Cooling System by Wind to Control Heat in a Dairy Cow Shed

By IWAO NOTSUKI

Animal Physiology Division, National Institute of Animal Industry

How to control the high temperature in the dairy cow shed in summer is an important problem of dairy farming because many disturbances such as decrease in milk yield or reproductive disturbance are often caused by high temperature.

Standard air cooling by refrigeration, however, is too expensive for a dairy cow shed; therefore in some sheds, only the breeze from an electric fan is utilized or air is blown to individual cow by means of vinyl ducts. But these cooling methods are not effective so a positively effective cooling system is desired to control the heat of shed in summer.

Meanwhile, a new cooling system called 'pad and fan system' attracted attention in the southwestern regions of Japan. This is a simple cooling system utilizing wind and cool water. Since then, another cooling system which uses only wind was devised and together with the previous one, it is now acclaimed as the 'simple ventilation device' to cool a dairy cow shed.

In this device, air current is forced in a certain direction being drawn by a big ventilating fan placed on a window of the cow shed and cool water is permitted to flow on a pad placed at the opposite opening of the shed or sometimes no water is used but only air is ventilated.

Since the entire animal body is exposed to the low-velocity wind, the effect of this device seems to be fairly promising compared with the electric fan system which cools only one part of the animal body.

The effect of the low-velocity wind, the device causing such wind and the major points on the construction of the device are described hereunder.

Effect of wind on the physiological function of dairy cow

There are few data describing the effect of wind which can control the heat in the cow shed under high temperature.

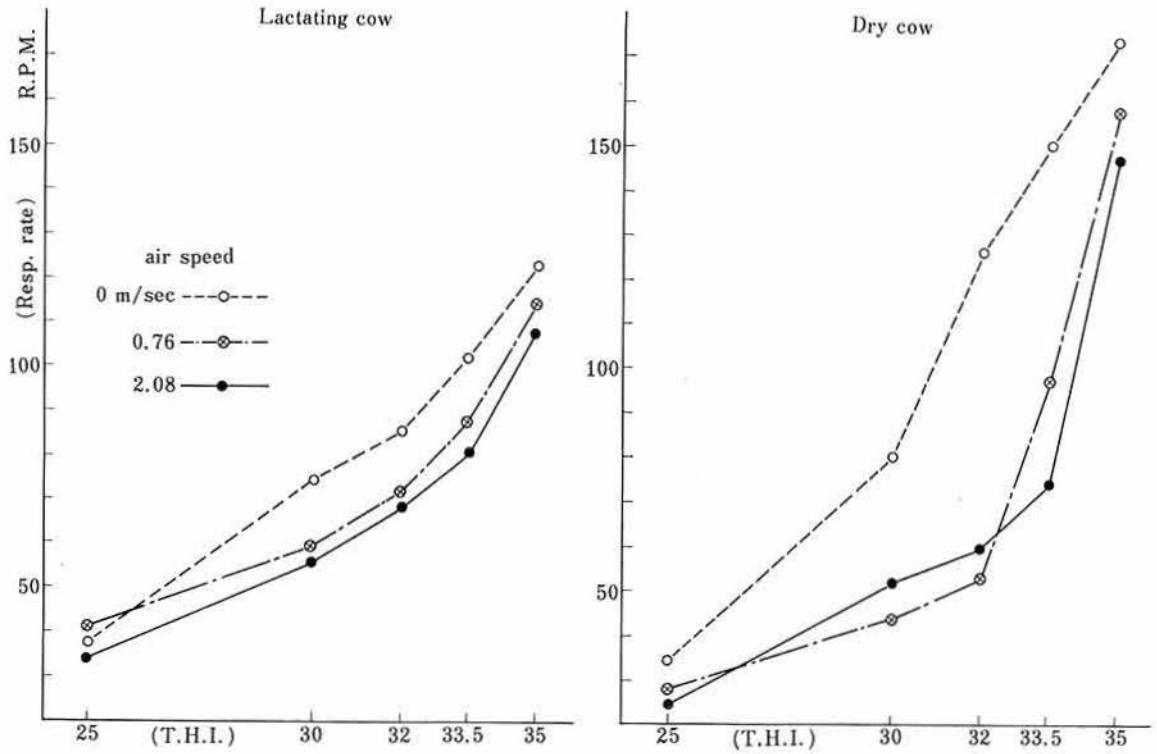
Though Brody et al.[1] reported on the heat control of dairy cow shed and Ittner et al.[2] on that of cow shed, their experimental wind velocity was too high.

