Technical description

Hybrid drive of a heat pump with Stirling generator

10/10/23 by Josef Frauscher /Copyright Frauscher Motors GmbH

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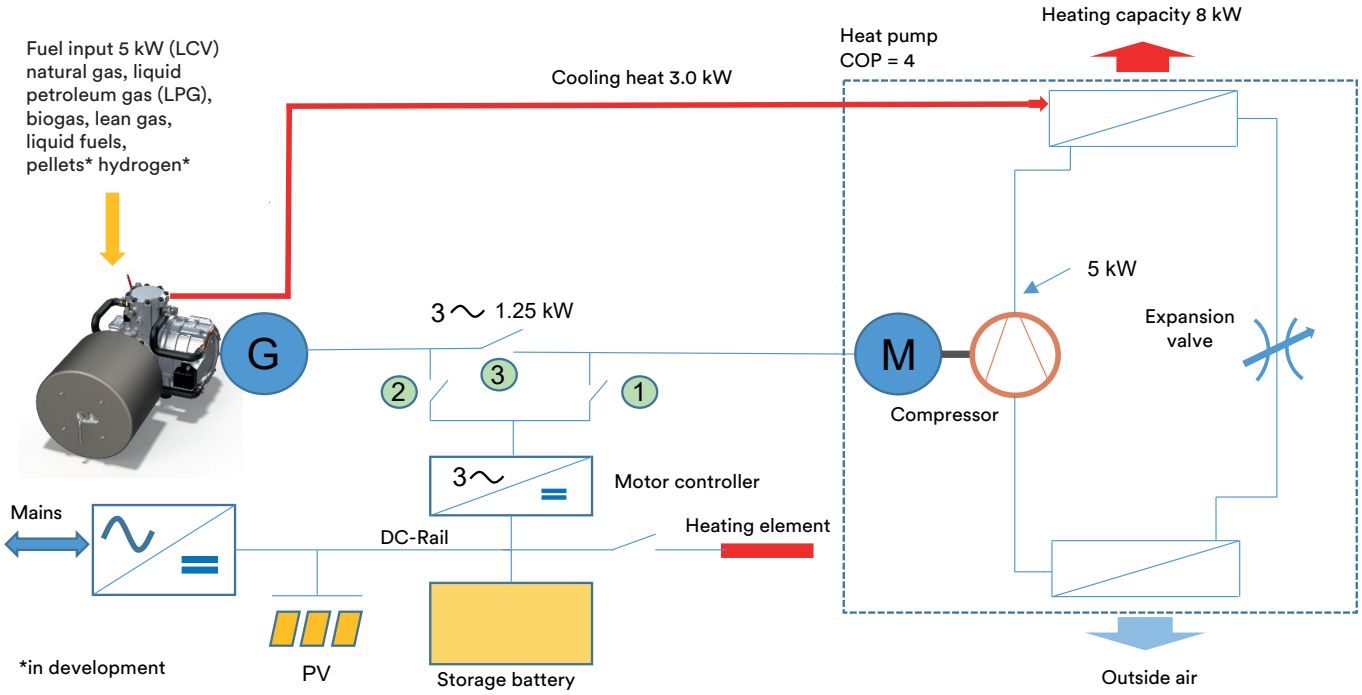

Detailed description of the operating modes:

For the coupling of an air-conditioning compressor to the Stirling engine, Frauscher uses a process developed in-house that does without couplings and shaft feedthroughs. This is very important for sustainable operation, as both the Stirling engine and a compressor module are under high gas pressure, which can hardly be kept tight in the long termwith shaft feedthroughs. In addition, low-loss transmission is guaranteed. Above figure shows the function and the energy flows in simplified form. The indicated individual contacts 1-3 each have 3 contacts for switching a 3-phase AC voltage.

Condition: the generator -G- of the Stirling machine and the electric motor of the compressor -M- are identical and coordinated permanent magnet excited 3-phase synchronous machines.

The possible operating modes can be represented as follows:

A) Standard heating mode

The motor of the heat pump is operated via the motor controller and contact 1 from the DC Rail. Depending on the operating state, the DC voltage comes from the storage battery, the PV system or from the mains or from parts of these sources.

B) Starting the Stirling engine

When contact 2 is closed, the Stirling engine starts after fuel heat has been supplied. The generator -G- acts as a starter motor.

C) Operation of the Stirling engine

After ramping up, the electrical generator power is routed via the motor controller to the DC Rail, where it is routed to the battery charging or to the house grid according to demand. Contacts 1 and 3 are open.

D) Synchronisation Stirling engine - heat pump

Contact 2 opens, contact 1 closes and brings the motor of the heat pump to approximately the same speed as the generator of the Stirling machine.
Contact 3 then closes, the Stirling generator drives the motor of the heat pump directly via the 3-phase link with low losses and avoids losses via the diversions of a direct and alternating direction.

E) Heating operation by the Stirling engine and power modulation

There are two variants; heating has operating priority.

Variant 1)

The heat pump is driven by the Stirling engine at full speed (output). As soon as the heat demand of the heating system switches off, the Stirling engine – heat pump connection is disconnected by opening contact 3 an the connection to DC-Rail is activated by closing contact 2. A state as described under C) is established. When heat is demanded, the states D) and E) are run through again.

Variant 2)

Since the Stirling engine delivers a constant torque, the output of the heat pump can be regulated via a speed control - starting from the throttle position of the expansion valve. A reduced speed automatically leads to less fuel demand, as the internal heat consumption of the Stirling machine decreases. The fuel supply for the Stirling machine‘s burner is automatically adjusted. This operating mode is advantageously selected in heating operation at low outside temperatures, as the best possible efficiency of the heating system is achieved.
During heating pauses, the Stirling generator takes over the battery charging again by disconnecting the 3-phase link (contact 3) and connecting contact 2. A state as described under C) is established.

F) Lack of mains supply - power failure

In this phase, the electrical supply has priority. The Stirling machine is started - if it is not already in operation - as described in B) and subsequently operates as described in C). The cooling heat is used entirely for the heating circuit to prevent the building installation from freezing. If there is no heating demand, the cooling heat is dissipated to the domestic water or to the outdoor environment. Should the battery be charged, the heat pump can start as described under E) or the electrical excess power is discharged to the heating system or domestic hot water via an E-heater. Advantageously, a PWM control can be used, which ensures a controlled charging regulation of the battery.

Summary:

The hybrid drive for heat pumps represents a new quality in heating technology. In addition to supplying heat with considerable fuel savings, the device also provides electrical energy from the fuel store or fuel network. This means that, in addition to heating operation, important consumers can be kept in operation if the electrical mains supply fails.