Study on the whole life cycle of farm air source heat pump

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Abstract

The air source heat pump uses electric energy to work to convert air energy into indoor heat energy, which is environmentally friendly and produces no pollutants such as exhaust gas. Investigate the farm model and obtain environmental pollution assessment by calculating the air source heat pump function heat system through the whole life cycle.

Keywords

Air source heat pump, Rural architecture heating, Life cycle.

1. Introduction

China's rural areas are vast and have a large population. The total area of residential buildings in the northern region is about 23.6 billion square meters, the rural living area accounts for 40% of the total area, the annual burning capacity of rural loose coal is 18 million t/a, and the heating energy consumption per unit of building area is 20kg/m^2 The energy consumption in the heating season in rural areas has gradually become the first in China's building energy consumption. Unreasonable combustion of pollutants can cause environmental problems such as "smog days" and "ozone layer holes".

At the end of 2016, the clean heating rate in northern China was 34%. However, the architectural forms and residents' lives of rural and urban houses are very different. It is impossible to blindly copy the urban building energy-saving strategy to the countryside. In the northern rural areas, the heating period lasts for 4 months, and the heating fuel is mainly coal.

The traditional air source heat pump is based on the inverse Carnot cycle. The air source heat pump uses electric energy to work to convert the air energy into indoor heat energy, which is environmentally friendly and runs without pollutants such as exhaust gas.

 Izzet Yuksek[1] conducted a study on the housing structure of the Turkish farmhouse and found that the layout, area, and window walls of the house played an important role in building energy conservation in the area.

G. Verbeeck proposed to build a list and model of the entire life cycle of the building, using the Ecoinvent database as the basic data for carbon emissions analysis of five different buildings in Belgium. He found that the internal carbon consumption of different buildings in the envelope structure is significantly different during the whole life cycle.[2]

AndersC. chmidt[3] evaluates the carbon emissions of polyurethane insulation foam, rock wool and bio-fiber insulation throughout the life cycle. Analysis of the results found that there are advantages and disadvantages in terms of human health, global warming and so on.

Yutaka Genchi mainly studied the carbon dioxide recovery period of district cooling and heating for ground source heat pump systems in high energy-consuming areas of Tokyo.[4]

Qunli Zhang et al.[5] used mathematical models to compare primary energy consumption, initial investment, and annual operating costs for different heating systems. Fanchang Hu et al.[6] used commercial CFD software to simulate two system characteristics.

In addition, the impact on the environment is not considered in most life cycle calculations. However, through the introduction of ecological costs[7], the pollution caused by the entire research object to the environment becomes a visual number, and the increase in the amount of calculation brings about a clear total cost.

2. Survey results and models Section Headings.

There are many rural houses in 1990s, and the layout of the rooms is mostly symmetrical. It faces south and has no eccentricity. Most households have not taken insulation measures on the external walls. The thermal performance of the farmhouse is poor and the energy waste is serious.
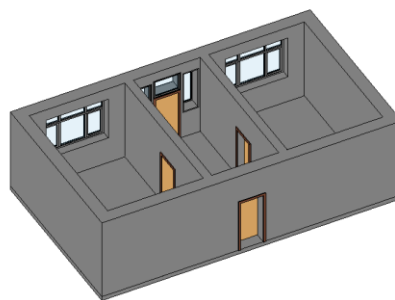

Figure 1. Farm tool model drawing

Import the DeST model based on the survey results. Its calculation parameters are as follows. The building area is 84m^2, the outer wall and inner wall are in the form of ordinary clay bricks. The thickness of the outer wall is 370mm, the thickness of the inner wall is 240mm, the outer wall is tiled, and the other walls are cement mortar and paint. The roof is in the form of reinforced concrete with a thickness of 200mm. The villagers did not take insulation measures when building the house. Establish a model and get its load calculation results. The heat pump power is brought into the life cycle of the air source heat pump heating model.

3. Life cycle assessment

The basic structure of life cycle assessment is mainly summarized into four organic linkages, definition purposes and scope, inventory analysis, impact assessment, and improved evaluation.

Air source heat pumps have a total life cycle of six parts. The life cycle stage of the air source heat pump main system includes: processing and forming: raw material collection, transportation, assembly and manufacturing into products, transportation process, use process: operation, maintenance and repair, a total of five processes.

The general list is as follows.

Table 1. Master list

List	resource	unit	total
resource	Iron ore	kg	30.7758
	Manganese ore	kg	0.763
	Copper concentrate	kg	21.7464
	Scrap copper	kg	5.6672
	quartz	kg	3.89568

	sulfuric acid	kg	0.066932
	Bauxite	kg	9.2
	soda ash	kg	0.492
	R22 refrigerant	kg	0.64
	water	kg	395.7076
	natural gas	m3	2537
pollutant emissions	CO_2	t	36.12936
	CO	t	0.011768
	SO_2	t	0.010475
	NO_X	t	0.064414
	mist	t	0.004153

(1)Product life is 15 years.

(2)Select the main components for calculation, and the smaller components will not be included in the life cycle assessment.

(3)This article sets the basic functional unit to ton standard coal or kg standard coal, tce or kgce.

As a comparison,the list of coal burning is as follows.

Table 2. Coal listing

List	resource	unit	total
resource	Iron ore	kg	61.5516
	Manganese ore	t	1.526
	water	t	177.2
	coal	t	30.22652
pollutant emissions	CO_2	t	99.84484
	CO	t	2.71265
	SO2	t	0.559261
	NO_X	t	0.263849
	mist	t	5.011486

It can be seen from the comparison that under the same load conditions, the pollutant discharge intensity loose coal is several times that of the air source heat pump. The figure below shows the improvement effect of pollutants obtained by changing the form of coal.

The following table shows the proportion of pollutant emission reduction.

Table 3. Improvement effect of pollutants

CO_2	CO	SO_2	NO_X	SF_4	烟尘
63.81%	99.57%	98.13%	75.59%	31.67%	99.92%

4. Conclusion

1. Through the questionnaire, the type of rural houses near Tangshan is obtained, and the insulation structure is poorly insulated.

2. Calculate the environmental pollution by calculating the existing model through the whole life cycle. The air source heat pump is superior to the loose coal combustion in solving the environmental pollution.

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