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Influence of Rotating Speed on Pressure Distribution in the Working Process of Milk Separator

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Abstract. The milk separator belongs to the disc separator, which is the key core equipment for dairy products processing. Its core functional component, the separation bowl, works at a rotating speed ranging from 7500 r/min to 12000 r/min, and structurally belongs to a vertical high-speed rotor with external suspension and external center of gravity. The thin-layer separation centrifugal flow field inside the separation bowl and the structural stress of the rotor are the key application basic theories in the design of the milk separator. The influence of rotating speed on the pressure distribution during the working process of milk separator is that the dynamic pressure simulation results of the flow field are distributed near the theoretical curve at all rotating speeds, and the simulation results are reasonable, especially the difference between the dynamic pressure distribution of the fluid in the disc channel and the theoretical value is very small. The research on the influence of rotating speed on pressure distribution in the working process of milk separator has very important theoretical value and application value for revealing the separation mechanism of milk fat, optimizing the structure design of separation bowl and developing new products.

Keywords. Milk separator, rotating speed, pressure distribution

1. Introduction

Milk separator is a kind of equipment used to separate fat and whey in fresh milk [1-2]. At present, milk separator has been widely used in dairy industry. With the continuous progress of science and technology, the technology of milk separator is constantly improving and updating. Modern milk separator adopts advanced separation technology, which can achieve efficient, fast and stable separation effect [3-4]. The equipment types of milk separators are diversified, including centrifugal separators and sedimentation separators. Different types of equipment have different working principles and separation effects, and appropriate equipment can be selected according to production requirements [5-6].

Marta Stachnik [7] and others established VOF three-phase flow model to study the sediment formation in a brewing industrial separator, and made relevant experiments to verify that VOF model is a multiphase flow model suitable for analyzing and predicting similar sediment formation. ZHOU Xin [8] and others carried

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out CFD simulation analysis for a typical NASA low-speed centrifugal compressor, studied the interaction effect and heat loss during the separation of hot fluid flow in the rotor by changing the flow rate and fluid temperature, and carried out experimental verification, revealing the relationship between heat transfer and loss during the separation of fluid flow in the rotor. Many scholars at home and abroad use CFD to simulate the flow field distribution in the separator, and the numerical simulation results are in good agreement with the experimental results, which fully shows the feasibility and reliability of using fluid simulation software to study the flow field in the disc separator.

2. Model Introduction

The structure of the separation bowl of the milk separator studied in this paper is slightly different from that of other types of disc separators, as shown in figure 1. It is mainly composed of disc gland, drum cover, rubber sealing ring, disc set, vertical shaft, drum body, disc rack and locking ring.

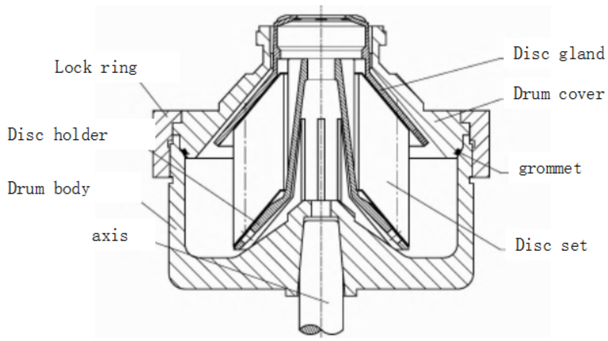


Figure 1. Structural sketch

3. Influence of Rotating Speed on Pressure Distribution

Disc separator relies on centrifugal force to separate materials, and the strength of centrifugal force field directly affects the separation effect of separator. Combined with the working situation of milk separator, this paper sets different speed grades of 8000 ~ 12000 r/min (taking the whole thousand speed) for the separator to explore the working situation of the separator under different centrifugal force field intensities. All data in this chapter are calculated after 20,000 steps. The cone angle of each model is 40, and the coordinate direction and some size positions of the model are shown in figure 2.

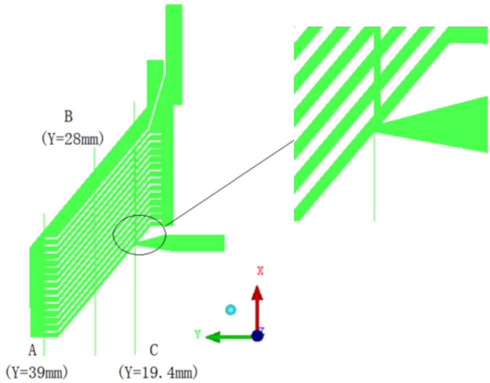
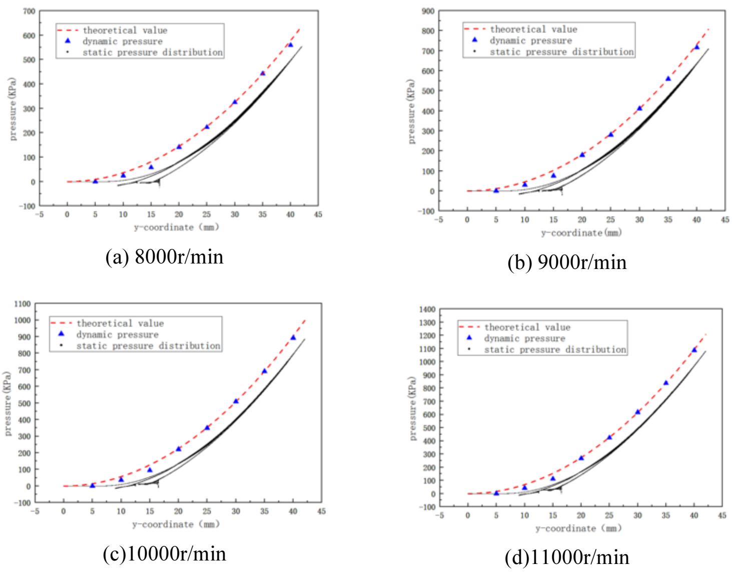


