically achievable.

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