ATLANTIS PRESS
Advances in Intelligent Systems Research, volume 130
6th International Conference on Mechatronics, Computer and Education Informationization (MCEI 2016)

A Shading-technology to improve the Thermal Environment of Tents

Jingbo Liu[1, a], Yingni Jiang[2, b] and Xiao Ma[3, c*]

[1]Graduate Management Department，Logistics University of PAP. Tianjin, China

[2,3]Architecture Engineering Department, Logistics University of PAP. Tianjin, China

[a]568818102@qq.com, [b]jyingnii@sina.com, [c]33227297@qq.com

Keywords: Tents; Thermal environment; Shading-technology; Camping

Abstract. An experiment of 3 groups was set up to cool the tent in summer. Compared with the ordinary tent, the researchers erected two kinds of screen, which is made of shading-net, on the top of tents. The results show that in the sunny summer of Tianjin, the shading-technology can cool down the tent temperature by 8 degrees Celsius, and the shading-technology can make a difference on the improvement of inner environment.

Introduction

Due to the thermal resistance and thermal inertia, the tent internal environment is hot and humid, poorly ventilated. It affects the efficiency of staff rest restrict the application level of the tent seriously. The research on tent heat environment has developed in the recent ten years, mainly focused on the development of material [1-3], structure upgrading[4-8] and tarpaulin coating[9], water cooling and aluminum foil [10] and so on, the results of various kinds, but rarely applied to actual forces.

In order to explore the simple cooling method, the author decides to use shading-technology to cool tent. The agricultural black screen is set up on tents and the comparative experiments are carried out in the hot weather. The effects of shading on tent thermal environment are effective, which provides data reference and theoretical basis for upgrading the tent.

Experimental preparation

Experimental Site and Tim. The experiment has been done in a college of Tianjin. Tianjin is located in the northeast of the North China Plain and has four distinct seasons. The region belongs to continental climate, cold and dry in winter, high temperature and humidity in summer, rainy in hot season. The annual average temperature of between 11.4 to 12.9 ℃, the hottest month is July, the monthly average temperature between 25.9 to 26.7 ℃. The test period is from June 15th 11:00 to June 19th 18:00, when the weather is sunny and cloudy.

Experimental Objects and Apparatus. The experimental object is the most widely used military cotton tent in the army. Tent long 4.4m, wide 4.6m, top high 2.57m, while high 1.4m, fabric for the grass green polyester waterproof canvas, in the material for the white Oxford cloth.

As the shading-net material is 10m*10m agricultural black screen. It is made of high density polyethylene as raw material and a certain proportion of fine woven are added into the color drawing, which has the characteristics of heat resistance and cold resistance, convenient use, long service life, low price, wide application. Two types of shading-nets were selected and erected on the top of the tents. The temperature and humidity recorder, globe thermometer and mercury thermometer are used as apparatus to record date.

Experimental Layout Method. There are 3 tents arranged in the school grounds from east to west. The door is on the east and the wall to the west; all the doors and windows are opened. Group A (vacuity control group) is on the east, Group B (experiment group 1. A tent covered with three needle shading-net) is on the middle side, Group C (experiment group 2. A tent covered with six needles shading-net) is on the west.

The experimental instrument hanging in the tent is at the height of 1.5m suspension temperature and humidity recorder and globe thermometer, temperature and humidity recorder (automatic) record data once every 10 seconds, globe thermometer (artificial) hourly data. The mercury thermometer inside the tent hung in the southeast and southwest, northwest, northeast and central five directions, each range respectively in 0.1m, 0.5m, 0.9m, 1.4m and 1.8m at the height of the suspension 5, the layout of the 25 root thermometer, in addition, the top of the tent at the height of 2.0m to build 3 thermometer, in order to measure the top the temperature.

Analysis of Experimental Results under Overcast Conditions

June 15th 18:00 - 11:00, the weather is overcast, the maximum temperature of 33 degrees Celsius. A temperature and humidity recorder are used recording data automatically, hung in the center of the tent 1.5 meters high, every 10 seconds to record once, the temperature trend is shown in Fig. 1.

