LEGION INTENSIVE CYCLE ENGINE

PULSE-DETONATION THERMODYNAMIC SYSTEM FOR SUSTAINABLE ENERGY

(LEGION INTENSIV SIKL DVIGATELI: BARQAROR ENERGIYA UCHUN IMPULSLI PORTLASH TERMODINAMIK TIZIMI)

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Abstract

[ENG] This paper presents the updated architecture of the **Legion Intensive Cycle Engine (LEGION)**. The system utilizes a "Twin-Flow" mechanism powered by controlled Hydrogen-Oxygen ($H_2 + O_2$) detonation within a Tantalum-Hafnium Carbide (Ta_4HfC_5) core. A key innovation is the management of **Thermal Dissociation** at $3200°C$, where the working fluid splits into a high-velocity mixture of steam (85%) and reactive gases (15%). By employing a high-frequency "Heartbeat" loop and Flash-Electrolysis (SOEC), the system prevents material thermal shock and achieves immediate fuel regeneration, creating a Quasi-Steady State resonance loop.

[UZB] Ushbu maqola **Legion Intensiv Sikl Dvigateli (LEGION)** ning yangilangan arxitekturasini taqdim etadi. Tizim Tantal-Hafniy Karbidi (Ta_4HfC_5) yadrosi ichidagi boshqariladigan Vodorod-Kislorod ($H_2 + O_2$) portlashi bilan quvvatlanadigan "Qo'sh Oqim" (Twin-Flow) mexanizmidan foydalanadi. Asosiy innovatsiya — bu $3200°C$ da sodir bo'ladigan **Termal Dissotsiatsiya** jarayonini boshqarishdir, bunda ishchi suyuqlik bug' (85%) va reaktiv gazlar (15%) aralashmasiga ajraladi. Yuqori chastotali "Yurak urishi" (Heartbeat) halqasi va Tezkor Elektroliz (SOEC) dan foydalangan holda, tizim materialning termal shokiga uchrashini oldini oladi va yoqilg'ini zudlik bilan qayta tiklab, Kvazi-Barqaror rezonans halqasini hosil qiladi.

1 INTRODUCTION

KIRISH

[ENG] The global energy sector requires solutions that combine the high energy density of combustion with the sustainability of renewables. The **Legion Intensive Cycle** proposes a mechanical-thermodynamic solution: using the explosive power of hydrogen in a controlled, pulsed manner within a refractory ceramic chamber. This approach eliminates the need for fossil fuels by recycling the working fluid (H_2O) in a continuous, AI-regulated loop.

[UZB] Global energetika sektori yonishning yuqori energiya zichligini qayta tiklanuvchi manbalarning barqarorligi bilan birlashtiradigan yechimlarni talab qiladi. **Legion Intensiv Sikli** mexanik-termodinamik yechimni taklif qiladi: vodorodning portlash kuchidan o'tga chidamli keramika kamerasida boshqariladigan, impulsli tarzda foydalanish. Ushbu yondashuv ishchi suyuqlikni (H_2O) uzluksiz, AI tomonidan boshqariladigan halqada qayta ishlash orqali qazilma yoqilg'ilarga bo'lgan ehtiyojni yo'qotadi.

2 SYSTEM ARCHITECTURE

TIZIM ARXITEKTURASI

2.1 The Core & Thermal Dissociation

Yadro va Termal Dissotsiatsiya

[ENG] The core is constructed from Ta_4HfC_5 (Melting point $\approx 4000^\circ C$) and lined with Boron Nitride thermal dampers. The fundamental reaction logic accounts for thermal dissociation:

$$H_2 + 0.5O_2 \rightarrow H_2O + 3200^\circ C \rightarrow H_2O(85\%) + H_2(15\%) + O_2(15\%) + 2750^\circ C \quad (1)$$

The initial detonation hits $3200^\circ C$, but due to thermal dissociation, the temperature stabilizes at an operational $2750^\circ C$. The unburnt 15% gas mixture is utilized as kinetic potential energy.

[UZB] Yadro Ta_4HfC_5 materialidan (Erish nuqtasi $\approx 4000^\circ C$) yasalgan va Boron Nitridi termal amortizatorlari bilan qoplangan. Asosiy reaksiya mantiqi termal dissotsiatsiyani hisobga oladi:

$$H_2 + 0.5O_2 \rightarrow H_2O + 3200^\circ C \rightarrow H_2O(85\%) + H_2(15\%) + O_2(15\%) + 2750^\circ C \quad (2)$$

Dastlabki portlash $3200^\circ C$ ga yetadi, ammo termal dissotsiatsiya tufayli harorat operatsion $2750^\circ C$ da barqarorlashadi. Yonmagan 15% gaz aralashmasi kinetik potensial energiya sifatida ishlatiladi.

2.2 Twin-Flow Mechanism

Qo'sh Oqim Mexanizmi

[ENG] The explosion energy is harvested via two simultaneous pathways (The 2x Process):

- **Internal Flow (Kinetic):** The exhaust mixture (85% steam + 15% dissociated gas) exits the core at supersonic speeds. Inside the **Secondary Turbine**, as pressure drops, the 15% $H_2 + O_2$ recombines (afterburning effect), releasing additional heat and thrust.
- **External Flow (Thermal):** A 360° Water Jacket surrounds the core. The immense heat ($2750^\circ C$) transfers through the core walls, instantly flashing the jacket water into high-pressure superheated steam to drive the **Primary Turbine**.

