

Study on internal structure optimization of drying chamber of sludge drying equipment

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Abstract: Aiming at the problem of uneven distribution of velocity field in the drying chamber of JKFF series low-temperature closed cycle sludge drying equipment, the influence of internal structure change of drying chamber on air distribution was studied by numerical simulation. Fluent software is used for simulation, through the analysis of three factors affecting the internal structure of the oven, such as the position of the blower, the spacing of the mesh belt layer and the size of the aperture of the nylon mesh belt. The results show that it is better to put the air blower inside the heat pump than to put the air blower outside the bottom of the oven. When the spacing between the second and third layers is 240mm, the overall air distribution in the drying room is the best; By comparing and analyzing 9 combined working conditions of mesh belt aperture size, it is concluded that when the aperture size of the first and second layer mesh belt is 2mm×2mm, and the aperture size of the third layer mesh belt is 1.5mm×1.5mm, the air distribution in the oven reaches the best state.

1 Introduction

In recent years, with the acceleration of the national economic process, the sewage treatment volume in urban and rural areas has gradually increased, and the sludge industry is booming. Dai Xiaohu pointed out in sludge treatment, if the sludge moisture content of 80% is calculated, the national sludge annual output is expected to reach 90 million tons in 2025^[1].

In the whole drying process, the energy consumption of the heat pump unit and the quality of the material drying directly depends on whether the air distribution in the heat pump drying room is reasonable^[2]. The more uniform the air distribution, the better the material drying quality, the lower the system energy consumption. Li Ruolan^[3] found that the distribution of air distribution in drying room was affected by the material tray spacing, tilt Angle and air inlet position in the drying of lycium barbarum. Li Shuguo^[4] took rose as the object, several structural changes such as air supply speed, cart specification and placement form, and baffle at the bottom of drying room were studied. The total air volume at the holding inlet is 7200 m³On the basis of /h, the uniformity of 2, 4 and 6 fans arranged symmetrically at the entrance to the heat airflow field inside the drying room was studied^[5]. The temperature field and wind speed field are optimized by adjusting the position of the air supply port and the height and spacing of the rear fan^[6].

At present, there are problems of velocity field and uneven distribution in the drying room of sludge drying equipment. The uniformity of velocity field and

temperature field in the drying room can be improved by changing the position of blower, adjusting the aperture size of mesh belt, changing the spacing between mesh belt layers and other measures, so as to improve drying efficiency, reduce drying time and improve drying effect.

2 Optimization of internal structure of drying room of sludge cryogenic drying equipment

2.1 Influence of blower position on air distribution in drying room

Original equipment at the bottom of the chamber two volute centrifugal blower, because blower distance is close to the third layer of conveyor belt, can produce two problems, one of, not even air, close to the speed of blower area is larger, drying effect is good, and stay away from the blower speed is small, poor drying effect, results in uneven sludge drying, secondly, the dust away due to uneven air distribution problem, Lead to more dust at the bottom of the drying room. In view of these two problems, the internal structure of the equipment is adjusted, and the blower is built into the heat pump part of the low-temperature closed cycle sludge drying equipment. The air outlet of the blower is downward, and the air is sent out through the condenser at the bottom side of the drying room. Fig. 1 and Fig. 2 show the simulation results before and after the position of the blower is changed.

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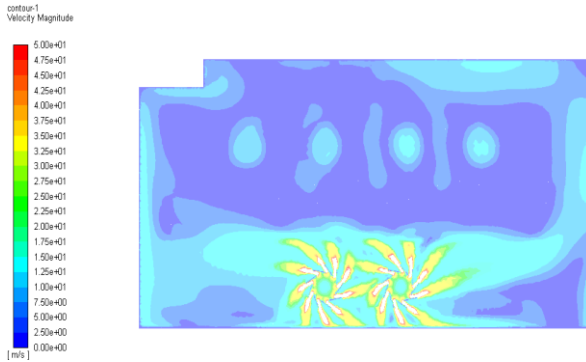


