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Payloadproject.com

Process Concept

Process concept for engines (e.g. rockets), air-breathing propulsion systems (turbojet, ramjet, scramjet, dual-mode pulsejet) turbopumps or nozzles (bell nozzles, aerospikes) to increase performance, service life and reduce energy losses (performance concept)

Content: **Sheet**

State of the art 2021 - Rocket launches from earth with chem. Rockets

economic:

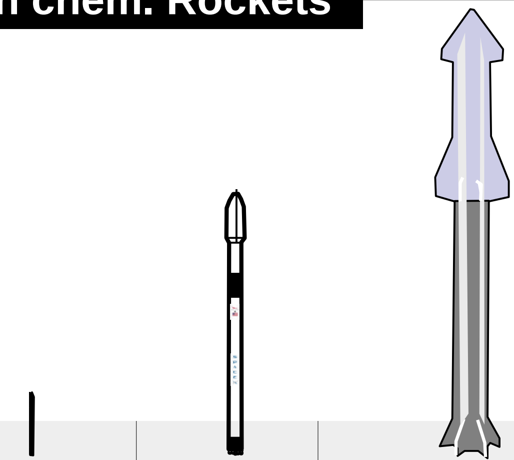
→ **Radical innovations necessary to keep up the pace of development and remain competitive**

technical:

→ **Payload share still limited!**

approx. 1-4% payload for Low Earth Orbit (LEO) - low earth orbit

for smaller rockets tends to be lower



Type	Electron (Rocket Lab)	Falcon 9 (SpaceEx)	planned Starship (SpaceEx)
Propellant	LOX, RP1	LOX, RP1	LOX, Methan
Take-off mass [t]	13	541	5.000
Payload LEO [t]	0,3	23	>100
Payload LEO [%]	**2,3**	**4,2**	**ca. 2,0**
Cost [US $ million]	7	62	2
spec. cost [$/kg]	**23.333**	**2.719**	**20 (Target: complete recycling)**

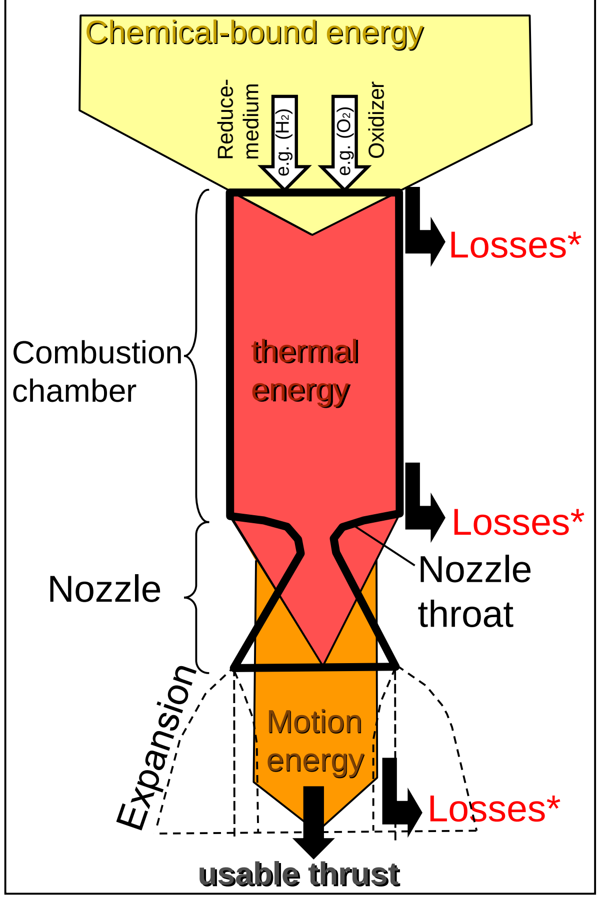
➔ **Goal of Lastprojekt.de: more payload share for rockets**

Multiple energy conversions

→ lossy (approx. 40-70% usable thrust[1])

[1] Source: Ernst Messerschmid et al: Raumfahrtsysteme; 4. Auflage, 2011, ISBN 978-3-642-12816-5

Energy model / scheme



Speed of chem. Conversion limited*
(chemical to thermal/motion energy)

Principle of thermo-chemistry

higher combustion chamber temperature
➔ higher exit velocity

➔ but*:

simultaneously increases:
cooling, heat losses/ aggressiveness of the reaction

simultaneously decreases: Strength/ life Materials

Nozzle adapted to specific external pressure ➔ but varies with height above zero*.