Figure 2. Position and direction identification map.

The pressure caused by the irregular movement of fluid molecules hitting the wall is called static pressure. Static pressure is an absolute pressure, but in Fluent, the static pressure is relative to the operating pressure. The operating pressure of this research model is set to atmospheric pressure, so the static pressure here refers to gauge pressure. It can be seen from the distribution diagram of static pressure scatter in figure 3 that the static pressure distribution forms are the same at all speeds, showing a quadratic parabola distribution (except the exit area), that is, with the increase of the radius of gyration, the static pressure value rises in a quadratic parabola, so the distribution forms of static pressure at all speeds can be expressed by the cloud diagram in figure 4.

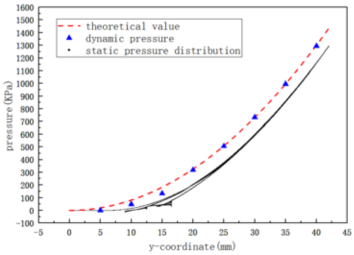


(a) 8000r/min

(b) 9000r/min

(c)10000r/min

(d)11000r/min



(e) 12000r/min

Figure 3. Comparison of dynamic pressure and static pressure distribution at different speeds.

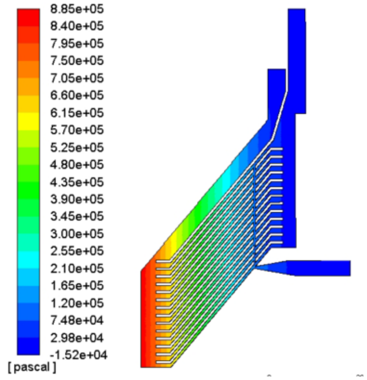
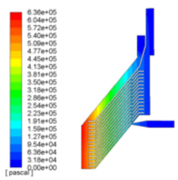
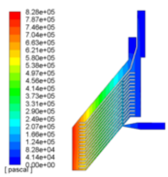


Figure 4. Static pressure distribution nephogram.

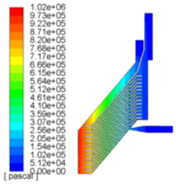
At the same rotational speed, the distribution of static pressure scattered points at the same radius of the flow field in the separation bowl is very concentrated, which shows that the static pressure changes little at the same radius. With the increase of rotating speed, the scattered point distribution of static pressure is closer to a thin line. According to the definition of static pressure, it shows that the higher the rotating speed, the smaller the fluctuation of static pressure at the same radius, and the more similar the flow state of fluid in each layer of channel. There is a negative pressure area in the flow field at all speeds, and the negative pressure is distributed between the radius of 9mm and the radius of 16.5mm, which corresponds to the radial position of the light and heavy phase outlets, indicating that the negative pressure appears in the outlet area, which is beneficial to the discharge of materials. The dynamic pressure distribution nephogram of the flow field in the separation bowl at various speeds is shown in figure 5.



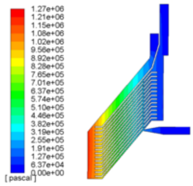
(a) 8000r/min



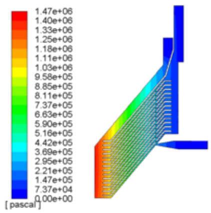
(b) 9000r/min



(c) 10000r/min



(d)11000r/min



(e) 12000r/min

Figure 5. Dynamic pressure distribution of flow field in separation bowl at different rotational speeds.

4. Conclusion

To sum up, at all speeds, the dynamic pressure simulation results of the flow field are distributed near the theoretical curve, and the simulation results are reasonable, especially the difference between the dynamic pressure distribution of the fluid in the disk channel and the theoretical value is very small; The dynamic pressure values of all positions in the flow field are almost greater than the corresponding static pressure; The dynamic pressure increases with the increase of radius. The higher the rotating speed at the same radius, the greater the dynamic pressure, and the higher the rotating speed, the higher the dynamic pressure value. The dynamic pressure in the inlet area is the smallest, the difference between the dynamic pressure in the outlet area and the theoretical value is the most obvious, and the dynamic pressure in the outer wall of the separation bowl is the largest.

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