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Self-Sustaining Power Machines enabled to operate without both heat sink and heat source

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Abstract

This paper presents a machine capable of generating energy without the need for a heat sink or external heat source. It is distinguished by its ability to exhibit the fundamental property of maintaining dynamic activity, a characteristic inherent to the atoms of any substance, thereby overcoming all forms of resistance or irreversibility, even in zero-point energy environments. Due to these groundbreaking characteristics, the machine functions as a hybrid isolated system. It operates both as an isolated system in relation to heat sources and sinks, and as a hybrid isolated system in its capacity to generate useful output energy for any energy-consuming application. This machine marks a significant advancement in combined cycles (CC), incorporating a Reversed Brayton Cycle (RBC) and a Self-Sustaining Power Machine (SSPM) of this kind. By combining these thermal engines, the technology enables operation without reliance on either an external heat source or heat sink, challenging traditional thermodynamic principles.

This paper addresses three core objectives related to SSPMs that operate without a heat sink or heat source:

Violation of the FLT: Energy balances involving contraction-based mechanical work performed by pull forces demonstrate a direct violation of the energy conservation principle.

Real Existence of Hybrid Isolated Systems (HIS): Partially isolated systems, or HIS, are capable of emitting energy beyond their isolation boundaries while remaining detached from external energy demands.

Violation of the SLT: The SSPM's ability to function without an external energy source or heat sink challenges the foundational principles that underpin the SLT.

A prototype design task based on the case study considers a combined cycle (CC) based on the combination of a heat pump consisting of a reverse Brayton cycle and a self-sustaining power machine (SSPM) is proposed to demonstrate these capabilities. The CC prototype consisting of a RBC and a SSPM was evaluated through the referred case study with helium for the RBC while using air and helium as real TWFs for the cascaded PUs of the SSPM. Results depicted in Tables 4-8 indicate that the proposed CC operating equipped with a SSPM composed by 6 PUs operating on a VsVs cycle achieved a total output net work of 617,4 kJ for air and 1092, 8 kJ for helium as TWFs

Keywords: Hybrid isolated systems, contraction work, reversed Brayton cycle, self-sustaining power machines, perpetual motion, and thermodynamics violations.

Nomenclature related to general SSPMs	
Acronyms/ abbreviations	***description***
CF	Carnot Factor
Cont.	contraction
CTF	Cooling Transfer Fluid (conventionally, thermal oil)
EM	electromagnetic
EP	Electric Power
Exp.	expansion
HTF	heating Transfer Fluid (conventionally, thermal il)
HP	heat Pump
Is_eff	Isentropic efficiency (open processes conducted by enthalpies)
LF	losses factor (include thermo-mechanical and thermo-hydraulic losses)
PMM	perpetual Motion Machine
m (kg)	Matter:
ext	sub-index to indicate external (heat, work etc)
PP	power Plant: a group of PUs coupled in cascade
PU	power Unit operating with the thermal cycle VsVs or VsVs cycle
RF	heat recovery factor (includes heat transfer losses and leaks)
RIT	ratio of low to high temp. $[T_L/T_H]$, $[T_1/T_3]$ for VsVs, and $[T_1/T_2]$ for VsVs,

SSI	self-Sustaining Index. or net free energy as %: [$SSI = (\eta_{th} - 100)/100$]
SSHS	self-Sustaining Heat Supply
SEP	self-Electric Power: SEP ≈ SSI (net mechanical power ≈ net SEP)
sp	state point of any stationary point state of a thermal cycle
SPPP	self-Powered Power Plant
SSPM	self-Sustaining Power Machine, Self-Sufficient Power Machine
RBC	Reverse Brayton Cycle
TWF	thermal Working Fluid
VsVs	cycle with processes: [isochoric (V), isentropic-adiabatic (s), V, s]
VTVT	cycle with the sequential processes: [isochoric (V), isothermal (T), V, T]
CC	combine Cycle: a group of several coupled thermal cycles
RBC	reversed Brayton Cycle
FLT,	first law of thermodynamics, as stated traditionally
SLT,	second law of thermodynamics, as stated traditionally
SSPM	self-sustaining power machine
HIS.	hybrid Isolated System: a thermodynamic system partially isolated
SHSk	self-heat sink: a system enabled to absorb the rejected energy
SHS	self-heat source: a system enabled to operate without external energy
p_{exp}	expansion pressure
p_{cont}	contraction pressure
p_s	surroundings pressure
A	piston cylinder cross-section area
Symbols/units	***description***
Ei	Total input energy: includes qi and wi
Eo	Total output energy: includes qo and wo
p(bar)	pressure
q_i(kJ/kg)	specific heat input to a cycle process
q_{i23} (kJ/kg)	Input heat to cycle process 2-3
q_o(kJ/kg)	specific heat output from a cycle process
q_{o41} (kJ/kg)	output heat from cycle process 4-1 in a VsVs cycle
q_{rec}	recovered heat from cycle process 4-1 in a VsVs cycle
Cp(kJ/kg-K)	specific heat capacity at constant pressure
Cv(kJ/kg-K)	specific heat capacity at constant volume
s(kJ/kg-K)	specific entropy
h(kJ/kg)	specific enthalpy corrected by isentropic efficiency
h'(kJ/kg)	specific enthalpy
T(K)	temperature
T_H(K)	top cycle temperature in a thermal cycle
T_L(K)	bottoming cycle temperature in a thermal cycle
u(kJ/kg)	specific internal energy
v(m^3/kg)	specific volume
V(m^3)	volume
w(kJ/kg)	specific work
w_i(kJ/kg)	specific work input
w_o(kJ/kg)	specific work out
w_{oexp} (kJ/kg)	output expansion work due to previously added heat
w_{ocont} (kJ/kg)	output contraction work due to previously cooling effect
w_{oexp23} (kJ/kg)	output expansion work w_{o23} due to previously heating effect
$w_{ocont41}$ (kJ/kg)	output contraction work w_{o41} due to previously extracted heat
w_n (kJ/kg)	net useful work ($w_{oexp} + w_{ocont}$) = ($w_{o23} + w_{o41}$)
wnT (kJ/kg)	total net-work (RBC work + Cascaded VsVs cycles works)
q_{rec}/PUi (kJ/kg)	heat recovered from every PU from cooling cycles processes

T_{q_rec}/PUi (K)	recovered heat temp. from PUs cooling cycles processes in every PU
TF (%)	heat transfer losses due heat recovery effectiveness
LF (%)	losses factor (thermal and mechanical irreversibilities)
η_{th} (%)	cycle thermal efficiency [w_n/qi]

1 Introduction

Among the first steam engines capable of producing useful mechanical work through contraction-based compression, primarily intended for pumping water in the coal mines of the United Kingdom, are those developed by Denis Papin [1-2] and Thomas Newcomen [3]. These engines, operating at atmospheric pressure and vacuum, represent significant technological advances. Papin's developments, and subsequently Newcomen's, are particularly noteworthy for their ability to perform useful mechanical work through thermal contraction achieved by steam condensation within a single-acting reciprocating cylinder. This process results in a reduction in volume and an increase in internal energy simultaneously, which is not accounted for by the first principle as considered by Carnot and later stated by Clausius.

References [4-8] present state-of-the-art technologies that enable operation through both thermal expansion and contraction, characterized by thermal cycles composed of closed processes without state changes. Using closed processes avoids losses due to flow work, while avoiding state changes prevents losses from vaporization and condensation heats.

Advances in this field have continued, and the current state-of-the-art includes machines that can operate at atmospheric pressure by utilizing a vacuum to perform useful work based on contraction. This is achieved using double-acting reciprocating actuators, including Reciprocating Double-Acting Cylinders (RDAC) and reciprocating thermo-hydraulic systems.

Three disruptive technological challenges must be addressed to implement efficient power units (PUs) capable of operating through thermal contraction based on vacuum under closed processes-based adiabatic-isentropic transformations, as described in [9-10], and optionally through contraction based on strictly isothermal closed processes. The first challenge is that a thermal machine must be capable of operating through the aforementioned thermal cycle. The second challenge is that the thermal cycles must be able to operate with strictly isothermal processes of both thermal expansion and contraction. The third challenge is that a thermal machine must develop highly effective forced thermal convection heat transfer media at the transfer rate required by the nominal power of each PU, where each PU is composed of a pair of RDACs equipped with associated heat transfer equipment.

Recent contributions have led to disruptive advances in power plants composed of groups of power units coupled in cascade, operating through thermal cycles characterized by performing work due to the expansion and contraction of the thermal working fluid, as referenced in [11-14] and [16-17]. Expansion is achieved by adding heat, while contraction is achieved by extracting heat. Studies for designing and prototyping such power plants have been conducted using real gases as working fluids, with data obtained from E. W. Lemmon et al [15].

The focus of these advances is on improving the performance of SSPMs by employing disruptive heat regeneration techniques in the PUs, utilizing cascade heat recovery to achieve significantly higher efficiencies compared to conventional technologies. The prototyping tasks for the studied cases are covered by patents referenced in [19-21].

1.1 The evolutionary path way

Based on a review of previously published references concerning SSPMs, [10-14] and [16-18], it is easy to see that we are starting from some incontrovertible facts, due to the empiricism they entail, and therefore irrefutable. These established facts concern to:

1-- the need to extend or broaden the definition of the first law of thermodynamics to take into account heat-work interactions based on thermal contraction and suction.

2-- the need to consider the existence of semi-isolated or partially isolated systems, since they allow energy transfer beyond the insulation boundaries while blocking any entry of matter or energy.

3-- the need to consider and adapt the second law of thermodynamics to admit the possibility of heat engines without a thermal source or sink.

4--accommodation of the concept of available energy or exergy that enables taking into account heat-work interactions based on thermal contraction and suction.

In Sections 2, 3, and 4, three fundamental aspects related to the pillars of SSPMs (Self-Sustaining Power Machines) are introduced, aligning with the objectives of this article:

1-- Violation of the **FLT**: Closed process-based energy balances that incorporate mechanical work performed by pull forces are shown to contradict the first law of thermodynamics, thereby violating the principle of energy conservation as stated so far. To support the **FLT**, in addition to considering expansion and compression work, which involves **push or thrust** forces, one must also consider heat-work interactions related to thermal contraction and work-heat interactions related to suction work, where both interactions involve **pull or tensile** forces.

2-- Existence of hybrid or partially isolated systems (**HIS**): The identification of isolated systems capable of emitting energy beyond their isolation boundaries. These systems, termed "hybrid isolated systems" (HIS) exhibit characteristics of isolation while simultaneously generating energy that can traverse these boundaries.

3-- Challenging the **SLT**: The proposal of an SSPM (Self-Sustaining Power Machine) enable to operate without an external energy source or heat sink, thereby defying the foundational pillars that sustain the SLT.

To guide the description of the disruptive concepts discussed in the article, allow me to comment on some concepts worth keeping in mind: As a result of the required adjustments, it is necessary to adapt the energy balances that constitute the fundamental pillar of modeling thermo-mechanical systems to real observations in such a way as to define absolute independence between ideal systems (which do not exist in the reality of physical existence) and real systems that inherently entail losses or irreversibilities. It also requires accepting the concept of entropy (a thermal state variable) as a consequence of prior events related to heat transfer, which involves temperature and matter, rather than considering it as the cause of something subsequent. In other words, the entropy of a system is not the cause of anything but the consequence of the conditions under which thermal energy transfer takes place.

For example, Emily Noether's main theorem is absolutely and rigorously true as a mathematical or ideal concept. For this reason, it is scrupulously observed in isolated ideal systems, because it is possible to model systems characterized by inherently exhibiting symmetries. However, it is not possible to observe it in real systems because it entails losses or irreversibilities that are asymmetrical and therefore not applicable to real-life situations. This is a serious problem for maintaining the laws of conservation of energy in real systems.

Thus taking into account that generating energy without the need for heat sources or heat sinks means independence or autonomy from the conditions of the generation site, the ultimate goal of this work is to urgently call upon the scientific community to reconsider and adapt the conventional principles of thermodynamics (the First and Second Laws) in light of experimental evidence observed in classical physics. This adaptation is essential to reconcile theoretical frameworks with empirical realities.

2. Most involved heat-work interactions

Exploring disruptive Self-Sustaining or Self-Sufficient Machines beyond the limits of a conventional thermodynamic perspective requires previous tools made available through the revision of heat-work-forces interactions, since it is not possible to achieve such disruptive machines without the contribution of mentioned special heat-work interactions. Therefore, before delving into the study of self-sustaining machines—characterized by the absence of an external power source and heat sink (though partially connected to their surroundings for energy exchange)—it is crucial to review key concepts related to heat-work interactions and the classification of thermodynamic systems (isolated, closed, and open).

With respect to heat-work interactions and types of systems, it is worth mentioning that expansion work and vacuum or thermal contraction work, achieved through heat addition and/or extraction, represent the most relevant modes of heat-mechanical work interactions. These interactions are essential for achieving cascade coupling of power units, enabling the creation of self-sustaining power machines.

Concerning to a Self-Sustaining Power Plant Prototype, prior to examining a prototype model of a thermal power plant capable of operating without an external power supply or thermal sink—while adhering to the SLT as defined by Clausius and Kelvin-Planck—we will briefly describe the operating principle of actuators that perform mechanical work through thermal expansion and contraction.

Taking into account the relevance of Vacuum-Induced Contraction and Compression, follows that one of the most useful heat-work interactions involves contraction-based compression achieved through a vacuum, where the vacuum is created by cooling a working fluid. To understand the effect of vacuum or negative pressure difference responsible for generating a thermally-induced contraction force, let's examine the behavior of a reciprocating single-acting cylinder. This cylinder is subjected to atmospheric pressure in its surroundings and to a pressure equal to or lower than atmospheric pressure inside, depending on the current temperature of the fluid within the cylinder. This internal pressure is manipulated by adding or removing heat. The general consequences are that considering vacuum as a negative pressure with respect to a reference or equilibrium pressure, it happens that by using high values of reference pressures, high values of depressions responsible for thermal contraction are obtained, which allows high proportions of work to be performed by contraction, which contributes to thermal efficiency because it is achieved by cooling at zero cost.

Considering the innovation, associated with the historical context follows that the technique of using single-acting cylinders to drive transfer pumps for extracting water from coal mines has been widely employed by inventors like Denis Papin and Newcomen. They used steam in open processes undergoing state changes (vaporization and condensation). While performing mechanical work by cooling steam (as a working fluid) to create a vacuum is not new, the true innovation lies in using closed processes without state changes. This approach avoids the losses inherent to flow work, vaporization, and condensation. However, the use of reciprocating double-acting actuators operating by expansion and contraction simultaneously represent a major technical advance that contributes significantly to the dramatic reduction in the volume and weight of the machines involved, where the reference pressure of the cycles can be elevated as much as required.

