INTRODUCTION OF SNOW AIR-CONDITIONING SYSTEM
USED IN PRESS CENTER OF HOKKAIDO-TOYA LAKE SUMMIT IN 2008

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ABSTRACT

Air-conditioning with the snow was executed in Press Center of the Summit held in the Hokkaido Toya Lake in Japan in 7-9th July, 2008. Air conditioning area was 11,000m$^2$, the snow of about 7,000 tons was carried into a stock snow room set up under the building of two floors at the end of winter. The maximum cold heat output that is design value was assumed to be 1,000kW, it dug up about 1,000 vertical holes in the layer of the snow stored of about 5.5m height, outdoor air was cooled directly through these holes, and the outlet air temperatures through the holes were about 4°C. By means of mixing with this cold air and outdoor hot air and after it had adjusted it to the temperature of about 18°C. The mixed air was supplied to the space of air-conditioning. It was popular among the journalist.

1. PREFACE

Air-conditioning with the snow was executed in Press Center (International Media Center: IMC) of the Summit that had been held in the Hokkaido Toya lake in Japan in 7-9th July, 2008. Air conditioning area was 11,000m$^2$, and air-conditioning day and night with design output for 11 days was assumed, the snow of about 7,000 tons was carried into a stock snow room of the capacity of about 15,000m$^3$ set up under the building of two floors at the end of winter. And we prepared for the air-conditioning of the Summit beginning on 7th July. The maximum cold heat output that is design value was assumed to be 1,000kW, it dug up about 1,000 vertical holes in the layer of the snow stored of about 5.5m, the outdoor air was cooled directly through these holes, and the outlet air temperatures through holes were about 4°C. By means of mixing with this cold air and outdoor hot air and after it had adjusted it to the temperature of about 18°C, the mixed air was supplied to the space of air-conditioning. It was the rain mixing weather of 3 days when the Summit was held. However it was about 22°C in indoor temperature and about 70% in humidity, a comfortable environment was able to be formed. Then it was popular among the journalist having been sent by each country.

Fig.1 Experimental apparatus
2. CHARACTERISTICS OF ALL AIR TYPE SNOW AIR-CONDITIONING

When air is assumed to be a heat transfer medium, the heat transfer coefficient of air is less than that of water medium, we have to secure the wider heat transfer area to obtain the low temperature regardless of the amount of the snow. Therefore, the author developed a method that open a lot of vertical holes into the snow pile to secure a necessary heat transfer area from beginning to end of snow use. This method is called “an all air and vertical hole type snow air-conditioning”. In this method, it is needed only a blower, some air ducts and a damper to control the air flow rate basically to obtain the air for air-conditioning. As this air-conditioning system is very simple, and there were already some successful execution examples, the author adopted this all air and vertical hole type snow air-conditioning to IMC.

![Fig.2 Temperature at the exit of snow room](image1)

![Fig.3 Output of cold heat](image2)

A part of the characteristic of this snow air-conditioning system with a vertical hole is shown here\(^3\)-\(^4\). Experimental apparatus with a rectangular shape with 1.2m sides and 3.5m height is shown in Fig. 1. However the height of snow charged in an experimental was 2m and it was shorter height, the air temperature at the exit of snow room is lower enough to use air-conditioning as shown in Fig. 2. And it can be understood that the outlet air temperature hardly depends on amount \(Z\) of the snow of the remainder in the snow room, and it depends only on the air flow rate. This characteristic is the just same as a usual heat exchanger.

The output of cold heat, shown in Fig. 3, also shows the tendency similar to the exit air temperature.

The experimental equation of Nusselt number \(Nu\) that shows the heat transmission of a snow hole is shown in Eq. 1.

\[
Nu_{hol} = (8.0 \ H_o + 5.0) \ Re_{hol}^{0.38} (H/d)^{-1.0}
\]

where

\[0.5 \ m \leq H_o \leq 5.0 \ m, \quad d > 0.25 \ m,\]
\[10^3 < Re_{hol} < 10^4\]

\(Nu\) is calculated by giving diameter \(d\), initial height \(H_o\) of the snow and the Reynolds number \(Re\) through a snow hole subscripted \(hol\). The diameter of a hole \(d\) and height of snow \(H\) are calculated by time-series analysis. \(Nu\) at a certain time is calculated from values of \(d\) and \(Re\) before small time. Melted amount of the snow is calculated from \(Nu\) that is heat transfer coefficient. And then the value of \(Re\) and the cold heat output are calculated with the shape change of a snow hole in the time series.
Nu, exit temperature $t_{ot}$, the diameter $d$ and cold heat output of the hole are shown in Fig. 4 under the typical conditions will be used in the thermal design of IMC, that is, air flow rate 150m$^3$/h, entrance temperature 25C, height of the snow 5m and density of the snow 0.5ton/m$^3$. To evade the contact of two snow holes, the distance between holes should be determined by the same value. For instance, the distance between holes is assumed to be 1m, it is understood that the operate time for air-conditioning is 250 hours. The output of cold heat is almost steady and the mean value is 0.95kW. Moreover, the temperature at the exit is lower enough to use for air-conditioning.

The driving parameter in all air and vertical hole type snow air-conditioning is an amount of the air, that is air flow rate, as well as a usual heat exchanger. Figure 5 shows the mean value of the cold heat output when the amount of the air is changed. For instance, when the cold heat output of 1kW is needed with the design point, it is understood that we may provide with a blower of amount 160m$^3$/h of the air flow rate.

