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Economic Investigation of Geothermal Energy in Low-temperature Granary

Wang Haixia, Zhao Qing and Wang Jun
School of Civil Engineering and Architecture, Henan University of Technology, Zhengzhou, 450001, Henan, China

Abstract: Food security and grain store energy consumption get much more important worldwide step by step. Construction and transformation of low-temperature granary is gradually increacing in our country. In the cold source scheme selection, technology about shallow geothermal energy attracts the attention of many engineers and technicians for its energy saving and environmental protection. This article introduces the application of geothermal energy in the construction of a low temperature granary in Southwest China in the design and economic aspects.

Key words: Geothermal energy, low grain storage, economics

INTRODUCTION

Shallow geothermal energy is solar energy absorbed and stored by soil and groundwater. It is usually less than 25°C. And it is different from the deep geothermal energy that below 5 km. For it is hardly affcted by region and climate, its temperature is relatively constant. So, it's a very important new energy. Development and utilization of shallow geothermal energy for heating and cooling has been an important alternative energy source. It has been widely applied in civil air-conditioning and heating (Shen and Xu, 2010). In this study, a low temperature granary in Southwest China using shallow geothermal energy is intorduced.

OVERVIEW OF THE PROJECT

In this project there are 4 warehouses (126×24 m), with store capacity 67,000 tons and 4 squat siloes with diameter of 25 m, loading grain hight of 18.5 m, with store capacity of 2.63 million tons. Outdoor summer air-conditioning temperature is employed as outdoor meteorological parameter. The calculation parameters of entering grain are as follows, maximum moisture content is 15%, the highest grain temperature is 25°C. Design parameters of Store is as follows, Grain storage temperature is 12°C and the relative humidity is less than 10% deviating form 60%.

CALCULATION OF COLD LOAD OF THE GRANARY

Based on the above parameters, assuming the height of the bulk grain in the warehouse is 8 m and the cold loads of starting stage and regular running stage of the refrigeration units are calculated separatly. The quantity of cooling required by each type of single granary is shown in Table 1 and 2.

Cold load of the refrigeration unit in starting stage is (Wang, 2009):

$$Q = \varepsilon(Q_1+Q_2+Q_3+Q_4+Q_5+Q_6)$$

Cold load in regular running stage of the refrigeration unit is:

$$Q' = \varepsilon(Q_1+Q_3+Q_5+Q_7)$$

Table 1: Calculation of cold loads of the warehouse

Granary size	Construction area (m^2)	Q_1 (kW)	Q_2 (kW)	Q_3 (kW)	Q_4 (kW)	Total cold load (kW)
126×24 m	3024	156.6	111.1	8	11.1	286.7
1.1Q'			-			315.4

Table 2: Calculation of cold loads of the squat silos

Granary size	Construction area (m^2)	Q_1 (kW)	Q_2 (kW)	Q_3 (kW)	Q_4 (kW)	Total cold load (kW)
Diameter 25 m	490	94	46.2	4.7	6.5	151.2
1.1Q'			-			166.4

Corresponding Author: Wang Haixia, School of Civil Engineering and Architecture, Henan University of Technology, Zhengzhou, 450001, Henan, China

Where:

ε	=	Safety factor, usually 1.1-1.3
Q	=	Cold load in starting stage
Q	=	Cold load in regular running stage
Q'	=	Cold load of the refrigeration unit in starting stage
Q_1	=	Cold load generated by heat gaining of building envelope
Q_2	=	Cold load generated by grain cooling
Q_3	=	Cold load gernerated by grain respiration
Q_4	=	Cold load generated by temperature falling of air inside the granary
Q_5	=	Cold load generated by the operation of blower
Q_6	=	Cold load gernerated by management, such as illuminating and opening doors, etc.
Q_7	=	Cold load generated by ventilation
Q_1~Q_4	=	Are the main components of the cold load. The other elements take a back seat in the cooling load, then they can be ignored (Liu, 2010)

DETERMINE OF COOLING MODE

In order to improve the utilization of refrigeration unit and save the initial cost in equipment investment, two granaries were put into a group. Yin and Yu (2006) The scheme will meet the cooling requirement of two rooms in one granary simultaneously that is the scheme will also satisfy 6 rooms in two granaries at different time. The following scheme selaction is based on such a consideration. For local groundwater resource is relatively abundant and geological conditions can agree with the recycling of the underground water. Employing groundwater as a source of water source heat pump units, a closed loop of air cooling system is formed by direct expansion blower with supply and return air ducts. Air is sent by undergrand trenches. The return air ducts built up with many branches are above the granay. When the granary needs cooling treatment, supply and return air valves are opened. After handled by the direct expansion chillers, the cool air gets through the ducts then penetrates the grain from the bottom to the top. Exchanging heat thoroughly and finally reaching the top of grain bulk, the air returns to the unit through the ducts. Then air goes the next cooling ventilating cycle. The supply and return valvs are shut off after the cooling process.

CONFIGURATION OF CRYOGENIC SYSTEM EQUIPMENTS OF WAREHOUSE

Considing two warehouses as a configuration unit, configurate 4 direct expansion refrigeration units for each unit. The nominal cooling capacity of each unit is 62.5 kW. Such a configuration sheme can meet the full cooling requirment of two rooms. The specific device configuration is shown in Table 3. The valves and connections in water and air loops and the insulation materials are determined by the project itself. Such materials above are not listed in the table.