Experimental evidence consistently demonstrates that heat-work interactions involving heat extraction or cooling of a thermal working fluid can produce useful mechanical work through vacuum or contraction. Additionally, the heat obtained during cooling can be efficiently reused, facilitating new thermal contraction-based cycles.

To conclude the introduction to the context of this section let us say that such approach to mechanical work performance, utilizing expansion and thermal contraction, give rise a cascade of conversion phases without energetic cost. Such a disruptive fact represents a significant advancement in the field of thermodynamics and energy efficiency, building upon historical techniques while introducing novel, closed-system approaches.

2.1 Single-acting cylinder operation principle

The reciprocating double-acting cylinder consisting of a double-acting reciprocating actuator operates with a force that is the sum of the forces exerted by the pressures in each cylinder chambers separated by the cylinder piston. Fig. 1 illustrates both, reciprocating single-acting cylinder and the reciprocating double-acting cylinder in Fig. 1, Fig. 1(i) and Fig. 1(j) and Fig. 1(k). Single-acting is composed by a active cylinder chamber while double-acting is composed by two cylinder chambers separated by a piston.

The following notation is used to interpret the concepts shown in Fig. 1 correctly:

Expansion pressure (p_{exp})

Contraction pressure (p_{cont})

Surroundings pressure (p_s)

Piston cylinder cross-section area (A)

Reciprocating single-actuating cylinder (RSAC):

Actuating force due to heating $F_{ah} = A \cdot (p_{\exp} - p_s)$, push force restricted to $p_{exp} > p_s$

Actuating force due to cooling $F_{ac} = -A \cdot (p_s - p_{cont})$, pull force restricted to $p_{cont} < p_s$

Reciprocating double-actuating cylinder (RDAC):

In the double-acting cylinder, the concept of surrounding pressure is not necessary, but the reference pressure (p_{ref}) —a pressure of equilibrium— under rest conditions.

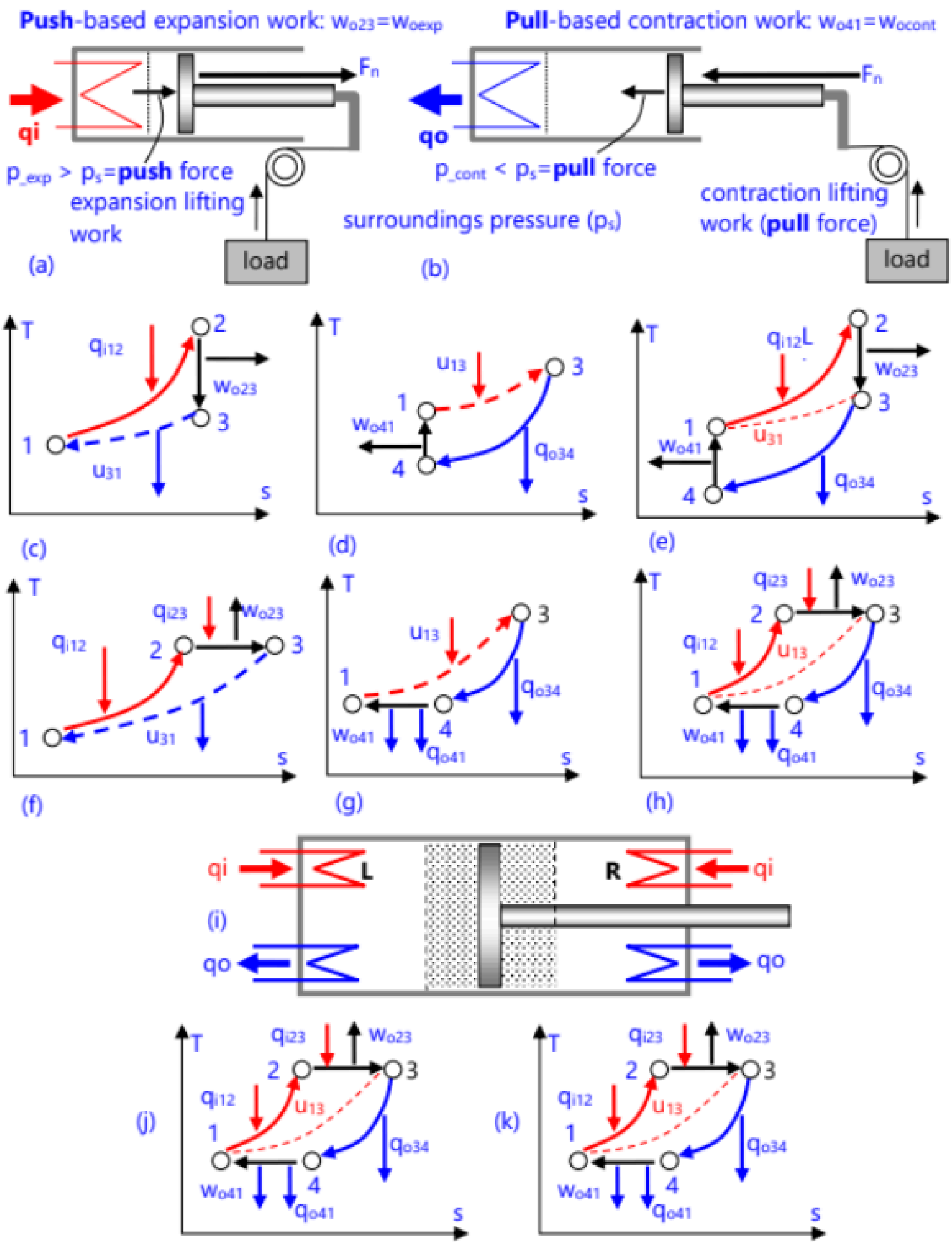
Actuating force due to heating in **left** (**L**) cylinder chamber $F_{ah} = A \cdot (p_{\exp} - p_{ref})$, push force restricted to $p_{exp} > p_{ref}$

Actuating force due to cooling in **right** (**R**) cylinder chamber $F_{ac} = A \cdot (p_{ref} - p_{cont})$, pull force restricted to $p_{cont} < p_{ref}$

Actuating net force $F_n = F_{ah} + F_{ac} = A \cdot [p_{\exp} - p_{cont}]$

Figure 1: Closed system-based expansion and contraction work concepts [10-14] for VsVs and VTVT thermal cycles

The effect of forces on the cylinder piston is such that:



When $F_{ah} > F_{ac}$ then the cylinder piston tends to move forward. $F_n > 0 \rightarrow$ Push force

When $F_{ah} < F_{ac}$ then the cylinder piston tends to move backward. $F_n < 0 \rightarrow$ Pull force

According to Fig. 1(a):

-1 the execution of useful mechanical work by means of the expansion –increase in volume– of the thermal working fluid into the cylinder chamber, obtained by the addition of heat responsible for generating pressure –a pressure greater than the surroundings pressure–. The addition of heat (heating) of a thermal working fluid causes an increase in temperature and its corresponding pressure, which gives rise to expansion, which leads to an increase in volume responsible for the useful mechanical work.

Fig. 1(b) shows that extracting heat or cooling a working fluid in a cylinder result in a vacuum or contraction-based work as consequence of a **pull** force, forcing the internal energy to increase, that has not been considered in the first law statement; furthermore, it is done without energetic cost. Furthermore, it is shown that useful contraction work is performed while internal energy increases, as shown in the T-s diagram of Fig. 1(d), which has not been considered in the first law statement.

According to Fig. 1(b):

-2 the execution of useful mechanical work by means of the contraction –decrease in volume– of the thermal working fluid into the cylinder chamber, obtained by the extraction of heat responsible for generating vacuum –a pressure lower than the surroundings pressure–. The extraction of heat (cooling) from a thermal working fluid causes a decrease in temperature and its corresponding pressure (vacuum), which gives rise to contraction, which leads to a decrease in volume responsible for the useful mechanical work.

With respect to the closed processes executed by the actuator shown in Fig. 1, which involve cause-effect sequences realized as individual closed heat-work interactions, the following observations have been made:

Figure 1(a): According to the FLT, the energy balance states that expansion work results from the difference between input and output heat in the closed process, as shown in the T-s diagram of Figure 1(c).

Fig. 1(a) illustrates that adding heat to a working fluid in a cylinder results in expansion work as consequence of a push force.

Fig. 1(g) shows that useful thermal contraction-based work is performed while entropy decreases; this fact has not been considered in the second law statement.

Fig. 1(c) and Fig.1(d) depicts the T-s and p-V diagrams of the VsVs cycle depicted in Fig, 1(e), where Fig, 1(e), is fragmented into Vsp (expansion) and psV (contraction) T-s thermal cycles, carried out in actuators (a) and (b), which has not been considered in the first law due to vacuum or contraction work.

Fig. 1(f) and Fig. 1(g) depicts the T-s diagrams of the VTVT cycle, fragmented into VTp (expansion) and pVT (contraction) thermal cycles, carried out in the actuator represented in Fig. 1(a) and Fig. 1(b), which has not been considered in the first law due to vacuum or contraction work. In general it has been shown that all heat work interactions involving pull forces due to a vacuum violates the energy balance as described by the first law of the thermodynamics.

Acceptable performance can be achieved by utilizing expansion and contraction forces. These thrust and pull forces act simultaneously in a double-acting reciprocating cylinder, as shown in Fig. 1(j). In this configuration, the expansion forces generated in one chamber act as thrust forces on the piston in one direction, while the contraction forces in the complementary chamber also act as pulling forces in the same direction. These results in the total force available to perform useful work being the sum of the absolute values of the expansion and contraction forces (thrust and pull). The relevant fact is that a net force not considered by the FLT includes a simultaneous push and pull force (PPF). Simply put, the net force, derived from the sum of the simultaneous expansion and contraction forces within both chambers of the cylinder, includes a simultaneous PPF not considered by the first law. This PPF invalidates conventional energy balance models related to thermal cycles that include contraction work and/or suction work.

2.2 The inconsistencies of Contraction-based compression and Suction-based expansion Forces (Pull Forces) on the energy balance according to the FLT definition

Introductory concepts

Experimental evidence regarding input suction forces and output contraction forces—both mechanical pull forces—demonstrates that mechanical pull forces violate the energy balance based on the FLT when considering compression and expansion forces (push forces). This claim has been demonstrated and described not only in previous studies, particularly in article [17] JAP-9706., but also over more than fifty years of observation of the atmospheric steam engine developed by Papin and Newcomen.

The FLT assumed as a conservation law

The FLT, a conservation law applied to closed processes, states:

1. If mechanical work is added to a process, its internal energy should increase.

2. If useful work is obtained from the process, its internal energy should decrease.

However, experimental observations in contraction processes reveal a contradiction:

- When useful work is obtained, the internal energy increases instead of decreasing.

- This observation, noted during the operation of Papin's and Newcomen's Atmospheric Steam Engines (ASEs) for over half a century, violates the FLT as stated by Clausius.

Contradiction with the FLT

The observed increase in internal energy while useful work is done contradicts the FLT. This implies that the conservation law, as initially assumed by Carnot and later stated by Clausius, is not fulfilled when contraction work is involved. Therefore, in the energy balance, contraction work should be considered instead of generic work (expansion work).

Historical Context: Papin's and Newcomen's ASEs

The ASEs, which operated successfully for over half a century, used a contraction heat-work interaction that defied the FLT as stated by Clausius. This statement is incomplete as it does not consider contraction work.

Energy Balance Assumptions

The energy balance, as assumed by Carnot and later generalized by Clausius, considers that both input and output heat of closed processes interact with two types of mechanical work:

1. ―Input work―: Work added to the process, contributing to the increase of internal energy.

2. ―Output work―: Useful work obtained from the process, contributing to the decrease of internal energy.

Conventionally, it has been assumed that:

1. Input work (mechanical work added to a process) exclusively increases internal energy.

2. Output work (useful work obtained from a process) exclusively decreases internal energy.

Experimental Evidence from ASEs

Observations of Papin's and Newcomen's ASEs reveal that these engines do not obey the energy balance established by the FLT. The real facts are:

1. ―Output useful work (w_{ocont}) ―: Mechanical work done by contraction (due to vacuum created by cooling steam) increases internal energy, violating the FLT.

2. ―Input work (w_{isuct}) ―: Mechanical work added to generate vacuum decreases internal energy, also violating the FLT.

General Statements Based on Theoretical and Experimental Evidence

1. Heat-work interactions involving ―expansion and/or compression works― fulfill the FLT and involve ―push forces―.

2. Heat-work interactions involving **suction and/or contraction works** do not fulfill the FLT and involve ―pull forces―.

3. The essential condition for the energy balance of a closed system to satisfy the FLT is that all interacting forces (both input and output) are ―push forces―.

4. Any energy balance affected by ―pull forces― (both input and output) violates the FLT.

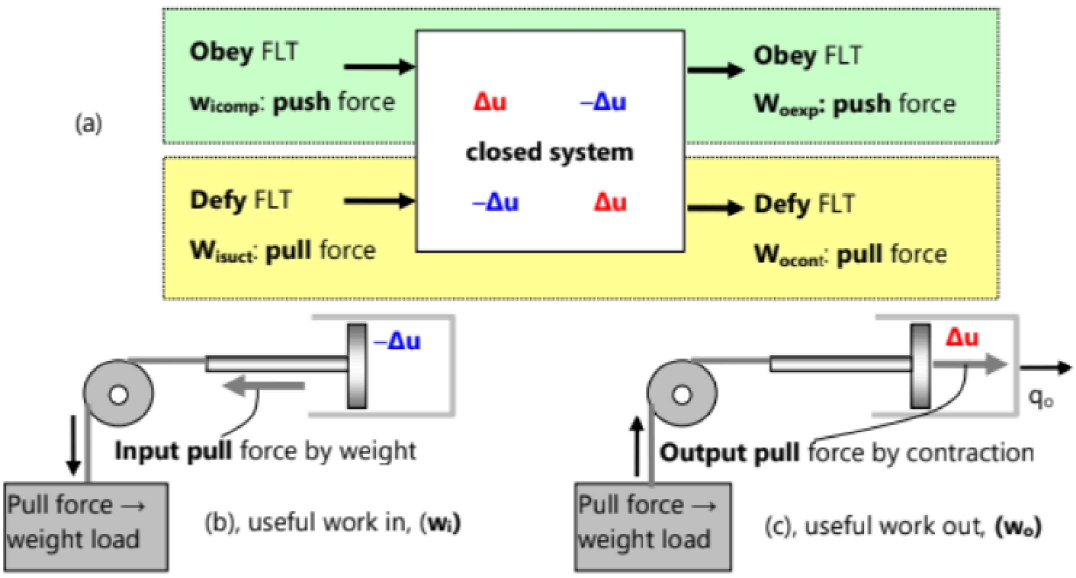


Figure 2 Illustration of observing the everyday behavior of a single-acting reciprocating cylinder to demonstrate how the energy balance of closed-system heat-work interactions involving pull forces challenges the FLT

Illustration of the behavior of Pull Forces according to Fig. 2

Figure 2 illustrates the effect of pull forces:

- (a): Depicts the energy balance formulation based on the FLT.

