

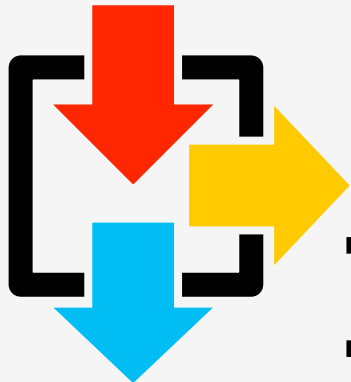
Fuel-Air Hybrid Engine

(Discrete Structured Engine)

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Engine Expo 2012

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Kanslab

Agenda

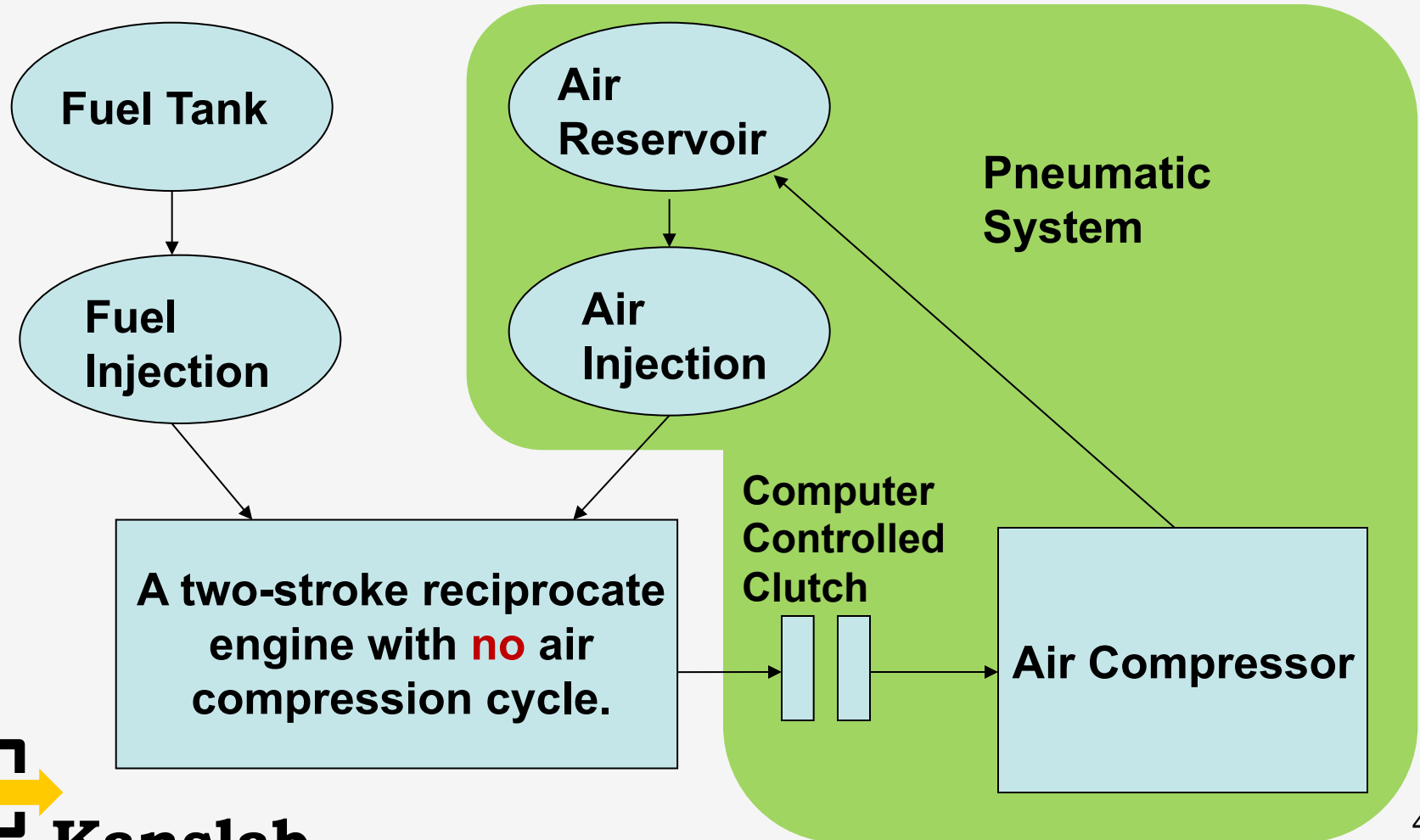
- 1. Shortcoming of traditional engines**
- 2. What is a Fuel-Air Hybrid Engine?**
- 3. Why discrete structure?**
- 4. Benefits of Fuel-Air Hybrid Engine**
- 5. Applications**
- 6. Q & A**

