Propane Saving in Poultry Farm through Waste Heat Recovery System

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Introduction

High and unpredictable fuel cost has been one of the biggest challenges to poultry growers and poultry companies. Any improvement in energy efficiency of the poultry houses will mean a more profitable and lower financial risk business for farmers.

Efficient heating will allow farmers to bring more fresh air into the barn and maintain a better air quality with lower ammonia and moisture levels, which will greatly benefit birds health and food quality.

Most of the heat is lost through intensive ventilation, which is required by thousands of birds inside a building. Recovering waste heat from high temperature exhaust air is one of the most economical ways to reduce heating fuel cost. Missouri Alternative and Renewable Energy Technology Center at Crowder College has been working on heat recovery ventilation in cooperation with the University of Arkansas and ALDES Ventilation Corporation. Detailed performance data can be found in the research publications. There are multiple commercial products available today for poultry applications. Due to the dusty and corrosive environment of poultry farms, development of durable and dependable technology and products are of interest to the industry.

Poultry House Thermal Analysis

Two factors make the ventilation the largest heat loss, and also the most valuable energy to be reclaimed. One is the large and continuous ventilation amount; for a typical broiler barn, 4 sidewalls fan with capacity of 8,000-10,000 cfm are required. The other fact is high temperature, which ranges from 65-90F based on birds types and ages.

![Figure 1 Heat loss analysis of a typical poultry house](image)

Figure 1 provides performance data including ventilation volume and actual daily propane usage collected from experimental barns. Building envelope heat loss, body heat generation, and ventilation heat loss at different ages of growing birds are shown as a response to ambient temperature (reversed axial scale). It shows that ventilation heat loss can be up to 90% based on the age of birds.
Waste Heat Recovery System

The biggest challenge to capturing waste heat from poultry exhaust air is the corrosive and dusty environment. In order to develop dependable and durable equipment, high conductivity polyethylene pipes (HDPE) are used as heat transfer components. Thermal conductivity of HDPE is about 2.5 times of commonly used PVC pipe. It is not as good as metal (copper and aluminum) material, but using those more conductive materials will not benefit overall heat transfer efficiency very much. Plastic material offers benefits of resistance to corrosive gas and moisture, and it is washable.

A timer controlled flushing system is installed in the heat recovery systems. Water washing is more effective than high pressure gas removal because the dust from the discharged air will exit the equipment as wet mud, rather than as dry particles which contribute to dust discharge problems.

The system is small and modular, which make manufacturing, shipping, and installation, easier. It also allows multiple locations of fresh air supply and is helpful in maintaining uniformed and balanced ventilation in different sections of a building. Preheated air is delivered into poultry barns through heavy duty flexible air tubes. Four inch diameter diffusion holes are cut along the pipe length. The system is designed for continuous operation without any on-off interval.

The system runs on single phase electric supply. Variable speed drivers (VFDs) are used to control both fresh air and waste air volume based on bird age. Lower levels of ventilation are allowed during the earlier days of bird growing since inlet air is not based on static pressure.

Field Test 1: Broiler Barn

Eight waste heat recovery units have been installed in 2 broiler barns. There are two other barns that have been kept unchanged to compare energy consumption. 12 propane gas meters have been installed in all 4 of these barns, and daily propane consumption has been recorded. More than two years of operating data has demonstrated propane savings in the range of 45-50% depending on weather and operations.

The following parameters are periodically or irregularly checked and recorded: carbon dioxide (CO2), ammonia, indoor and outdoor air temperature and humidity, energy (gas and electric), and ventilation amount (which is controlled by VFD frequency). Waste heat recovery units are closely monitored with temperature sensors attached to the fresh air stream and the waste air stream.

