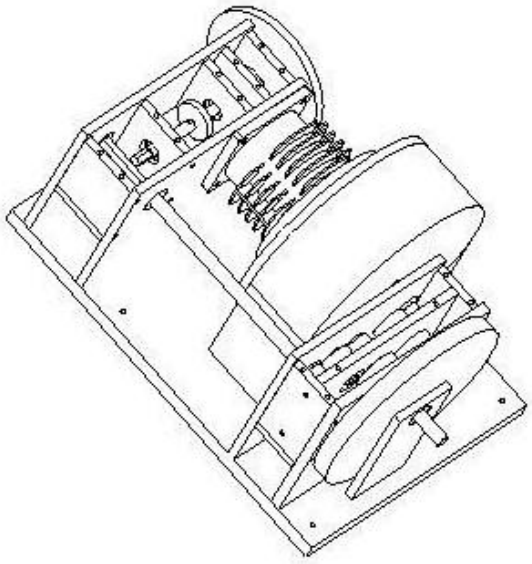

Sanjay Amin's Entropy Engine – deflated?

Earnest S.I. Gullible and Gerhard W. Bruhn
Department of Mathematics, Darmstadt University of Technology, FRG

August 2000 [1])

When the opinions of two authors on the subject of their joint research are as diametrically opposed as ours are, they really ought to publish them separately. In view of our long and close relationship, we have nevertheless decided to publish jointly, but we do not intend to spare each other. We hope that the reader will attribute the occasional harsh remarks to the devotion of the respective author to his beliefs and form his or her own well-balanced view on the matter. Given our contradictory opinions, the authorship of the various text passages will be self-evident.

Our quarrel started last November when Earnest, a faithful listener to the science magazine of our local radio network DLF, heard about a new miracle engine that had just been publicly announced in the USA [1]. He's been getting on my nerves ever since, waxing delirious about "Free Energy from the atmosphere" just like his favorite radio station did. But let the fool tell us about it himself.

1. An ingenious inventor arrives on the scene

What had happened? Sanjay Amin, a student of Youngstown State University (YSU) in Youngstown, Ohio, had a brilliant idea, an idea for the construction of an engine that would do nothing less than convert heat from the atmosphere into readily available mechanical energy. The idea was so astounding that important persons from circles linked with YSU were suitably impressed by it. Of these, Mr. Charles Cushwa, one of the foremost industrialists of Youngstown and a member of the financial board of YSU, deserves special mention. A company named Entropy Systems Inc. (ESI) was founded forthwith for the exploitation of Amin's invention. The board of directors has eight members and over $3.4 million working

---

[1]) The authors acknowledge with thanks the assistance of James B. Kuipers and Johan Bakker in translating this article from the original German [11] that was published in April 2000.

capital was furnished by 42 shareholders, one of which is the Youngstown State University Foundation. At the age of 32 Sanjay Amin was appointed director and CEO of the fledgling company. Professional guidance for the company's launch was of course provided by YSU's Cushwa Center for Entrepreneurship in the form of a business plan evaluation, while the Mechanical Engineering department monitored the invention's technical implementation. Above all, the public relations were organized in a masterly fashion - any information you can think of relating to the company's launch and subsequent progress can be found at

http://www.entropysystems.com

Obviously no one is in a better position to explain the advantages of the new engine than ESI themselves, and I have no doubt that they will approve my using the following quotations from their "Brief Technical Information" [2]:

- Entropy Engine technology converts atmospheric heat to power. This heat can be at any temperature, (even sub-zero). Entropy Engines operate on the Amin Cycle.
- Entropy Engines can produce zero emissions and require no fossil or nuclear fuels to operate.
- Entropy Engines can require no cryogenic liquids or any fuel storage systems. This technology has the potential of not using any fuels like Gasoline (Petrol), Coal, Wood, Natural gas, Methane or Hydrogen.
- Entropy Engines have efficiencies higher than conventional engines, refrigerators, air conditioners or fuel cells.
- Entropy Engines can operate year around in any kind of weather.