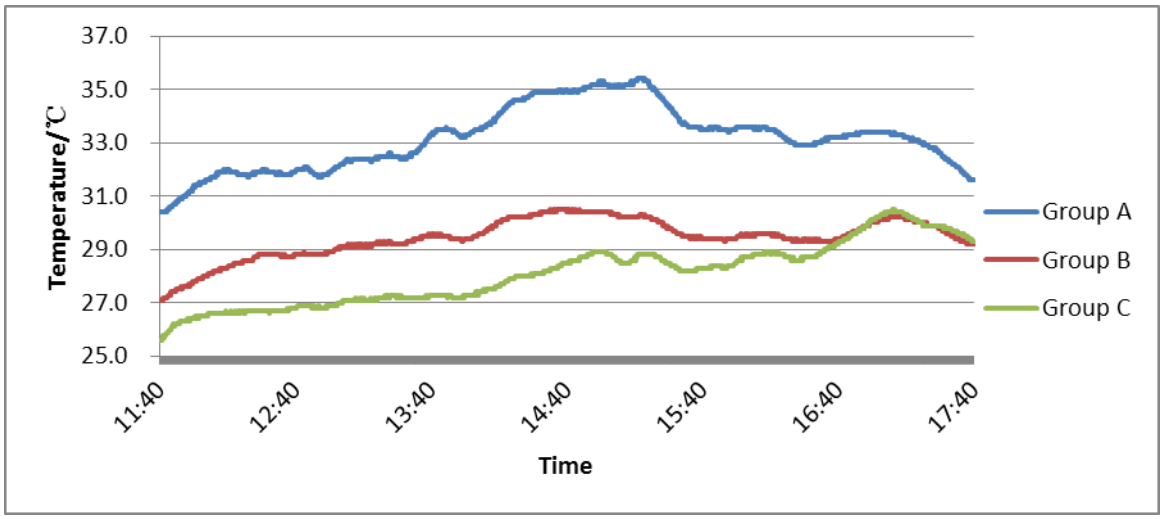

Figure 1. 6 - 15 17:30 - 11:40 temperature contrast

It can be seen clearly from Fig. 2 that the temperature of Group A is the highest without shade, the temperature of Group B is lower and the temperature of Group C is the lowest. In 15:20, the maximum temperature of Group A is about 35.7 degrees Celsius; at this time, the temperature of Group C is only 28.6 degrees Celsius, the temperature difference of about nearly 7 degrees Celsius, the temperature of Group B is 30 degrees Celsius, the temperature difference of nearly 6. Thus, two kinds of shading can also cool tent on a overcast day, and the cooling effect of Net B is better.

Analysis of Experimental Results under Sunny Conditions

In order to deepen the research, the author uses temperature and humidity recorder of the tent was nearly 24 hours of full time detection. Select sunny period June 15th 18:00 - June 16th 18:00, the maximum air temperature of 37 degrees during the period, the same temperature and humidity recorder automatic recording data, the temperature trend shown in Fig. 2.