[UZB] Portlash energiyasi ikki bir vaqtda sodir bo'luvchi yo'l orqali yig'ib olinadi (2x Jarayon):

- **Ichki Oqim (Kinetik):** Chiqindi aralashmasi (85% bug' + 15% dissotsiatsiyalangan gaz) yadrodan tovushdan tez tezlikda chiqadi. **Ikkilamchi Turbina** ichida bosim tushishi bilan, 15% $H_2 + O_2$ qayta birikadi (forsaj effekti) va qo'shimcha issiqlik hamda impuls chiqaradi.
- **Tashqi Oqim (Termal):** 360° Suv Qozoni yadroni o'rab turadi. Katta issiqlik ($2750^\circ C$) yadro devorlari orqali o'tib, qozondagi suvni bir zumda yuqori bosimli o'tkir bug'ga aylantiradi va bu **Birlamchi Turbina**ni harakatga keltiradi.

3 ADVANCED REGENERATION LOGIC

ILG'OR REGENERATSIYA MANTIQI

3.1 Flash-Regeneration Loop

Tezkor Qayta Tiklash Halqasi

[ENG] Unlike traditional systems, the **Legion Engine** uses **Solid Oxide Electrolyzer Cells (SOEC)**. The high-temperature exhaust steam ($> 800^\circ C$) is fed directly into the electrolyzer. Since the water is already hot vapor, electrolysis requires significantly less energy. The 85% steam is split back into H_2 and O_2 within milliseconds and immediately re-injected into the core.

[UZB] An'anaviy tizimlardan farqli o'laroq, **Legion Dvigateli Qattiq Oksidli Elektroliz (SOEC)** dan foydalanadi. Yuqori haroratli chiqindi bug' ($> 800°C$) to'g'ridan-to'g'ri elektrolizerga uzatiladi. Suv allaqachon qaynoq bug' holatida bo'lgani uchun, elektroliz sezilarli darajada kam energiya talab qiladi. 85% bug' millisekundlar ichida qayta H_2 va O_2 ga ajratiladi va darhol yadroga purkaladi.

3.2 Pulse Frequency & Material Safety
Impuls Chastotasi va Material Xavfsizligi

[ENG] To prevent the brittle ceramic core from cracking due to **Thermal Shock**, the system employs a **High-Frequency Resonance** strategy. The fuel injection and detonation occur so rapidly ($100+$ Hz) that the core wall never cools down. This maintains the material in a thermally expanded "Quasi-Steady State" at $\approx 2700°C$, eliminating dangerous expansion/contraction cycles.

[UZB] Mo'rt keramik yadroning **Termal Shok** tufayli yorilib ketishining oldini olish uchun tizim **Yuqori Chastotali Rezonans** strategiyasini qo'llaydi. Yoqilg'i purkash va portlash shunchalik tez sodir bo'ladiki ($100+$ Gs), yadro devori sovishga ulgurmaydi. Bu materialni $\approx 2700°C$ da termal kengaygan "Kvazi-Barqaror Holat"da ushlab turadi va xavfli kengayish/qisqarish sikllarini yo'q qiladi.

4 MATHEMATICAL MODEL
MATEMATIK MODEL

[ENG] The total Energy Output (E_{total}) is defined as:

$$E_{total} = E_{kinetic}(Flow1) + E_{thermal}(Flow2) + E_{recombination}(15\%) \tag{3}$$

The AI regulates the frequency (f) to match heat transfer rates, ensuring structural integrity:

$$f_{target} \approx \frac{Q_{loss}}{m \cdot c_p \cdot \Delta T_{allowable}} \tag{4}$$

[UZB] Umumiy Energiya Chiqishi (E_{total}) quyidagicha aniqlanadi:

$$E_{total} = E_{kinetic}(Oqim1) + E_{thermal}(Oqim2) + E_{recombination}(15\%) \tag{5}$$

AI strukturaviy butunlikni ta'minlash uchun chastotani (f) issiqlik uzatish tezligiga moslashtiradi:

$$f_{target} \approx \frac{Q_{loss}}{m \cdot c_p \cdot \Delta T_{allowable}} \tag{6}$$

5 CONCLUSION
XULOSA

[ENG] The updated **Legion Engine** architecture transforms the disadvantage of thermal dissociation into an advantage. By utilizing a Twin-Flow 2x Process, the system captures energy both kinetically and thermally. The Immediate Flash Regeneration strategy ensures a closed-loop fuel cycle, effectively operating as a high-efficiency thermodynamic resonance engine.

[UZB] Yangilangan **Legion Dvigateli** arxitekturasi termal dissotsiatsiya kamchiligini ustunlikka aylantiradi. Qo'sh Oqim 2x Jarayoni yordamida tizim energiyani ham kinetik, ham termal jihatdan qamrab oladi. Zudlik bilan Tezkor Regeneratsiya strategiyasi yopiq konturli yoqilg'i siklini ta'minlaydi va tizimni yuqori samarali termodinamik rezonans dvigateli sifatida ishlatadi.