![Figure 2 Daily propane consumption at the barns with waste heat recovery system and at the conventional barns without WHR.](image-url)
Figure 2 shows daily propane consumption at the 2 test barns and 2 reference barns. The tops of red bars show daily propane consumption in gallons in the barns without heat recovery. The tops of the blue bars indicate daily propane consumption in the test barns with heat recovery. The length of red barn shows daily propane savings in gallons. During the first week, heat recovery is not significant (15-25%) due to limited amount of ventilation. It gradually increases to 50% in the second week. After 4 weeks, there is almost 100% of saving. The barn does not need propane heating even if the outdoor temperature stays as low as 30-40F, because of the poultry body heat generation. Table 1 summaries propane saving of each flock from a cold period (December through February), through a warm period (April through June). The total amount of propane saving changes with different seasons, but the percentages do not change substantially.

### Field Test 2: Turkey Barn

An independent turkey grower in Cooper County, Missouri installed both waste heat recovery system and hybrid ground source heat pump system. The waste heat recovery system with 5 units has been run for two full flocks up to the middle of March, 2015. The hybrid heat pump system is undergoing field testing and will be in full operation for the following flock.

Heat recovery efficiency is defined as

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HR\% = \frac{T_{preheated} - T_{fresh}}{T_{waste} - T_{fresh}}
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Based on the field operation, heat recovery efficiency is shown in the Figure 3. It can be seen that the ambient temperature varied in the range of 15F-75F, but the heat recovery efficiency did not correspond the temperature change. It stayed in the range of 50-60%. In the earlier stage it is slightly higher due to the small amount of air flow.
Figure 4 shows an average of 16.5KW of energy saving for each heat recovery unit, which is equivalent to 17 gallon propane for each unit, and 84 gallon of propane per day with 5 units.

There is very minimal difference between the heat recovery units (Figure 5). On average during the operating period, each unit’s contribution to barn energy saving is about 16.5 KW/unit, which is equivalent to propane saving of 0.7gal/hour/unit.

Additional Outcomes for the Turkey Farmer

Most the turkey barns are still with drop-curtain, instead of solid wall. Cold air entering trough loose fitting curtain quickly falls to the floor leading to a cold spot. One of the benefits of the alternative heat recovery ventilation is to fitting the gap and minimized this type of air leakage.

Based on farmer’s operating experience, there are significant benefits from the waste heat recovery system for turkey farmers, in addition to propane savings. These are:

1. Because there is no movement of the curtains any more, any holes or gaps between the wall and curtains can be fixed and patched to stop leaking. This will significantly reduce the common chilling or cold spot problems.
2. Weather independence and labor reduction: It is very challenging for growers to manage the curtains during winter time. It is a very sensitive operation based on bird’s condition and outdoor weather. Growers are required to take action based on temperature change, wind speed and direction change, even in the middle of the night. With the waste heat recovery system, the curtain will remain completely closed, and ventilation will be controlled by motor control frequency. So growers can be under less stress from their operation.
3. It has been show that central attic inlet pulling air into the attic space helps mixing of indoor air. Similar to this, very good air mixing has been observed because gradually sinking of cold air from top of the barn space. When the heat
recovery units were operating, the farmer stopped running the mixing fans for the first time.

4. Without air dropping along the wall or direct cold air movement from open curtains, the farmer has not observed turkey “coughing” for the first time.

**Production Benefits Verification**

The University of Missouri has receive additional funding from the U.S. Department of Agriculture to work with the University of Arkansas to verify the production benefits, including possible increased average weight, mortality reduction, and feed conversion improvement.

The authors are looking forward to working with people in the poultry industry to improve the energy efficiency of poultry houses, in order to reduce farmer’s energy cost and improve the air quality in the buildings which should result in healthier food being produced.

**Acknowledgement**

The authors appreciate the great assistance from Dr. Yi Liang, Dr. Susan Watkins and Dr. David McCreery at the University of Arkansas, and Dr. Jeffre Firman at the University of Missouri, for their information that helped our understanding of the poultry industry and their assistance in technology development and field testing. Past operating data from the experimental barns were a significant help to our analysis and equipment design. Special thanks to Dr. Firman for his help in identifying a pilot farm for demonstration.

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