Research on the Performance of Air Source Heat Pump Auxiliary Heating Solar Drying System

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Abstract: Solar drying system is an energy-saving and environmentally friendly drying system, but a single solar drying system cannot solve the defect problem that is easily affected by climatic factors during drying operations, and the evaluation is unreasonable. Therefore, this paper proposes a big data algorithm, combined with an air-source heat pump to assist a solar drying system, and conducts innovative performance evaluation and analysis of the system. First of all, the energy-saving theory is used to evaluate the drying operation, and the indicators are divided according to the performance evaluation requirements to reduce the performance evaluation in the interfering factor. Then, the performance evaluation of the innovative solar drying system is formed by the energy-saving theory, and the performance evaluation results are carried out Comprehensive analysis. MATLAB simulation shows that under the condition of certain evaluation criteria, the thermal performance, drying energy efficiency and energy saving of the air-source heat pump assisted heating solar drying system of big data algorithm are better than those of conventional drying system .

1 INTRODUCTION

Solar drying technology is an effective grain preservation and drying technology (Bai, Jia, et al. 2023), which has the advantages of low cost, easy installation and operation, and environmental protection, and is widely used in rural and agricultural production. However, traditional solar drying systems have seasonal and weather limitations (Ballerini, Di et al. 2023) in order to solve this problem, this paper will discuss the design and analysis of auxiliary heating solar drying systems based on air source heat pump technology.

1.1 Basis of Air Source Heat Pump Technology

Air source heat pump technology is a new type of clean energy technology, the principle of which is to generate high-grade heat through the low-grade heat in the air (Bellos, Tsimpoukis, et al. 2023), which is converted through the compression and expansion process. Specifically, the air-source heat pump system passes low-temperature air through an evaporator to obtain low-grade heat; Then through the compressor, the low-temperature, low-pressure refrigerant is compressed into high-temperature, high-pressure gas; The high-temperature gas is then passed through the condenser to release high-grade heat, and finally the refrigerant is returned to the evaporator through the expansion valve to complete a cycle (Buday, and Buday-Bodi, 2023).

Air-source heat pump technology offers a variety of advantages, including high energy efficiency, environmental protection, safety, and ease of operation. At the same time, it is suitable for many different application scenarios, including heating, air conditioning, hot water, etc (Capone, Guelpa, et al. 2023).

1.2 Solar Drying System Design Based on Air Source Heat Pump

1.2.1 System Structure

Based on air source heat pump technology, the designed auxiliary heating solar drying system includes the following main parts:

(1) Solar collector panel: Solar collector panel is the core component of the solar drying system, and its function is to convert solar energy into heat energy and supply the drying system for use [(Chen, Li, et al. 2023).

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(2) Air source heat pump system: The air source heat pump system includes compressors, evaporators, condensers, expansion valves and other main components, which are converted into high-grade heat through low-grade heat in the air to provide auxiliary heating for the drying system (Cui, Geng, et al. 2023).

(3) Thermal energy storage device: The thermal energy storage device is used to store the heat energy generated by the air source heat pump so that the drying system can be used when needed (Duc, Kien, et al. 2023).

(4) Fan and duct system: The fan and duct system are used to circulate and transmit the air in the drying system to ensure the normal operation and effect of the drying system.

1.2.2 System Performance

The auxiliary heating solar drying system based on air source heat pump has the following main properties:

(1) High energy efficiency: Air source heat pump technology has the characteristics of high energy efficiency, which provides auxiliary heating for the drying system by converting low-grade heat in the air into high-grade heat, and greatly improves the energy efficiency of the system (Fan, Jiang, et al. 2023.

(2) All-weather: The auxiliary heating solar drying system based on the air source heat pump has all-weather and can operate under various climatic conditions, regardless of the season and weather.

(3) Environmental protection: Air source heat pump technology belongs to clean energy technology, which has the characteristics of environmental protection and will not cause pollution to the environment (Fu, Shi, et al. 2023).

(4) Easy to operate: Air source heat pump technology has the characteristics of simple operation and easy maintenance, which can reduce the operating cost and operation difficulty of the system (Hasrat, Jensen, et al. 2023).

1.2.3 System Optimization

In order to further improve the performance and effect of the auxiliary heating solar drying system based on air source heat pump, the following optimization measures can be taken:

(1) Optimize the system structure: The energy efficiency and performance of the system can be further improved by improving the material and structure of the solar collector panel, improving the compressor and refrigerant of the air source heat pump system (Hou, Zheng, et al. 2023).