- (b): Depicts the pull force created by a counterweight, consisting of a suction input force and work, which contributes to decreasing internal energy.

- (c): Depicts the pull force created by a vacuum, consisting of a contraction output force and work, which contributes to increasing internal energy.

Experimental Observations according to Fig. 2

- Fig. 2(b): An input pull force creates a suction effect and vacuum while decreasing internal energy, which violates the energy balance stated on the basis of the first law

- Fig. 2(c): A vacuum obtained by extracting heat creates a pull force that increases internal energy, which violates the energy balance stated on the basis of the first law

Summary of Experimental Evidence in Closed Processes

1. —Work done on a system—:

- Through —suction (increasing volume) —: Internal energy decreases.

- Through —compression (decreasing volume) —: Internal energy increases.

2. —Work done by a system—:

- Through —contraction (decreasing volume) —: Internal energy increases.

- Through —expansion (increasing volume) —: Internal energy decreases.

3. —Key Observations—:

- Work done through —suction— contributes to a decrease in internal energy.

- Work done through —contraction— contributes to an increase in internal energy.

4. —Controversy with the FLT—

- The experimental observations, summarized in Fig. 2 and validated over 50 years of ASE operation, demonstrate a flagrant controversy with the FLT.

- The energy balances of heat-work-force interactions must be modified to reflect real facts.

Summary

As a preliminary conclusion, it can be stated that:

- Closed processes involving —suction-work— or —contraction-work— include —pull forces—.

- Closed processes involving —compression-work— or —expansion-work— include —push forces—.

- Energy balances incorporating —pull forces— violate the FLT.

- Energy balances involving —suction-work— or —contraction-work— violate the FLT.

- Energy balances involving —compression-work— or —expansion-work— fulfill the FLT.

General Statement:

--Closed process-based energy balances that include mechanical work performed by —pull forces— violate the FLT and, consequently, the law of energy conservation.

As consequence, the FLT needs an urgent adaptation to the observed reality.

2.3 Closed processes-based adiabatic expansion work

Every adiabatic transformation is characterized by its ability to isolate heat transfer, both in and out. That is, in an adiabatic process there is no heat transfer. For example, in an isothermal process heat flows into or out of a thermal work fluid to be converted into expansion or contraction work, depending on whether it enters or leaves. Therefore such process cannot be adiabatic since heat is being transferred.

Fig. 1 shows that in a single or double-acting cylinder, the added heat is partially converted to work by the expansion of the working fluid. Meanwhile, cooling the working fluid generates a vacuum or thermal contraction, leading to work associated with contraction-based compression (volume decreases while internal energy increases).

Extracting heat or cooling a working fluid in a cylinder result in vacuum or contraction-based work without energetic cost. This alters the energy balance in **closed systems** and affects the definition of the first principle of thermodynamics.

The energy balance of the expansion and contraction-based cycle is described as follows:

Fig. 1(a): Adiabatic closed expansion process.

Fig. 1 (c): According to the first law, the energy balance suggests that:

$$Ei = \sum qi + \sum wi; \quad Eo = \sum qo + \sum wo$$
$$Ei - Eo - \Delta u = 0 \rightarrow \Delta u = q_i - w_o \qquad (1)$$

Applying this to a heat-work interaction governed by a closed adiabatic-isentropic expansion process when no input work is done on the process yields:

$$q_i = q_o = 0; \; w_i = 0$$
$$Ei = \sum wi = 0; \quad Eo = \sum wo = w_{o23} = w_{o\exp}$$
$$Ei - Eo - \Delta u = 0 \rightarrow 0 - w_{o\exp} - \Delta u = 0 \rightarrow w_{o\exp} = -\Delta u \qquad (2)$$

This means that closed adiabatic-isentropic expansion work is due to the decrease in internal energy, obviously fulfilling the first law.

2.4 Closed processes-based adiabatic contraction work

However, the process depicted in Figure 1(b) corresponds to an adiabatic closed contraction process. According to Figure 1(d), based on observational evidence, the energy balance in an adiabatic-isentropic internal energy-work interaction suggests that:

$$Eo = \sum wo = \Delta u_{34} + | w_{o41} | \rightarrow w_{o41} = | w_{ocont} | = \Delta u_{41} \qquad (3)$$

In this equation, contraction-based work $|w_{ocont}|$ is useful output work. Furthermore, it suggests that in a closed adiabatic-isentropic heat-work interaction dominated by vacuum or contraction-based compression, contraction-based work is done while internal energy increases. This result, although real, is inconsistent with the FLT.

This surprising result suggests a review of the concept of energy and its conventional definitions. In this heat-work interaction, a thermal working fluid produces useful mechanical work while increasing its internal energy. This behavior, although real, is incomprehensible within our current understanding of energy.

Summarizing, Eq. (3) suggest us that:

- It is possible performing work by cooling a thermal working fluid under a closed adiabatic-isentropic process

- It is possible performing useful contraction-based work while increasing internal energy

2.5 Closed processes: Isothermal expansion work

Contraction work and vacuum work can be achieved through isothermal closed expansion or contraction processes, as shown in Figure 1(f). Applying the first law to a closed isothermal contraction process yields:

$$Ei = \sum qi + \sum wi = 0; \quad Eo = \sum qo + \sum wo = w_{o23} = w_{o\exp}$$
$$Ei - Eo = 0; \quad \Delta u = 0; \quad \Delta u = 0 \rightarrow$$
$$q_{23} - w_{o\exp} = 0 \rightarrow w_{o\exp} = q_{i23} = T_3 \cdot \Delta s_{23} \qquad (4)$$

In this equation, the internal energy remains constant along the isothermal closed process.

2.6 Closed processes: Isothermal contraction work

Following the formulation structure depicted in Eq. (4), according to Fig. 1(g):

$$Eo = \sum qo + \sum wo = w_{o41} = w_{ocont}$$
$$Ei - Eo = 0; \quad \Delta u = 0;$$
$$\Delta u = 0 \rightarrow q_{o41} - w_{o\exp} = 0 \rightarrow w_{o\exp} = q_{o41} = T_1 \cdot \Delta s_{41} \tag{5}$$

This suggests that:

-- Useful work without energy cost is done by isothermal cooling of a thermal working fluid.

-- Entropy decreases while useful output work is done.

Summarizing, doing useful work by vacuum or contraction achieved by cooling the thermal working fluid has some positive consequences:

- Performing work without energy cost by cooling a thermal working fluid
- Opportunity to efficiently reuse the ejected cooling heat
- Taking into account that doing useful contraction-based work while increasing internal energy had not been considered by first law of thermodynamics.
- Doing useful contraction-based isothermal work while decreasing entropy has not been considered by the second law statement.

2.7 The energy balance of closed processes-based cycles: Adiabatic expansion and contraction works

The energy balance of closed processes-based VsVs cycles is depicted in T-s diagram shown in the Fig. (e). Therefore the net work done along the VsVs cycle is due to adiabatic-isentropic expansion-based work as consequence of adding heat to the thermal working fluid and due to the adiabatic-isentropic contraction-based work as consequence of cooling the thermal working fluid by extracting heat.

$$q_{i12} - q_{o41} \neq w_n$$
$$w_{o\exp} = w_{o23} = \Delta u_{23}$$
$$w_{ocont} = w_{o41} = \Delta u_{41}$$
$$w_n = \sum w_o - \sum w_i = w_{o\exp} + w_{ocont} = w_{o23} + w_{o41} \tag{6}$$

2.8 The energy balance of closed processes-based cycles: Isothermal contraction and expansion works

The energy balance of closed processes-based VTVT cycles is depicted in T-s diagram shown in the Fig. (h). Thus, the net work done along the VTVT cycle is due to isothermal expansion work as consequence of adding heat to the thermal working fluid and due to the isothermal contraction work as consequence of cooling the thermal working fluid by extracting heat.

$$\Delta s_{23} = \Delta s_{41} = \Delta s$$
$$w_{o\exp} = q_{i23} = w_{o23} = T_2 \cdot \Delta s_{23} = T_2 \cdot \Delta s$$
$$w_{ocont} = q_{o41} = w_{o41} = T_1 \cdot \Delta s_{41} = T_1 \cdot \Delta s$$
$$w_n = \sum w_o + \sum w_i = w_{o\exp} + w_{ocont} = w_{o23} + w_{o41} = (T_1 + T_2) \cdot \Delta s$$
$$q_i = q_{i12} + q_{i23} = \Delta u_{12} + T_2 \Delta s$$
$$q_o = q_{o34} + q_{o41} = \Delta u_{34} + T_1 \Delta s$$
$$q_i - q_o \neq w_n \tag{7}$$

3 Characteristics of Heat-Work Interactions in Processes and Cycles with Expansion or Expansion and Contraction-based processes

In the context of this research, a partially isolated system is one that is isolated with respect to both power supply (or heat addition) and heat sink, while remaining open in its ability to provide energy to the external environment. Such a system consists of a self-sufficient power machine capable of supplying energy without any external heat supply or heat sink. Based on the information provided regarding heat-work interactions involving expansion and contraction processes, we can summarize these interactions for various types of thermal cycles:

Closed process-based cycles —include processes involving solely heat-work transfer—

Open process-based cycles —include processes involving heat-work and mass transfer—

Isolated cycles —no interchanges of heat, work or matter with the surroundings that is non contact with surroundings—

Partially isolated cycles —non contact with surroundings except energy delivery—.

The classification of characteristics inherent to the heat-work interactions discussed includes:

Closed and open processes and cycles with expansion work

Closed and open processes and cycles with both expansion and contraction work

Isolated open and closed processes and cycles with expansion and contraction work.

3.1 Reversible Thermodynamic Processes Performing Work by Expansion

Fig 3 illustrates the behavior of single-closed and single-open reversible heat-work interactions in terms of energy (heat-work) and matter balances.

These energy balances are based on the conventional first law statement, which describes expansion work as a consequence of heat addition and compression work as a result of work input. However, the first law of thermodynamics fails to account for other possible heat-work interactions that are common in everyday applications of physics. These interactions, which challenge the conventional first law, include:

Adiabatic thermal contraction: A form of compression resulting in decreased volume and increased pressure and temperature.

Adiabatic suction-based work: A form of expansion input work involving the application of mechanical work to draw in a gaseous or liquid fluid while decreasing the pressure and temperature of a cylinder actuator gas chamber. This interaction elicits an adiabatic contraction work response.

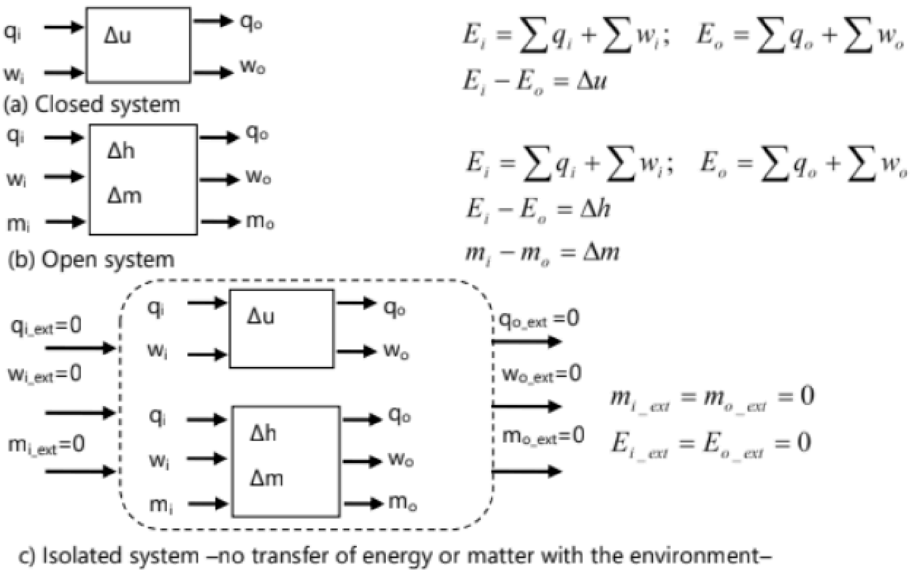


Figure 3: Applying first law to reversible thermodynamic closed processes doing work by expansion. (a), closed systems; (b), open systems; (c), isolated systems.

Fig. 3 depicts the schemes of energy and matter balances for:

(a) Closed systems

(b) Open systems

(c) Isolated systems.

It is crucial to note that reversible heat-work interactions performing work by expansion due to heat addition strictly adhere to the conventional statement of the FLT.

3.2 Reversible thermodynamic cycles doing work by expansion

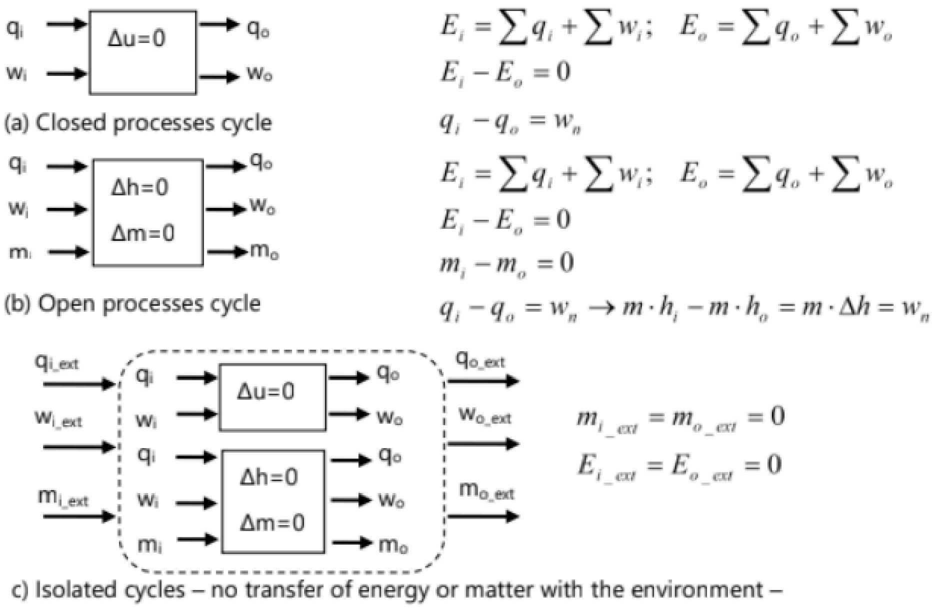


Figure 4: Applying first law to reversible thermodynamic cycles doing work by expansion

The schemes depicted with Fig. 4 deals with the behavior of closed and open heat-work interactions involved in thermal cycles in terms of energy and mater balance. The condition to complete a cycle requires that in every thermal cycle the initial and final value of each state variable are equal. This implies that the initial and final specific entropies of any cycle are equal. This a property of any thermal cycle as well as the rest of involved state variables. The above concept is described in Eq. (8).

$$\Delta T = \Delta p = \Delta V = \Delta s = 0 \tag{8}$$

3.3 Thermodynamic processes in cycles doing work by expansion and contraction

The schemes depicted with Fig. 5 deals with the behavior of cycles conducted by closed and open heat-work interactions involved in such thermal cycles in terms of energy and mater balance. The particularly disruptive feature that is added is the concept of useful work done by thermal contraction of the thermal working fluid exerted within the thermal cycle that conducts a considered actuator. Modeling cycles involving mechanical works by expansion and contraction as well as adjusting the energy balances require the equations (6) and/or (7)

Fig. 5 illustrates the addition of a disruptive concept of isolated system. The objective is to compare a conventional isolated system depicted in Fig. 5(c) with such disruptive hybrid isolated system depicted in Fig. 5(d). It is characterized by exhibiting all characteristics of a conventional isolated system plus a disruptive ability to supply power to the environment.