Data on the effect of breeze on heat control are seldom found. Therefore, the minimum velocity of effective wind is not yet determined clearly. But Mount[3] reported that wind of 0.25 m/sec is effective to accelerate the radiation of body heat of pigs, and Drury[4] reported that even wind of 0.1 to 0.25 m/sec is effective to quicken the growth of chicks.

Notsuki et al.[5,6] experimented twice on the effect of wind velocity generally found in the simple air-conditioned cow shed of the dairy farmer.

In the first experiment[5], a zootron equipped with a wind tunnel was used and the heat controlling effect of the 0.7 m/sec breeze was examined under artificial conditions of 25°C, 50 per cent (r.h.) to 40°C, 70 per cent. In the second experiment[6], the same zootron was employed under some artificial high temperature conditions and the effect of the wind of 0.76 m/sec or of 2.08 m/sec, which was allowed to flow around the body of the cow, was investigated.

As the result of each experiment, the breeze



T.H.I. = Temperature humidity index
= D.B.T. × 0.1 + W.B.T. × 0.9

Fig. 1. Effect of wind on the respiration rate

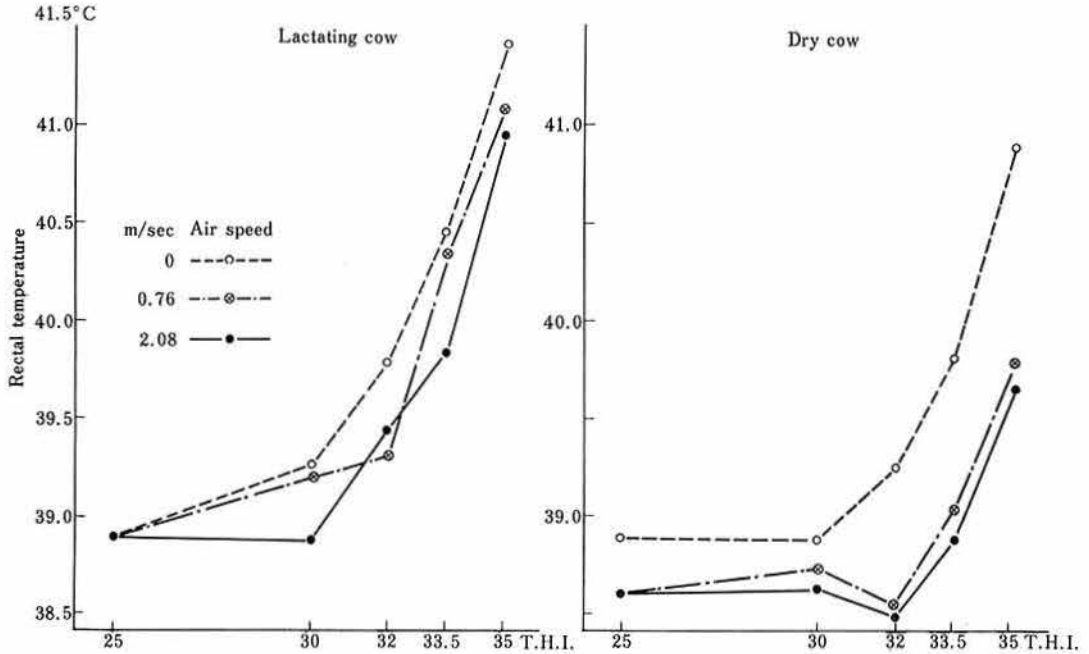


Fig. 2. Effect of wind on the rectal temperature

of about 0.7 m/sec was found to be effective to control the increase of respiration and body heat of dairy cow caused by high temperature (Figs. 1 and 2).

As to the favorable wind velocity of the cooling system in dairy farming, Drury[4] reported that the cooling effect of the wind is in proportion to the square root of wind velocity. And Brody et al.[1] reported that the result of his experiment on the effect of the wind of more than 1.4 m/sec for the dairy cow shows that the higher the wind velocity, the more the controlling effect on the increase of body heat and respiration and on the decrease of milk yield, but the rate of increase in the controlling effect declines in accordance with the rising of wind velocity.