Fig. 1. Simulation results before the change of blower position

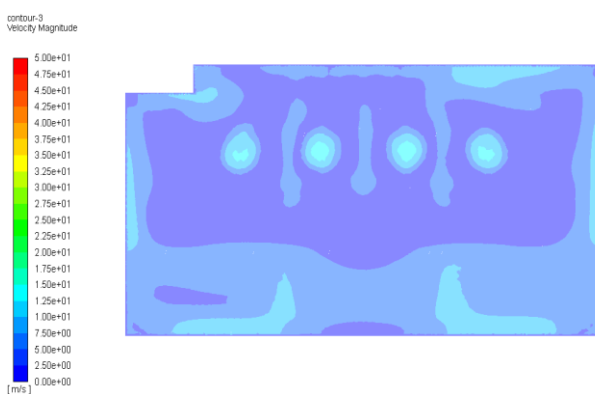


Fig. 2. Simulation results after the position of the blower was changed

As shown in Fig. 1, the air flow is generated by clockwise rotation of the blower. The upper part of the blower and the middle area of the third layer net belt have large velocities in the middle and small velocities on both sides, and the velocity distribution is extremely uneven. The air outlet of the blower at the bottom of the drying room is blocked by the conveyor belt and the walls on both sides of the left and right sides, and the air flow gradually flows upward, converging to the return air outlet, presenting a large speed area. At the same time, eddy current area appears at the edge of the corner of the drying room. The minimum wind speed ranges from 0 to 2.5m/s, and the velocity distribution is not uniform, which affects the sludge drying effect.

As shown in Fig. 2, after the position of the blower is changed, the overall velocity distribution under the third layer conveyor belt is uniform, which reduces the area with large wind speed above the blower. The overall airflow distribution is more gentle and the velocity distribution is more uniform, which is more conducive to sludge drying. Under the third layer conveyor belt, the velocity is concentrated in the range of 2.5-5m/s, and the average surface velocity is 2.85m/s. The overall velocity tends to be stable, and the average velocity decreases to reduce dust dispersion and improve the drying effect.

2.2 Influence of mesh belt layer spacing on air distribution in drying room

In the actual operation process of sludge cryogenic drying equipment, the spacing of part of the mesh belt layer will have a certain influence on the air distribution. Therefore, the study of the spacing of mesh belt layer has a certain engineering significance. Due to the first layer mesh belt near the location bar cutting machine, change the first layer mesh belt position, easy to cause the drop height changes in sludge forming problems, the third layer mesh belt near the discharging mouth, change the third layer mesh belt position, will affect discharge position, and adjust the second layer mesh belt position is not easy to affect other mechanical mechanism. This numerical simulation mainly studies the influence of the spacing of mesh belt layer on the air distribution in the drying room. By changing the position of the second layer of mesh belt, the spacing of the second and third layers of mesh belt is respectively adjusted to 210mm, 220mm, 230mm, 240mm, 250mm for simulation calculation.

As can be seen from Fig.3, when the distance between the second and third layers of mesh belt increases from 210mm to 250mm, the overall trend of change is similar. From left to right, the overall movement law is first down and then up, and the average speed is the maximum at X=1000mm, which is caused by the bottom air supply flow at the edge of the mesh belt. The average speed at X=3000mm is the lowest, because it is close to the center of the net belt and the influence degree of air flow on both sides is weakened.

From the motion law of different mesh belt layer spacing in the graph, you can see that as the mesh belt layer spacing increases gradually, the total average speed has also been gradually rise, but do not represent the spacing, the greater the wind speed is higher, when increases from 240 mm to 250 mm, total began to reduce the average wind speed, therefore, as a whole, helps to increase the mesh belt layer spacing hot air circulation, But there is a certain limit, otherwise it is not conducive to improve the drying effect.

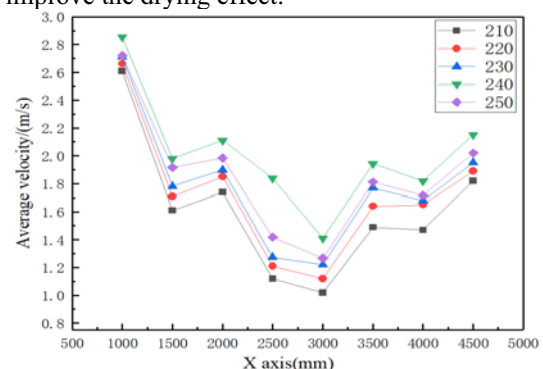


Fig. 3. Average velocity distribution

It can be concluded from Fig. 4 that in the range of 1000-2000mm, the velocity inhomogeneity coefficient decreases continuously, and the uniformity of air distribution increases gradually. In the range of 2000~2500mm, the velocity inhomogeneity coefficient is increased, which proves that the uniformity of airflow velocity is gradually weakened. In the range of

2500~4500mm, the velocity inhomogeneity coefficient shows a downward trend, and the uniformity of air velocity is improved, which improves the rationality of air distribution.