*** Conclusion: Alternatives to Thermo-Chemistry are advantageous**

Ignition in general (laminar / turbulent)

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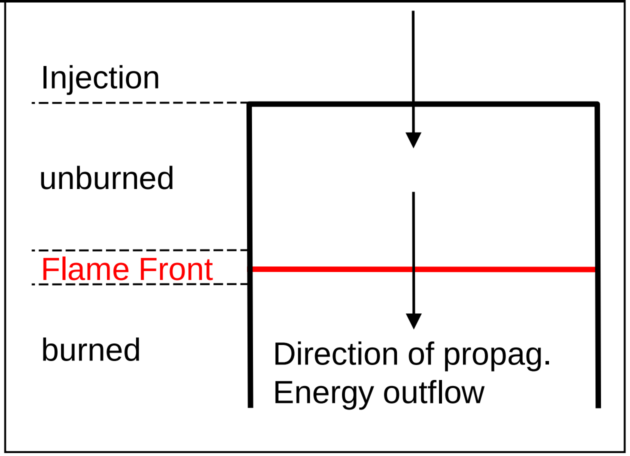
Dependent on numerous factors (injection rate, pressure, combustion speed and size of ignition range).

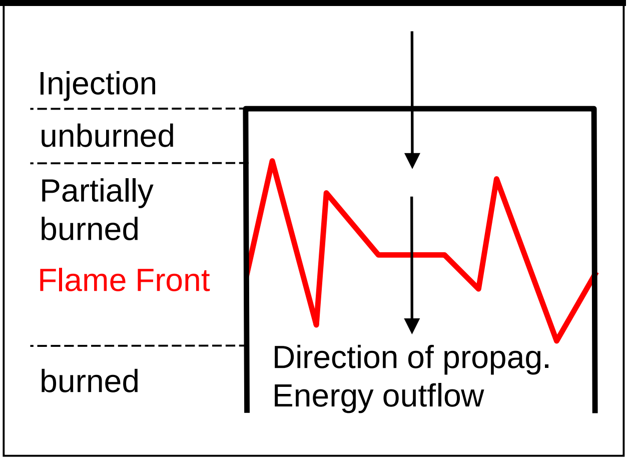
laminar combustion in comb. chamber



Properties:

- uniform conversion of chemical to thermal energy
- ideal for thermal power plants
- due to preceding pressure waves and their reflection
- or possible extinction with trailing combustion, however, can result in a high proportion of internal friction (rather disadvantageous) → more heat
- **Conclusion: not necessarily for drives**
  can have a disadvantageous effect

