Spotlight on Sustaining Member

Cryogenic Circulators: The Solution for Cooling Problems?

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Cryogenic gas circulators (CryoFans) are not very well known in the industry as a possible solution for cryogenic process design. In case a complex system needs to be cooled and a direct connection of a cryocooler is impossible, difficult or causes other issues, such as vibration, a gas circulator might solve the problem.

With a gas circulator, a system designer can thermally connect an application to a remote cryocooler by flowing a gas as thermal fluid. Typically helium gas is used in the temperature range of 100 to 10K. This immediately shows the beauty of these systems: Almost all required temperatures can be achieved, allowing the designer to go as high in temperature as the application allows for, giving more freedom and flexibility in the design.

A cryogenic gas circulator is nothing more than a gas pump that "gets the gas flowing," transporting the heat (energy) created by an application to the cryocooler which in turn removes this heat from the system.

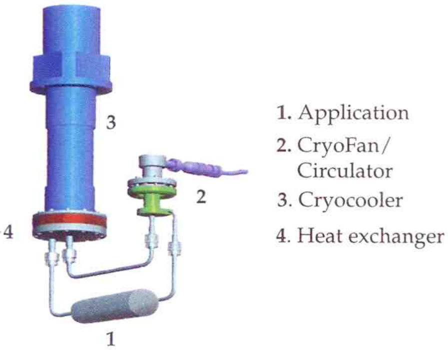


Figure 1. Simplified process design.

As with most pumps, flow and pressure drop are the main specifications, and seem pretty straightforward. However, as we are dealing with cryogenic temperature gas, instead of, for instance, an ambient T liquid, things like density (mass flow), efficiency, thermal insulation, maintenance and the fact that cooling capacity is limited/expensive, become huge factors in the pump design and selection.

Figure 1 shows a simplified process design of a gas-cooled system. Item **1** is the customer's application. This is shown as a black box (gray cylinder), but it can be anything that is required to operate at a cryogenic temperature, generating X amounts of watts. It can be a high temperature superconducting (HTS) device (motor, generator, cable), a magnet, a space simulation chamber, etc. Sometimes this application is also visualized as a heat exchanger.

Item **2** is the gas circulator (CryoFan). By connecting all of the components, a loop is created with pressurized helium as transfer media. By switching on the cryocooler and the gas circulator, the helium gas becomes cold and is pumped through the application and cools it as the gas is heated/absorbs energy. The warmer gas is then transported to the cryocooler where this absorbed energy will be removed and the loop is closed.

Item **3** is a cryocooler (or any other cooling device) which will remove the heat generated by **1** and the rest from the system.

Item **4** is a heat exchanger that connects to the selected cryocooler. Cryocoolers typically have a copper flat plate which provides the cooling power. In case of liquefaction of a gas or by direct contact, this is fine, but when trying to cool a gas stream an optimized heat exchanger is required to guide the gas over the cold head with enough surface area. This will allow for a heat flow between the gas being cooled and the cold head.

For this application, heat exchangers typically made of copper are designed to be mounted on the cryocooler—or they can be an integral part of the cold head. Not shown in Figure 1 is the cryostat/vacuum space which will contain all or most of the equipment for thermal insulation.

Picture 1. CryoZone CryoFans.

CryoZone and Stirling Cryogenics (both CSA CSMs), both from the Netherlands, manufacture several products for this kind of application. CryoZone offers a range of gas circulators, called CryoFans (see Picture 1 and Figure 2), which are used as described above. The CryoFans range in size from a flow of around 0.2 to 150 m^3/hr of gas, with increasing pressure heads. Of course, as with most cryogenic equipment, the larger the CryoFan, the higher the heat load (input) into the system.

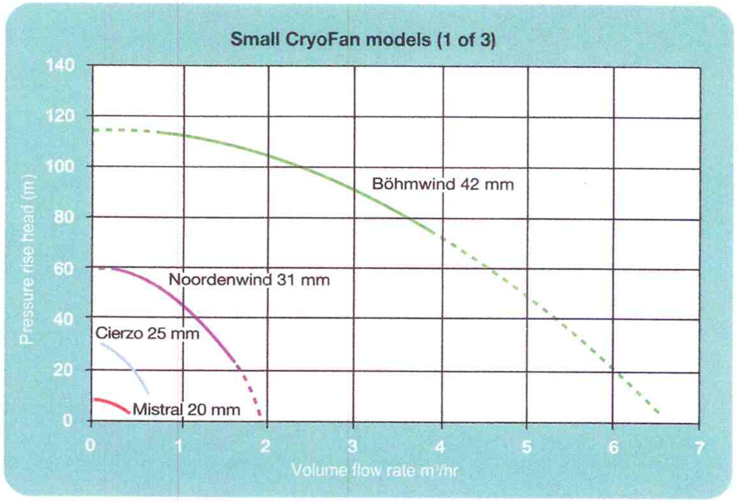
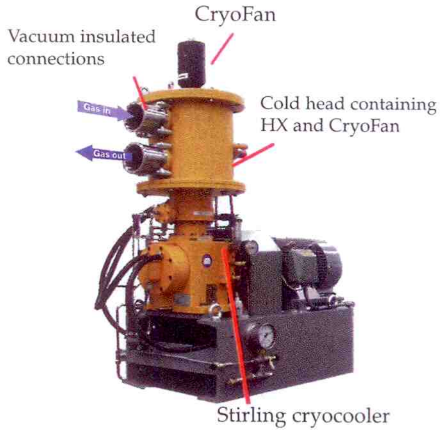


Figure 2. CryoZone's small CryoFan range (flow vs. pressure head).

Picture 2. CryoZone heat exchangers.

CryoZone also supplies a range of heat exchangers (HX; see Picture 2) which are specifically designed for common commercially available cryocoolers, such as the Cryo-mech 300 series, AL60, Sumitomo 415D, Helix, etc. These heat exchangers are designed to match, and be bolted to, the cold head and allow for a heat exchange that meets that specific cooler capacity.



Picture 3: Stirling Cryogenics GPC-1 with integrated CryoFan (circulator).

Stirling Cryogenics manufactures Stirling cycle-based cryocoolers called Cryogenerators. Their gas process cooler (GPC) range (see