This latter relation can also be seen in the results of the experiment conducted by Notsuki et al.[6] as shown in Figs. 1 and 2; that is, the difference of the effect of the wind between the velocity of 0 m/sec and 0.76 m/sec is great but that between 0.76 m/sec and 2.08 m/sec is not so great.

On the other hand, from a physical point of view, to raise wind velocity too high may result in economical disadvantage owing to the augmentation in cost of the equipment and its maintenance because the output of a fan motor is in proportion to the cube of wind velocity.

In consideration of these points, therefore, the most economically effective wind velocity must be determined in the future and for the time being, the wind velocity of about 0.7 m/sec seems to be the most appropriate.

Structure of the cooling system by wind

According to the investigation made by Notsuki et al.[5] on the actual using condition of the ventilation system in the simple air-conditioned cow shed of dairy farmers in Japan, the equipment structure may be outlined as follows:

The cow sheds of six dairy farmers investigated were all of double field face-out type with ranging from 115.9 m^2 to 705 m^2 (the number of cow was 15 to 108 head).

As seen in Fig. 3 and Plates 1 and 2 indicating the structure of such cow shed, several fans are equipped on one side of the structure, and the water-sprayed pad is set on the opposite side as is shown in Fig. 3 and Plate 3

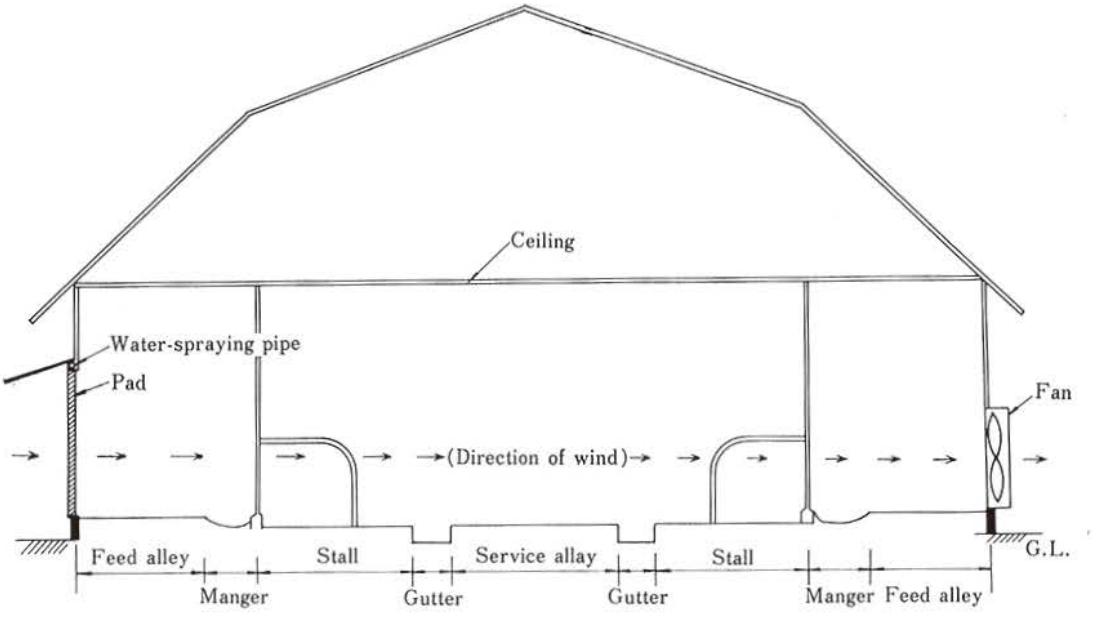


Fig. 3. Sectional plan of dairy cow shed with ventilation device

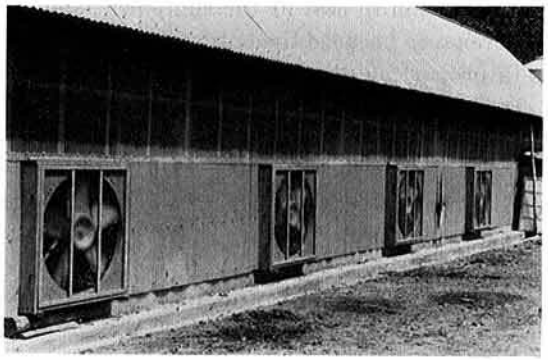


Plate 1. Ventilating fan (outer side)