In previous research works [references [10-16], it has been demonstrated that low-grade heat can be efficiently converted to high-grade heat. This high-grade heat can then be supplied to the system. Achieving this requires a heat manipulation strategy involving a series of successive conversions with high efficiencies: low-grade heat to mechanical work, mechanical work to electrical power, and electrical power to high-grade heat.

According to the SLT on the basis of experimental observations, heat can only transfer spontaneously from a higher temperature to a lower temperature. This assertion is irrefutable, supported by extensive experimental evidence. However, this statement is not entirely complete. Low-grade heat can be converted to high-grade heat, which can then be transferred in accordance with the initial principle. This solution solves the problem of supplying thermal energy from the outside, i.e. from the environment. However, it does not solve the problem of absorbing the heat evacuated to the thermal sink.

The proposed system depicted inFig.5(d), which could be nominated as “hybrid insulated”, or ”partially insulated”, must be able to do without both the external heat source and the external thermal sink. This means that it only contacts the environment to provide energy to the environment.

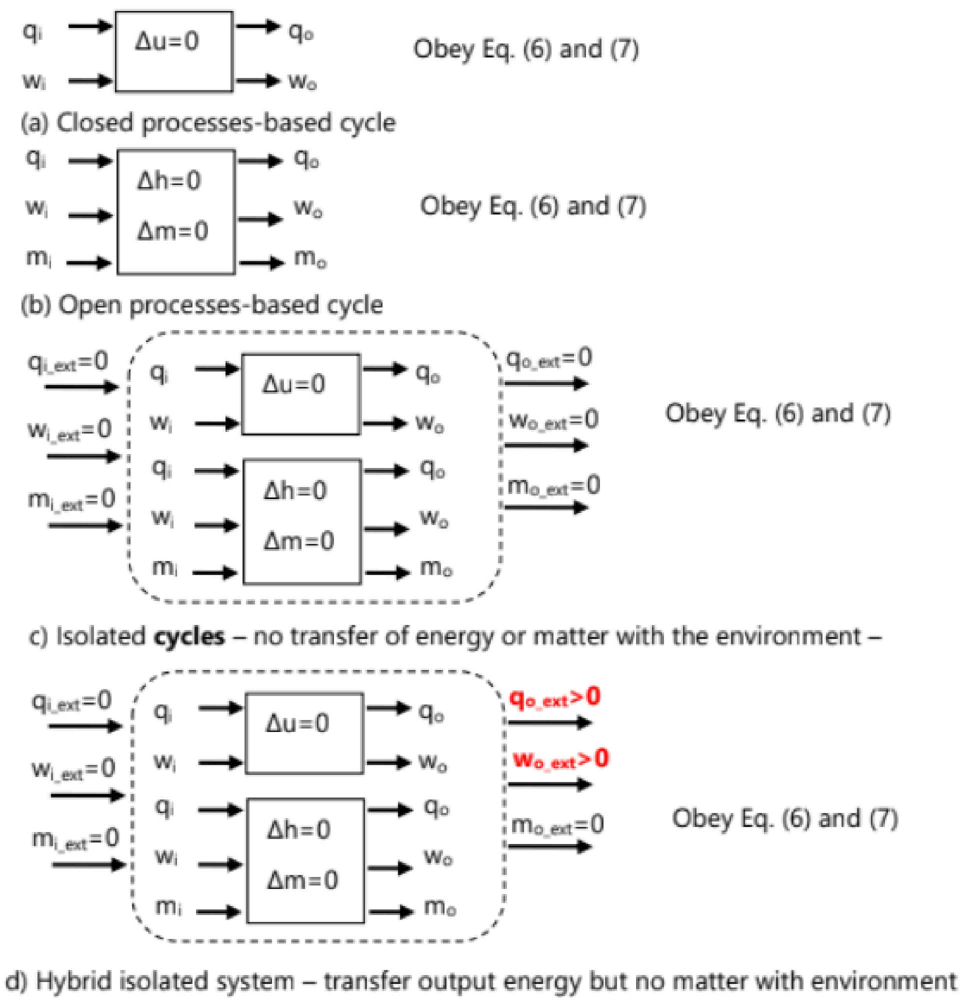


Figure 5: Applying FLT to ***irreversible*** thermodynamic cycles doing work by expansion and contraction

3.4 Discussion about the consequences of the HIS on SLT

The common feature of the systems depicted in Fig. 5(c) and 5(d) is their ability to function as “Self-Sustaining Power Machines.” Specifically, the hybrid insulated system shown in Fig. 5(d) lacks both a power source and a heat sink. According to the SLT, such resources are necessary. **Therefore, the hybrid insulated system flagrantly violates the second law as stated by Clausius and Kelvin-Planck**.

An irrefutable observation of the second law is that heat flows spontaneously only from hotter to colder environments.

According to Clausius:

“Heat cannot spontaneously flow from a colder region to a hotter region without external work being performed on the system.”

According to Kelvin-Planck:

“It is impossible for a heat engine operating in a thermal cycle to convert all the heat absorbed from an external source into mechanical work.”

The direct consequence of the Kelvin-Planck statement is that since not all absorbed heat can be converted into work, a fraction of the absorbed heat must be ejected to a heat sink.

Thus, ***a heat sink is required***.

General consequence: *the conventional statements of the second law are irrefutable when applied to single transformations and single thermal cycles.*

However, ***according to recent disruptive advances involving interactions between cascaded cycles operating with expansion and contraction techniques, such constraints may not apply.***

In summary, heat engines that operate with thermal cycles involving the performance of mechanical work by expansion and contraction, as well as strategies for recovering and converting low-grade heat to high-grade heat for efficient reuse, do not obey the restrictions imposed on individual thermal processes and cycles according to the SLT.

Consequently, once known the operating principle of the actuators, next section task consists of examining the prototype model of a SSPM enabled to operate without a power supply or thermal sink, while adhering to the SLT as defined by Clausius and Kelvin-Planck, while using actuators that perform mechanical work through thermal expansion and contraction simultaneously.

3.5 Consequences of the SLT based on real observations

Considering the system depicted in Fig. 4(c) which concerns to isolated systems, the following comments should be taken into account:

1 All real systems exhibit the inherent losses ─contain dissipative variables─ responsible for irreversibilities or inherent losses.

2 The second law states that in any real transformation, some energy must be dissipated due to these inherent irreversibilities or losses.

In the real world, it is highly challenging, or perhaps impossible, to create an ideal or perfectly isolated system due to various forms of energy like:

1 among outside losses: EM radiation, gravitational forces, and even thermal leakages,

2 among inside losses: friction, drag, flow work, isentropic losses, heat losses among the most commonly known losses.

Consequences:

1 In isolated systems, during a sequence of transformations, energy cannot be conserved due to irreversibilities. This is the basis of the second law.

2 However, since energy still exists after billions of years, it implies that some energy must be continuously created to sustain the current state of the existence dynamics assumed as eternal ─*because after **after** there will always be another after, which implies that before **before** there always had to have been another before*─.

3.6 Procedure for absorbing the heat rejected, released or evacuated to the heat sink.

The solution proposed to avoid rejection of heat to an external heat sink is depicted in Fig. 5. It consists of a conventional heat pump that could be implemented under two common techniques:

1 Reversed Brayton cycle-based plant also known as the Brayton Refrigeration Cycle

2 Compression-based cooling machine by means of an expansion valve.

Since the reversed Brayton cycle is more reliable in terms of performance than the compression-based cooling systems, reversed Brayton will be the technology of choice. The reverse Brayton cycle is implemented by a compressor and an expander, commonly coupled by a mechanical shaft. Its advantage over the compression-based cooling machine is that the expander produces useful work besides it does not require any state change, so that it is superior in performance.

Fig. 6(a) and (b) shows the hybrid isolated system (HIS) to be compared with the structural scheme depicted in Fig. 6(c) that represents a HIS implemented by means of a **Reversed Brayton Cycle (RBC)** coupled to a SSPM. The structure composed by the RBC coupled to the SSPM represented in Fig. 6(c) exhibit the ability to operate without rejecting heat to any external heat sink.

The operation mode of the Reversed Brayton cycle according to Fig. 6(c), assumed to operate as a heat pump consist of recovering heat from the cold side to be transferred or pumped to the hot side. Such reusable heat is used to feed a set of cascaded power units (PU1, PU2... PUn), responsible for convert the pumped heat into useful work. According to Fig. 6(c), the rejected heat from the PU1, PU2.... and PUn can be easily reused again by RBC yielding yet more useful work.

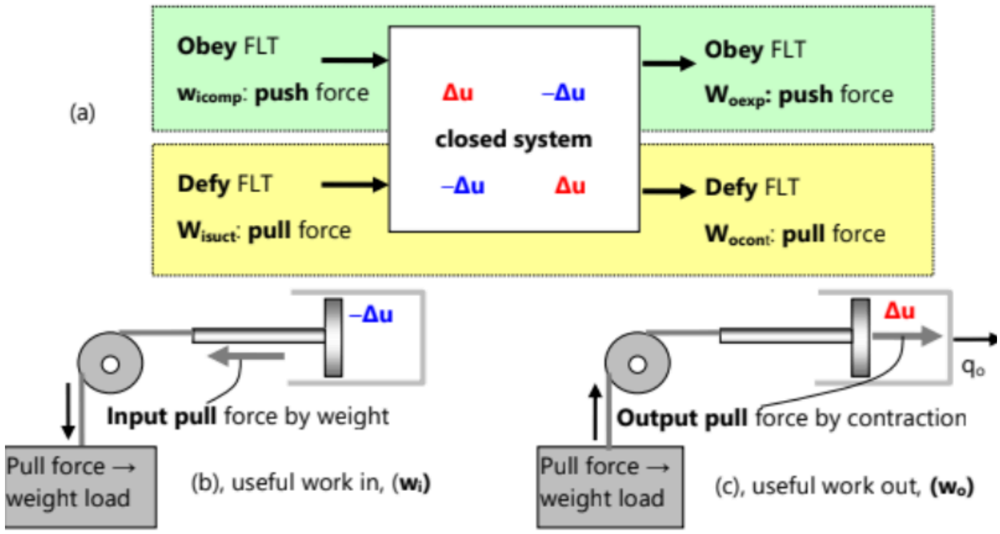


Figure 6: Illustration of a HIS concept structure consisting of combining a Reversed Brayton cycle-based heat pump with a SSPM enabled to avoid an external heat sink. Fig. 6(a) and (b) are equivalent, showing the HIS, which can be compared with the structural scheme depicted in Fig. 6(c) in which a CC based on a heat pump composed by a RBC is coupled to a SSPM. Fig. 6 includes a dashed line indicating the boundary limits through which thermal and mechanical energies can traverse out ─energy, consisting of heat and useful work can be send to the environment─.

According to the proposed structure depicted in Fig. 6(b), the unique design of the proposed thermoelectric plant, which operates without a power supply or heat sink, enables it to function effectively in a wide range of temperatures, from 50 K to more than 800 K. This capability allows it to perform in both extremely high and low-temperature environments. Additionally, the plant can operate in radiation-contaminated environments, coming from cosmic radiation including UV radiation, thanks to artificial insulation using magnetic fields, since another interesting aspect is to use a fraction of the energy produced in protection against environment radiation effects.

4 Implementation of a SHSk using an RBC-based Heat Pump

A disruptive SHS will be proposed by considering the scheme depicted in Fig. 7(d) and 7(e). Thus, assuming its reliability as real, it follows that energy can be achieved out of any difference of potential of a physical magnitude; that means without an external power supply such as a fuel. Such difference of potential of a physical magnitude is obtained from a RBC combined with a cascaded group of power units as depicted in references regarding with SSPMs. It only requires a suitable disruptive strategy to obtain more energy than is needed to obtain it. Therefore, taking into account that energy has persisted for billions of years despite the losses associated with dissipative variables in all real dynamical systems, as described by the SLT and observed in everyday life, it seems reasonable to conclude that if energy could not be created, it would have been exhausted by now due to these dissipative effects.

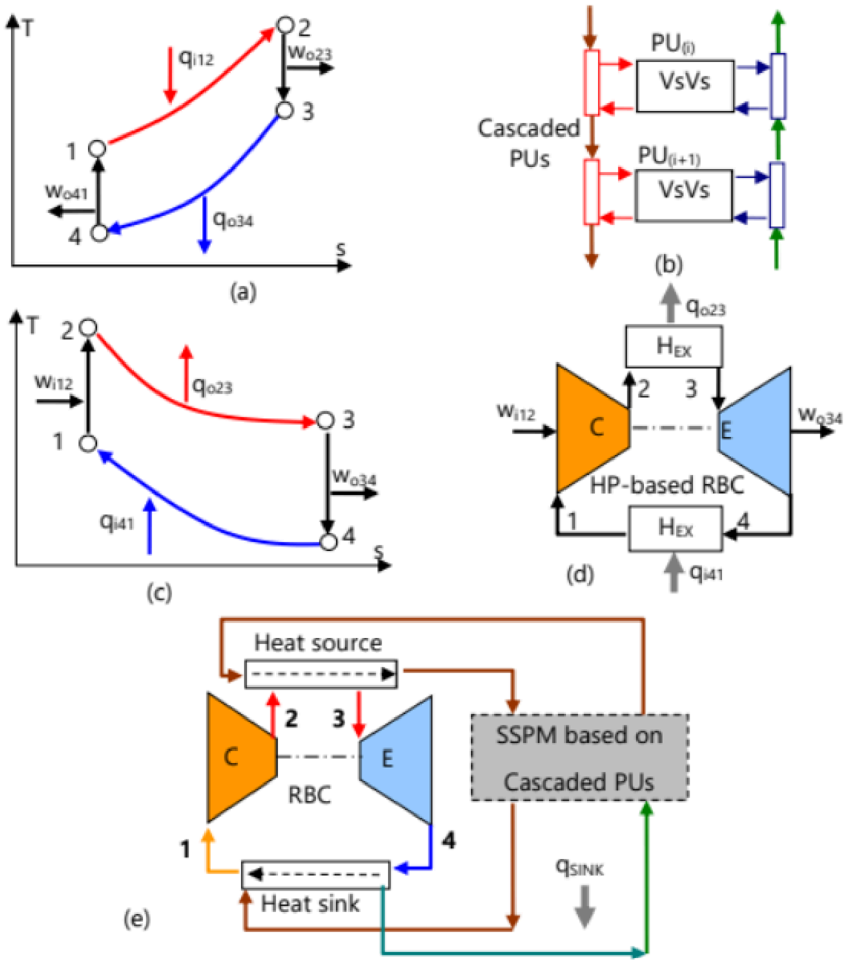


Figure 7: SHSk structure-based combined cycles composed of a heat pump-based RBC and a set of cascaded VsVs cycles: PU_{01}, PU_{02} as depicted in Fig. 7(e).

