Cooling System with Water Mist Sprayers for Mitigation of Heat-island

Tomohiro ISHII*, Makoto TSUJIMOTO*, Gyuyoung YOON**, Masaya OKUMIYA**
*Tokyo University of Sience, Tokyo, Japan; **Nagoya University, Nagoya, Japan

Abstract
The purpose of this study is to establish the water mist (Dry-Mist) spraying system that improves environmental conditions in the cities. In Japan we have traditional method for cooling, which is called "*Uchimizu*" (fig.1) by utilizing the effect of water evaporation. This time we have developed the system which utilizes this effect more efficiently. This study is based on the idea that if the system is capable of supplying water mist whose size is small enough to evaporate, it could be possible to mitigate heat island phenomenon without depending on greening.

Key words: Dry-mist, Transpiration, Heat-island

1. INTRODUCTION

It is said that the impact of exhaust heat from air conditioners which are used in buildings on urban warming is large and the recent data indicates that penetration rate of family-use air conditioner in Japan is approximately 100% which prompts the increase of artificial exhaust heat.
In Japan we have a traditional culture for cooling which is called "*Uchimizu*" by using the effect of water evaporation from a long time ago. The method of "*Uchimizu*" is just scattering water in front of residences. However the effect of this cooling is temporary and it is not able to cool down three-dimensional space. Furthermore the efficiency of evaporation of "*Uchimizu*" is completely lower than transpiration from plants, because the efficiency depends on the surface of vaporization i.e. two or three dimensions.

Fig1.*Scene of Uchimizu*

From the knowledge stated above, we've developed the system which is based on the idea that if the system is capable of supplying mist whose size is small enough to evaporate, it could be possible to utilize only cooling effect and to help reduce air-conditioning load of perimeter buildings without depending on greening.

2. CONCEPT OF DRY-MIST

Fig2 shows "Concept of DRY-MIST". If the effect of DRY-MIST causes the outdoor temperature to fall, it will reduce the air-conditioning load in the perimeter space. Also it will improve the coefficient of performance (COP*) of the outdoor units of air conditioners which are used in surrounding buildings[1)].
Because the air condition is changing on the isenthalpic line within the DRY-MIST coverage area, temperature drop of 1℃ raises relative humidity by 5% in the vicinity of the temperature of 30℃. So attention needs to be paid to the undue increase of relative humidity while spraying mist.
The DRY-MIST has following two functions which are illustrated in Fig2.
Two potential effects: 1) to improve the unpleasant thermal environment during summer season and 2) to reduce air conditioning load in buildings (energy saving as a whole system)

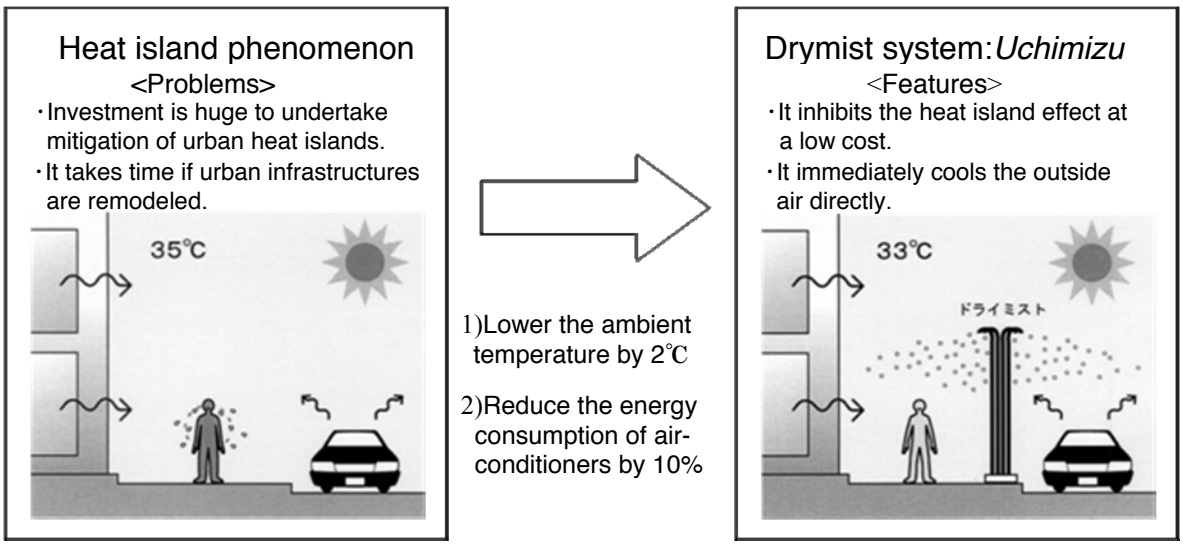


Fig2.*Concept of DRY-MIST*

3. DETAIL OF DRY-MIST SYSTEM

Fig3 shows the system diagram of DRY-MIST. The system consists of high pressure pump (6MPa) which is used for pressing out water supply and atomizing mist, plumbing, various kinds of valves and mist nozzles. In case of automatic-control, various meteorological sensors and control panel are also equipped. In addition to them, review on the position and the density of spraying, technology for preventing drop of water at the moment of start-stop by controling pressure and consideration to hygienic control of water (because in many case mist is spraying toward visitor directory) are necessary. Value of temperature, humidity and wind velocity and rainfall are the criteria for controlling. In automatic controlling, the environmental conditions to start spraying mist are the temperature of more than 28℃ and the relative humidity of less than 70% and the wind velocity of less than 3m/sec without rainfall. Only when all the conditions are met the system is activated. In case of DRY-MIST system applied to residence, generally it is just controlled by rainfall for reducing initial cost.