turbulent comb. in combustion chamber

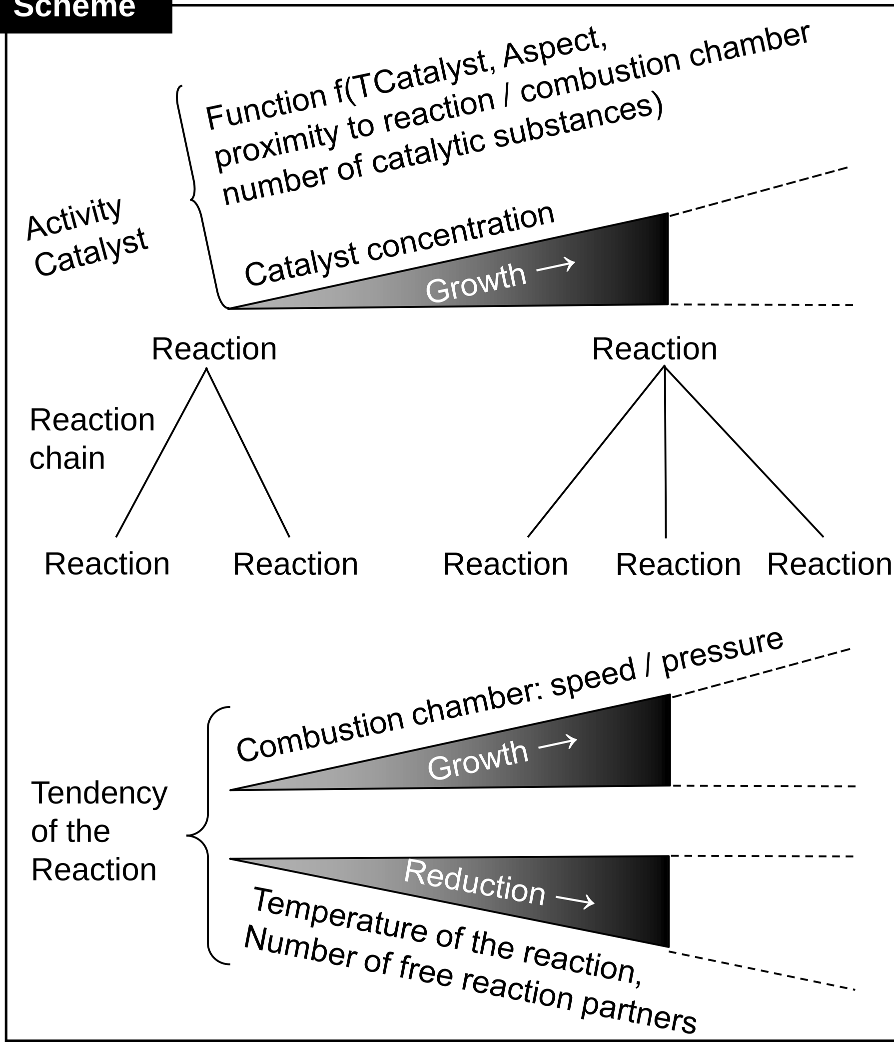


Properties:

- requires larger ignition range and higher comb. speed
- is partly aimed at in the automotive sector (discont. systems) due to better conversion of chemical into
- kinetic energy with closed combustion chamber
- Pressure surges should remain limited to avoid engine damage
- Conclusion: modified change of state
  for propulsion systems partly advantageous

Activity → conversion rate / effectiveness

Scheme



Major factors influencing activity:

higher application temperature = higher activity

→ **Use in combustion chamber advantageous**

if necessary, targeted excitation with electromagnetism

Use of different catalysts

Very economical with high activity

with homogeneous catalysts: often proportions of millionths (mg/kg) or billionths parts (µg/kg) in fuel sufficient for high effects

For heterogeneous catalysts, in some cases layer thicknesses <1 µm are already sufficient

therefore also the use of precious metals is very useful (e.g. platinum, platinum metals or gold)

→ **e.g. motor vehicle consumption reduced by approx. 12 to 48** (patent specification DE 600 16 706 T2)

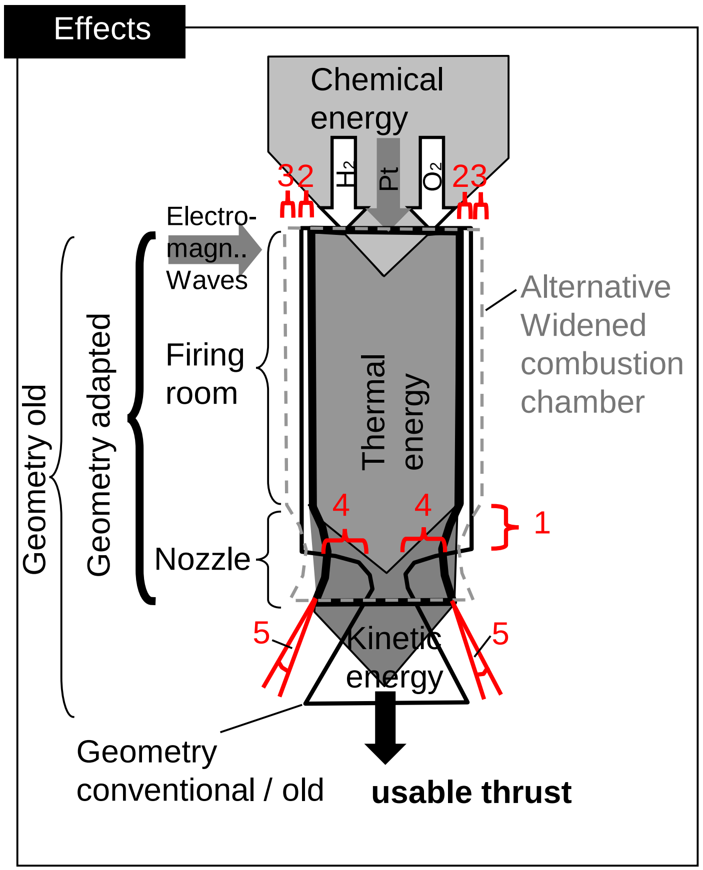
→ **homogeneous catalyst only approx. 0,01 €/l fuel in the example 1,5 €/lfuel -> up to 0,71 €/lfuel saved**

→ **in aerospace potential high - reduction fuel mass → less to accelerate**

Alternatively, however, base catalysts such as iron with higher loads - which serve as absorbers for electromagnetic waves (e.g. for microwaves)

Limitation of thermal + kinematic losses approx. 30-60% of applied chemical power [1]

[1] Source: Ernst Messerschmid et al: Raumfahrtsysteme; 4. Auflage, 2011, ISBN 978-3-642-12816-5



Effects when adapting the combustion chamber according to the performance concept:

1. shortening of combustion chamber possible
- → due to accelerated reaction
- → less friction in combustion chamber

2. optional reduction of combustion chamber possible
- → due to accelerated reaction
- → less friction in combustion chamber

3. alternative enlargement of combustion chamber possible
- → due to improved / more reliable reaction
- → energetically advantageous
- → fewer individual engines

4. reduction constriction of nozzle throat possible
- → due to lower combustion chamber temperature
- → reduction of lossy thermodyn. change of state.
- → reduction of radial acceleration / more net thrust.