The self-confidence of the inventor is also quite remarkable. During a press conference Amin was asked about the scientific importance of his invention. According to the “Vindicator”, a local newspaper,

> “This is not just a new technology,” he said, grinning broadly. “It’s a major discovery in science.”

On his website Amin proudly proclaims [4]

> "No scientist has found any logical or mathematical flaw in the Amin Cycle paper."

This makes sense if one reads the statements regarding the miracle engine made during interviews by two experts on mechanical engineering. According to Wired News, one of them, Bill Dunn from the University of Illinois, said

> "The logic appears sound, but the outcome - free power - doesn't make sense."

However he does admit

> "that he hasn't devoted time to figure out why the engine shouldn't work. To track down where (Amin's) thinking may be flawed is a difficult thing to do."

And - hedging his bets - he adds

> "Breakthrough technologies have frequently been greeted with skepticism. Every time someone suggests something like this, you should at least give them the benefit of an open mind."

The other expert, D.E. Foster of the University of Wisconsin-Madison, told USA Today that

> "They're claiming that wherever you have a temperature difference, you can generate heat transfer, and that's absolutely correct."

This is followed by a remark that demonstrates his failure to grasp the Amin cycle (he appears to be thinking of the Carnot cycle), nevertheless he concludes that

> "You just can't get the (Entropy Engine's) power density high enough."

Ford Co. engineers arrived at a similar conclusion. Vice President Mr. S. Rushwin wrote to me that

> "the technical knowledge is sound, but requires much more development to achieve practical automotive application."

So perhaps YSU Cushwa Center business analyst Rufus Hudson was not exaggerating when he characterized Sanjay Amin as "a second Bill Gates".

Naturally the omnipresent professional pessimists and grouches such as my colleague Gerhard will object that this miracle engine is simply a perpetual motion machine of the second kind and we all know that the Second Law of Thermodynamics explicitly rules out the possibility of such a machine. But whatever the law says, would you - cross your heart now - wish to have your faith taken from you, your faith in a machine that opens the gates to Never-never Land? Thanks (!) to the greenhouse effect there is more than enough heat surrounding us and at last we can actually make good use of it. Just imagine: every means of transport, all cars, ships and airplanes will be equipped with the new engine. Instead of polluting the air they will soon all be cooling it. Operating costs will plummet and pollution of the environment will be eliminated - it's like a wonderful fairytale, too good to be true. But the fairytale is reality, and you can see it with your own eyes on Amin's website. Last November, Amin announced that the first environmentally friendly lawnmowers were scheduled for delivery around now. Happy are they who placed their orders in good time!

Besides there is plenty of reason for optimism. After all, the Second Law, like any other law in Physics, rests solely on experimental proof. Obviously it has been verified experimentally by numerous scientists on countless occasions since it was formulated by J.R. Clausius (1822-1888), nevertheless it could still be refuted, or else modified. This has happened to many other laws of Physics, so why couldn't it happen again? Perhaps a new thermodynamic cyclic process of extraordinary ingenuity could do the trick. It would certainly bring fame and fortune to the inventor. And now such a cycle, the Amin cycle, has indeed been invented, so the next Nobel prize must surely go to Sanjay Amin of Youngstown, Ohio. ESI can even refer to the great Richard Feynman who many years ago more or less predicted a modification of the Second Law [7]. As will be explained in the next section, this breakthrough has been realized by amazingly simple means and without violating the limits of Classical Physics.

Feynman would have been amazed had he lived to see it and the circle of Amin's admirers is steadily growing wider [6].

2. The Amin Cycle

The operating principle of the Amin engine is ingeniously simple. In order to simplify the theoretical description Amin utilizes a model system consisting of a gas-filled cylinder which is fixed to a wheel that rotates about its axis. The cylinder axis is aligned radially with respect to the wheel axis. The cylinder is sealed by a movable piston at the end nearest to the wheel axis. It contains an ideal gas that is maintained at a fixed temperature T_0 throughout the cycle by intimate thermal contact with the surroundings, so isothermal conditions are assumed. The energy extracted from the surroundings is transferred to the piston and from there, through some mechanical linkage and intermediate storage, to the wheel in such a way that the motions of the cycle are carried out as described below.