Shortcoming of traditional engines

- **Traditional engines are reliable mechanical state machines, but are not optimized for thermodynamics and power efficiency.**
 - **Thermodynamics inefficiency due to congregating four thermal cycles into one cylinder.**
 - **Power inefficiency due to synchronous operation.**

What is a Fuel-Air Hybrid Engine?

A **clean** two-stroke engine that uses a **dedicated** pneumatic system to supply air for combustion.

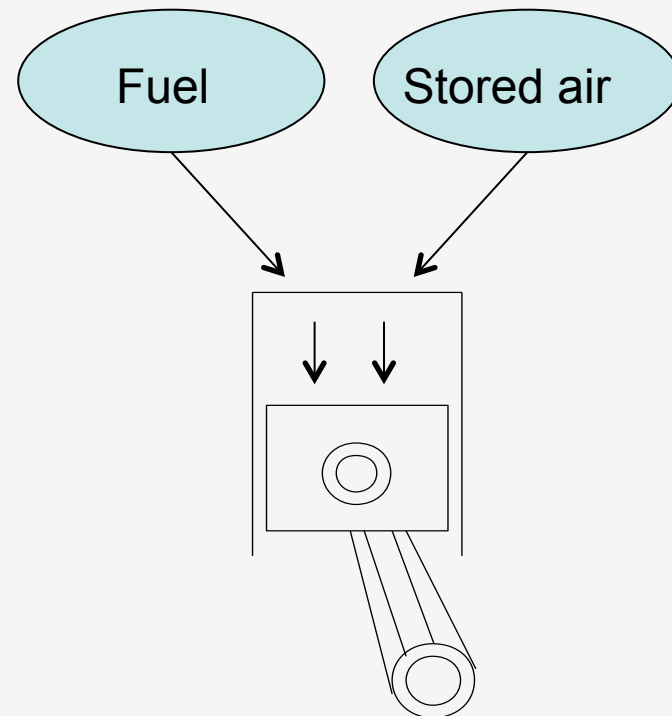
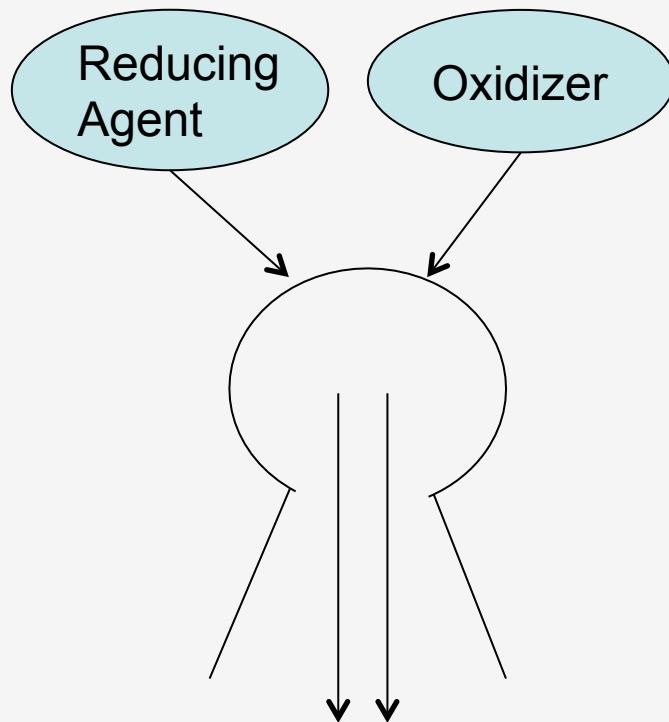


Why discrete structure?

