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C1Or2B-01: A dynamic simulation model for gas guided pistons in Stirling machines

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Superconducting motors offer high power-to-weight or -to-volume ratios and are the natural choice for applications such as the electrification of heavy transport. A particular challenge is the cooling of the superconducting rotor coils. While one option is to use a stationary cryocooler and to provide the cooling via a gas circuit on the rotating side –which introduces other technical challenges such as the sealing of the coolant on the rotating side –an alternative is to install the cryocooler on the rotor. In order to make this approach feasible and to eliminate problems that arise from rubbing seals, gas-guided pistons are proposed as are commonly used in free-piston Stirling machines. In combination with the reduction of side loads, the reliability of free-piston Stirling machines can be significantly improved. In contrast to conventional static gas bearings, no external pressure supply is required. This is made possible by using check valves for buffering parts of the compression pressure in a piston cavity and release it via tiny throttles into the gap between piston and cylinder. Due to the resulting fluctuations in the supply pressure, the properties of the gas-lubricated guide are highly dynamic and also affect the Stirling process. Therefore, calculating the load capacity required a new approach for which the dynamic modelling software Simulink was chosen. This paper presents the resulting model in the form of a fluidic network in which clearance gaps and throttles between volumes are considered as resistances. The model outputs enable the determination of the load capacity and static stiffness of the gas-lubricated guide as a function of the piston eccentricity and the phase angle of the piston movement.

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