5. reduction of nozzle inclination (if necessary nozzle length)
- → due to lower combustion chamber temperature
- → reduction of divergence / more net thrust

→ lower specific power-to-weight ratio / engine mass

→ in the ideal case: tubular / conical combustion chamber possible

Alternative to thermochemistry
Goal: Limitation of losses

DIRECT INFLUENCE:

physical-chemical measures

- Catalysts - e.g. platinum
  (variable load and composition)
- additional load of catalysts above the level for "complete" reaction, e.g. to further minimize temperature or to further maximize reaction rate

- Electromagnetic waves
  (for ignition, stimulation and alignment during combustion).

→ Supply e.g. via Generators at turbopump, at engine or via thermocouples

- metallic additives (e.g. iron compounds) - also as absorbers
- thermodynamic changes of state, e.g. by adjusting combustion kinetics between laminar / partially turbulent

EFFECTS ENGINE:

Reduction of combustion chamber temperature

→ +acceleration of reaction/exit velocity:

adaptation of combustion chamber,

constriction of nozzle

→ **Use of simpler and less expensive materials**

Control of thermodynamic processes

(e.g. adaptation of outlet pressure to variable external pressure in vertical starts)

further technological basis for

→ **improved feasibility of advanced nozzle concepts (e.g. aerospikes)**

→ **effective use of air-breathing propulsion systems (e.g. ramjets, possibly scramjets)**

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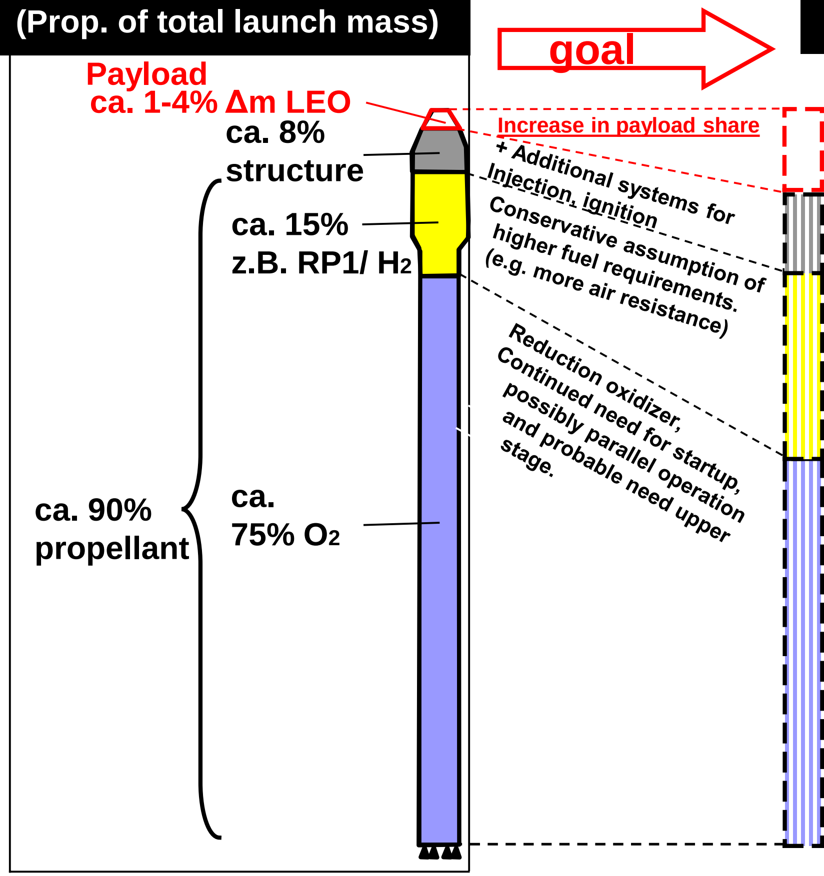
Goal: Alternative to thermo-chemistry

ACTUAL vertical takeoff (Prop. of total launch mass)



targeted advantages:

- **lower combustion temperature**
- **higher combustion speed**
- **optimization/ control of combustion kinetics**
- for air-breathing engines better burnout and lower consumption
- **optimization of combustion chamber / nozzle**
- **larger engines possible (additionally energetically advantageous)**