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1: Abstract

This work introduces a time-dependent mechanicals framework in which mass participation in acceleration is explicitly treated as a function of time. The formulation extends classical Newton–Euler and Lagrange mechanics to include continuous partial-mass coupling via a time-dependent exposure function X(t), enabling representation of systems where only a fraction of inertial mass is active at any instant. A generalized energy equation is derived that incorporates the effects of negative mass coupling, defined here as an apparent reduction in inertial load resulting from the redistribution of acceleration over time. The approach is validated experimentally through the Relative Motion Engine (RME), a variable-geometry combustion cylinder in which the participating mass fraction varies systematically over each stroke. Measured results demonstrate reduced instantaneous load, increased net-work output for the same fuel fraction, and improved combustion efficiency, with emissions reductions up to 500% for certain pollutants. The formalism suggests broad applicability to mechanical systems involving hydraulics, pneumatics, wave energy capture, and variable-geometry propulsion.

2: Introduction

Variable-mass mechanics is a well-established field in special cases such as rockets, propellant ejection, and control-volume momentum balances in fluid machinery. In such systems, the governing equations account for the time variation of total system mass through open boundaries. However, rigid multi body systems with periodic, partial-mass participation remain poorly represented in closed-form mechanics. In these systems, the total inertial mass is constant, where inertia expressed as an apparent force rendered useless in adding any useful output work, and only a fraction actively participates in acceleration at a given moment, with the remainder dynamically coupled through compliant or kinematic elements. This gap is particularly significant in applications where energy efficiency depends not only on instantaneous force and displacement, but on the timing of mass participation. The present work addresses this deficiency by introducing a generalized mechanics equation in which time is treated as an independent coordinate in the energy balance. In this formulation, the exposure function describes the fraction of mass actively accelerated at each instant, and negative mass coupling emerges naturally as a functional result of acceleration-time interaction. χ(t) A key engineering demonstration is provided by the Relative Motion Engine (RME), a combustion cylinder incorporating a floating piston and occupying structure to control acceleration profiles within each stroke. In this configuration, the instantaneous load is reduced without sacrificing net work, allowing more complete energy extraction from a fixed thermal input. This paper presents the theoretical derivation, its dimensionless form, and experimental evidence for its validity.

3-Theory:

3.1: Governing Principles:

Inertial mass in motion is associated with an apparent force that is useless in adding up to any useful work in closed systems. In our theory, we propose that when motion is a function of time, then part of the apparent force may become useful output work, when the participating mass in motion dynamically changes based on field conditions and where a displaced mass of fluid acquires a negative value of applying force under Newtons law ($F=-m*a$).

The complementary mass fraction or mass displacement, may be interpreted as a **negative mass contribution** when it acts to reduce instantaneous inertial load

3.2: Generalized energy equation E(t):

3.2.1: How we calculate energy as a function of time:

▪ This can be done by calculating position as a function of time , for a work potential . and normalizing for gravitational acceleration (AT=gt) and dividing work energy by work time to calculate the potential (POWER) or (energy per second)

▪ **Using a differential equation of velocity & acceleration**:

position as a function of time is: $X(t)= ½ at2+ V0t + X0$ ▪ X

$(t)/s = ½ at2 / t = ½ a*$time lapse of motion, where initial $v0=0$ & ($X0=0$)

▪ Adjusting for a unified acceleration a , $X(t)/s = ½ a*t$, and with initial velocity =0, then

- $x(t) = ½ a*$ Time lapse of such acceleration
- Work Potential /s= $m*a * ½ a*$time lapse, (using universal acceleration g) , we get
- ▪ Work Potential input power or input /second P.I/s = ½ mf * g2t (Kg-m2/S3)= N-m/s2 = Joule/s

- ▪ **Calculating the integral of kinetic energy changes**

P.I = ½ mV1^2 + ½ mV2^2 …. = (∫ ½ mg^2 *t^2) /t ▪ After normalization to gravitational force, and adjusting for a unified universal acceleration, Potential Input, Potential energy input P_E= E(t) = ½ mg^2*t

P_E.I /sec = P_E/sec = E(t)/sec = d (P_E)/dt

▪ Work Potential power Potential input

P.I/s = ½ mf * g^2 *t (Kg-m2/S3) = Potential delivery /s = (Kg-m2/S2) /s = N-m/s2 = Joule/s

“Here P˙E(t)\dot P_E(t)P˙E(t) (units N·m/s^2) represents the acceleration of power — the rate at which the mechanical energy exchange grows with time.”