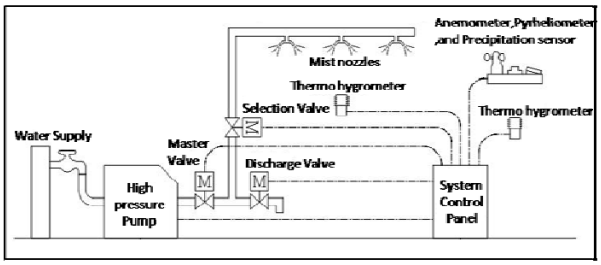
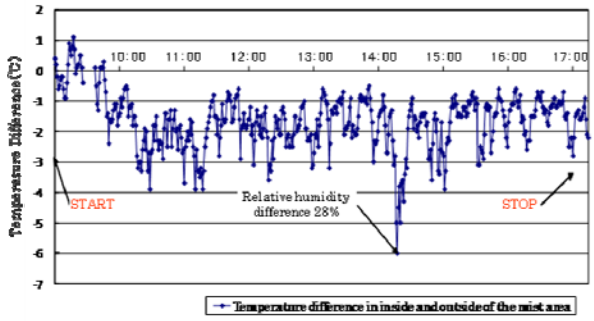


Fig3. *Detail of DRY-MIST system*

4. EFFECT OF DRY-MIST

DRY-MIST system is considered as an effective measure for environment improvement on semi-open space like a railway station, while the heat source of these space are mainly sensible heat from train as well as solar radiation.
The following example[2)] of DRY-MIST system was applied in the station platform on summer of 2007. Total of 30 DRY-MIST nozzles were installed in two zones of the staircase that connects platform and concourse (fig.4) and then environmental measurement was conducted.
Fig5 shows the difference of air temperature between inside and outside of the spray zone. The cooling effect of DRY-MIST was confirmed throughout the survey day and the difference of air temperature achieved by DRY-MIST is 1.63K which is mean value during 9:00 to 13:00 and 1.9K during 13:00 to 15:00.
DRY-MIST was operated by periodic on-off operation; operate for 2 minutes and stop for 3 minutes. However it is considered that 2-minute is short to obtain enough cooling effect. Therefore if this DRY-MIST system will be controlled by humidity, it is possible to extend operate time and to achieve more cooling effect over 2K of mean difference throughout a day.
Figure 6 shows the answer to a questionnaire about the mist. The number of answer was 200 and more than 80% replied that they felt “very comfortable”, “comfortable” or “a little comfortable”.

Fig4. *Pictures of spraying DRY-MIST in Futamatgawa Station Sagami Railway*



※The temperature difference compared the points of 1500mm in each height in the inside and outside of the Drymist.

Fig5. *Temperature difference inside and outside of the mist area*

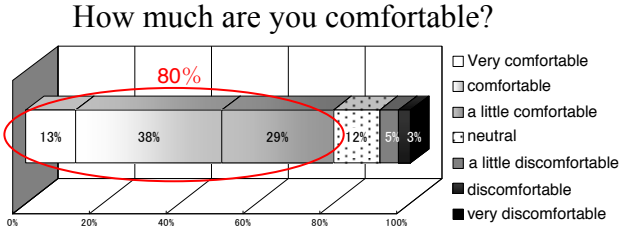


Fig6. *Result of the questionnaire to station user*

CONCLUSION

The future work of this study is to promote application of the DRY-MIST system in a residence. So, it is necessary that DRY-MIST system should be a small one; composing of several nozzles and a small pump. In this case, the important issue for downscaling the coverage area of DRY-MIST is performance degradation. The COP of existing system is about 300. The COP of miniaturized system is about 50. However, the COP of air-conditioner for family-use is about 5, so miniaturized DRY-MIST system is more efficient than air-conditioner. The potential of DRY-MIST is so high, and the experimental introductions have already begun.

References

＊COP＝(quantity of heat that is removed by evaporation)/(input energy for spraying DRY-MIST)
1)Tsujimoto, M., Okumiya, M., Harada, M. Dry Water Mist Spray System to Urban Heat Island Problem -Its Concept and Elementary Assessment- , Society of Heating, Air-Conditioning and Sanitary Engineers of Japan.,2003 .3,In Japanese
2) Ishii, T., Tsujimoto,M., The Experiment at the Platform of Dry-Mist Atomization, Summaries of technical papers of the annual meeting of the Architectural Institute of Japan, Kanto.,2008.9,In Japanese