(2) Adjust system parameters: Parameters such as temperature, humidity and air flow of the system can be adjusted according to the characteristics of dry materials and climatic conditions to better meet the drying needs (Hou, Quan, Kim, 2023).

(3) Application of intelligent control technology: through the application of intelligent control technology, the system operation process can be finely controlled and optimized, and the automation degree and efficiency of the system can be improved (Hou, Guo, et al. 2023).

The auxiliary heating solar drying system based on air source heat pump technology has broad application prospects and market demand, which can meet the needs of drying technology in rural and agricultural production fields. Through continuous optimization and innovation, it is hoped that the system can be more widely used and promoted, and contribute to the construction of a resource-saving society and sustainable development.

Conventional drying operations of heat sources mainly based on coal and electricity have high energy consumption and environmental pollution problems. In order to reduce the energy consumption of drying operations, clean and efficient drying technology and equipment are sought. Based on this, some scholars believe that the big data algorithm combined with the air-source heat pump auxiliary heat supply is applied to the analysis of solar drying system. It can effectively analyze the performance evaluation scheme and provide corresponding support for performance evaluation. On this basis, this paper proposes a big data algorithm to optimize the performance evaluation scheme and verify the effectiveness of the model.

2 RELATED CONCEPTS

2.1 Mathematical Description of Big Data Algorithms

The big data algorithm uses data theory to optimize the performance evaluation scheme is x_i, and finds the unqualified values in the solar drying system according to the index parameters in the performance evaluation In order to and integrate the performance evaluation scheme is y_i, the parameters is finally judged to the feasibility of the solar drying system is $T(x_i)+F(d_i)$, and the calculation is shown in Equation (1).

$$T(x_i)+F(d_i)=\sum_{i=1}^{n}\tau_{ij}+(x_i,y_i) \tag{1}$$

Among them, the judgment of outliers is shown in Equation (2).

$$p(x_i)=\sum_{x\in\aleph}p(x)(1-p) \tag{2}$$

Big data algorithms combine the advantages of data theory and use solar drying systems for quantification, which can improve the performance of solar drying systems.

Suppose I. The performance evaluation requirements is x_i, the performance evaluation scheme is F, the satisfaction of the performance evaluation scheme is γ, and the performance evaluation scheme judgment function is $p(d_i)$,As shown in Equation (3).

$$p(d_i)=\sum x_i\bigcap_{\rightarrow}\tau F\gamma \tag{3}$$

2.2 Selection of Solar Drying System Scheme

Hypothesis II The solar drying system function is $G(x_i,y_i)$,and the weight coefficient is d_i , then, the performance evaluation requires an unqualified solar drying system as shown in Equation (4).

$$G(x_i,y_i)=\mathrm{w}_i\sum_{i=1}^{n}(d_i)-u\tau \tag{4}$$

Using assumptions, I and II, a comprehensive function of system performance can be obtained, as shown in Equation (5).

$$p(d_i)+G(x_i,y_i)\le\sum_{i=1}^{n}\tau_{ij}+(x_i,y_i) \tag{5}$$

In order to improve the effectiveness of performance evaluation, all data needs to be standardized and the results are shown in Equation (6).

$$p(d_i)+G(x_i,y_i)\leftrightarrow\sum_{x\in\aleph}p(x)(1-p) \tag{6}$$

2.3 Analysis of Performance Evaluation Schemes

Before the big data algorithm, the performance evaluation scheme should be analyzed in multiple dimensions, and the performance evaluation requirements should be mapped to the solar drying system data database, and the unqualified performance evaluation scheme should be eliminated is $TP(y_i)$, According to Equation (6), the anomaly evaluation scheme can be proposed, and the results are shown in Equation (7).

$$TP(y_i)=\frac{p(d_i)+G(x_i,y_i)}{\sum_{x\in\aleph}p(x)(1-p)} \tag{7}$$

Among them, the parameter is to explain the scheme is $\frac{p(d_i)+G(x_i,y_i)}{\sum_{x\in\aleph}p(x)(1-p)}\le 1$,needs to be proposed, otherwise the scheme needs to be integrated The parameter is $Th(x_i)$, and the result is shown in Equation (8).