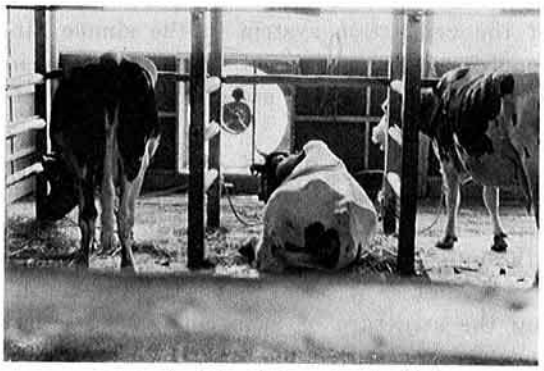


Plate 2. Ventilating fan (inside)

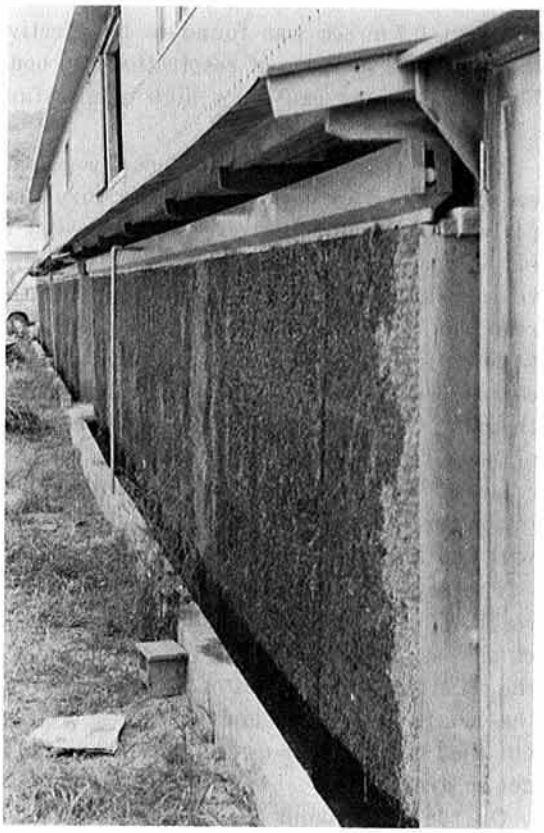


Plate 3. Water-spraying pad

but the opposite side is left opened when such pad is not used. All the other openings of the shed are kept closed and most of the sheds are boarded ceiling rising to a height of 2.14 m to 2.82 m to minimize the cross section area of air passage.

One side of the cow shed is equipped with several fans at the rate of one per each five to eight head, and the performance of the motor of a fan is 0.4 kw in output, 400 or 460 in revolution per minute and 315 or 320 m^3/min in the quantity of wind.

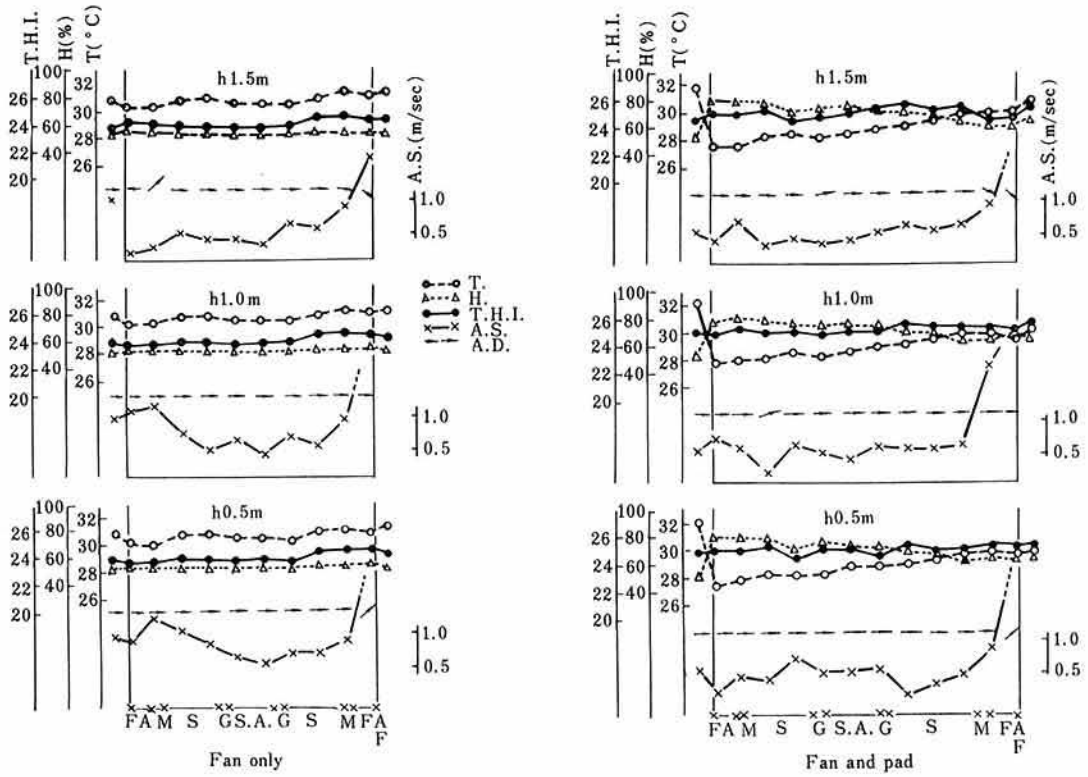
The size of the pad set on the opposite side of the cow shed varies depending upon the farmers, but the structure of the pads is almost similar to each other; that is, cotton or plastic pieces are stuffed between the wire net stretched on both sides of a wooden frame.