- Independent air compression and gas expansion units for optimal efficiency.
- Dedicated air injection for complete fuel combustion.
- Air compressor can be off-loaded from the engine during power spike period (hybrid mode).

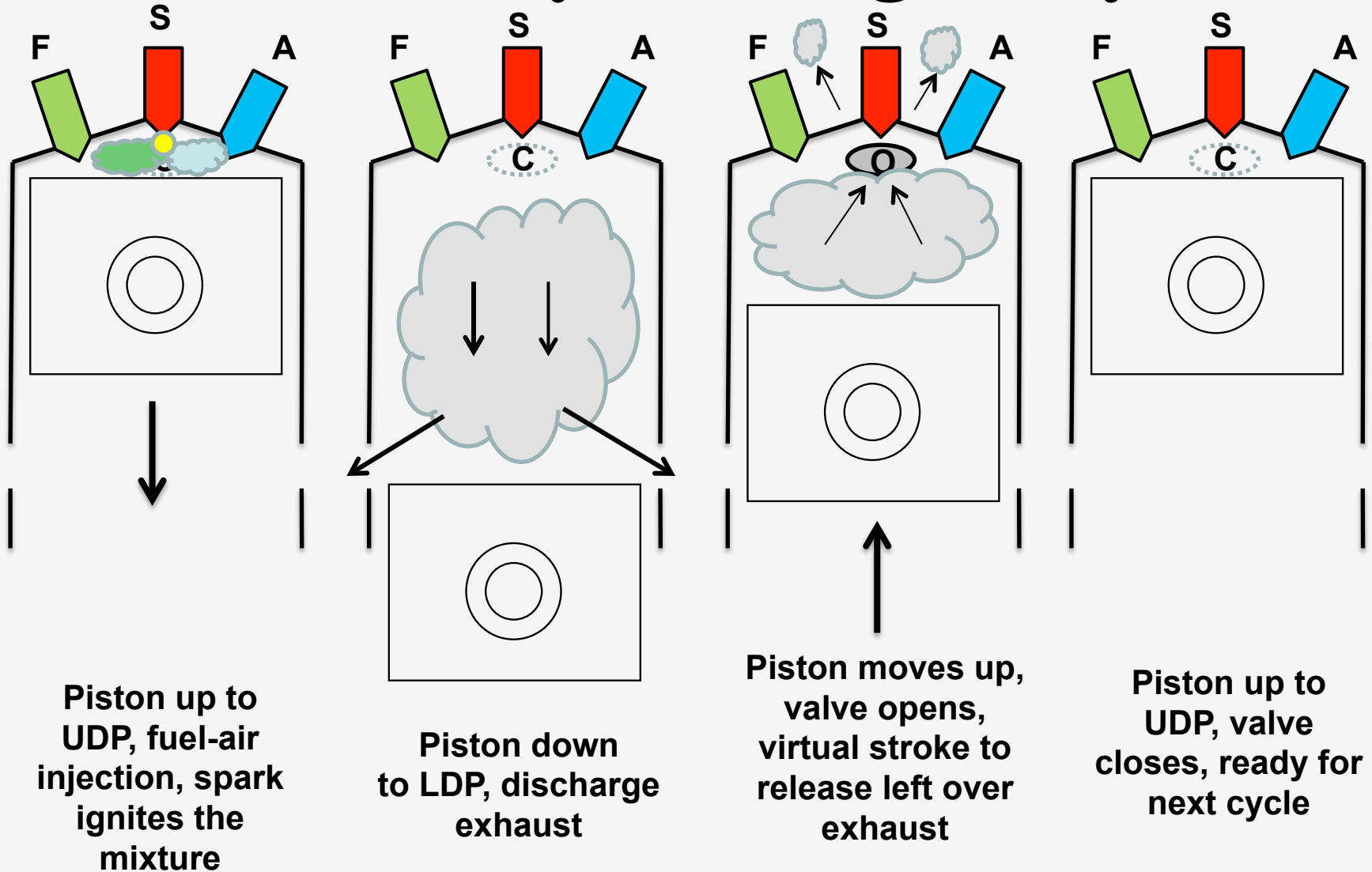