CONFIGURATION OF CRYOGENIC SYSTEM EQUIPMENTS OF SQUAT SILO

Considing a single squats silo as a configuration unit, configurate 4 direct expansion refrigeration units for each unit. The nominal cooling capacity of each unit is 80.8 kW. Such a configuration sheme can satisfy the cooling requirment of 6 quat siloes at different time. It can also meet the full cooling requirment of two squat siloes at the same time. The specific equipment configuration is shown in Table 4. The valves and connections in water and air loops and the insulation material are determined by the project itself. Such materals above are not listed in the table.

ECONOMIC ANALYSIS

For sigle refrigerating unit of warehouse, the initial investment and running costs of grain cooler and direct expansion water source heat pump are compared as follows.

Table 3: Major equipment configuration of warehouse cooling unit

Equipment	Format	Quantity	Remark
Refrigeration unit	HGB80A	4	Motor power is 21.5 kW unit^{-1} and nominal cooling capacity is 62.5 kW
Pump	25 (m^3 h^{-1})	2	One is running and the other is spare
Rotary filter	XLJ-800	1	-
Well	Diameter is 300 mm	3	The depth is 80 m and volume flow rate is 40 m^3 h^{-1}

Table 4: Major equipments of squat silo cooling unit

Equipment	Format	Quantity	Remark
Refrigeration unit	HGB80A	4	Motor power is 28.5 kW unit^{-1}, nominal cooling capacity is 80.8 kW
Pump	35 (m^3 h^{-1})	2	One is running and the other is spare
Rotary filter	XLJ-800	1	-
Well	Diameter is 300 mm	3	The depth is 80m and volume flow rate is 40 (m^3 h^{-1})

Table 5: Initial cost of major equipments of geothermal cooling unit

Equipment	Format	Quantity	Price (¥)	Total cost (¥)
Refrigeration unit	HGB60A	4	325,000	1,300,000
Pump	25 ($m^3 h^{-1}$)	2	3,500	7,000
Rotary filter	XLJ-800	1	6,000	6,000
Well	Diameter is 300 mm	3	15,000	45,000
Total		1,358,000		

Table 6: Initial cost of major equipments of grain cooler

Equipment	Format	Quantity	Price (¥)	Total cost (¥)
Grain cooler	GLA50	4	350,000	1,400,000
Total	-	1,400,000		

Table 7: Power consumption per ton of grain

Grain temperature change (°C)	Power consumption (kWh)	Powe consumption per ton of grain kWh/(t.°C)
21.6→19.6	622.80	0.192
21.6→18	1152.00	0.198
21.6→16	2106.36	0.232
21.6→15	2606.76	0.242
21.6→13	3975.60	0.285
21.6→12	4656.00	0.299

Table 8: Cooling time for 1centigrade of whole storage

Grain temperature change (°C)	Cooling time (h)	Grain storage capacity (t)	Average cooling time of per ton grain (h/t)
21.6→15	76.0	1620	11.52
21.6→10.3	186.5	1620	16.50
15→12	61.0	1620	20.33
12→10.3	49.5	1620	29.12

Initial cost: For the quantity of pipes and ducts and other accessories is almost the same, in this comparison the prices of valves in water loop and air duct, supply and return air ducts, connecting pipes, insulation materials are not included. The initial costs of cooling scheme with geothermal system and grain cooler are shown in Table 5 and 6 separately. The tables show that the initial costs of the two schemes are nearly same. The scheme with geothermal energy takes some advantage slightly.

Comparion of running cost: According to the refrigeration scheme, compute the cooling speed of the entire grain bulk and the power consumption per ton of grain when the ambient temperature is 23~25°C at day time. The results are shown in Table 7 and 8. At normal perfomance, the power consumption of grain cooler is different accoding to the style of the storage. The average power consumption of warehouse is 0.5-0.75 kWh/t.°C (Wang and Li, 1994). The power consumption of geothermal energy system is relatively small. Then it agrees with the purpose of energy saving.

Average power consumption of per ton grain is 0.241 kWh/(t.°C).

CONCLUSION

Shallow geothermal energy enriches the diversification of the engineering application of low temperature grain granary solutions. Compared with the grain cooler, the initial cost and the running cost of geothermal energy system have some advantage. In the construction of low temperature granary, the renewable energy should have priority. And enviromental protection is another important factor in the chosen of refrigeration scheme.

REFERENCES

Liu, W., 2010. The reasonable application of grain cooler in shallow squat silo. J. Sci. Technol. Cereals Oils Foods, 5: 69-71.

Shen, Y.F. and J.M. Xu, 2010. Space temperature contol of grain storehouse with groundwater and heat exchanger. J. Grain Storage, 1: 25-28.

Wang, R.L., 2009. Grain and Oil Storage Science. China Light Industry Press, China, pp: 155-161.

Wang, X.Z. and M.D. Li, 1994. The application of grain storage technology under air-conditional standard low temperature. J. Guanxi Inst. Technol., 1: 72-75.

Yin, G.H. and L.P. Yu, 2006. Discussion and research on model of low temperature grain storage in large warehouse in north China area. Grain Storage, 4: 23-25.