Water is sprayed on the pad flowing out through many small holes bored at intervals of some centimeters on the vinyl chloride pipe located above the pad.

Cooling effect in practical use

Fig. 4 shows one example of the change of microclimate at the inside and outside of the cow shed.

At points of 1 m in height, the wind blows in a nearly fixed direction with the constant velocity of 0.5 to 0.7 m/sec at the inside of the cow shed. As a result, it was found that, as to the temperature, humidity and temperature-humidity index which is most suitable to change the physiological function of cow, no great difference exists between the inside and outside of the cow shed. This fact means that the temperature and humidity around the cow body, which might have inevitably been augmented if the wind did not exist, had been kept almost in the same condition as the climate of the outside owing to the existence



T	Dry bulb temperature
H	Relative humidity
THI	Temperature humidity index (D.B.T. × 0.1 + W.B.T. × 0.9)
A.S.	Air speed
A.D.	Air direction
h	Height of measurement point (from floor level)
F	Fan
O	Open the window
P	Pad
F.A.	Feed alley
M	Manger
S	Stall
G	Gutter
S.A.	Service alley

Fig. 4. Comparison of the microclimate in the cowshed with fan only and fan and pad

of the wind.

Consequently, the effect of the fan on the improvement of environment around the cow body has been manifested positively in addition to the cooling effect of the wind which radiates body heat of the cow as mentioned above.

As a result of a hearing investigation, the utilization of the fan also proved effective to decrease milk yield decline in summer, reproductive disturbance, injurious insect and bad smell in the cow shed and to improve working environment.

As to the dairy farmer who had used the water-spraying pad, ventilation device showed the same effect as well as in the cow shed with fan only, but the effect of the pad used together with the fan was obscure. That is, as is shown in the microclimate at the inside and outside of the cow shed in Fig. 4, inside temperature was nearly 4°C less than the outside; therefore, inside environment seemed cooler but humidity, which affects greatly the physiological condition of the cow, was about 25 per cent higher in the inside than the outside. Consequently, the most appropriate temperature-humidity index

for the physiological change of dairy cow was almost the same as that the cow shed with the fan only.

The condition to obtain sufficient effect of a water-sprayed pad seems to depend on the temperature and amount of sprayed water.

Since the temperature-humidity index can be lowered by the evaporation and heat conductivity of cool water, the water of which temperature is higher than the wet-bulb temperature of the outside cannot be proved effective. With the water temperature which is lower than that indicated by the wet bulb, the lower the water temperature and the more the amount of cooling water, the greater the effect.

The ineffective results of the water-sprayed pad might have been caused by inappropriate temperature and amount of used water.

Precautions in the construction of the cooling system

The following precautions must be followed in the construction of the cooling system by air ventilation in the dairy cow shed:

(1) Inside air must be ventilated by the fan in the same direction as that of the natural wind in summer.

(2) Air capacity of the cow shed should be small as far as possible.

(3) Air inlet opposite to the fan must be large, and there should be no other opening and obstacle in the cow shed.

(4) Water temperature must be low, water flow must be abundant and the surface of the pad must be large as much as possible when the water-sprayed pad is used together with the fan.

This cooling system, if it is constructed under these conditions, may be the most practical and effective one today.

References

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