That is to say, the nature of existence, by itself is capable of creating energy simply because it exists and has not vanished or annihilated because it is not a material entity but the consequence of at least a creation strategy. Consequently, this article shows an example of such a characteristic of nature based on empirical evidence.

Fig. 7 illustrates the following components of the CC based on a HP composed by a RBC and a SSPM composed by a cascade of PUs. This includes a self heat source SHS and a self heat sink SHSk:

(a), T-s diagram of VsVs cycles for the cascaded structure of PUs responsible for absorbing the output heat q_{o23} delivered by the RBC;

(b) cascaded structure of VsVs cycles;

(c) T-s diagram of the reverse Brayton cycle;

(d) Schematic structure of a RBC;

(e) Schematic structure of the combined cycles consisting of the RBC and a set of cascaded PUs operating with VsVs cycles responsible the absorbing the heat produced by the RBS.

4.1 Brief description of the operation modes

The combined cycle responsible for absorbing heat from the heat sink depicted in Fig. 6(b) y Fig. 7 (e), operates in such a way that the thermal working fluid assumed as helium or air in state (1), i.e. at pressure P_1 and temperature T_1 is drawn in by the compressor of the reverse Brayton cycle and compressed to the pressure given by the pressure ratio specified in state (2), i.e. at pressure P_2 higher than P1 and temperature T_2 higher than T_1. The mechanical work applied to the compressor to pass from state 1 to state 2 has been converted into thermal energy given by P_2 and T_2. This energy is transferred to the cascade power units PU_{01} and PU_{02} so that the thermal working fluid is cooled by heat conversion at constant pressure P_2, i.e. it passes to state 3 which carry temperature T_3. In this state it is expanded in the Expander converting part of the thermal energy it still contains into useful mechanical work as the pressure and temperature decrease until state 4, i.e. at pressure $p_4 = p_1$ and temperature T_4. In state 4, the thermal working fluid absorbs heat from the heat sink at constant pressure p_1, thereby increasing its temperature to the initial temperature T_1 or initial state 1. This cycle is repeated indefinitely.

To extract or absorb the amount of heat evacuated to the heat sink, the flow rate of the thermal working fluid is modulated in the RBC so that the heat evacuated by the power plant SSPM is absorbed by the cascaded PUs of the Self Heat Sink SHSk. To do this it is necessary a heat flow modulation device. Therefore, the heat flow modulation task is carried out according to the ratio of heat transfer fluid flows of the SHS and the SSPM.

4.2 Case study implementation

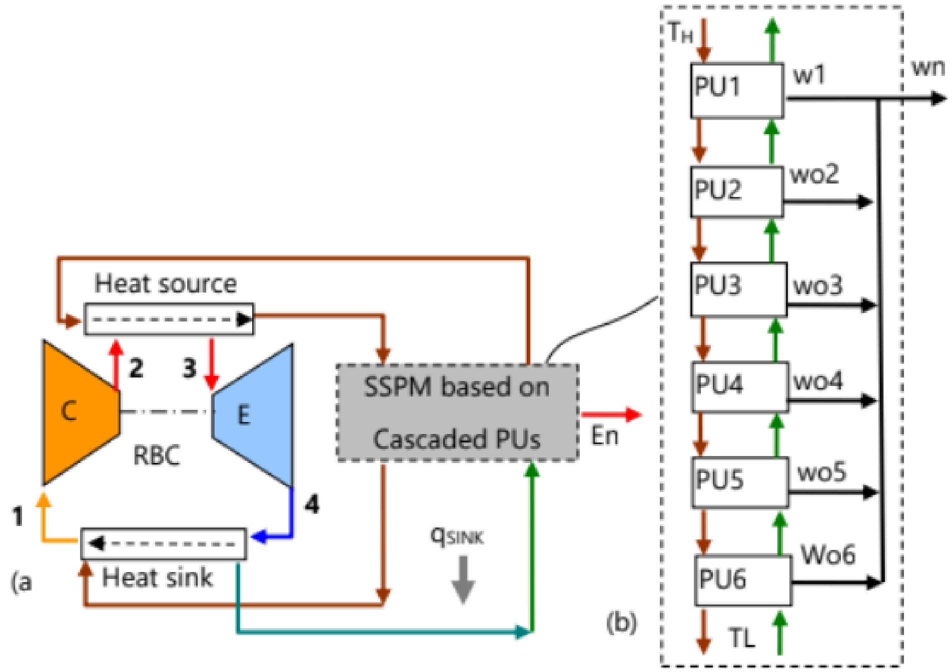


Figure 8: Schematic structure a CC composed by a SSPM coupled to the RBC. (a) Depicts the HP based on a RBC. (b), illustrates the SSPM composed by a cascade of 6 PUs

The case study implementation involves studying a combined-cycle structure consisting of a HP heat pump consisting of a reverse Brayton cycle (RBC) and a cascade of power units that constitute a SSPM. The RBC operates with helium as the TWF. The reason for using helium as the TWF instead of air is that the adiabatic expansion coefficient of air is too low compared to that of helium. The power units operate with either air or helium as the TWF.

Fig. 8 illustrates a simplified coupling scheme of a heat pump formed by the RBC with the SSPM formed by a cascade of PUs. The design of the heat pump must satisfy the condition of supplying the heat demand of the first PU of the SSPM plant, as well as absorbing the heat rejected by the last power unit of the PU cascade of the SSPM plant.

4.3 Implementation of a Case study

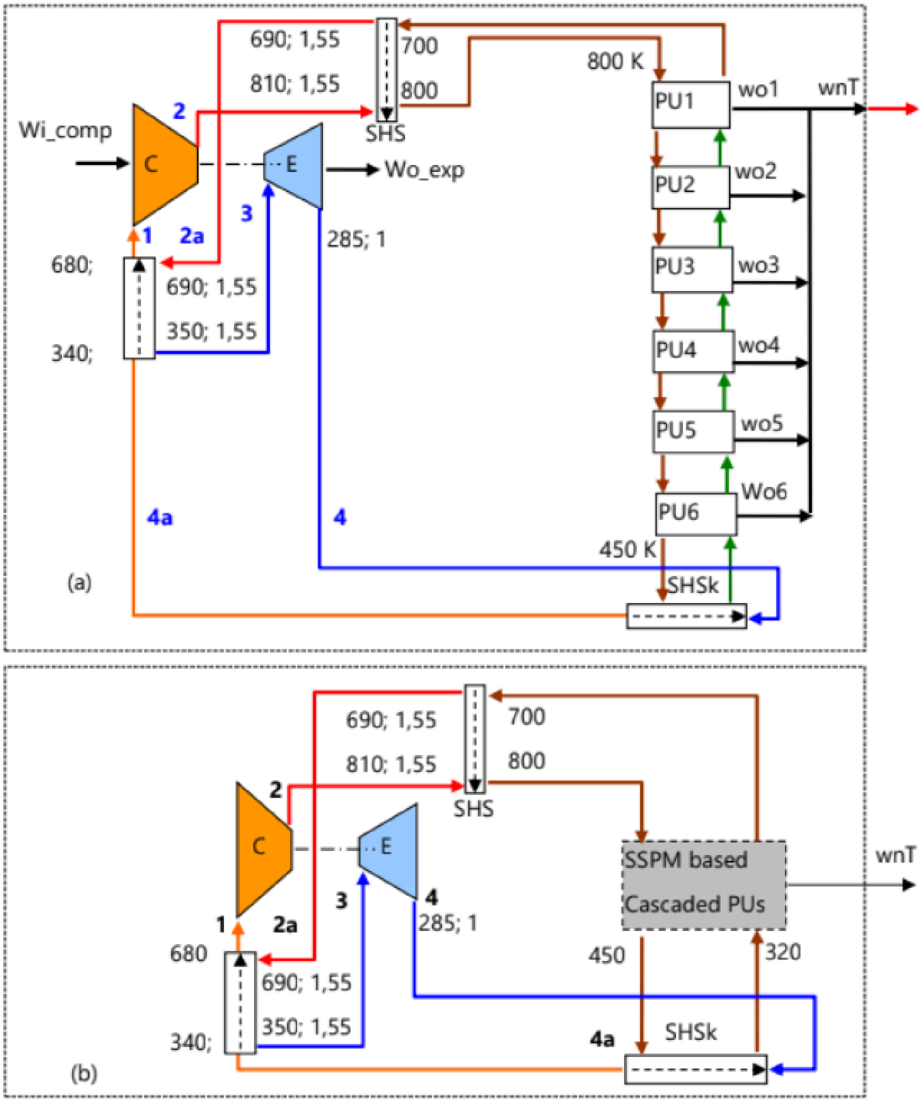


Figure 9: Schematic structure of a HIS composed of a CC including a RBC and a SSPM as the basis of the case study. (a) shows the extended CC with data corresponding to the case study. (b) depicts the compacted representation of the same CC

Fig. 9 illustrates a RBC coupled to a SSPM to achieve the SHS and SHSk giving rise to a complete autonomous SSPM enabled to operate without any external power source and power sink, which defy some second law statements. In the concerned case study, a reversed Brayton cycle (RBC) is combined with a cascade of PUs enabled to perform useful mechanical work under operational self-sufficiency. The function of the RBC is to perform the functions of a thermal energy supply source and a thermal energy sink source while the cascade of PUs is responsible for transforming the thermal energy into work and/or electrical power.

Fig. 10 (a), represents the CC structure equipped with only a SSPM exhibiting sufficient capacity to absorb the heat supplied by the RBC, where the RBC exhibit the sufficient capacity to absorb the SSPP released heat by its last PU. Fig. 10 (b), represents the CC structure equipped with several SSPMs coupled in parallel to satisfy sufficient capacity to absorb the heat supplied by the RBC, where the RBC exhibit the sufficient capacity to absorb the SSPPs heat released by every last PUs

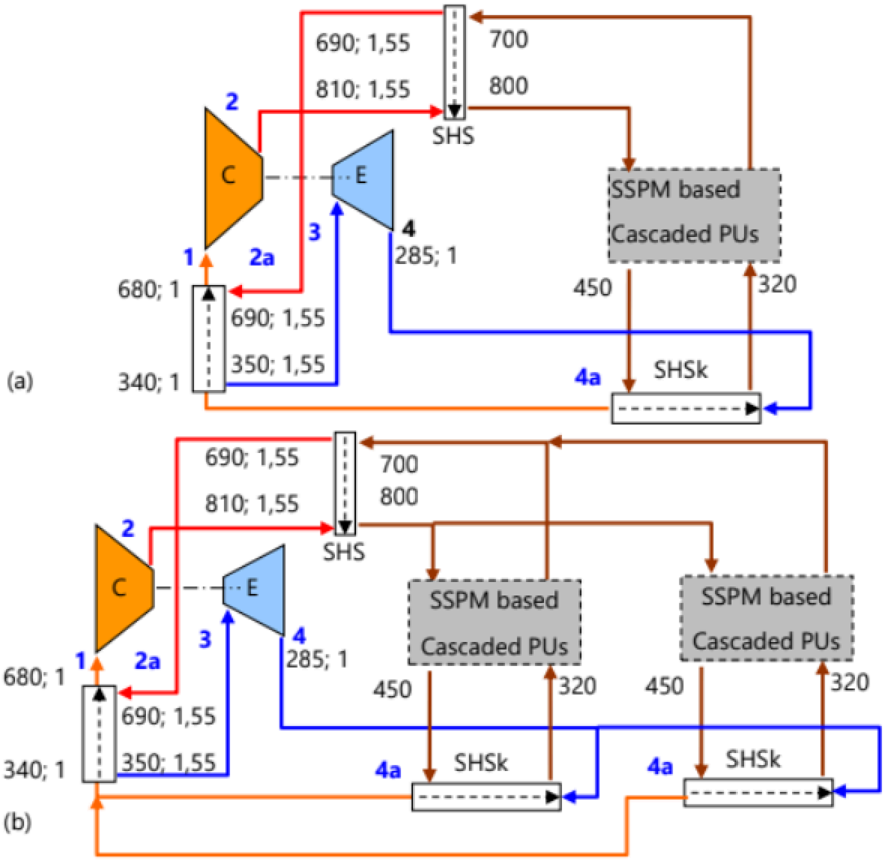


Figure 10 Illustration of the structural options of the proposed CC

Table 1: Heat pump-based RBC data with helium as TWF enabled to operate as heat pump to provide SHS and SHSk to/from the SSPM.

RB-He	T(K)	p(bar)	V(m3/kg)	u(kJ/kg)	h(kJ/kg)	h'(kJ/kg)	s(kJ/kg-K)
1	680.00	1	14.1280	2123.90	3536.7	3536.7	32.257
2	810.00	1.5487	10.8670	2529.00	4287.0	4212.0	32.257
2a	690.00	1.5487	9.2575	2155.10	3588.8	3588.8	31.424
3	340.00	1.5487	4.5633	1064.50	1771.2	1771.2	27.749
4	285.43	1	5.9322	894.45	1516.1	1487.7	27.749
4a	340.00	1	7.0656	1064.50	1771	1771	28.658

Table 1 depicts the data corresponding to the open-process-based RBC responsible for performing the tasks of heat supply power source and heat sink, both operating as a heat pump with helium as the thermal working fluid. The sequence of open processes corresponds to the RBC structure depicted in Fig. 7(d) and 7(e). Used data has been taken from the database referenced as [ss]. The design criteria for both heat and cold sources are more in line with the need to satisfy the cold and heat demands to feed the PU cascade than to obtain a high COP value. Table 2 illustrates the main RBC results operating as heat pump with **helium** as working fluid. Results correspond to the data depicted in Table 1.

