

Why MDE and Not Stirling?

A concise technical summary

Development-stage engineering analysis; measured prototype performance remains to be established.

The central distinction

The MDE does not depend on discovering whether adiabatic compression/expansion and isochoric heating/cooling are physically possible; they are. The engineering uncertainty is how much of the ideal Maximum Delivery advantage survives in a real machine once finite heat-transfer rates and ordinary mechanical/thermal losses are included.

That is the proper starting point for comparing the Maximum Delivery Engine with a practical Stirling engine. Adiabatic compression naturally raises the working-gas temperature; adiabatic expansion naturally lowers it. The MDE uses those naturally occurring temperature changes as part of the intended cycle, then adds and rejects external heat during essentially constant-volume portions of the cycle.

At the Maximum Delivery condition, adiabatic compression preheats the working fluid before isochoric heating, and adiabatic expansion precools it before isochoric cooling, eliminating the need for regenerative preheating and precooling.

A different external-combustion architecture

Röntgen described the historical Maximum Delivery thermodynamic condition. For fixed hot and cold temperature limits, the constant-volume form uses adiabatic compression, isochoric heating, adiabatic expansion, and isochoric cooling; under the Maximum Delivery condition, the regenerator is of no effect. David Bird developed and patented the Maximum Delivery Engine architecture that implements that thermodynamic condition through matched hot and cold caps, a closely fitted isolator that alternately shields the thermal ends, an active common space, and direct communication with the power piston.

Issue	Practical Stirling	MDE
Regeneration	Relies on a regenerator to store heat from the working gas and return it later in the cycle.	Uses natural adiabatic preheating during compression and natural adiabatic precooling during expansion; no regenerator is required under Maximum Delivery.
Gas path	Working gas commonly oscillates through heater, regenerator, cooler, and connecting passages; exact layouts vary.	Short active communication through the chamber/common-space/piston path without a porous regenerative matrix.
Inactive volume	Heater, cooler, regenerator, manifolds, and connecting passages can contain substantial simultaneously unswept gas.	Design objective is approximately 1% or less true simultaneously inactive volume; active common space is not treated as conventional dead volume.
Compression / expansion	Real work spaces become substantially adiabatic at useful speeds even though the ideal cycle is commonly presented with isothermal compression and expansion.	Adiabatic compression and expansion are intended parts of the cycle.
Thermal function	Heat-exchanger and regenerator systems must perform much of the internal thermal shuttling.	The cycle itself provides preheating and precooling through compression and expansion before external heat transfer occurs.

Why the differences matter

First, eliminating the regenerator removes more than its weight. A Stirling regenerator can be highly effective, but it also introduces matrix volume, oscillatory pressure drop, imperfect regeneration, hot-to-cold conduction, and manufacturing complexity. The MDE does not omit regeneration as a compromise. Under Maximum Delivery, regenerative heat storage is not required because adiabatic compression and expansion already provide the intermediate temperature changes needed before external heating and cooling.

Second, the MDE is intended to avoid the same dead-volume burden. In a practical Stirling, working gas occupies heater passages, cooler passages, the regenerator, manifolds, and connectors that influence pressure but do not all contribute directly to piston work. In the MDE, the common space and piston communication path are active volumes. Hot-end and cold-end minimum clearances also occur at different isolator states and should not simply be added as though they were simultaneously dead.

Third, the MDE uses adiabatic behavior rather than treating it as an unavoidable departure from an idealized cycle. At useful engine speeds, compression and expansion cannot remain perfectly isothermal. The MDE deliberately incorporates the temperature rise of compression and the temperature fall of expansion into the cycle itself. During isochoric heating, the isolator shields the cold cap while exposing the working gas to the hot cap; during isochoric cooling, it shields the hot cap while exposing the working gas to the cold cap.

Fourth, the MDE avoids forcing the working gas through a porous regenerative matrix as part of every thermal transfer. Its pressure losses are therefore associated with ordinary passage flow, local accelerations, clearances, and mechanical communication rather than with a required regenerator matrix. Those losses still have to be quantified by CFD and prototype testing, but they are conventional engineering losses rather than a required thermodynamic feature.

What still determines real MDE efficiency

At 900 K hot and 325 K cold, ideal Maximum Delivery efficiency is about 39.91%. A real MDE will necessarily perform below that value. The principal remaining penalties are expected to include finite-rate heat transfer, hot-to-cold conduction or heat creep, mechanical friction, seal leakage, imperfect timing and gas nonuniformity, ordinary pumping loss, and auxiliary power.

With true simultaneously inactive volume held near 1% or less, dead volume should not be the dominant penalty. Likewise, the MDE's architecture does not depend on eliminating all pumping or mechanical loss; it depends on keeping those ordinary losses sufficiently small that a substantial portion of the Maximum Delivery work remains available at the shaft.

The fraction of ideal Maximum Delivery efficiency retained at the shaft will be determined through CFD, component-level analysis, and instrumented prototype testing.

Conclusion

The argument for the MDE is not that Stirling engines cannot work; they clearly can. The argument is that Maximum Delivery permits a different way of organizing an external-combustion engine. The MDE removes the need for regenerative heat storage, targets very low true inactive volume, uses a short active working-gas path, and deliberately employs adiabatic compression and expansion as useful parts of the thermodynamic sequence.

Its defining thermal substitution is simple: regenerative heat storage is replaced by the naturally occurring temperature changes of adiabatic compression and expansion. The decisive engineering question is therefore not whether those processes can occur, but how much of the ideal Maximum Delivery performance remains after finite heat transfer, conduction, friction, leakage, pumping, materials, and other real-machine losses are included.