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Short Communication

Analysis of Internal Environment of a Pig House using Energy Recovery Ventilator

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ABSTRACT: *In this study, Energy Recovery Ventilator (ERV) was applied in a pig house model where the internal temperature, relative humidity, and CO_2 were analyzed. The experiment was performed in a pig house model where an ERV was installed and two pigs (8 months, ca. 20 kg) were bred. In the pig house model, the internal temperature, relative humidity, and CO_2 were divided into three cases and were then measured. In Case (A), ventilating fan and ERV were not used. In Case (B), a ventilating fan was installed and operated. In Case (C), an ERV was installed and operated in the pig house model. In Case (A), the internal temperature between 12:00-17:00 hours was measured at about 23-24 °C, which was lower than usual temperature for breeding. For Case (B), the internal temperature was 22-25 °C and the relative humidity was about 70-80%. In Case (C), the internal temperature was 29-32 °C.*

Keywords: *Energy recovery ventilator, pig house, ventilation, waste heat*

INTRODUCTION

In recent years, due to consumption of fossil fuel, climate change and safety concerns on atomic energy, the interest in new and renewable energy has increased worldwide. Because new and renewable energy provides clean alternative energy resources, its importance as well as its marketability has increased. As a result, countries from around the world including major developed countries have devoted financial resources and efforts to acquire shares from the fast-growing renewable energy market. Developing countries such as China, India, and Brazil have also been actively participating in the race to develop innovative technologies for new and renewable energy. Under the national vision of low-carbon green growth, Korea has also invested a lot of resources to the new and renewable energy sector to contribute solutions to the energy problems and to establish domestic market shares (Choi *et al.*, 2013).

One example of renewable energy source is the use and dissemination of Energy Recovery Ventilator (ERV) which has been increasing steadily as effective energy-saving equipment that can be achieved through energy conservation enthalpy recovery of air supply and return (Chung and Oh, 2012). Such technologies can be utilized in the livestock industrial sectors.

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As the pork industry enlarges and breeding herd sizes increase, the importance of temperature and ventilation factors that affect the productivity of livestock breeding should be given much emphasis. In Korea, the climate for an appropriate breeding temperature is too high in summer and too low in winter, so the economic burden of livestock farming and the necessity of scientific ventilation and heating have increased to improve the productivity of livestock (Yoo, 1997). Therefore, breeding parameters such as temperature, relative humidity, odours, noxious gases and dust must be managed optimally to maximize the ability of pigs to breed and develop (Kim *et al.*, 2004).

In this study, ERV was applied in a pig house model where internal temperature, relative humidity, and CO_2 were analyzed. Basic data was applied to actual pig house fuel cost reduction and optimum calculation of pig breeding environment.

METHODOLOGY

The experiment was performed in a pig house model where an ERV was installed and two pigs (8 months, ca. 20 kg) were bred. The pig house model was designed based on a sandwich model panel with a 50-mm thickness (W×L×H: 3,300 mm × 5,400 mm × 2,200 mm) as shown in Figure 1. The pig house model used data logger (midi LOGGER GL 820, GRAPHTEC) and temperature sensor (K-Type thermocouple) for measurement of internal temperature. Portable humidity sensor (Mini data logger Testo 174H, Testo) was used for measurement of relative humidity. Portable CO_2 instrument (TSI 7525 Indoor Air Quality Meter, TSI) was used for measurement of CO_2 concentrations. A total of 27 temperature measurement points were measured in the pig house model. Temperature sensors were installed at the entrance of Supply Air (SA), Outdoor Air (OA), Exhaust Air (EA) and Return Air (RA), according to temperature change, in order to measure the operation efficiency of the ERV. Relative humidity and CO_2 levels were measured in 7 points (centre, top, bottom, left, right, front and back). The measurement points of model pig houses were measured from a distance of 0.2 m from the floor and wall (Figure 2).