Hybrid Mode

- Similar to a rocket engine, the hybrid mode has **no retardation** due to air compression, all output power is delivered to the load.



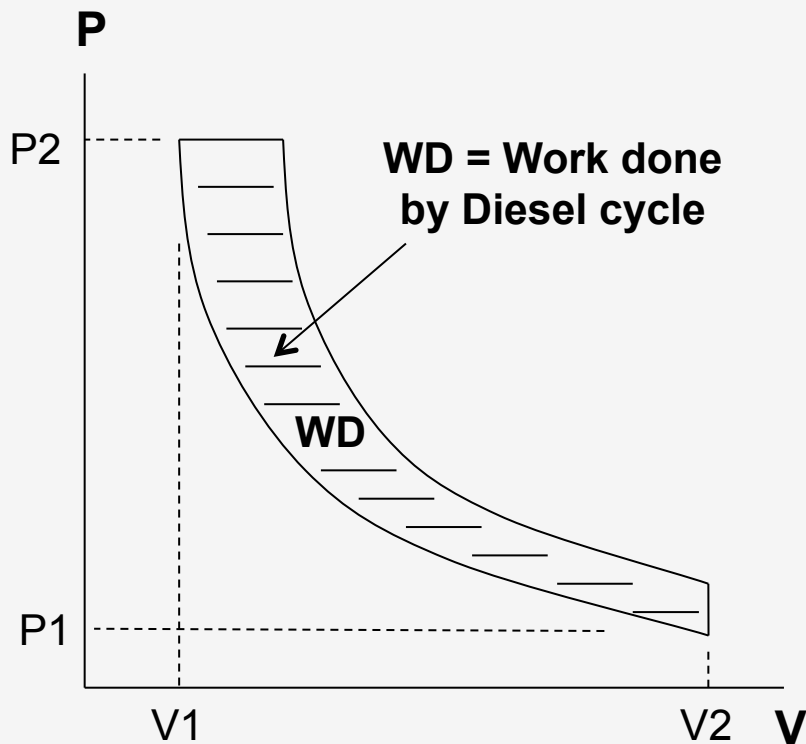
Under hybrid mode, the air compressor
is **off-loaded** from the engine