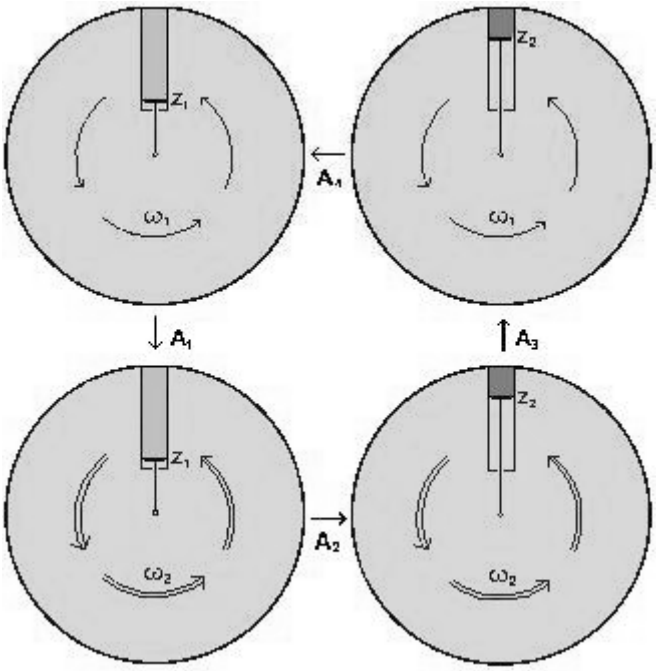

Figure 1. The Amin cycle

Let ω be the angular velocity of the wheel and let z be the distance from the piston crown to the wheel axis. The state of the system at any point in the cycle is then described by the parameters z and ω, which cycle between lower values z_1 and ω_1 and upper values z_2 and ω_2 respectively. The cycle invented by Amin (which he calls the Amin cycle in an obvious reference to the familiar Carnot cycle of Thermodynamics) consists of the transitions A_1, A_2, A_3 and A_4 during each of which only one of the two system parameters z or ω changes. It is tacitly assumed that the transitions are reversible, i.e. slow enough to prevent losses through turbulent motion of the gas. The system state follows a rectangular path in the (z,ω) plane (see fig. 1)

$$\begin{array}{ccccc} & & (z_1,\omega_2) & \xrightarrow[(A_2)]{} & (z_2,\omega_2) \\ & & \uparrow (A_1) & & \downarrow (A_3) \\ \text{Start} & \rightarrow & (z_1,\omega_1) & \xleftarrow[(A_4)]{} & (z_2,\omega_1) \end{array}$$

During the first step A_1 the angular velocity is increased from ω_1 to ω_2. The increased centrifugal force causes the gas pressure on the piston to drop from p_{11} to p_{12}. A_2 is the compression step, where z goes from z_1 to z_2 and the pressure on the piston increases monotonically from p_{12} to p_{21}. The work done by the piston on the gas is then

$$\int_{z_1}^{z_2} p(z,\omega_2)\,dz > 0,$$

whereas no work is done by the piston during the preceding step A_1 because there is no change in z. This is also true for A_3, where the reduction of the centrifugal force causes the pressure to increase from p_{21} to p_{22}. The final step A_4 is the expansion step $z_2 \rightarrow z_1$, whereby the pressure on the piston drops from p_{22} to the initial value p_{11}. The work done on the piston is then

$$\int_{z_2}^{z_1} p(z,\omega_1)\,dz \;=\; -\int_{z_1}^{z_2} p(z,\omega_1)\,dz \;< 0.$$