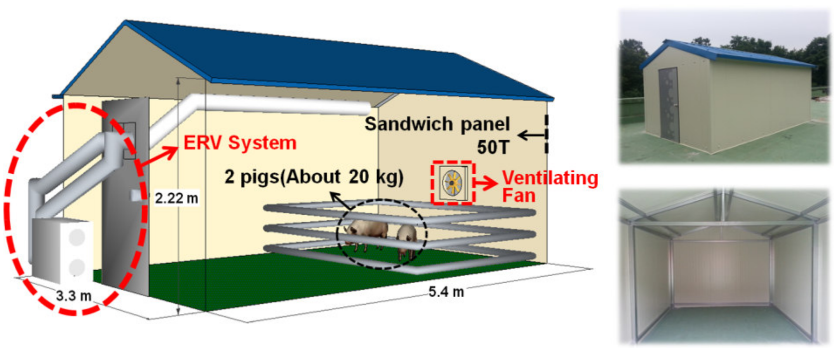

Fig. 1. Designs of pig house model and actual pictures

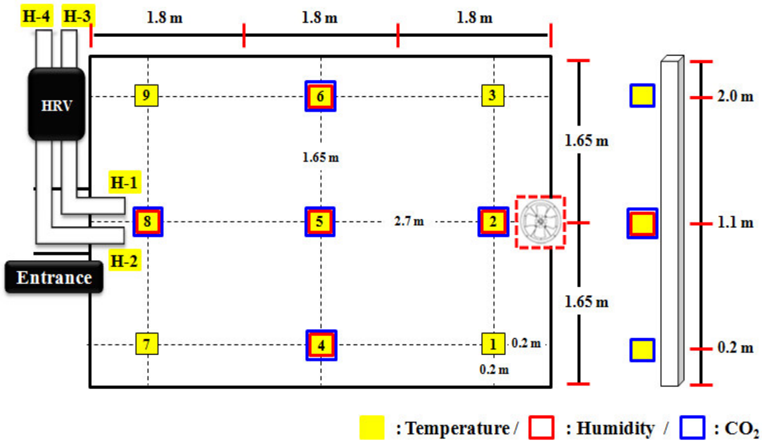

Fig. 2. **Measurement location in the pig house model**

Internal temperature, relative humidity and CO_2 were initially divided into three cases and were then measured. In Case (A), ventilating fans and ERV were not used. In Case (B), a ventilating fan was installed and operated. In Case (C), EVR was installed and operated in the pig house model (Figure 3). In order to analyze the internal environment due to temperature gradient between day and night, 12:00-16:00 and 20:00- 22:00 hours were measured, respectively. In the case when ERV was not installed, ventilating fan was used and two bred pigs (about 20 kg) in pig house model were studied to measure the internal environment between day and night (date of measurement: October 21, 2013). In accordance to installation and operation of the internal environment, ventilating fans and ERV were carried out during day and night of October 22-23, 2013. The specifications of the ventilating fan blades are; diameter (350 mm), flow rate (3,300 m³/h), rotation speed (1,650 RPM).

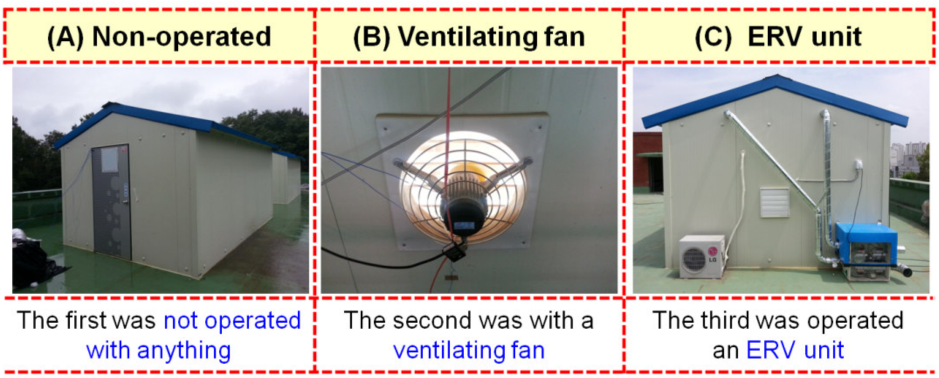

Fig. 3. **Testing methods of pig house model**

In measuring the temperature of each part of the ERV, calculations of the temperature exchange efficiency was based on Eq. (1) (Kim *et al.*, 2012). In this equation, η_T is sensible heat exchange efficiency (%), t is temperature (°C); the subscripts OA, SA, and RA are outside air, supply air and return air, respectively.

$$\eta_T = \frac{(t_{OA} - t_{SA})}{(t_{OA} - t_{RA})} \times 100 \qquad (1)$$

where:

η_T = Temperature efficiency (%)
t_{OA} = Ourdoor air dry bulb temperature(°C)
t_{SA} = Supply air dry bulb temperature(°C)
t_{RA} = Return air dry bulb temperature(°C)

RESULTS AND DISCUSSION

In Case (A), the temperature distribution between 12:00 to 14:00 hours for top, middle, and bottom areas are approximately 34-36 °C, 30-32 °C , and 26-28 °C , respectively. Temperature difference among top, middle, and bottom areas was about 1-2 °C; top and bottom areas showed 8 °C temperature difference. The inside temperature of pig house model becomes generally low after 14:00 hours and it was found that the temperature of all the three parts are the same. After 20:00 hours, the temperature throughout the whole room was also similar between 17-20 °C. Temperature of pig house model according to ventilating fan operation can be seen in Figure 5. The ventilating fan operation and basic situation at 12:00-13:00 hours show a similar temperature with only a slight 1-3 °C difference. After 13:00 hours, the internal temperature of the pig house rapidly becomes uniform. The temperature of the pig house was found to be lower by about 2-3 °C than the basic situation (Case (A)) of about 20 °C at 16:00 hours. Temperature of the pig house according to ERV was measured and can be seen in Figure 6. Conclusively for Cases (A) and (B), the internal temperature of the pig house became entirely uniform at a faster rate. From 16:00-17:00 hours, the air supply of heat exchanged was higher than during the operation of ventilating fan.