Fuel-Air Hybrid Engine Cycles

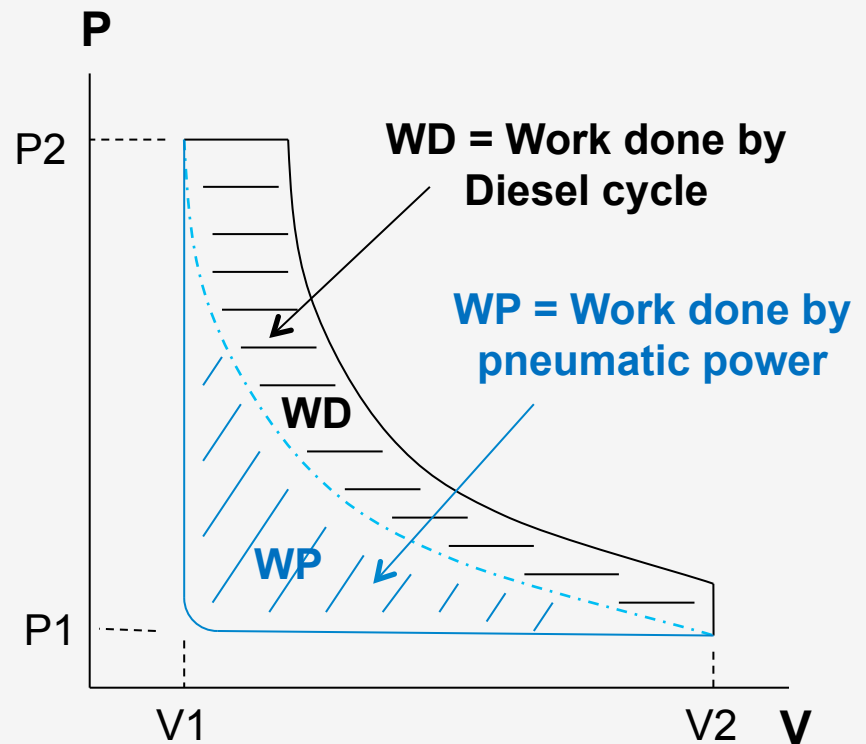


P-V chart of Fuel-Air Hybrid Cycle

Work done by **Fuel-Air hybrid** cycle (WD + WP) is about 40% more than traditional Diesel cycle (WD)



P-V chart for Diesel Cycle



P-V chart for **Fuel-Air hybrid** Cycle

Power ratio comparison

Note: Output of traditional four-stroke Diesel engine is normalized to 1.

	Output of Diesel cycle	Output of pneumatic power	Total output power
Traditional four stroke Diesel engine	1	0	1
Traditional two stroke Diesel engine	2	0	2
Fuel-Air hybrid with air compressor off (hybrid mode)	2	0.8	2.8
Fuel-Air hybrid with air compressor on (refill mode)	2	0 (Pneumatic output consumed by air compressor)	2

Benefits of Fuel-Air Hybrid Engine

- High power ratio and power density.
- Diversified heat results in less cylinder bore distortion and more effective lubrication.
- Utilizes various sources of fuel.
- Air storage tank refill can be fast and cost-effective.
- Increasing air tank capacity does not significantly increase weight or cost.
- Unidirectional gas flow reduces turbulence.
- Uses compressed air to start the engine.
- Cylinder valve consumes minimum energy.
- No dependency on rare materials or special processes.
- Oxygen injection is possible.
- Air expansion absorbs heat.