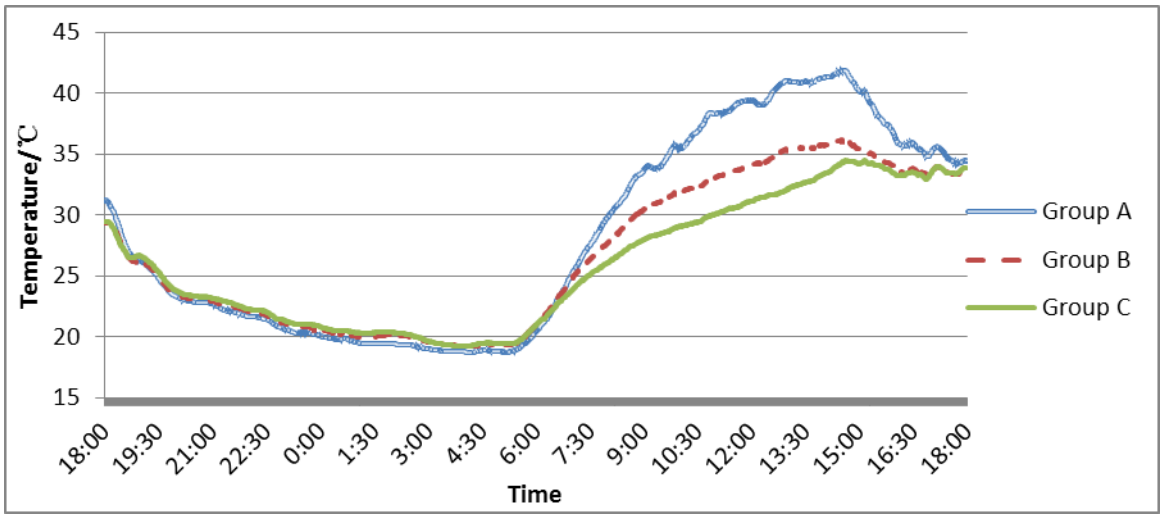

Figure 2. 6 - 15 18:00 - June 16th 18:00 temperature contrast

It can be seen from Fig. 2 that the temperature distinct is not obvious at night, during the day time, with the enhancement of the radiation of the sun, the cooling effect of shading gradually. The highest temperature is in June 16th 14:20, when Group A temperature is about 42 degrees Celsius without shade, Group B temperature is about 36 degrees Celsius, the temperature difference with Group A is 6 degrees Celsius; Group C temperature is about 34 degrees Celsius, the temperature difference of 8 degrees. Both net cooling effects are obviously, while the six needle density net cooling effect is better.

It can be seen from the trend of temperature during the day that with the increase of solar radiation, the temperature difference between the tent increases gradually, then can be inferred that stronger the solar radiation is, more obvious the net cooling effect is. Further analysis shows that in sunny weather, the greater the amount of solar radiation, the cooling effect is more obvious.

Analysis of Experimental Results under Cloudy Conditions

In order to further verify of the net cooling rate, the author have done a 24 hours of full time test through the overcast and cloudy weather, which time is from June 16th 19:30 to June 17th 19:30, at this time the weather mostly cloudy, with the same temperature and humidity recorder, the temperature trend is shown in Fig. 3.

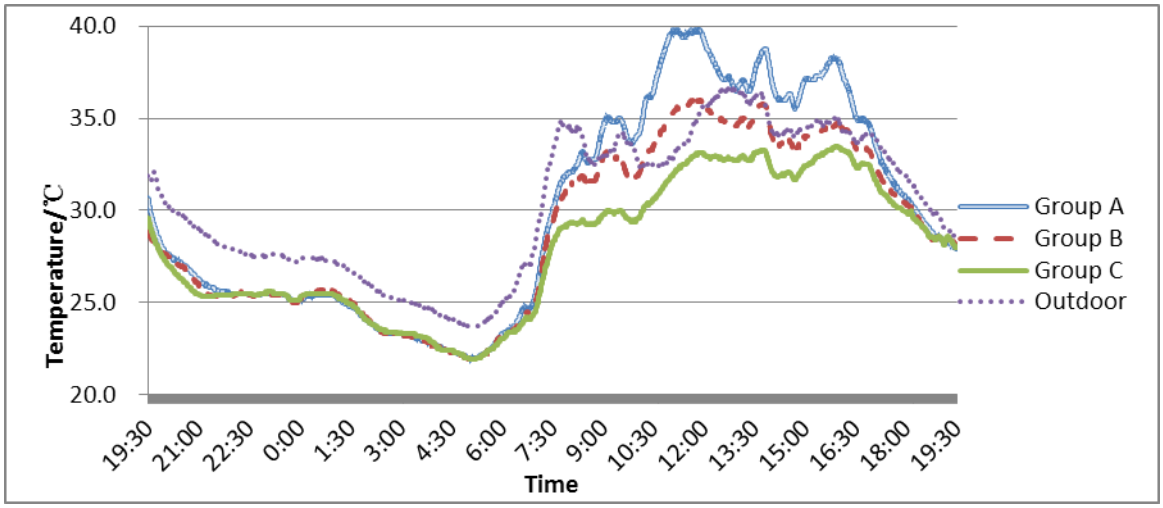

Figure 3. 6 - 16 19:30 - June 17th 19:30 temperature contrast

As can be seen from Fig. 3, 3 tents temperature were very close at night, but the indoor temperature is always lower than the outdoor about 3 degrees Celsius. During the day the weather is