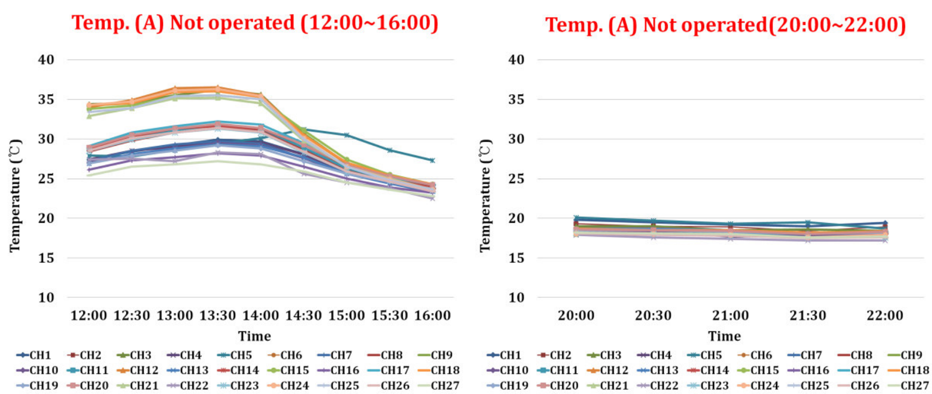

Fig. 4. Internal temperature data for Case (A)

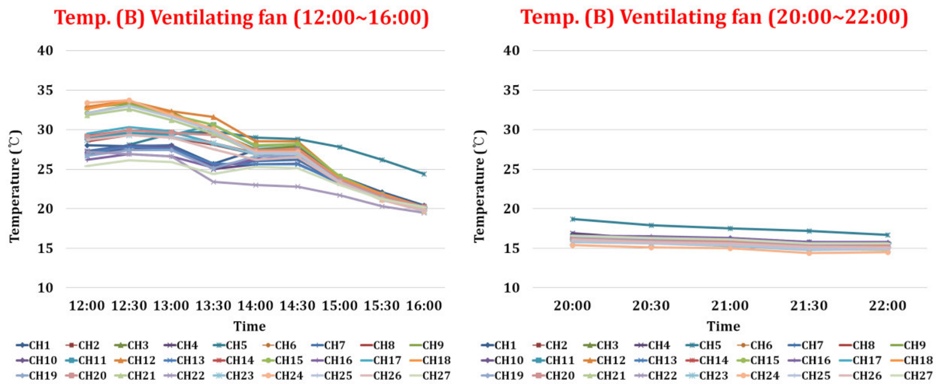

Fig. 5. Internal temperature data for Case (B)

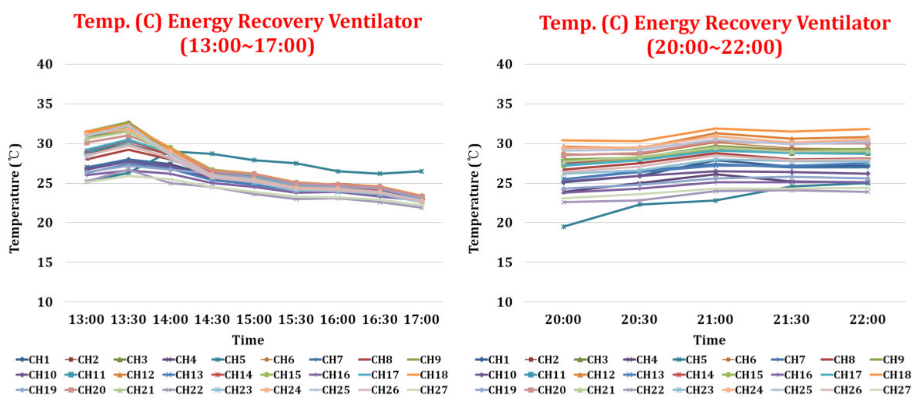

Fig. 6. Internal temperature data for Case (C)

In the case when a ventilating fan and ERV were not installed in the pig house (Case (A)), CO_2 concentration was about 400~800 ppm up to a maximum of about 900 ppm. Overall, CO_2 concentration increased over time. CO_2 concentration for Case (B) was 1 to as low as 400 ppm. For Case (C), CO_2 concentration was measured to be lower than Case (A) at about 400~600 ppm. CO_2 concentration for Case (C), however, was higher than Case (B).