Table 2: RBC results derived from the heat pump implemented by means of a RBC operating under open system-based processes and computed with data from Table 1. Inlet compressor pressure p_1=1(bar); outlet compressor pressure p_2=1.55; compressor pressure ratio (PR)=1.55

Work done on the compressor of the RBC	Wi12=wi_comp (kJ/kg)	750.33
Total pumped heat	qo23 (kJ/kg)	2515.83
Work done on by the expander of the RBC	Wo34 = wo_exp(kJ/kg)	255.15

Total recovered heat to the compressor suction side	qi41 (kJ/kg)	2020.65
Isentropic efficiency	Is_eff (%)	90
wn (RBC)=wi_comp-wo_exp=qi-qo	RBC work demand (kJ/kg)	-495.18
Coefficient of performance for the RBC	COP	5.71
Available SHS	Available SHS_(qo2-2a) RBC(kJ/kg)	**698.2**
Available SHSk	Available SHSk_(qi4-4a)RBC(kJ/kg)	**255.0**

Since the RBC is responsible for supplying the demanded amount of heat as well as the demanded amount of cold to ensure the isolated heat sink tasks, let's consider the relevance of the data shown in Table 2. Therefore, in order to supply the necessary heat and dissipate the rejected heat to/from the SSPM consisting of a group of cascaded PUs, an energy balance of heat input and dissipation is carried out using a heat dissipation energy balance to obtain the flow rate of heat dissipation fluid through the RBC. This determines the RBC cycle stress so that it meets the heat sink demand. This results in excess high-grade thermal energy produced by the RBC compressor, which can be utilized both as direct heat and to power other devices, including another power plant.

The cascaded PUs responsible for converting the heat and cold obtained from the heat pump implemented by the RBC as available SHS and available SHSk are depicted in Table 3 showing the sets of six PUs operating with the VsVs cycle data for air and helium as working fluids, The ratio of cascaded temperatures (RIT) is selected as 0.85 and the losses inherent to irreversibilities LS(%) and RF(%) are assumed 0.85 and 0,95 respectively.

Table 3: VsVs cycle data for air and helium as working fluids with RIT of 0.85

sp	T(K)	p(bar)	V(m^3/kg)	u(kJ/kg)	s(kJ/kg-K)	T(K)	p(bar)	V(m^3/kg)	u(kJ/kg)	s(kJ/kg-K)
PU1-Air						**PU1-He**				
1	680.00	1	1.95310	623.14	4.732	680.00	1	14.12800	2123.90	32.257
2	800.00	1.1765	1.95310	718.84	4.862	800.00	1.1765	14.12800	2497.80	32.764
3	766.62	1	2.20190	691.89	4.862	749.72	1	15.57600	2341.20	32.764
4	650.7	0.8487	2.20190	600.31	4.732	637	0.8497	15.57600	1989.90	32.257
PU2-Air						**PU2-He**				
1	578.00	1	1.66010	544.50	4.560	578.00	1	12.00900	1806.10	31.413
2	680.00	1.1766	1.66010	623.13	4.685	680.00	1.1765	12.00900	2123.90	31.919
3	650.85	1	1.86940	600.42	4.685	637.14	1	13.23800	1990.40	31.919
4	552.50	0.8488	1.86940	525.22	4.560	542.00	0.8507	13.23800	1693.90	31.413
PU3-Air						**PU3-He**				
1	491.30	1	1.4110	479.48	4.3917	491.30	1	10.2080	1535.90	30.569
2	578.00	1.1766	1.4110	544.48	4.5135	578.00	1.1765	10.2080	1806.10	31.075
3	552.71	1	1.5875	525.36	4.5135	541.57	1	11.2520	1692.60	31.075
4	469.30	0.8490	1.5875	463.24	4.3917	460.60	0.6989	11.2520	1440.30	30.569
PU4-Air						**PU4-He**				
1	417.61	1	1.19930	425.33	4.226	417.61	1	8.67770	1306.30	29.725
2	491.30	1.1766	1.19930	479.46	4.345	491.30	1.1764	8.67770	1535.90	30.232
3	469.46	1	1.34830	463.34	4.345	460.42	1	9.56690	1439.70	30.232
4	398.70	0.8492	1.34830	411.59	4.226	391.50	0.8503	9.56690	1225.00	29.725
PU5-Air						**PU5-He**				
1	354.96	1	1.01920	379.88	4.061	354.96	1	7.37640	1111.10	28.881
2	417.61	1.1767	1.01920	425.31	4.179	417.61	1.1765	7.37640	1306.30	29.388

3	398.88	1	1.14550	411.70	4.179	391.35	1	8.13230	1224.50	29.388
4	338.70	0.84891	1.14550	368.17	4.061	332.70	0.85013	8.13230	1041.70	28.881
PU6-Air						**PU6-He**				
1	301.72	1	0.86603	341.53	3.897	301.72	1	6.27050	945.20	28.037
2	354.96	1.1768	0.86603	379.85	4.014	354.96	1.1764	6.27050	1111.10	28.544
3	338.83	1	0.97277	368.24	4.014	332.65	1	6.91290	1041.60	28.544
4	286.00	0.84382	0.97277	330.27	3.897	282.60	0.84955	6.91290	885.62	28.037

Table 4: Results of VsVs cycles computation derived from the Table 3 for cycles VsVs types with air as thermal working fluid

PU	1	2	3	4	5	6	totals
LF(%)	0.85	0.85	0.85	0.85	0.85	0.85	0.85
RF(%)	0.95	0.95	0.95	0.95	0.95	0.95	0.95
RIT*100	85.0	85.0	85.0	85.0	85.00	85.0	85.00
T2(K)	800.00	680.00	578.00	491.30	417.61	354.96	
T1(K)	680.00	578.00	491.30	417.61	354.96	301.72	
qi_12/PU(kJ/kg)	95.70	78.63	65.00	54.13	45.43	38.32	377.21
qo_34(kJ/kg)	91.58	75.20	62.12	51.75	43.53	37.97	362.15
q_recov(kJ/kg)	87.00	71.44	59.01	49.16	41.35	36.07	344.04
Tm_qrecov(kJ/kg)		601.68	511.01	434.08	368.79	312.42	
wn(kJ/kg)	**40.20**	**33.91**	**28.55**	**24.11**	**20.45**	**18.47**	**165.68**
η_th/PU(%)	42.00	43.12	43.93	44.54	45.01	48.19	
η_th/plant(%)							173.13
SSI(%)							73.13
wnT(kJ/kg)=	**Total net work out = wn(SSPM)*CCF(SHSk) - wn(RBC)=**						**617.30.**

Table 5: Results of VsVs cycles computation derived from the Table 3 for cycles VsVs types with helium as thermal working fluid

							totals
PU	1	2	3	4	5	6	0.85
LF(%)	0.85	0.85	0.85	0.85	0.85	0.85	0.95
RF(%)	0.95	0.95	0.95	0.95	0.95	0.95	85.00
RIT*100	85.0	85.0	85.0	85.0	85.00	85.0	
T2(K)	800.00	680.00	578.00	491.30	417.61	354.96	
T1(K)	680.00	578.00	491.30	417.61	354.96	301.72	
qi_12/PU(kJ/kg)	373.90	317.80	270.20	229.60	195.20	165.90	1552.60
qo_34(kJ/kg)	351.30	296.50	252.30	214.70	182.80	155.98	1453.58
q_recov(kJ/kg)	333.74	281.68	239.69	203.97	173.66	148.18	1380.90
Tm_qrecov(kJ/kg)	693.36	589.57	501.09	425.96	362.03	307.63	
wn(kJ/kg)	**234.66**	**198.40**	**168.85**	**143.33**	**122.09**	**104.23**	**971.57**

η_th/PU(%)	53.35	53.07	53.12	53.06	53.17	53.40	
η_th/plant(%)							259.85
SSI(%)							159.85
wnT(kJ/kg)	**Total net work out = wn(SSPM)*CCF(SHSk) - wn(RBC)**						**1092.85**

In order to accommodate the heat and cold needs generated by the Reversed Brayton Cycle to feed the sets of cascaded PUs, it is necessary to determine the flow demands of the cooling and heating thermal fluids. Thus, the Cooling Capacity factor (CCF) is defined as the ratio of the available heat the must be absorbed by the heat sink (Available SHSk-qi4-4a-RBC) to the heat released by the last PU of the cascaded PUs (qo_34-PU6). This concept is depicted in the last two rows of table 6. That is, the CCF for any thermal working fluid is defined as:

CCF=Available (SHSk_qi4-4a_RBC)/(qo34-PU6) (9)

In the same way, the HCF for any thermal working fluid is defined as:

HCF=Available (SHS_qo2-2a_RBC)/(qi12_PU1) (10)

Table 6: Shared parameters between RBC and SSPM based on cascaded PUs using data from Table 2.

Shared parameters between RBC-SSPM	Air		Helium	
RBC work demand (kJ/kg)		-495.18		-495.18
qo_34(kJ/kg) at PU6		38.0		156.0
qi_12(kJ/kg) at PU1		95,7		374
Available SHS-qo2-2a (kJ/kg)		698.2		698.2
Available SHSk-qi4-4a (kJ/kg)		255.0		255.0
Cooling capacity factor of RBC(CCF)	255/38	**6.71**	255/156	**1.63**
Heating capacity factor of RBC(HCF)	698,2/95,7	**7.30**	698,2/374	**1.87**

From table 5 we have that the available Self Heat Sink of the RBC expressed as available SHSk_(qi4-4a)RBC(kJ/kg) = 255. Therefore for both thermal working fluids (air and helium) follows that according to the results of Table 6 the CCF is 6.7 for air and 1.6 for helium. That is the flow of heat transfer fluids must be 6.7 Kg for air while 1.6 kg for Helium as working fluids. The CCF is based on the ratio of the available SHSk_qi4-4a of the RBC to the qo_34 of the PU6.

In order to accommodate the demands of heat and cold generated by the Reversed Brayton Cycle to feed the cascaded PUs of the SSPM, it is necessary to determine the flow demands of the cooling and heating thermal fluids. Because the heat produced by the heat pump composed of the reverse Brayton cycle is greater than the heat demanded by the PUs cascade of the SSPM, it is sent to the exterior as usable energy. Therefore, according to the results shown in Table 7, the TWF flow rates required by the PUs cascade to absorb heat available for delivery to the RBC heat sink are 6.7 kg for air and 1.6 kg for helium as TWF.

Table 7: Illustration of the cooling capacity factor for a CC composed by a RBC and a SSPM equipped with 6 cascaded PUs for air and helium as TWFs

TWF	CCF algorithm	**CCF**
air	[SHSk_qi4-4a of the RBC]/[qo_34 of the PU6] = **255/38**	**6.7**
helium	[SHSk_qi4-4a of the RBC]/[qo_34 of the PU6] = **255/156**	**1.6**

5 Analysis of results and discussion

The prototype of the CC consisting of a RBC and a SSPM enabled to operate without external heat sink and source was developed and evaluated through the referred case study with helium for the RBC while using air and helium as real TWFs for the cascaded PUs of the SSPM. Results depicted in Tables 4-8 indicate that the CC composed of RBC and a SSPM equipped with six cascaded PUs operating on a VsVs cycle achieved a total output net work of **617,4 kJ** for **air** and **1092, 8 kJ** for **helium** as TWFs. Thus Table 8 illustrates a summary of the relevant data and applied algorithms corresponding to the CC components.

Table 8: Summary of relevant data and applied algorithms on the CC components

wn [RBC] (kJ/kg-he) = wi_comp-wo_exp=qi-qo= RBC work demand		RBC: He	**-495.18**
SSPM with air as TWF: CCF = (SHSk_qi4-4a of the RBC)/(qo_34 of the PU6)= 255/38			**6,70**
wn[SSPM] (kJ/kg-air)		SSPM: air	**165.68**
Total net work out (kJ/kg-He RBC)	$wnT = wn[SSPM] \cdot CCF[SHSk] + wn[RBC]$		**617.30**
SSPM with helium as TWF: CCF = (SHSk_qi4-4a of the RBC)/(qo_34 of the PU6)= 255/156			**1.60**
wn[SSPM] (kJ/kg-He)		SSPM: He	**971.57**
Total net work out (kJ/kg-He RBC)	$wnT = wn[SSPM] \cdot CCF[SHSk] + wn[RBC]$		**1092.85**

Therefore, the discussion focuses on the most relevant aspects of how SSPMs can operate without a heat source or heat sink, thus approaching a balanced, evidence-based discussion while openly addressing disruptive and revolutionary claims.

5.1 Disruptive findings

Let us succinctly restate the three core findings:

Inconsistence of the FLT:

In section 2 it has been demonstrated that contraction work, achieved trhough (pull forces) increases internal energy while performing useful work, which is not consistent with the FLT's energy conservation principle.

Part of the controversy lies in the fact that, although energy is strictly conserved even assuming the irreversibilities inherent in real systems, each energy conversion process entails an increase in entropy derived from the loss of heat energy, such that, after a few successive heat-work conversion processes, the rejected heat is no longer recoverable because it lacks sufficient potential of the thermal energy. This phenomenon can be stated as follows: The ability of any thermal cycle to recover the heat rejected or evacuated in successive conversion stages is finite.

This occurs because the degree of heat rejection is sufficiently low. Consequently, the cycle cannot perform useful work, so that useful work cannot be conserved but dissipated energy which is conserved.

Hybrid Isolated Systems (HIS):

Based on the main objective of this work which deals with a preliminary design task for the implementation of a prototype of a SSPM enabled to operate without external heat sink and source, it has been possible the identification of systems that emit energy beyond isolation boundaries, challenging traditional definitions of isolated systems, which consist on hybrid isolated systems. Fig. 5 (d) depicts such concept.

Challenge to the consistence of SLT:

The proposal of SSPMs that operate without external energy input or heat sinks is not consistent with Kelvin-Planck and Clausius statements. This is due to the following two resources:

An individual SSPM do not require external power supply and or,

Combined cycles composed by a heat pump that operate by means of a RBC coupled to a SSPM do not require external heat sink or heat source.

5.2 Experimental and Theoretical Evidence

-- It is important to note that empirical observations with regard to the developments due to (e.g., Papin and Newcomen's engines [17] , including useful contraction-based work using double-acting cylinders) support the inconsistencies and/or contradictions to classical thermodynamics.

It is worth emphasizing the role of **closed adiabatic/isothermal processes** involving expansion/contraction work, particularly the unexpected results:

--Work performed via cooling (contraction) increases internal energy.