uncertain, so the temperature of each curve is not the same. The outdoor air temperature is seemed as the reference curve to analysis shading effect. It can be seen from the figure, in the morning 5:00-8:00 period, as the sun rises, this period four temperature curves suddenly rise, the temperature continued to rise. In the 8:00-10:00 period, mostly cloudy weather, four temperature curves rise slowly, there are different degrees of volatility. The maximum temperature of Group A increased gradually during this period, the highest temperature is about 35 degrees Celsius, The temperature of Group C does not increase significantly, about 29 degrees Celsius, the temperature difference is about 6 degrees Celsius, shading effect gradually. In the time of 10:00-17:00, the high temperature curve of Group A was higher than others, also higher than the outdoor temperature and the highest temperature near 40 degrees Celsius. The temperature is not conducive to the personnel living in this period, Group C temperature was low, at about 33 degrees Celsius, the temperature difference is about 7 degrees Celsius. Visible, even in cloudy weather, the cooling effect of the net is still very obvious. After 17:00, four temperature curves showed a steady downward trend, close to the final temperature.

Summary

In summer, whether cloudy or sunny weather, the temperature of the tent is higher, and generally higher than the outdoor temperature, is not conducive to the rest of the people. In cloudy weather, while the outdoor temperature is 32 degrees Celsius, the highest temperature is 36 degrees Celsius in the tent; in the sunny weather, the outdoor temperature is 37 degrees Celsius, the temperature can reach 42 degrees inside the tent.

The source of tent main heat is from solar radiation in summer. Erecting screen on the top of the tent can greatly reduce the amount of solar radiation and the cooling effect is obvious. In cloudy weather, when the ordinary tent temperature is at 36 degrees Celsius, the temperature of the tent under six needle shading-net is about 29 degrees Celsius, cooling 7 degrees Celsius; in the sunny weather, when the ordinary tent temperature is at 42 degrees Celsius, the temperature of the tent under six needle shading-net is about 34 degrees Celsius, cooling 8 degrees Celsius.

Reference

[1] Xiling Du. Canopy structure parameters on temperature and humidity effect of tent [D]. Supervisor: Guangyin Xie. Xi'an Polytechnic University, 2012.

[2] Xiaogang Wang. Different Porosity Tents Base Cloth [J]. SHANDONG FANGZHI KEJI, 2012, 05:53-56.

[3] Tao Wang, Chen Hong. Research on Thermal Insulation Effect of Double-roof Tent [J]. BUILDING SCIENCE, 2010, 12:59-63.

[4] Wanguo Yang, Shaoxiang Li, Wenfang Wang. Research on Army Green Heat Reflective Coatings for Tents [J]. PAINT&COATINGS INDUSTRY, 2008, 09:22-24.

[5] Shaohua Hu, Qinglin Meng, Wang Lin. Experimental study on the improvement of the thermal environment of the tent [J]. Journal of Logistic Engineering University, 2007 (02): 81-83+87.

[6] Wanguo Yang, Shaoxiang Li, Wenfang Wang. Research on Army Green Heat Reflective Coatings for Tents [J]. PAINT&COATINGS INDUSTRY, 2008, 09:22-24.

[7] Erqing Zhao, Yuhui Di, Zhao Wei. Analysis and Improvement Measures of Tent Thermal Environment [J]. Low Temperature Architecture Technology, 2015 (4): 152-154.

[8] Xuefeng Wei, Ruifang Zhao, Fuzhong Zhu. Current Situation and Development of China's tent [J]. Development of Textile Technology, 2012 (2): 24-27.

[9] Xiang Zhao, Long Enshen, Lili Zhang. Design of New Nomadic Tents in West Sichuan Based on Green Building Principles [J]. BUILDING SCIENCE, 2013, 02:91-95.

[10] Ruofei Xu Guofu Du. Development of Field Inflatable Medical Tent [J]. Chinese Medical Equipment Journal, 2013, 04:85-87.