$$Th(x_i)=p(d_i)+G(x_i,y_i) \tag{8}$$

The solar drying system conducts comprehensive analysis and sets the threshold and index weight of the performance evaluation scheme to ensure the accuracy of the big data algorithm. Solar drying system is a system test performance evaluation scheme, which needs to be innovatively analyzed. If the solar drying system is in a non-normal distribution, its parameters is $unno(j_i)$, its performance evaluation scheme will be affected, reducing the accuracy of the overall performance evaluation , whose argument is $a^{\tau}x+b$, the calculation result is shown in Equation (9).

$$a^{\tau}x+b=\frac{\min[\sum p(d_i)+G(x_i,y_i)]}{\sum p(d_i)+G(x_i,y_i)}\times 100\% \qquad (9)$$

The survey performance evaluation scheme shows that the solar drying system scheme presents a multi-dimensional distribution, which is in line with the objective facts. The solar drying system is not directional, indicating that the solar drying system scheme has strong randomness, so it is regarded as a high analytical study. If the stochastic function of the solar drying system is $randon(j_i)$, then the calculation of equation (9) can be expressed as formula (10).

$$a^{\tau}x+b=\frac{\min[\sum p(d_i)+G(x_i,y_i)]}{\sum p(d_i)+G(x_i,y_i)}\times 100\%+randon(j_i) \qquad (10)$$

Among them, the solar drying system meets the normal requirements, mainly because the data theory adjusts the solar drying system, removes duplicate and irrelevant schemes, and supplements the default scheme, so that the dynamic correlation of the whole performance evaluation scheme is strong.

3 OPTIMIZATION STRATEGY OF AUXILIARY HEATING SUPPLY OF AIR SOURCE HEAT PUMP

The big data algorithm adopts the random optimization strategy for the auxiliary heating supply of the air source heat pump and adjusts the drying operation parameters to realize the optimization of the auxiliary heating supply of the air source heat pump. The big data algorithm divides the auxiliary heat supply of air source heat pump into different performance evaluation levels, and randomly selects different schemes. In the iterative process, the performance evaluation schemes with different performance evaluation levels are optimized and analyzed. After the optimization analysis is completed, the performance evaluation level of different schemes is compared, and the optimal air source heat pump auxiliary heating solar drying system is recorded.

4 PRACTICAL CASE OF AUXILIARY HEATING SUPPLY OF AIR SOURCE HEAT PUMP

4.1 Performance Evaluation Presentation

In order to facilitate performance evaluation, this paper takes the air-source heat pump auxiliary heating solar drying system under complex conditions as the research object, with 12 paths and a test time of 12h, and the performance evaluation of the specific solar drying system The scheme is shown in Table 1.

Table 1: System Performance Evaluation Requirements

Scope of application	grade	Energy saving effect	Innovative effect
Air collectors	I	90.82	89.00
	II	89.63	89.90
Centrifugal fan	I	90.02	90.75
	II	91.24	91.60
Air volume regulating valve	I	88.84	89.53
	II	89.94	89.15

The performance evaluation process in Table 1 is shown in Figure 1.

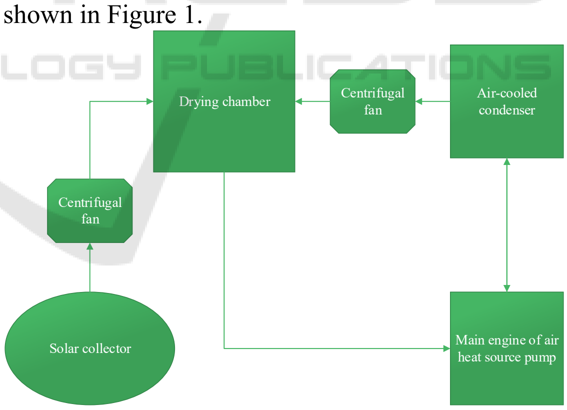

Figure 1: Analysis process of auxiliary heat supply by air source heat pump

Compared with conventional drying systems, the performance evaluation scheme of big data algorithm is closer to the actual performance evaluation requirements. In terms of the rationality and fluctuation range of the air-source heat pump auxiliary heating solar drying system, the big data algorithm is better than the conventional drying system. Through the change of performance evaluation scheme in Figure 2, it can be seen that the stability of the big data algorithm is better, and the energy-saving effect is better. Therefore, the performance evaluation scheme of big data algorithm has better thermal performance, drying energy efficiency, energy-saving effect, and summation stability.