The net work done by the piston over a complete cycle is obtained by addition

$$\int_{z_1}^{z_2} [\,p(z,\omega_2) - p(z,\omega_1)]dz\,.$$

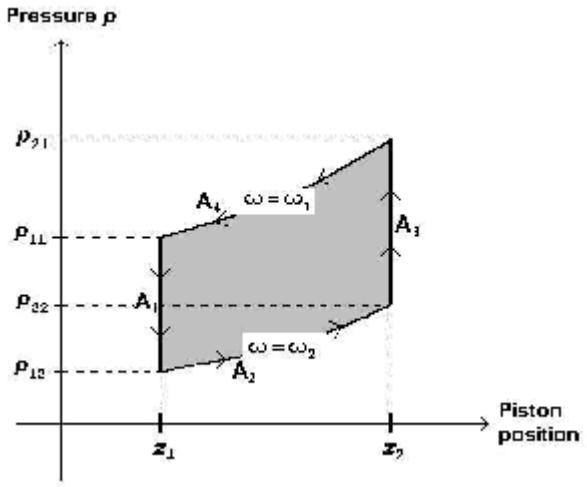

Figure 2. The piston pressure during an Amin cycle

Now $p(z,\omega_2)$ is less than $p(z,\omega_1)$ for any z due to the centrifugal effect, so the integrand is always negative, hence the integral is also negative. Thus we have confirmed the outcome that was predicted by that ingenious inventor Sanjay Amin:

The net work output on the piston over one Amin cycle is positive.

(Remark by the co-author: I can't stand much more of this! True? - yes, but ingenious? - hardly. If the sign is reversed we only need reverse the sequence in which the cycle is carried through and the outcome is once again net positive work.)

With this simple explanation on their website, Entropy Systems Inc. has demonstrated that the engine has a net positive output of mechanical work. Now compare the economy of Amin's device with the billions that are spent on particle accelerators, on super telescopes on earth and in space, on space probes and on other nonsense, all in aid of scientific discoveries. What a fantastic idea - cracking the Second Law armed with no more than an air pump on a spinning wheel - ingeniously simple, simply ingenious! Now that this has been established, and with an eye to the general trend towards globalization, I am seriously considering a

takeover of ESI, friendly or otherwise. Interested parties may notify me by e-mail – together, we stand stronger.

Maybe I am allowing myself to get carried away by my enthusiasm for "Free Energy from the atmosphere". Therefore, in all fairness (and I emphasize the fairness), I should make way for my co-author, one of those persistent grumblers who think they can prove everything with formulas. The poet and playwright Johann Wolfgang von Goethe characterized their kind in his own inimitable way:

> What you don't touch, for you lies miles away;
> What you don't grasp, is wholly lost to you;
> What you don't reckon, you believe not true;
> What you don't weigh, that has for you no weight;
> What you don't coin, you're sure is counterfeit.

(Faust, part II, act 1, by J. W. von Goethe, 1808, from the translation of George Madison Priest)

Earnest, these words are spoken by Mephistopheles.

3. A cooling draught from the realm of Thermodynamics

Any reversible cyclic thermodynamic process can be represented by a closed diagram in the (*S*,*T*) plane, where *S* denotes the entropy of the system and *T* the temperature. A well-known principle of Thermodynamics is that the change in the energy of the system over one cycle equals the area enclosed by that diagram. The derivation of this result as customarily found in textbooks assumes that the temperature at any instant is equal or homogeneous throughout the system. Now Amin assumes isothermal conditions and for isothermal processes in general the area enclosed by the state diagram in the (*S*,*T*) plane is obviously zero. However the Amin engine is more complicated since there are different conditions at different points in the cylinder, even though the temperature is homogeneous. Thus the above method for evaluating the energy balance is not directly applicable.

Nevertheless, a different outcome, such as the nonzero result claimed by ESI, would be most astounding.

4. Completion of the Amin cycle energy balance

If one draws up an energy balance, as my euphorical friend does in section 2, it has to be complete. In examining that balance, we immediately note that the energy transfers through the drive shaft of the spinning wheel are absent from Earnest's analysis. Due to an elementary error in Amin's calculation of the rotational energy [3] Amin concludes that the energy that is supplied through the shaft of the wheel to increase the rotational kinetic energy of the system during step A_2 is exactly compensated by the amount retrieved during step A_4, regardless of the fact that the mass distributions of the gas differ. The distribution is also affected by the piston movements during steps A_1 and A_3 and as any observer of pirouettes performed during figure-skating can testify, this will in turn affect the angular velocity unless it is again compensated for with energy flowing through the wheel drive mechanism. These energy terms are simply neglected by Amin. A more detailed list of the flaws in Amin's "theory" can be found in [8]. Thus:

An energy balance for the Amin cycle that merely takes account of work flowing through the piston is incomplete.