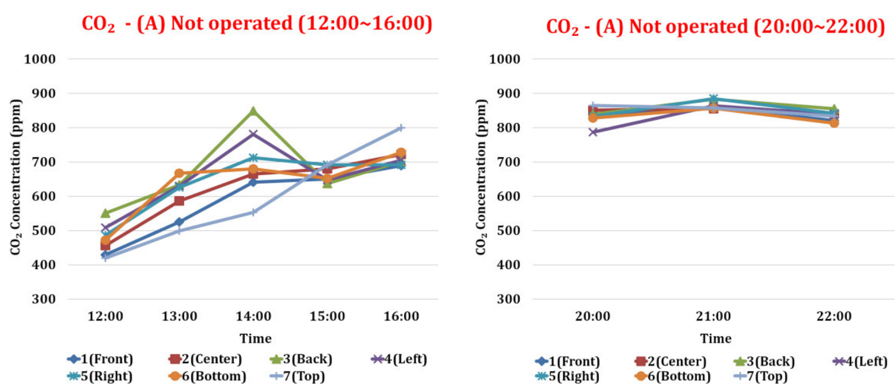

Fig. 7. Internal CO_2 data for Case (A)

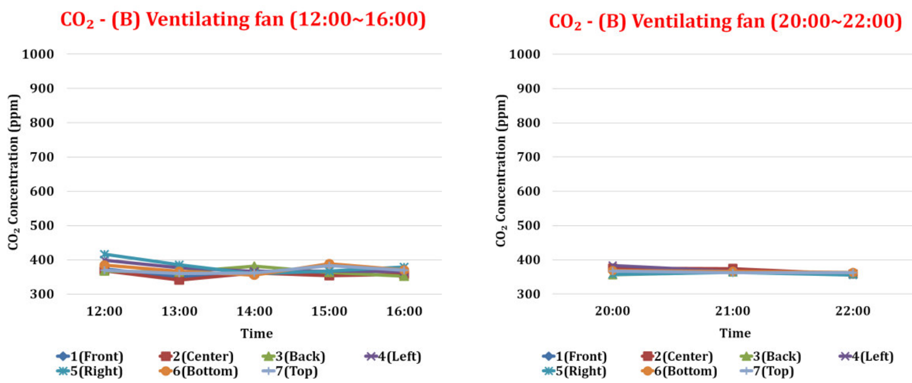

Fig. 8. Internal CO_2 data for Case (B)

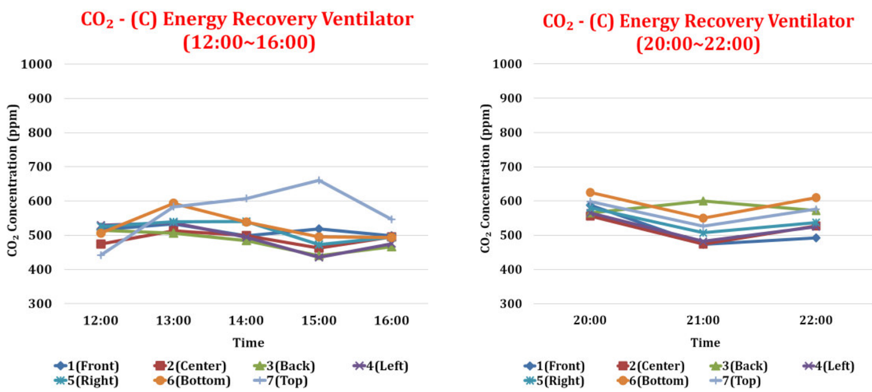

Fig. 9. Internal CO_2 data for Case (C)

CONCLUSIONS

In this study, Energy Recovery Ventilator was applied in a pig house model and the internal temperature, relative humidity and CO_2 were analyzed. This was done to take advantage of the basic data in application to actual pig house fuel cost reduction and optimum calculation of pig breeding environment.

In Case (A) where a ventilating fan and ERV were not installed, the temperature distribution in the top, middle and bottom parts was not uniform and high temperature was maintained, and no ventilation indicates high CO_2 concentration. In Case (B) where ventilation fan was utilized, lowest CO_2 concentration was measured compared to Cases (A) and (C). This is thought to be good in the environmental aspect (internal air quality) but there is a continuous loss of thermal energy. In Case (C), ERV proved to be beneficial since results suggest that the temperature of the top, middle and bottom areas shows rapid uniformity due to the sufficient supply of heat-exchanged air. It was also found that the temperature in the pig house was higher in Case (C) than Case (B) (ventilating fan operation).

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