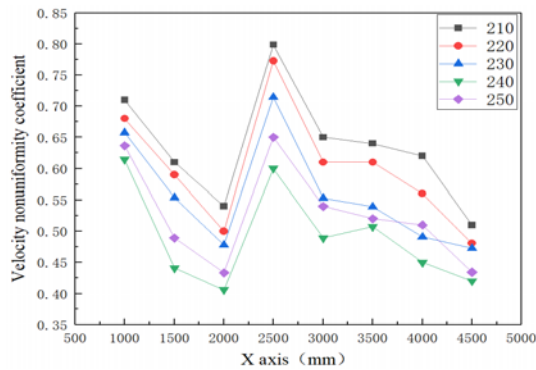


Fig. 4. Distribution of velocity inhomogeneity coefficient

As a whole, speed nonuniformity coefficient have been falling in the X direction after the trend of rising and falling, as the second and the third layer mesh belt span increases gradually, the speed gradually reduce uneven coefficient, when the mesh belt layer spacing of 240 mm, the uneven coefficient of minimum, better air flow velocity distribution, when net belt layer spacing increased to 250 mm, As the coefficient of inhomogeneity increases, the uniformity of airflow velocity distribution decreases.

2.3 Influence of nylon mesh belt aperture size on air distribution in drying room

In the process of sludge drying, the pore size of nylon mesh belt has a certain influence on the air distribution in the drying chamber. Selecting the appropriate pore size will have a certain influence on the air velocity. The greater the air intensity in the drying chamber, the more uniform the air velocity distribution, the better the drying effect and the better the air distribution. This numerical simulation mainly studies the effect of mesh belt aperture size on air distribution in drying room.

2.3.1 Selection of different mesh belt aperture sizes

Combined with the existing wind area of sludge and whether the sludge particles are easy to fall from the mesh belt after drying, the aperture size of the first and second layers of mesh belt is selected as 2mm×2mm, 3mm×3mm, 4mm×4mm, and the aperture size of the third layer of mesh belt is selected as 1mm×1mm, 1mm×1.2mm, and 1.5mm×1.5mm to match in pairs. Group matching of the aperture size of the first and second layer mesh belt and the aperture size of the third layer mesh belt was conducted to form 9 working conditions..

2.3.2 Air distribution evaluation of drying room

It can be seen from Table 1 that the average velocity of condition 3 is 2.9879m/s, which is the maximum of the average velocity among the 9 working conditions, and

the non-uniformity coefficient is 0.4491, which is the minimum of the 9 working conditions. The two evaluation indexes have reached the optimal value, which proves that the air flow intensity in the drying room is large, the velocity distribution is relatively uniform, and the air distribution is good.

Table 1. Summary of numerical simulation results

Working condition	Aperture size	Average velocity	Coefficient of nonuniformity
1	2×2-1×1	2.6605	0.5313
2	2×2-1×1.2	2.6789	0.5046
3	2×2-1.5×1.5	2.9879	0.4491
4	3×3-1×1	2.7039	0.5456
5	3×3-1×1.2	2.7634	0.4915
6	3×3-1.5×1.5	2.9676	0.4993
7	4×4-1×1	2.7595	0.5527
8	4×4-1×1.2	2.8394	0.4812
9	4×4-1.5×1.5	2.8762	0.4949

3 Conclusion

Through the adjustment of three kinds of internal structure of the oven, namely, the position of the blower, the spacing of the mesh belt layer and the size of the mesh belt aperture, the change of air distribution in the oven was analyzed, and the flow field before and after the change was evaluated by the evaluation criteria such as the air velocity cloud chart, average velocity and non-uniformity coefficient. The main conclusions are as follows:

(1) By comparing the position of blower speed cloud can be found, before and after the change will be placed in the low temperature blower closed cycle heat pump sludge drying equipment section, blower outlet down, wind flow through the condenser in the bottom of the chamber side sent outside the blower is obviously better than the way in at the bottom of the dryer air supply mode, position of blower dryer after change the air distribution is more gentle, Dead corners and swirling areas are reduced, drying effects are improved and airflow organization is improved.

(2) By adjusting the spacing between the second and third layers of mesh belt, the change of air distribution in the oven is compared and analyzed when the spacing increases from 210mm to 250mm. It is concluded that the overall air distribution in the oven is the best when the spacing between the second and third layers of mesh belt is 240mm.

(3) By comparing and analyzing the average speed and non-uniformity coefficient of 9 combined conditions of mesh belt aperture size in the oven, it is concluded that the third combined condition of mesh belt aperture size is the best condition, that is, when the aperture size of the first and second layer mesh belt is 2mm×2mm and the aperture size of the third layer mesh belt is 1.5mm×1.5mm, the airflow distribution in the oven reaches the best state.

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