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Analysis on the Heat Transfer Process of the Burning Cave -- a Traditional Heating System in Rural Houses of Northern China

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Abstract

Nowadays, inhabitants living in rural areas of northern China still rely on traditional heating methods, such as kangs (bed-stoves), radiators heated by mini stoves, and burning caves in cold winter period. Burning caves are increasingly used due to free fuels from crop wastes, simple structures, and better heating effect than kangs and mini stoves. In this study, field measurements of indoor environment in several rural houses with burning caves located in northern China were carried out in 2010~2011. The results show that indoor temperatures maintained at above 18℃, and it was felt more comfortable than houses heated by kangs and mini stoves. By comparing analysis on exergy efficiency, using burning cave and kang is the highest to 55%, and the thermal efficiency was up to 42%.

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Keywords: Burning cave, Radiant floor heating, Heat transfer;

1. Summary

Burning cave heating system is widely used and more popular, because of its continuous radiant heating, biomass energy resources, indoor environment improvements, and easy for integration with house. Through a long-term study on traditional heating system in rural houses of Northern China, indoor thermal environment could be improved in a house heated with burning cave, which could take the average indoor air temperature maintain at 15.5℃, and the temperature difference between the day and night could be reduced to 6℃. In this paper, indoor thermal environment, thermal comfort, and exergy efficiency has been analysed by experimental researches. It

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illustrates that the average indoor air temperature could be more than 16℃, which is more comfortable than the room heated by kang.

2. Introduction

For thousands of years, Chinese people live in harmony with the nature and take actions that suit local circumstances to adapt the climate change, which has been proved by house construction modes, energy consumption modes, and indoor environment control strategies. With times changing, the forms of dwellings for residents living in were constantly updated developed. At the same time, in order to adapt to the harsh outdoor climatic and environmental changes, the reasonable optimized approaches of rural houses design is a great challenge for people to resist the cold winter, but also the constant practice of human wisdom. As shown in Fig. 1, the original form of Chinese residential northern cold region could be traced back to ancient times, people had always lived in the rocks or caves for social life, relying on a simple way of direct firing heating in winter [D. Lu.]. In order to increase the privacy of a family, civil engineering structures began to develop gradually until Shang Dynasty, at the same time, using the high temperature gas flames to heat the heating facilities have begun to emerge, such as “heating-wall”, “Di-Huolong”. Besides, kang was birthed gradually to make the heating surface warmer and better heating effects on human bodies, and the direct contact area has been much bigger [H.G. Ren.]. Chinese people’s living styles and history cultures have been significantly affected by traditional heating approaches such as kangs, smoke heated walls and grounded kang (burning cave) which utilize biomass (crop wastes collected from farmland and excrements from animals) to heat the rooms in a long and severe cold winter in vast northern China. Different kangs are taken as the prototype of radiation heating systems, have been used since 10,000 B.C [Building Energy Research Center of Tsinghua University]. They are not only domestic heating systems, but also places for cooking, eating, sleeping and communications. In order to achieve the needs of modern variety architectural space layouts, square-shaped, L-type, and other forms of kangs have appeared in different houses, and have been in use ever since. Thus, technological improvements closed to people’s daily lives have been carried out on these original heating systems, which reflect people’s wisdom. A large amount of field surveys, experimental and theoretical research on the forms, constructions, and integrated application modes of the traditional heating systems like kangs and burning caves have been conducted [B. Robert, X.Y. Zhang, B. Chen, W.Z. Tian, Z. Zhuang, Y.G. Li, etc.].

Fig.1. Original heating systems developed with the evolution of architectural forms

In recent years, burning cave, an ancient traditional heating method, has been attracted much more attention in some rural areas of northern China. Although its form is original, it’s still popular because of its simple technology, low cost, and better heating effect. Especially, many demands for integrated houses with improved burning cave heating system based on craftsman experience are increasing day by day, account for the continuing improvement