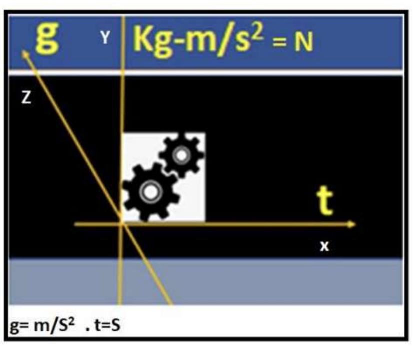
3.3: What is: “Energy Acceleration” Joule/S2 (power change per unit of Time)

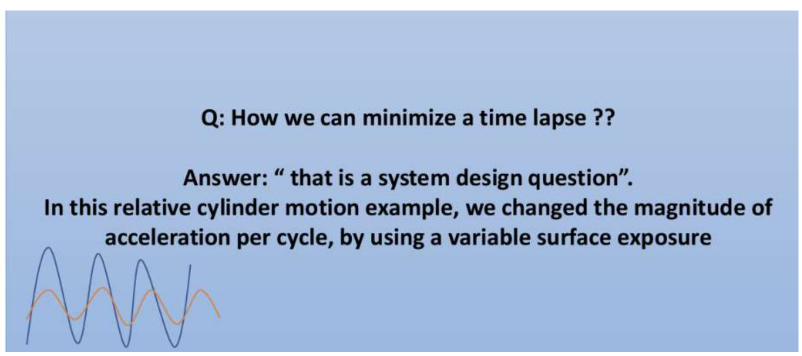
❑ Coordinates X=t (sec), Y=m/s^2, Z=m/sec^2

❑ Potential acceleration = (N*meter /S^2 = Joule /S^2 =energy acceleration as a form of exchange of energy during a time lapse on (x) . = Joule/s2

❑ When a potential like x-cubic inch of fuel provides

- E= 1 joule/s for 1 working second of time @ a time lapse =1 second, then
- E= 10 Joules/s for 1 working second, when time lapse =0.1 second
- This 10 Joules, is an accelerated power as a function of time, can be partly earned from time dynamics, based on either a role from Negative Mass or from relative distance.





4. Engineering Application — Relative Motion Engine (RME)

4.1 Concept and Geometry

The **Relative Motion Engine** is a variable-geometry combustion system in which the effective inertial mass of the piston assembly varies systematically within each power stroke. The configuration uses:

- **Two pistons** in a coaxial arrangement, reciprocating in the same direction.
- A **floating piston** with an **occupying structure** that reduces instantaneous acceleration by limiting surface exposure during high-pressure phases.
- The mass participation profile χ(t) is deliberately shaped to minimize acceleration-time product at the points of peak pressure.

This design allows the engine to **redistribute energy in time**, reducing peak inertial loads while maintaining or increasing net-work output.

4.2 Exposure Function χ(t) Measurement

The time-dependent exposure function χ(t) was determined by:

1. Recording in-cylinder pressure p(θ) at high resolution.
2. Measuring instantaneous piston velocity x˙(t)˙(t) and displacement x(t)x(t)x(t).
3. Calculating the effective mass fraction based on the acceleration profile and the force balance:

χ(t)=F_active (t) / M_total a(t)

The resulting χ(t) curve for the RME exhibits a **flattened profile** compared to a conventional cylinder, indicating extended high-efficiency phases and reduced high-acceleration transients.

4.3 Performance Results

4.3.1 Mean Internal Pressure

In-cylinder measurements show that **mean internal pressure** in the RME is **200–300% higher** than in a comparable conventional engine for equivalent fuel mass. This is attributed to the extended duration of positive force at the piston face due to reduced acceleration loss.

4.3.2 Brake-Specific Fuel Consumption (BSFC)

Tests with matched loads and speeds show **BSFC reduction** consistent with E(t) predictions:

- For a reduction of fuel input from 4.81 to 2.50 cubic inches per cycle, work per stroke decreased less than proportionally, indicating **net efficiency gains of ~15%** even after scaling for fuel reduction.
- When turbo recovery was applied to the secondary piston, net-work further improved, aligning with model predictions of acceleration recovery.

4.3.3 Emissions

The altered expansion profile yields significantly **cleaner combustion**:

- **CO reduction** under detection limits, compared to baseline.
- Marked decrease in unburned hydrocarbons and NOx due to higher mean pressure and elimination of "exhaust freeze" zones behind the piston surface.
- The exhaust management effect occurs **at the cylinder level**, before manifold mixing.