-- Entropy decreases during isothermal contraction work.

5.3 Implications for Thermodynamics

Reinterpretation of Energy Balances:

-- Traditional FLT formulations accounted for input and output energies (heat and/or work) based on expansion and/or compression-based works. These works are characterized by push forces. Thus, the FLT formulation did never take into account energy balances in which pull-based forces achieved by contraction or suction-based processes were considered.

-- Consequently, traditional FLT formulations must account for **pull forces** suction/contraction work) [10-11], which violate conventional energy balances. This means that for energy balances based on conventional thermodynamics to be consistent and coherent, they must include the real facts due to traction or pull forces, that is, the useful work of suction and contraction, as well as their effects on the internal energy and entropy of the involved processes.

Redefinition of Isolated Systems:

--A HIS is a hybrid isolated system characterized by not allowing the transfer of input energy or matter. However, it does allow the output of energy (heat and work), but not matter. It consists of an isolated system that only allows the supply of output energy (heat and work), which apperas to be unsustainable in any way.

--In fact, all SSPMs] published so far [12-16] exhibit the capabilities of hybrid systems, since they provide energy (heat and work) without an external heat source. However, they require a heat sink, so SSPMs are also hybrid isolated systems, allowing output energy transfer; the heat transferred to the environment by the heat sink.

--In essence, isolated (absolutely isolated) systems cannot exist as a consequence of field interactions: in experimental reality, field dynamics are permeable to the physical limits imposed on fully isolated systems. Only ideal systems (nonexistent in reality) can be modelled as isolated in terms of mathematical models.

SLT Limitations:

--According with the results published in [12-16], SLT requires an urgent modification and adaptation to be consistent with the results achieved [10-16], both Clausius and Kelvin-Planck statements should be adapted to the observations (empirical and observational). On the basis of the above mentioned references I must acknowledge that while SLT holds for single cycles, cascaded cycles (e.g., SSPMs as well as combined cycles composed by RBC as heat pumps and SSPMs), may circumvent its restrictions by reusing ejected heat internally.

5.4 Case Study Validation

Combined Cycle between a heat pump-based RBC and a SSPM:

--In reference [9] it has been described the case where the combination of a Reversed Brayton Cycle operating as a heat pump coupled to a SSPM conducted by contraction based thermal cycles yielded acceptable results. These results have been taken into account to advance towards a thermal engine enabled to operate without external heat source and heat sink

SSPMs yielded acceptable results as practical validation:

--The RBC-based heat pump enables a **SHSk**, eliminating reliance on external sinks.

--Tables 4–8 show net positive work output (617–1092 kJ/kg) for air/helium working fluids, supporting SSPM feasibility.

The **Cooling Capacity Factor (CCF)** as critical for scaling the system to absorb rejected heat:

--CCF is an essential and critic parameter in the SHSk design task. The solution to satisfy the demand of cooling capacity requires scalability of the heat pump that means the capacity of the RBC.

--The energy balance of the CC increases as the size of the heat pump and consequently CCF increases.

-- The demand of CCF decreases as the amount of cascaded PUs of the SSPM increases.

--This contributes to increment the net output energy.

5.5 Addressing Controversies

Criticism and Counterarguments:

--Recent studies carried out [10-18] have emphasized the need to adapt both FLT and SLT to address the challenges posed by the design and implementation tasks of a patented disruptive family of self-sustaining plant prototypes [19-21], giving rise to an energy utilization scenario never before considered. As a fact inherent to all real heat-work interaction processes involving dissipative parameters that affects the heat to work conversion processes and vice-versa, some non recoverable or lost energy is achieved as thermal energy potential decreases during successive conversion steps with a clear tendency towards zero potential.

To address these concepts which deals with the FLT let's consider two examples

--Natural scenario, which addresses among a huge number of phenomena the problem of potential loss in a recurring succession of heat-work conversion processes by natural means

--An artificial scenario, which addresses the problem of heat-grade or potential differences in a recurring succession of heat-work conversion processes by thermal cycles that operate with contraction-based heat-work conversion processes that induce pull forces.

Considerations on the natural scenarios:

The natural scenario considered addresses the problem of potential loss from a recurring succession of heat-to-work and work-to-heat conversion processes through natural means. Among the numerous useful energy conversion chains, radiant solar heat on the Earth's atmosphere is a key example. Every day, the atmosphere undergoes expansion and contraction following the radiation flow: expansion work during daylight hours and contraction work at night. These open system-based processes convert work back into heat of a lower grade with each cycle, continuing cyclically. These transformations are non-deterministic, stochastic, and often chaotic. The thermal efficiency of these processes is very low for heat-to-work conversion but nearly 100% for work-to-heat conversion, as this conversion is driven by drag forces from winds.

Considerations on the artificial scenarios:

Artificial scenarios exhibit determinism such for instance combined cycles which addresses the problem of heat-grade or losses due to potential differences in a recurrent succession of heat-work conversion processes conducted by thermal cycles. In this regard let's analyze the problem of "total useful work over infinite steps" step by step, considering the given assumptions and the implications of an unlimited sequence of energy conversion processes which include heat-work and work-heat transformations. Therefore, to estimate the amount of useful mechanical energy that could we obtain from an infinite sequence e of successive conversion processes belonging to a recurrent cycle of the VsVs type characterized by expansion and contraction-based useful work, in which the thermal efficiency doesn't depend on the heat-grade of the input energy to the cycle. With regard to the estimation of the "total useful work over infinite steps" the following key assumptions are taken into account:

Energy as potential difference of any physical magnitude**:** Energy is defined as the difference in potential of some physical quantity (e.g., height in gravity, voltage in electricity, pressure in fluids, temperature, velocities y systems dynamics, etc.). In the proposed example temperature difference or gradient is the energy potential.

Conversion process to useful work**:** This potential difference can be converted into useful mechanical work, but when the potential difference approaches zero, no work can be extracted.

Inherent losses in heat-work conversion under dissipative forces**:** Every conversion process has losses (dissipation, irreversibilities, etc.), meaning input energy is converted to useful work, rejected heat (sometimes not recoverable), and inherent losses due to dissipative forces.

The sequence of recurrent conversions**:** The useful work output from one conversion process is used as the input for the next conversion process, and this sequence continues indefinitely.

Math-Modelling procedure:

Let's formalize the problem according to the following assumptions:

1 Let the initial energy available be E_0 (from some initial potential difference).

2 Let the efficiency of each conversion process be η, where $0 < \eta < 1$ (since there are losses).

3 Efficiency η represents the fraction of input energy that is converted to useful work; the rest is lost (e.g., as heat)..

4 Efficiency is assumed as constant in order ensure as much determinism as possible. The reason for choosing a value for the thermal efficiency of cycles as constant is that in thermal cycles that use thermal contraction and expansion, efficiency is independent of the heat-grade under certain operating conditions related with the ration of input-output temperatures or heat potential.

In order to facilitate the understanding of the mathematical modelling strategy of a sequence of recurrent heat-work and work-heat conversion cycles to feed back the input heat, the observation of Fig. 11 is proposed. Therefore, Figure 11 shows that useful work, as the capacity or ability to perform useful work by means of a recurrent cycle, evolves from a given grade of heat toward a lower grade of heat in each recurrent cycle.

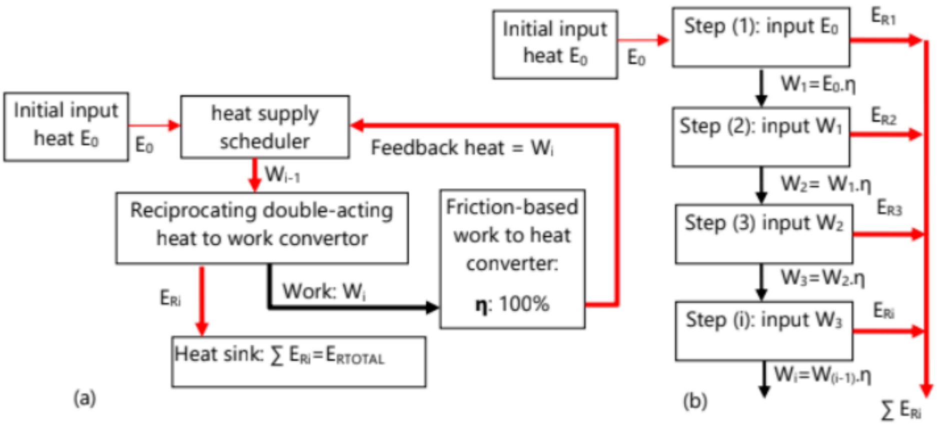


Figure 11: Illustration of the competing strategy to estimate the total useful work over an infinite sequence of conversion steps. (a) Shows the block diagram depicting the energy flow path as the heat grade evolves toward zero. (b) Shows the sequential energy (work and rejected heat) paths

Sequence of processes —conversion steps— doing useful work:

According to the first principle of thermodynamics, traditionally assumed until now, the energy balance of any thermal cycle, considering the irreversibilities inherent in the rejected heat (E_R), establishes that:

$$q_i - q_o \rightarrow E_0 - E_R = W_{out} \tag{11}$$

where E_o is the input heat and W_{out} is the useful work output in the first cycle step

Thus, the first conversion step can be written as:

$$W_1 = E_0 \cdot \eta \tag{12}$$

where W_1 from the first conversion step is W_{out}

The remaining energy (E_R) is lost energy since it is not used in this study. Therefore the remaining energy can be accounted in each conversion step as:

$$E_{R1} = E_0 \cdot (1-\eta) \, , \tag{13}$$

since $$W_1 + E_{R1} = E_0 \cdot \eta + E_0 \cdot (1-\eta) = E_0 \tag{14}$$

$$E_{R1} = E_0 - W_1 = E_0 - E_0 \cdot \eta = E_0 \cdot (1-\eta) \tag{15}$$

Second conversion phase:

The useful work W_1 is now the input for the next conversion.

$$W_2 = W_1 \cdot \eta = (E_0 \cdot \eta) \cdot \eta = E_0 \cdot \eta^2 \tag{16}$$

$$E_{R2} = W_1 - W_2 = W_1 - W_1\eta \cdot = W_1 \cdot (1-\eta) = E_0 \cdot \eta \cdot (1-\eta) \tag{17}$$

Third conversion phase:

$$W_3 = W_2 \cdot \eta = (E_0 \cdot \eta^2) \cdot \eta = E_0 \cdot \eta^3 \tag{18}$$

$$E_{R3} = W_2 - W_3 = W_2 - W_2\eta \cdot = W_2 \cdot (1-\eta) = E_0 \cdot \eta^2 \cdot (1-\eta) \tag{19}$$

And so on…, yielding

$$W_i = W_{i-1} \cdot \eta = \cdot E_0 \cdot \eta \cdot \eta^{i'} = E_0 \cdot \eta^i \tag{20}$$

Generalising, the sequence of indefinite conversion steps yields

$$W_i = E_0 \cdot \eta^i \tag{21}$$

Estimating the Total Useful Work over Infinite Steps:

The total useful work W_{total} extracted over an **infinite sequence** is the sum of an **infinite geometric series**:

$$W_{TOTAL} = W_1 + W_2 + W_3 + \cdots + W_n = E_0 \cdot \eta + E_1 \cdot \eta + E_2 \cdot \eta + E_3 \cdot \eta + \cdots + E_n \cdot \eta =$$

$$= W_1 + W_2 + W_3 + \cdots + W_i = E_0 \cdot \eta + E_0 \cdot \eta^2 + E_0 \cdot \eta^3 \cdots + E_0 \cdot \eta^i = E_0 \sum_1^i \eta^i \tag{22}$$

Therefore, the total useful work W_{total} extracted over an infinite sequence of conversion steps is

$$W_{TOTAL} = E_0 \sum_0^i \eta^i \tag{23}$$

This is a geometric series with first term **a =E₀.r** and common ratio **r = η**.

Therefore, the sum of an infinite geometric series of the type

$a + a \cdot r + a \cdot r^2 + \cdots + a \cdot r^i$ on an infinite geometric series is given as

$$a + a \cdot r + a \cdot r^2 + \cdots + a \cdot r^\infty \to a \cdot \sum_1^\infty \eta^\infty = \frac{a}{1-r} \tag{24}$$

provided **|r| < 1**, (which is true since **0 < η < 1**).

Thus:

$$IF \left[a + a \cdot r + a \cdot r^2 + \cdots + a \cdot r^i \to \frac{a}{1-r} \right]$$

$$THEN \left[E_0 \cdot r + E_0 \cdot r^2 + E_0 \cdot r^3 + \cdots + E_0 \cdot r^i \to \frac{E_0 \cdot r}{1-r} \right] \tag{25}$$

Consequently, the total useful work W_{total} extracted over an infinite sequence is the sum of an infinite geometric series is:

$$W_{TOTAL} = \frac{E_0 \cdot r}{1-r} = \frac{E_0 \cdot \eta}{1-\eta} \tag{26}$$

Let's evaluate the effects of the efficiency on the total work. Thus, taking limits follows that:

$$\underset{\eta \to 1}{Limit} [W_{TOTAL}] = \underset{\eta \to 1}{Limit} [\frac{E_0 \cdot \eta}{1-\eta}] \to \infty \tag{27}$$

The function defining total useful work clearly tends toward infinity as the total thermal efficiency involved in all conversion steps approaches unity. However, if the efficiency tends toward zero, the total work follows the trend of the current efficiency.

The same reasoning and consequently the same procedure can be applied to determine the total heat rejected in an infinite sequence of conversion processes:

$$E_{RTOTAL} = W_{TOTAL} \cdot (1-\eta) = \frac{E_0 \cdot \eta}{1-\eta} \cdot (1-\eta) = E_0 \cdot \eta = W_1 \quad (28)$$

According to Eq. (28) the total rejected heat is equal to the useful work delivered in the first conversion step.

$$E_{RTOTAL} = E_0 \cdot \eta = W_1 \quad (29)$$

From (11) and (12) follows that

$$E_0 - E_{R1} = W_1 = E_0 \cdot \eta \quad (30)$$

From (29) and (30) follows that

$$E_{RTOTAL} = E_0 - E_{R1} = W_1 \quad (31)$$

$$W_{TOTAL} + E_{RTOTAL} = \frac{E_0 \cdot \eta}{1-\eta} + W_1 = \frac{E_0 \cdot \eta}{1-\eta} + E_0 \cdot \eta =$$

$$= \frac{W_1}{1-\eta} + W_1 = W_1(\frac{1}{1-\eta} + 1) = W_1(\frac{2-\eta}{1-\eta}) \quad (32)$$

The influence of the efficiency on the total energy involved (work and rejected heat is achieved taking limits, so that: follows that:

$$\underset{\eta \to 1}{Limit}\,[W_{TOTAL} + E_{RTOTAL}] = \underset{\eta \to 1}{Limit}\,[W_1 \frac{2-\eta}{1-\eta}] \to \infty \quad (33)$$

The total useful energy (heat and work) as function of efficiency clearly tends toward infinity as the total thermal efficiency involved in all conversion steps approaches unity. If the efficiency tends toward zero, the total work follows the trend of the current efficiency. Thus, function clearly tends to infinity as the total thermal efficiency involved of conversion steps approaches unity.