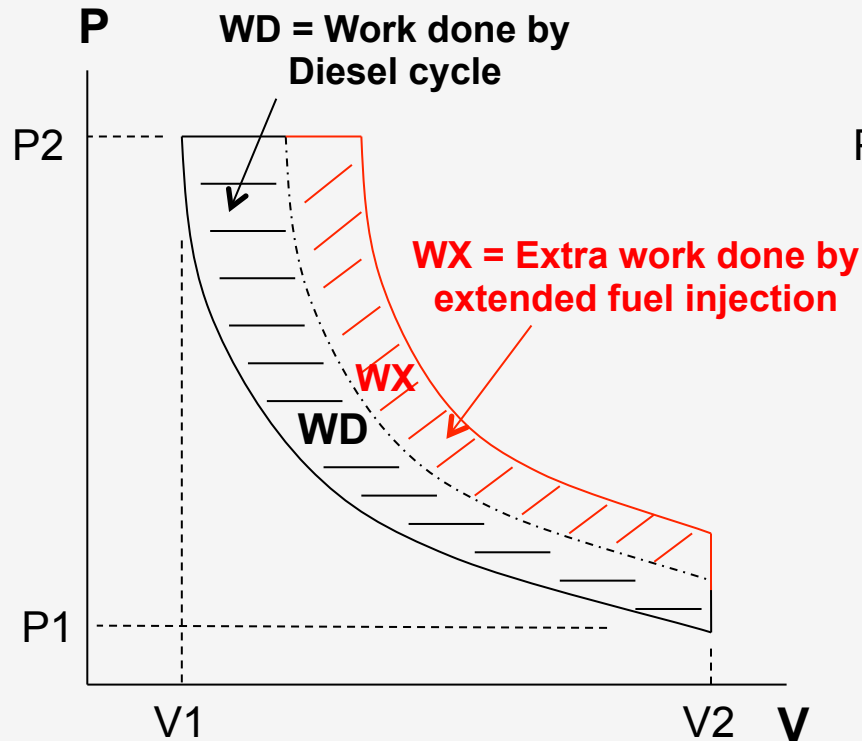
Environmental Benefits

- **Increased system efficiency.**
- **Kinetic energy is recovered.**
- **Cost-effective grid refill.**
- **No battery and chemical waste.**
- **Very clean combustion.**
- **Extended air injection may contribute additional power without generating additional pollutants.**

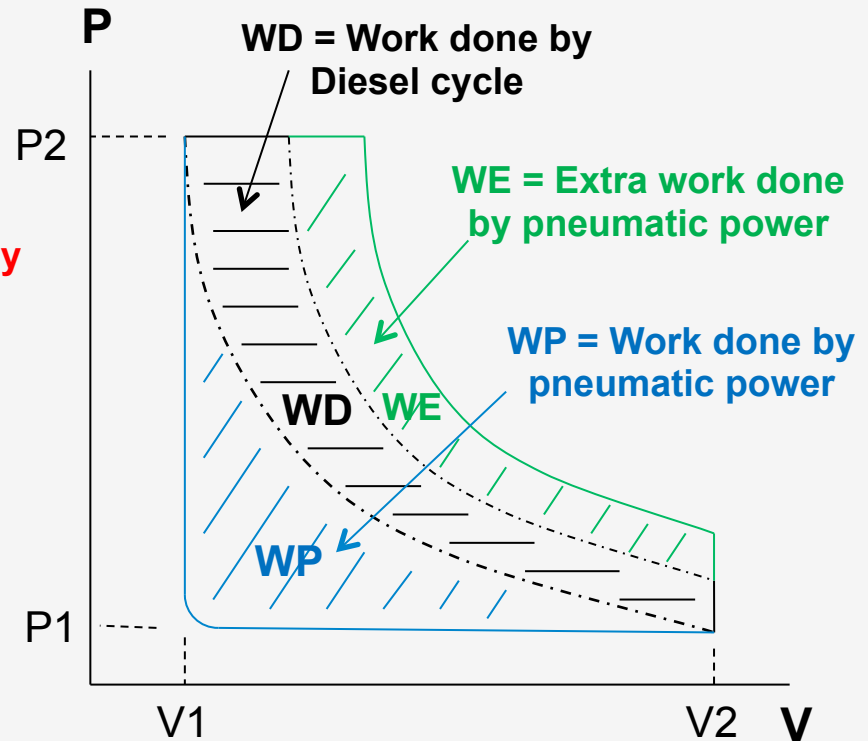
Why is **Fuel-Air Hybrid** cycle clean?

Power spikes often cause extended fuel injection (**red**), which results in incomplete combustion and fuel inefficiency.

Extended air injection delivers extra power (**WE**) and clean burn, with better fuel efficiency than extended fuel injection.