4.2 Auxiliary Heating Situation of Air Source Heat Pump

The performance evaluation scheme of auxiliary heating of air source heat pump includes non-structural information, semi-structural information and structural information. After the pre-selection of big data algorithm, a preliminary performance evaluation scheme of auxiliary heating supply of air source heat pump is obtained, and the auxiliary heating of air source heat pump is obtained the feasibility of the performance evaluation scheme is analyzed. In order to more accurately verify the innovative effect of the air-source heat pump auxiliary heating solar drying system, the solar drying system with different performance evaluation levels was selected, and the performance evaluation scheme is shown in Table 2 shown.

Table 2: The overall situation of the solar drying system solution

Category	Drying energy efficiency	Analysis rate
Solar hot air subsystem	89.92	90.67
Air source heat pump subsystem	88.93	88.49
Drying room	89.08	89.57
mean	90.39	90.58
X^6	38.62	37.59
	P=3.98	

4.3 Energy Saving and Stability of solar Drying System for Performance Evaluation

In order to verify the accuracy of the big data algorithm, the performance evaluation scheme is compared with the conventional drying system, and the performance evaluation scheme is shown in Figure 2.

It can be seen from Figure 2 that the solar drying system of the big data algorithm is higher than that of the conventional drying system, but the error rate is lower, indicating that the performance evaluation of the big data algorithm is relatively stable the performance evaluation of conventional drying systems is uneven. The average performance evaluation scheme of the above two methods is shown in Table 3.

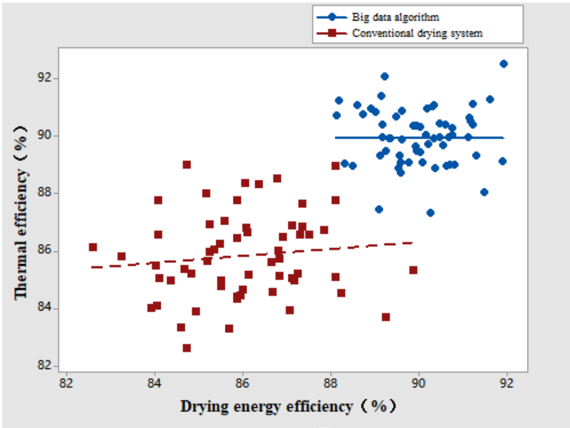

Figure 2: Solar drying systems of different methods

Table 3: Comparison of performance evaluation accuracy of different methods

Algorithm	Solar drying system	Magnitude of change	Error
Big data algorithms	88.97	90.68	1.69
Conventional drying system	82.79	86.94	4.15
P	37.06	38.26	36.73

By Table 3, it can be seen that the conventional drying system has deficiencies in thermal efficiency and drying temperature in terms of drying energy efficiency, and the drying system has undergone significant changes. High error rate. The general result of the big data algorithm is higher for solar drying systems, which are better than conventional drying systems. At the same time, the solar drying system of the big data algorithm is greater than 88%, and the accuracy has not changed significantly. In

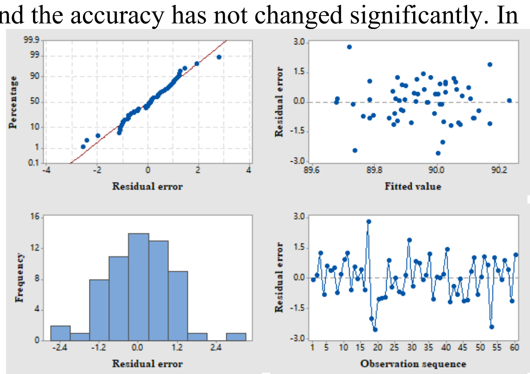

Figure 3: Solar drying system for performance evaluation of big data algorithm

order to further verify the superiority and effectiveness of the big data algorithm, the general analysis of the big data algorithm is carried out by different methods, Figure 3 shown.

By Figure 3, it can be seen that the solar drying system of the big data algorithm is significantly better than the conventional drying system, and the reason is that the big data algorithm combines the air source heat pump to assist the heating and set up the drying operation thresholds to reject non-compliant performance evaluation schemes.

5 CONCLUSIONS

Aiming at the problem that a single solar drying system is not ideal; this paper proposes a big data algorithm and optimizes the solar drying system by combining the auxiliary heat supply of air source heat pump. At the same time, the performance evaluation innovation and threshold innovation are analyzed in depth to construct the drying operation set. The research shows that compared with the traditional drying system, the air source heat pump auxiliary heating solar drying system with big data algorithm has the advantages of energy saving and environmental protection and has the characteristics of high thermal efficiency and low drying temperature.

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