In this research, we analyzed the case where a compressor was used in the circulation of multiple coils, and the cryofan was used, including the case where helium and hydrogen were used as the refrigerant, and the cooling in the cooling performance was studied. We also analyzed and studied the effect of the heat generated by the cryofan motor on the cooling performance if it were present in the circulation flow path for the motor used for the cryofan.

**Analysis in case of multi coil cooling**

**Analysis condition**
- Heat input: 20 x (Number of coils) W
- Number of coils: 1, 2, 3
- Refrigerant transport pipe: 1.0 m
- Inlet pressure: 0.5, 1.0, 1.5, 2.0 MPa
- Compressor
  - Inlet temperature: 295 K
  - Mass flow rate: 0.1, 0.5, 1.0 g/s
- Outlet pressure: Calculated based on the pressure loss of the entire flow path
- Outlet temperature: Same temperature as 1 mesh on the upstream side
- Cryofan
  - Inlet temperature: Based on the temperature of the cryofan
  - Mass flow rate: Calculated every hour
- Outlet pressure: Based on the mesh on the discharge side of the cryofan
- Outlet temperature: Based on the temperature of the refrigerant in the cryofan

**Analysis model**

Here, the analysis was performed assuming that the motor required to move the cryofan was in the circulation path. Here, heat intrusion from the outside via the cryofan body is not assumed, but instead, the heat generated in the coil part of the motor body is considered to transfer heat to the refrigerant inside.

For the purpose of analysis, it is necessary to estimate how much calorific value is balanced to have the same cooling performance as the compressor.

As a result, as shown in the graph on the upper right, it was found that a cooling performance equivalent to that of a compressor can be obtained with a calorific value of about 10 W in 50 W. In particular, it was shown that if there is a heat input with a coil of 20 W or more, a motor with a calorific value of up to 40 W can be expected to have cooling performance equal to or better than that of a compressor.

**Analysis in case of heat generation is occurred by motor**

Here, the analysis was performed assuming that the motor required to move the cryofan was in the circulation path. Here, heat intrusion from the outside via the cryofan body is not assumed, but instead, the heat generated in the coil part of the motor body is considered to transfer heat to the refrigerant inside.

For the purpose of analysis, it is necessary to estimate how much calorific value is balanced to have the same cooling performance as the compressor.

As a result, as shown in the graph on the upper right, it was found that a cooling performance equivalent to that of a compressor can be obtained with a calorific value of about 10 W in 50 W. In particular, it was shown that if there is a heat input with a coil of 20 W or more, a motor with a calorific value of up to 40 W can be expected to have cooling performance equal to or better than that of a compressor.

**Summary and future prospects**

It was shown that in the circulation cooling of multiple coils, it is possible to cool to 50K or less in series with up to three coils. In this case, it was confirmed that the cryofan as a circulation device has higher cooling performance than the compressor.

Similarly, it was confirmed that even when hydrogen was used as the refrigerant, the cooling performance was higher than that of helium. It was shown that in the case of the cryofan, the motor is placed in the circulation flow path. Its output should be about 40W.

In the future, in addition to proceeding with analysis on the cooling of multiple coils in parallel, we will proceed with the planning of an experiment for circulating cooling that actually uses a cryofan.

**Analysis in case of single coil**

**Analysis condition**
- Heat input: 0.0 W
- Number of coils: 1
- Refrigerant transport pipe: 1.0 m
- Inlet pressure: 2.0 MPa
- Compressor
  - Inlet temperature: 295 K
  - Mass flow rate: 0.1–1.5 g/s (every 0.1 g/s)
- Outlet pressure: By the pressure loss of the entire flow path
- Outlet temperature: Same temperature as 1 mesh on before side
- Cryofan
  - Inlet temperature: Based on the temperature of cryofan
  - Mass flow rate: Calculated every hour
- Outlet pressure: Based on the mesh on the discharge side of the cryofan
- Outlet temperature: Based on the temperature of the cryofan
  - Heat generating at cryofan: 0.00 W

**Analysis model, method**

Here, the one used for the analysis will be described. The analysis conditions are described on the analysis result of the poster. For the governing equation, the energy equation on the upper left was used. The symbols used in the equation are as described below the governing equation.

The analysis model is placed in the lower left. As an analysis model, when a compressor is used, the refrigerant flows from the inlet of the two-phase heat exchanger and flows through the pre-cooler, and then a refrigerant is cooled in the cryofan. The flowing refrigerant is then cooled in the cryofan. Then, one or more coils connected in series by the refrigerant transport pipe are cooled and heat is input. After heat is input when a cryofan is used, the refrigerant flows through the cryofan, and when a compressor is used, it flows through the pre-cooler and returns to the compressor. The figure below is a performance table that partially describes the model of the cryofan used.

The analysis model of the cryofan was studied. We also analyzed and studied the effect of the heat generated by the cryofan motor on the cooling performance if it were present in the circulation flow path for the motor used for the cryofan.