P-V chart for Diesel Cycle



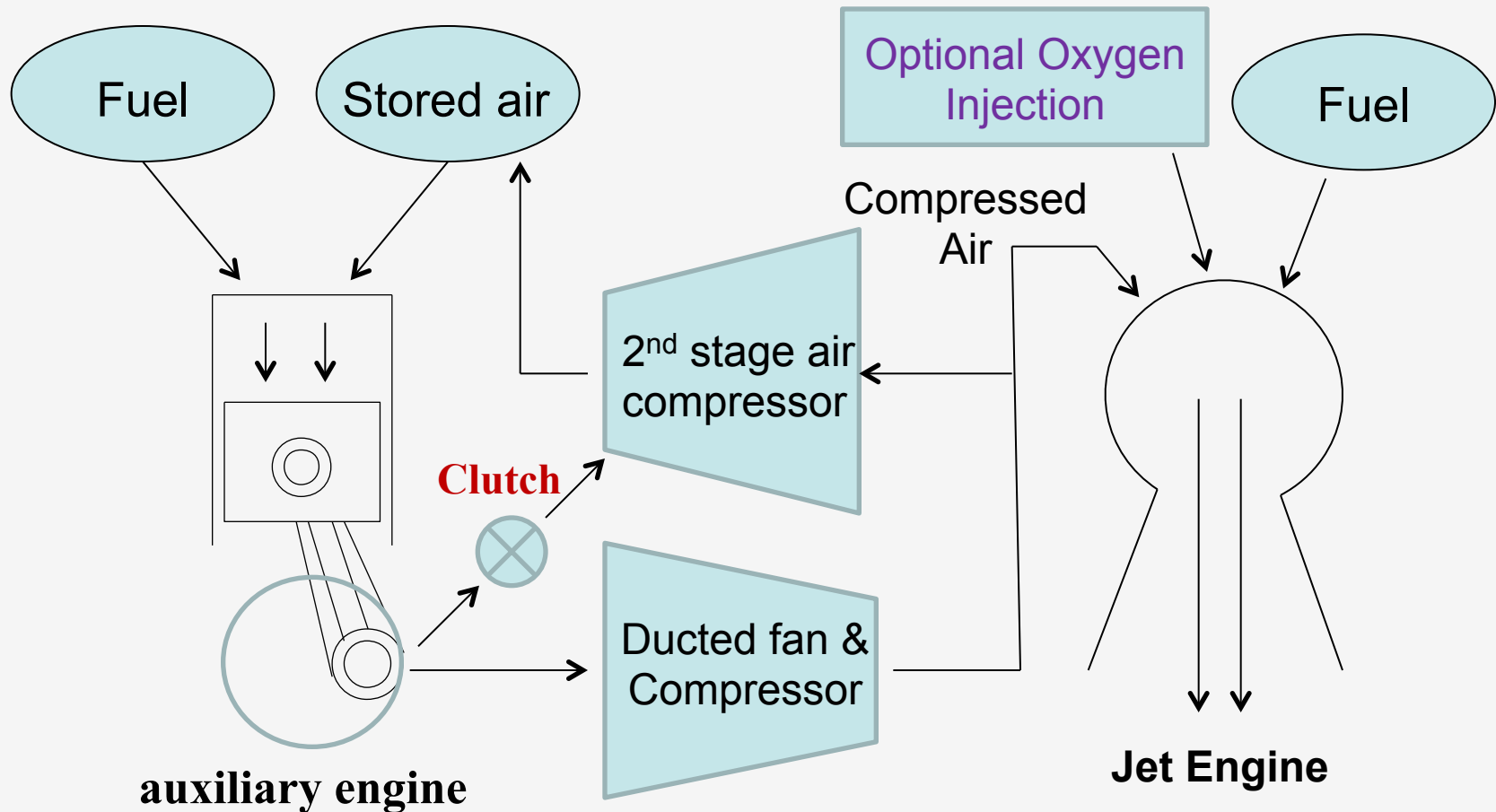
P-V chart for Fuel-Air hybrid Cycle

Applications

- **Engine operational modes:**
 - 1. Hybrid mode**
 - 2. Air-refill mode**
 - 3. Pneumatic (air motor) mode**
 - 4. Kinetic energy recovery mode**
 - 5. Grid refill mode**
- **Power trains for light and heavy-duty vehicles, airplane or machinery**
- **Portable pneumatic tools**
- **Turbine-less jet-fan engine or vertical take-off applications**

Fuel-Air Hybrid driven Turbine-less Jet-Fan Engine

Clutch off during take off power spike; **clutch on to refill** air reservoir



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Note: For more information, a non-disclosure agreement (NDA) is required.

