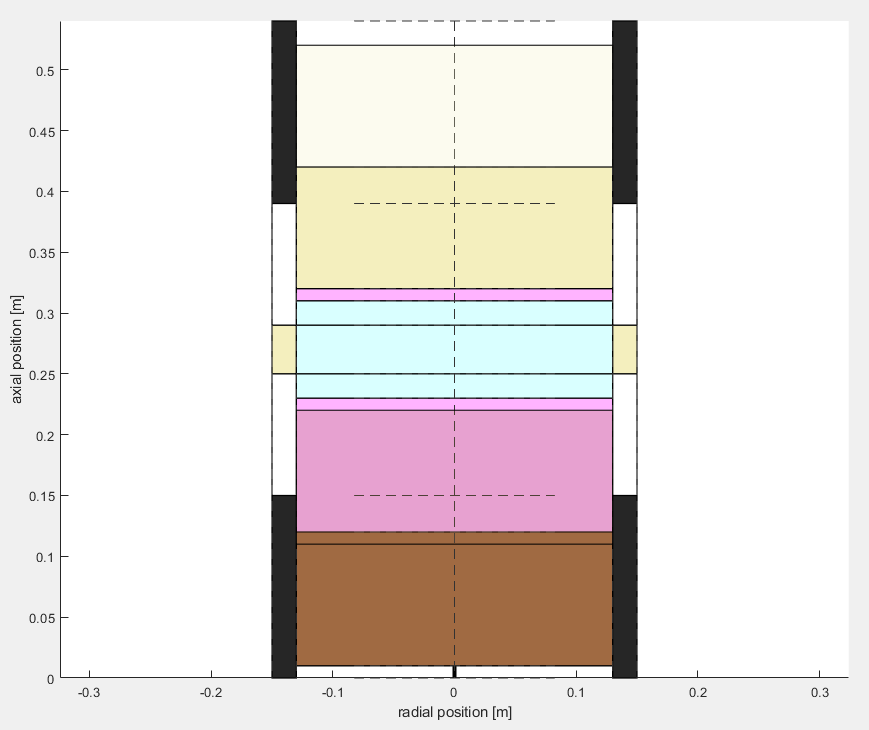
|  |
| --- |
| MSPM  Sample Alpha Stirling Engine Model |

# Brief Overview of Alpha Stirling Engines

An alpha Stirling engine is a two-piston engine that operates on the Stirling cycle. There is a hot-side piston and a cold-side piston. The working gas can flow from the hot-side piston area, through the hot heat exchanger, through the regenerator, through the cold heat exchanger, to the cold-side piston area. The flow reciprocates through each cycle, and work is extracted from the expansion and contraction of the working gas as it changes temperature.

# Modelling Constraints in MSPM

Models in MSPM must have axial symmetry. Although it is possible to create a more realistic looking model with sections at different angles (for examples having the two pistons rotated 90 degrees from each other) with the use of groups and bridges, for the sake of simplicity, the sample alpha Stirling engine model has been built as a single group with no bridges. This sample engine is not designed to be manufacturable in real life, it is simply designed to showcase MSPMs ability to model and simulate an alpha style Stirling engine.



# Bodies

This section explains what each body represents in this model.

## Outer Walls

The black bodies on the outer edges are perfect insulator bodies representing the walls containing the pistons. They are simply there to seal the working gas inside of the engine, and are perfect insulators to help speed up the simulation with little affect on the results, since little surface area is in contact with the working gas.

## Heat Source/Sink

The white bodies between those black insulator bodies are the constant temperature heat source and heat sink. They represent the area where heat is transferred to the engine in a relatively constant temperature, for example a hot/cold roughly constant temperature fluid flowing through this area. These bodies will transfer heat to/from themselves to surrounding bodies, including the working gas through convection across its surface. Since these are directly touching the hot and cold heat exchanger bodies, heat will rapidly transfer to those heat exchangers to keep them close to the source/sink temperatures.

## Pistons

The beige body on the top is the hot side piston, and the brown body on the bottom is the cold side piston. The pistons in this model are made of two randomly chosen materials, simply to make it easy to understand that these are different pistons on different strokes. The actual materials of the pistons have negligible effect on the simulation results in this model, since the material of the pistons does not determine their mass, and the mass of the pistons does not affect the friction they encounter. The strokes of the pistons were chosen to have an approximately ideal compression ratio for the temperature difference between the heat source and sink (450K and 270K respectively). There is a small clearance between the end of the strokes and the heat exchangers, as can be seen in the picture, between the top/hot piston and the hot heat exchanger.

## Working Gas

The pink bodies are the working gas, in this case 99% helium / 1% air. This gas is connected together through the heat exchangers and regenerator, and flows through those areas in a reciprocating manner throughout the cycle.

## Heat Exchangers

The outer light blue bodies are the hot and cold heat exchangers. These are actually 99% helium bodies as well, like the pink bodies, but they have a matrix component to them, hence the light blue shading. These heat exchangers are identical in size and parameters to each other, their only difference is that one is physically connected to the hot source while the other is connected to the cold source. The parameters used for these heat exchangers were simply the default parameters, they may not be physically realistic, but are good enough for a sample model.

## Regenerator

The inner light blue body in the middle of the model is the regenerator. This is also a 99% helium body with a matrix applied to it.

## Other

The beige body between the two white constant temperature bodies (source and sink) is a rigid polyurethane foam, chosen simply to model some heat transfer between the source and sink and regenerator, although it is probably insignificant and could be replaced by a perfect insulator.

# Discretization

Bodies are subdivided/discretized in MSPM to increase the accuracy of simulation and resolution of outputs at the cost of increased simulation time. This MSPM model is very simple and does not have many bodies or require much discretization, so it simulates very quickly. Feel free to play around with the amount of discretization subdivisions of different bodies to see how it affects the output PV work and shaft power results. For any model that you will be using a lot, it is usually worth your time to do a few tests to minimize simulation time while maintaining reasonable accuracy, especially for test sets or optimizations where the model will be simulated dozens or even hundreds of times.