Calculating the missing energy terms one by one is a tedious task. There is, however, a more elegant road towards a complete energy balance. As pointed out quite correctly by our ingenious inventor, the energy supplied by his engine (to my colleague Earnest and his clan) is extracted from the environment.

"The Entropy Engine acts like a heat sponge," he writes *"absorbing heat from the atmosphere and converting it to power."*

This is nothing more or less than the Law of Conservation of Energy: The total amount of mechanical work that is exchanged through the piston crown and the wheel shaft must be balanced by energy transferred through any other system interfaces. The only other interface in this case is the wall of the gas cylinder, where heat is exchanged. Heat is produced when the gas is compressed and in order to fulfill the requirement that the process is isothermal – this heat is presumed to be conducted to the environment through the chamber walls. During expansion step A_4 the converse is true; heat must be supplied to maintain the temperature of the system so it is absorbed from the environment.

We will now draw up the heat balance for one cycle. Heat (positive or negative) is generated by the volume deformation of the mass elements *dm* of the gas, and differs for mass elements located at different radial coordinates *r*. Because it is more convenient to relate the deformation heat contribution to a mass element than to a volume element we now define a mass coordinate *m*, where *m* is the amount of gas contained in the volume situated between the piston crown (r=z) and the radial coordinate *r*:

$$m = m(r,z,\omega) = \int_z^r \rho(s,z,\omega)\, ds\,.$$

By this definition we then have $m(z,z,\omega) = 0$ and $m(R,z,\omega) = M$, where M is the total gas mass inside the cylinder. Furthermore the local pressure p and the local density ρ are considered to be functions of (m,z,ω). Because the process is isothermal the ratio between p and ρ is a constant γ.

The volume of the mass element *dm* is $\rho^{-1}dm$ which will vary due to changes *dz* and $d\omega$ of the piston position and the angular velocity respectively. The associated mechanical works are

$$p\frac{\partial}{\partial z}\left(\frac{1}{\rho}\right)\, dm\, dz \quad \text{and} \quad p\frac{\partial}{\partial \omega}\left(\frac{1}{\rho}\right)\, dm\, dz$$

respectively. Thus the total amount of heat liberated during step A_2 is

$$\int_{z_1}^{z_2} dz \int_0^M p\frac{\partial}{\partial z}\left(\frac{1}{\rho}\right)\, dm = -\gamma \int_{z_1}^{z_2} dz \int_0^M p\,\rho^{-1}\frac{\partial}{\partial z}(\ln\rho)\, dm$$

$$= -\gamma \int_{z_1}^{z_2} dz \int_0^M \frac{\partial}{\partial z}(\ln\rho)\, dm = -\gamma \int_{z_1}^{z_2} dz \frac{\partial}{\partial z}\int_0^M \ln\rho\, dm\,,$$

where $\rho = \rho(m,z,\omega_2)$. Step A_4 yields analogously

$$\int_{z_2}^{z_1} dz \int_0^M p\frac{\partial}{\partial z}\left(\frac{1}{\rho}\right) dm = -\gamma \int_{z_2}^{z_1} dz \frac{\partial}{\partial z}\int_0^M \ln\rho\, dm\,,$$

where $\rho = \rho(m,z,\omega_1)$. The same approach yields for steps A_1 and A_3

$$\int_{\omega_1}^{\omega_2} d\omega \int_0^M p\frac{\partial}{\partial \omega}\left(\frac{1}{\rho}\right) dm = -\gamma \int_{\omega_1}^{\omega_2} d\omega \frac{\partial}{\partial \omega}\int_0^M \ln\rho\, dm\,,$$

where $\rho = \rho(m,z_2,\omega)$ and

$$\int_{\omega_2}^{\omega_1} d\omega \int_0^M p \frac{\partial}{\partial \omega}\left(\frac{1}{\rho}\right) dm = -\gamma \int_{\omega_2}^{\omega_1} d\omega \frac{\partial}{\partial \omega} \int_0^M \ln \rho \, dm,$$

where $\rho = \rho(m, z_1, \omega)$.