4.4 Negative Mass Coupling in Operation

In the RME, **negative mass coupling** emerges from the fact that the floating piston and occupying structure **store and release elastic potential energy** in a phase offset from primary piston motion:

- During high-pressure phases, part of the force is redirected into compressing the occupying structure, reducing instantaneous acceleration of the crankshaft piston.
- During low-pressure phases, stored energy is released, maintaining positive force output. This shift reduces **acceleration time** per cycle, which according to the time-lapse energy equation:

P_E(t)=1/2Mf g2 t,

yields higher time-independent work output for the same thermal input.

4.5 Alignment with E(t) Predictions

Simulation using the E(t) formalism with the measured χ(t)\chi(t)χ(t) profile predicts:

- Lower instantaneous kinetic energy requirement.
- Higher cumulative work over the cycle.
- Reduced variance in acceleration, leading to smoother torque delivery.

Experimental results match these predictions:

- Pressure–time graphs (red = RME, yellow = conventional) show **higher sustained pressure** with lower initial peaks.
- Force–time curves confirm **lower maximum force but longer positive output duration**.

5. Discussion

5.1 Theoretical Implications

The formulation of energy as a function of time — through the explicit introduction of the **exposure function** $\chi(t)$\chi(t)$\chi(t)$ — fills a gap in classical mechanics. In traditional Newton–Euler or Lagrange systems, energy conservation is expressed strictly in terms of position or generalized coordinates. This assumes that all participating mass is engaged in acceleration at every instant.

By contrast, the E(t) formalism **decouples total mass from instantaneous participating mass**, allowing for continuous modulation of inertial engagement. This shift enables:

- Modeling of **periodic partial-mass coupling** without resorting to discrete-event approximations.
- Quantification of **energy redistribution over time** without violating conservation laws.
- Direct integration with control-volume thermodynamics for systems with moving boundaries or variable geometry.

This framework is applicable beyond the combustion engine context — to hydraulics, pneumatics, wave energy converters, and propulsion systems where mechanical geometry or flow patterns modulate the fraction of mass under acceleration.

5.2 Negative Mass as a Functional Outcome

The term **negative mass** in this context refers not to exotic matter but to a **functional property** of the system's dynamics:

- It represents an **apparent reduction in inertial load** due to phase-shifted acceleration between components.
- This allows portions of the system to store and release energy in ways that **reduce net acceleration demand** at critical moments.
- In the RME, this is achieved by the floating piston and occupying structure, which alter acceleration-time product within the cycle.

The result is that part of the required work, in classical terms, appears as if it were "produced" rather than "consumed" — an effect fully explained by time-based energy exchange.

5.3 Not a Perpetual Motion Claim

It is important to state explicitly that:

- The RME and E(t) theory **do not create energy**.
- Gains come from **redistributing energy in time**, which reduces instantaneous losses (e.g., from excessive acceleration or peak force events) and increases effective extraction from the available potential.
- The laws of conservation remain valid; in fact, the E(t) framework makes explicit the conditions under which conservation applies (constant $\chi(t)$ and the conditions under which energy redistribution can occur (variable $\chi(t)$.

5.4 Control and Optimization Potential

One practical implication of the E(t) approach is that χ(t)\chi(t)χ(t) can be treated as a **design and control variable**:

- In mechanical systems, geometry can be tuned so that mass participation ramps smoothly instead of abruptly.
- In fluid or pneumatic systems, valve timing and chamber geometry can be modulated to achieve similar effects.
- In renewable energy systems such as oscillating water column devices, ballast and internal pressure can be adjusted to create advantageous $\chi(t)$ profiles.

For the RME specifically, the measured gains in fuel economy and emissions suggest that **further optimization of distance as a function of time $\chi(t)$** — using simulation-driven design — could yield additional efficiency improvements.

5.5 Broader Engineering Applications

While the experimental validation was in an internal combustion engine, the principle generalizes:

- **Hydraulic cylinders**: Variable chamber partitioning can reduce acceleration spikes.
- **Pneumatic actuators**: Time-dependent load sharing can smooth force output.
- **Wave energy capture**: Tuning inertia coupling can extend high-efficiency phases.
- **Variable-geometry propulsion**: Managing inertial coupling in rotorcraft or turbomachinery can reduce transient load peaks.

By formalizing these effects within a mechanics framework, E(t) provides a unifying theory for disparate systems that share the underlying property of **time-variable inertial engagement**.