It is understood that we can provide a larger capacity blower merely to secure the cold heat output more than the design point from the consideration of the safety.

3. THERMAL DESIGN BY THE ALL AIR AND VERTICAL HOLES TYPE SNOW AIR-CONDITIONING SYSTEM IN IMC

A cross section of IMC, which was constructed on the uphill of stairs, is shown in Fig. 6 and the position of the snow room that is the stockroom of the snow, which has been installed in the underground part.

In general, the temperature of the supply air to the air-conditioning room is adjusted by mixing with the exhaust high temperature air from the air-conditioning room and the cold air from the snow room in the proper quantity. As the outdoor mean air temperature for the Summit period is 25C and is not so high, and the exhaust air temperature from air-conditioning area will be 28C, then we can not expect the decreasing the amount of use of the cold heat source, that is snow, by mixing with the exhaust air. The author adopted the method of leading outdoor air directly to hole in the snow room as shown in Fig.7.

The space of the snow room is divided 13 spans as shown in Fig.8 because various pillars are arranged complexly in the passage of the cold air by means of the temporary spaces.
One blower, air taking duct and opening and shutting motor damper were set up in each span, and each span can be driven individually. The upstream sides of the blower of each span were connected by using a header duct. The downstream sides of the blower were connected with a header. A by-pass duct between both headers was installed and the motor damper control (differential pressure control) was set up to keep constant the differential pressure of both headers.

Melted water generated by snow air-conditioning was used for the cold heat for air-conditioning of the Interview Center Building through fan coil unit (FCU), and was used for rest room washing water and planting water mixed with rain water. And, a no-fluorocarbon refrigerator (180kW) is set as a backup.

It was calculated that the snow of 7,000 tons was preserved in the snow room² of the volume of about 15,000m³ (w=98m, d=22m, h=7m) as assumption of the total cooling load of IMC, that had area 11,000m² of air-conditioning, was 1,000kW consideration of the use for 11 days and night of about the Summit period by the design cold heat output.

The cold heat output of each hole was assumed to be 1 kW/hole and the flow rate of air to each vertical hole was assumed to be 150m³/h with expectation of the cooling effect of air at the upper and under surfaces of each hole. As a result, about 1,000 holes are vertically secured in the layer of the snow of about 5.5m to obtain the design cold heat output of 1,000kW and the digging the holes were secured with the dropping town water.
4. OPERATION AND RESULTS

4.1 OPERATION

The test runs of the snow air-conditioning facilities were started at 1st Jun, the regular operation was started at 1st July, and the day of Summits 7-9th July. Operation was ended at 14th July.

4.2 CARRYING AND THROWING SNOW OPERATION, AND AMOUNT OF COLD HEAT AT BEGINNING

Carrying and throwing the snow was as follows (Photo. 1):
- The snow carrying date: 7-18th April, 2008, 11 days
  - Carrying place: Adjacent farming roads and ski area
  - Number of carrying vehicle: 904 by 8ton dump cars
  - Stored snow: 6,906ton
- Snow situation when beginning to operate it (1st June, 2008) is as follows:
  - Mean density of snow: 0.70ton/m$^3$
  - Mean height of snow: 5.2m
- Amount of cold heat stored by snow: 292,000 kWh

4.3 THERMAL ENVIRONMENT OF IMC WHEN SUMMIT WAS HELD

It was the rain mixing weather for 3 days when the Summit was held. However, the indoor temperature being about 22C and 70% humidity were able to form an excellent environment (Judging by the discomfort indices, it was comfortable) within the range of the change of ±1C of the temperature and the humidity ±5%, and it was popular among journalists having been sent by each country (photo 2). The detail datum will be reported in a few days.
4.4 TRANSITION AND ACCUMULATION OF COLD HEAT OUTPUT OF SNOW AIR-CONDITIONING, AND CO2 REDUCTION

The cold heat output of snow air-conditioning of 1st Jun to 14th July is shown in Fig. 9. The output of cold heat was little during June because it had driven for test and growth of holes, the output increased rapidly because of an increase in an entering indoor load in July. The output of cold heat during the session was indicated about the maximum 1,100kW.

Figure 10 shows the accumulated values of the cold output of snow, backup refrigerator and melted water for air-conditioning and amount of melted water. The total heat use for operation period by the snow air-conditioning system (Air and the melting of snow were contained) was 160,213KWh and the contribution rate to all heat sources was 90%. The contribution rate of the heat use for melted water was 3%, and that of the refrigerator for the backup was 7%.

The effect of the CO2 reduction in the snow air-conditioning system at the operation period was 29ton-CO2.

![Fig. 9 Cold heat output of snow air-conditioning](image_url)

![Fig. 10 Accumulated values of the cold output and amount of melted water](image_url)
5. CONCLUSIONS

In this report, it introduced the outline of air-conditioning with the snow applied to Press Center (International Media Center : IMC) of the Summit that had been held in the Hokkaido Toya lake in Japan in 7-9th July, 2008.

There was no trouble to make the system of snow air-conditioning and to use it, and was popular among the journalist having been sent by each country.

It is author’s pleasure to report this paper referring as one of the explanatory notes that effectively uses the peculiar circulation type natural energy of the local region, even if IMC is facilities only in the snowy country in Japan where a large amount of snow falls in winter and it is hot in summer.

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REFERENCES