The sum of the four heat amounts is evidently nothing other than the path integral $\oint_\Gamma dF$, where F is the function $F(z,\omega) = -\gamma \int_0^M \ln \rho \, dm$, and Γ is the *closed* rectangular path

$$\begin{array}{ccc} (z_1, \omega_2) & \xrightarrow[(A_2)]{} & (z_2, \omega_2) \\ \uparrow (A_1) & & \downarrow (A_3) \\ (z_1, \omega_1) & \xleftarrow[(A_4)]{} & (z_2, \omega_1) \end{array}$$

in the (z,ω) plane. The outcome of any such integration, and thus of the heat balance of the Amin cycle is ZERO. As predicted in section 3 we can therefore conclude:

Contrary to the claim made by its inventor, the Entropy Engine is not suitable for absorbing heat from the environment. The best it can achieve is the dissipation of heat resulting from losses not accounted for in the idealized model.

You cannot run an engine on elementary mistakes alone (and certainly not trip up the Second Law), not even by burning the accompanying internet publications - what a shame that websites are fireproof!

Whoa there! This wise guy has definitely overstepped the line and it's high time for me to take over once again. If my friends at ESI were better at math this smart technology would never have been invented, the world would have been a sadder place and nobody could poke fun at it.

Consider the monstrous mechanical automata of the Swiss artist Jean Tinguely. Everybody looks at them with amazement and nobody cares about their energy balance. Just like ESI's contraption, they are energy gluttons but otherwise completely useless.

I guess I should revise my plans for the takeover of ESI but I'm certain that a better new engine will be invented soon, and then ...

Earnest is right. This kind of invention seems to be, literally, in the air. Sadly, the demise of a similar project was recently reported from Switzerland [9], and ESI's future doesn't look particularly rosy either [10].

References

[1] Deutschlandfunk, Sendung Forschung aktuell, Nov 12, 1999, 4:35 – 5:00 p.m.

[2] Entropy Systems Inc., Brief Technical Information,
http://www.entropysystems.com/AminCycle.htm

[3] Entropy Systems Inc., Non-technical explanation on how the Entropy Engine works, in
http://www.entropysystems.com/workingexplanation.htm

[4] Entropy Systems Inc., Views of the scientific community
http://www.entropysystems.com/views.htm

[5] Entropy Systems Inc., The Amin Cycle,
http://www.entropysystems.com/AminCycle.htm ,
where the entry “A brief analysis of the Amin Cycle” should be opened.

[6] Entropy Systems Inc., News and Events,
http://www.entropysystems.com/News.htm

[7] Entropy Systems Inc., Dr. Richard Feynman’s Analysis on Laws of Science,
http://www.entropysystems.com/Feynman.htm

[8] G.W. Bruhn, The Entropy Engine of the Entropy Systems Inc., Ohio, a Flop, in
http://www.skepdic.com/essays/entropysystems.pdf
and in "'Too good to be true" in
http://www.skepdic.com/refuge/entropysystems.html

[9] GWUP, N.N., Raumquanten-Motor, in Skeptiker, Zeitschrift für Wissenschaft und kritisches Denken, 4/99, p.181.

[10] L. Kahney, Miracle Engine’s Tank is Empty, in WIRED NEWS
http://www.wired.com/news/technology/0,1282,37963,00.html

[11] E.S.I. Gläubig and G.W. Bruhn, Der Entropie-Motor der Entropy Systems – ein Flop?
in Mitteilungen der Deutschen Mathematiker Vereinigung, 2/2000.

The authors
Prof. Dr. Gerhard W. Bruhn
Prof. Dr. Earnest S. I. Gullible
Department of Mathematics
Darmstadt University of Technology
Schlossgartenstr. 7
D 64289 Darmstadt

bruhn@mathematik.tu-darmstadt.de
gullible@mathematik.tu-darmstadt.de