Interpretation of the consequences:

1 The total useful work obtainable with a constant value of the conversion efficiency less that unity over an infinite sequence of conversion steps is finite, given by $W_{total} = \frac{E_0 \cdot \eta}{1-\eta}$ (34)

2 This is because each step recovers only a fraction **η** of the previous step's output, leading to diminishing returns in an amount of **(1—η).**

3 The system never fully "runs out" of energy to convert (since the sequence is infinite), but the total recoverable work is bounded.

Example:

If η = 0.5 (50% efficiency) and E_0=1 unit: Then, W_{TOTAL} = 0.5×1/(1-0.5) = 0.5/0.5 = 1 unit.

So, the total useful work is equal to the initial energy (but extracted over infinite steps).

Therefore, for **η > 0.5**, $\mathbf{W_{TOTAL} > E_0}$, and for **η < 0.5**, $\mathbf{W_{TOTAL} < E_0}$ (35)

This means that

IF η < 0.5 THEN $\frac{E_0 \cdot \eta}{1-\eta} < E_0$ and, IF η > 0.5 THEN $\frac{E_0 \cdot \eta}{1-\eta} > E_0$ (36)

on the contrary,

IF η < 0.5 THEN $\frac{E_0 \cdot \eta}{1-\eta} < E_0$ (37)

In an unlimited sequence of energy conversion processes with efficiency *η* per step, the total useful mechanical energy obtainable from an initial energy E_0 is:

$W_{TOTAL} = \eta . E_0/(1-\eta)$

This is a finite amount determined by the efficiency of each conversion step.

To verify the meaning of the above example lets illustrate the example in Fig. 12:

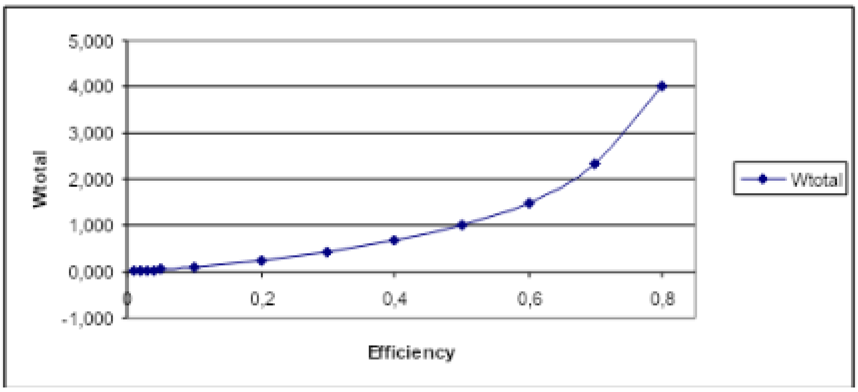


Figure 12: Illustration of the previous example showing that the nominal amount of input energy (unit E_0) as a function of efficiency can vary from zero to a value greater than E_0

It is observer in Fig. 12 that when efficiency equals the value of 0.5, then total work equals the unity. However as efficiency increases the total work increases dramatically, so that for an efficiency of 0.8, the total work is 4 while the amount of initial energy is a unit.

It can be seen in Fig. 12 that as per empirical evidence, the total energy (heat and work) exceeds the initial heat energy added to the system. Therefore, is energy conserved according to these results?

A form of infinitesimal fractions of non-useful energy is conserved. However, as per daily observational evidence, useful work is not conserved at all. The ability to perform useful work has disappeared. This implies that the possibility of perform any heat-work interaction disappeared.

Is it correct to define useless energy as "energy" if it lacks the ability to transform or cause physical changes, which is the fundamental pillar of the definition of "energy"?. It appears that the principle of conservation of energy de facto violates the second principle with respect to the behaviour of real systems, which are inherently affected by dissipative components and are therefore all irreversible.

Summarizing the main physical implications:

1 Even with an infinite number of steps, the total useful work is limited by the efficiency of each step.

2 The system cannot extract infinite work from a finite initial energy because of the dissipative losses at each step.

3 This aligns with the SLT: energy cannot be converted entirely to work in a cyclic or repeated process.

4 If the energy generated under given conditions cannot be completely converted into work in a cyclical or repeated process, is the fraction of energy that could not be converted annihilated energy? Can such lost or destroyed energy be counted as useful energy, given that it has the following characteristics?

For any physical magnitude lack of a difference or potential (Δρ) such that $0 < |\Delta\rho| <$ lowest usefulness limit:

Lack the ability to do useful work

Lack the ability for being manipulated

Lack the ability to be converted

Lack the capacity to do changes in any physical magnitude

Lack capacity to be measured or observed experimentally direct

Lack of its evidence of existence since cannot be directly measured or accounted.

As an irrefutable example let's observe the final state of the more than 99.99% of the radiated energy from all stars of the known cosmos, loss its capacity to do changes on the baryonic matter at the deep space under a temperature lower that the local value, e.g., about 2 K. This fact in real terms means that lost the ability to changes or useful work anymore, because tends to zero.

Any concept of energy that exhibits all these characteristics can be called by different names, except useful energy, because it doesn't exist. However, there is a concept of lost energy, non-recoverable energy, which confirms the lack of conservation ability to do changes on baryonic matter.

6 General Conclusion

This paper presents a groundbreaking advancement in thermodynamics by introducing a **SSPM** capable of operating without an external heat source or heat sink. The proposed machine functions as a **HIS**, challenging conventional thermodynamic principles, particularly the **FLT and SLT**. Achieving such milestones and contributions has required challenging the foundations of physics, particularly everything related to energy. Therefore, the key findings and contributions include:

Inconsistence exhibited by the FLT: The SSPM demonstrates that **contraction-based mechanical work (pull forces)** violates the traditional energy conservation principle. With regard to experimental evidence (e.g., Papin and Newcomen's engines) shows that **useful work can be performed while increasing internal energy**, contradicting the FLT as formulated by Carnot in his energy balance based only in expansion and compression works and later Clausius.

Existence of Hybrid Isolated Systems (HIS): The SSPM operates as a **partially isolated system**, emitting energy beyond its boundaries while remaining independent of external energy inputs. This challenges the conventional definition of isolated systems in thermodynamics. In fact, rigorously, Isolated systems are impossible since the fields interacting with closed and isolated systems exists everywhere.

Inconsistence exhibited by the SLT: The SSPM **does not require an external heat source or sink**, defying the Kelvin-Planck and Clausius statements. Furthermore, by combining a RBC-based heat pump with a SSPM composed by a set of cascaded power units (PUs) characterized by doing useful work by expansion and contraction, the system recycles heat internally, eliminating the need for external thermal reservoirs.

Prototype Validation: A CC-based prototype integrating an RBC and SSPM was evaluated using **helium and air** as working fluids. Results of a case study showed net work outputs of **617.4 kJ (air)** and **1092.8 kJ (helium)**, proving the feasibility of self-sustaining operation.

The theoretical and practical Implications undergo the following considered topics:

-- Reinterpretation of Thermodynamics: The findings necessitate revising the FLT and SLT to account for **pull forces, contraction work, and hybrid isolated systems**.

-- Energy Independence: The SSPM enables **autonomous power generation** without fuel or external heat exchange, with applications in extreme environments (e.g., deep space, radiation zones).

Future research: Further empirical validation, along with a broader scientific discourse, is required to integrate these findings into mainstream thermodynamics. Finally, it is noteworthy that this work seeks a paradigm shift in thermodynamics, urging the scientific community to reconsider fundamental principles in light of empirical evidence. The SSPM represents a disruptive innovation with the potential to revolutionize energy systems by enabling self-sustaining and perpetual operation without traditional thermodynamic constraints.

References

1. DenisPapin,British physicist, Encyclopedia Britannica, https://www.britannica.com/biography/Denis-Papin
2. Wikipedia. Denis Papin, https://en.wikipedia.org/wiki/Denis_Papin.
3. Wikipedia. Thomas Newcomen. https://en.wikipedia.org/wiki/Thomas_Newcomen

4. Ferreiro R. Ferreiro B. Isothermal and Adiabatic Expansion Based Trilateral Cycles. British Journal of Applied Science & Technology. 2015; (8) 5: 448-460. https://www.doi.org/10.9734/BJAST/2015/17350.

5. Ferreiro R. Ferreiro B. The Behavior of Some Working Fluids Applied on the Trilateral Cycles with Isothermal Controlled Expansion. British Journal of Applied Science & Technology. 2015; (9) 5: 694 450-463. https://www.doi.org/10.9734/BJAST/2015/18624.

6. Ramon Ferreiro Garcia, Jose Carbia Carril. Closed Processes Based Heat-Work Interactions Doing Useful Work by Adding and Releasing Heat. International Journal of Emerging Engineering Research and Technology. Volume 6. Issue 11. 2018. pp 8-23. ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online). Accessed at: https://www.ijeert.org/papers/v6-i11/2.pdf; https://www.ijeert.org/v6-i11.

7. Ramon Ferreiro Garcia, Jose Carbia Carril, Manuel Romero Gomez and Javier Romero Gomez. Energy and entropy analysis of closed adiabatic expansion based trilateral cycles. Energy Conversion and Management 119 (2016) 49–59. http://dx.doi.org/10.1016/j.enconman.2016.04.031.

8. Ramon Ferreiro Garcia. Reply to: Comment on "Energy and entropy analysis of closed adiabatic expansion based trilateral cycles" by Garcia et al. Energy Conversion and Management 119 (2016) 49–59. Energy Conversion and Management 123 (2016) 646–648. http://dx.doi.org/10.1016/j.enconman.2016.06.05.

9. Ramon Ferreiro Garcia, Jose Carbia Carril. Combined Cycle Consisting of Closed Processes Based Cycle Powered by A Reversible Heat Pump that Exceed Carnot Factor. Journal of Advances in Physics, Volume 15, (2018), Pages: 6078-6100. ISSN: 2347-3487. DOI: 10.24297/jap.v15i0.8034.

10. Ramon Ferreiro Garcia. Study of the disruptive design of a thermal power plant implemented by several power units coupled in cascade. Energy Technol. 2023, 2300362 (1-17). Published by Wiley-VCH GmbH. DOI: https://doi.org/10.1002/ente.202300362.

11. Ramón Ferreiro Garcia. Efficient disruptive power plant-based heat engines doing work by means of strictly isothermal closed processes. Journal of Advances in Physics Vol 22 (2024), p 30.53, ISSN: 2347-3487. https://rajpub.com/index.php/jap/article/view/9587. DOI: https://doi.org/10.24297/jap.v15i0.9587.

12. Ramón Ferreiro Garcia. Design study of a disruptive self-powered power plant prototype. Journal of Advances in Physics Vol 22 (2024), p 62.92, ISSN: 2347-3487. https://rajpub.com/index.php/jap/article/view/9596. DOI: https://doi.org/10.24297/jap.v22i.9596.

13. Ramón Ferreiro Garcia. Prototyping a Disruptive Self-Sustaining Power Plant enabled to overcome Perpetual Motion Machines. Journal of Advances in Physics Vol. 22 (2024), p 141.178, ISSN: 2347-3487. https://rajpub.com/index.php/jap/article/view/963. DOI: https://doi.org/10.24297/jap.v22i.9633.

14. Ramón Ferreiro Garcia. Prototyping Self-Sustaining Power Machines with Cascaded Power Units Composed by Pulse Gas Turbines. Journal of Advances in Physics Vol. 22 (2024), p 141.178, ISSN: 2347-3487. https://rajpub.com/index.php/jap/article/view/9648. DOI: https://doi.org/10.24297/jap.v22i.9648

15. E. W. Lemmon, M. L. Huber, M. O. McLinden, NIST Reference Fluid Thermodynamic And Transport Properties - REFPROP Version 8.0, User's Guide, NIST, Boulder, CO. 2007.

16. Ramón Ferreiro Garcia. Prototyping disruptive self-sufficiency power machines composed by cascaded power units based on thermo-hydraulic actuators. Journal of Advances in Physics Vol 22 (2024), p 141.178, ISSN: 2347-3487. https://rajpub.com/index.php/jap/article/view/9662. DOI: https://doi.org/10.24297/jap.v22i.9662.

17. Ramón Ferreiro Garcia. How to violate the first law of thermodynamics with an ASE of Papain and Newcomen before it was stated by Clausius. *JOURNAL OF ADVANCES IN PHYSICS*, *23*, 9–27. (2025) https://doi.org/10.24297/jap.v23i.9706

18. Ramon Ferreiro Garcia. Power Plants and Cycles: Advances and trends. Book (2020):

    ISBN: 9789390431595; DOI:10.9734/bpi/mono/978-93-90431-59-5.

    https://www.researchgate.net/publication/347635047_Power_Plants_and_Cycles_Advances_and_Trends.

19. Patent: Planta térmica con máquina de doble efecto, acumuladores térmicos, convección forzada y alimentación térmica reforzada con un ciclo Brayton inverso y procedimiento de operación. Thermal power plant with double-effect machine, thermal accumulators, forced convection and reinforced thermal supply with a reverse Brayton cycle and operating procedure. Ramon Ferreiro Garcia, Jose Carbia Carril. application number 201700667 and publication number 2 696 950 B2. Accessed at: https://consultas2.oepm.es/ceo/jsp/busqueda/busqRapida.xhtml;jsessionid=MDkG1OIa9BfQrxSiImwxtYlC.ConsultasC2.

20. Patent: Procedimiento de operación de una máquina alternativa de doble efecto con adición y extracción de calor y convección forzada. Operating procedure of a double-acting reciprocating machine with heat addition and extraction and forced convection and operating procedure. Jose Carbia Carril, Ramon Ferreiro Garcia, application number P201700718 and publication number 2 704 449 B2. Accessed at: https://consultas2.oepm.es/ceo/jsp/busqueda/busqRapida.xhtml;jsessionid=-wHy58sbfVYQutIYN8s0+JKK.ConsultasC1.

21. Patent: Planta termoeléctrica multiestructural policíclica y procedimientos de operación. Polycyclic multi-structure thermal power plant and operating procedures. Ramon Ferreiro Garcia, application number P202200035 and publication number 2 956 342 B2. Accessed at: https://consultas2.oepm.es/ceo/jsp/busqueda/busqRapida.xhtml;jsessionid=-wHy58sbfVYQutIYN8s0+JKK.ConsultasC1.