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DROPWISE CONDENSATION—THE EFFECT OF THE CRITICAL SIZE OF DROP DETACHMENT (II)

滴状凝縮過程の実験的研究—液滴の離脱径の影響 (II)

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1. Inprovement on the Experimental Apparatus

As was described in the preceding report[1], the centrifugal acceleration was utilized in order to reduce the critical size of drop detachment during the process of dropwise condensation. Figure 1 shows the sketch of the centrifuge. When compared to the apparatus used in the preliminary experiment, there can be seen several improvements. In the first place, the condensing chamber is mounted on a duralumin disc of 1100 mm dia. and 20 mm thick in place of a rotating arm made of veneer plates and aluminum angle bars. This is to advoid oscillation and deformtion of the arm due to rotation. Secondly, two mirrors, the one above the condensing chamber and the other above the rotating axis, are prepared. These mirrors are used for taking motion pictures of the process of condensation and obtaining the values of critical diameters of departing drops. Since the high-speed movie camera is too heavy to be mounted on the rotating disc, it is fixed above the central axis. Therefore it is necessary to transfer the image of the condensing surface with two mirrors. A 200 mm long-focus lens is used to take the pictures. The 16 mm films of the motion pictures taken at the speed of 100∼500 frames/sec are analyzed by a film-editor and the critical sizes are determined. The third improvement is that a mercury transmitter is used to take out the outputs from thermocouples instead of a solid-contact type slip-ring. This is to avoid the possible error owing to frictional heat generation. The fourth is the way of cooling. As is illustrated in Fig. 2, the condensing block made of copper is cooled at the bottom by multiple water jets, thus preventing nonuniformity of the cooling that may have occurred in case of the former single jet cooling.

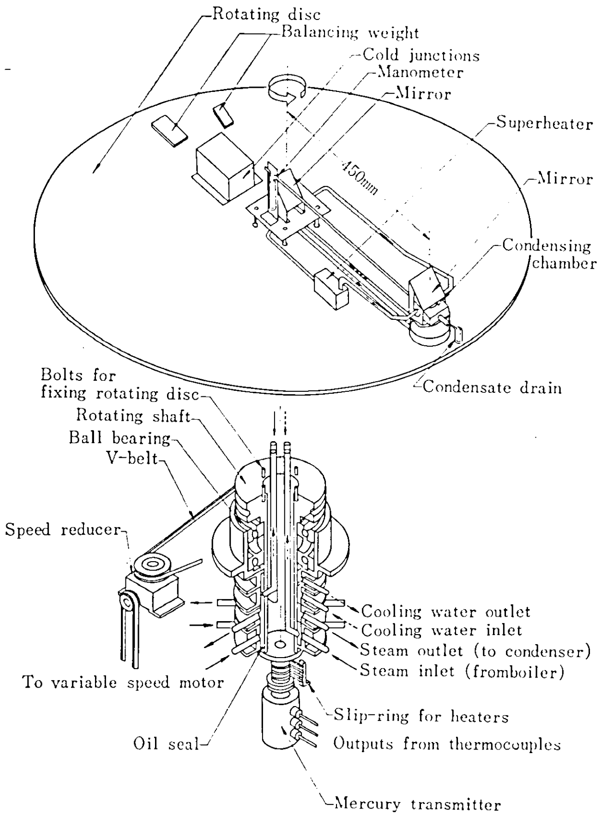

Fig. 1 A sketch of centrifuge

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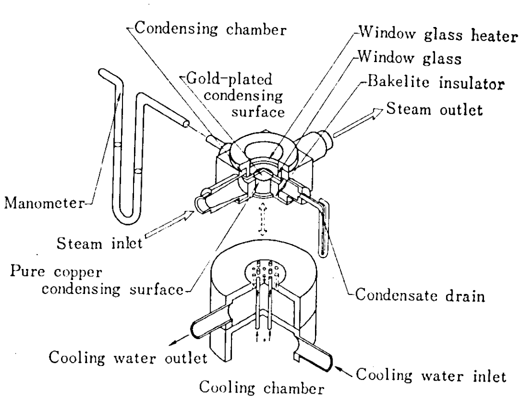

Fig. 2 Condensing chamber and cooling chamber

2. Results of Measurements

The distance between the axis of rotating shaft and the center of the condensing surface is 450 mm, and the rotation of about 7.5 r.p.s. is to generate acceleration as high as 100 times the normal gravity on the earth surface. In the present experiment the highest acceleration realized was 37.6 g_0, where g_0 denoted the acceleration of gravity taken as 9.80 m/sec^2.

In Figs. 3 and 4 the results of measurements on the coefficient of heat transfer and the critical diameter of departing drop against the centrifugal acceleration are plotted, respectively. Since the the effect of the steam velocity (5 m/sec), which is necessary to blow off non-condensable gases, becomes relatively large where the centrifugal acceleration is small, the least square method is applied only to the data obtained for the acceleration higher than 3.3 g_0. As the results,

$$h=0.18\times 10^6\, G^{0.083} \qquad (1)$$

(G: ratio of the centrifugal acceleration to g_0)

is derived for Fig. 3, and

$$D=1.8\, G^{-0.26} \qquad (2)$$

is obtained for Fig. 4.

Combining ordinates of Figs. 3 and 4, Fig. 5 is obtained. Again, the least square method is applied to the points for $G\geqq 3.3$, the relation between the coefficient of heat transfer and the critical·diameter is derived as follows;

$$h=0.21\times 10^6\, D^{-0.31} \qquad (3)$$

In case when the steam shear stress was utilized, the relation was found to be

$$h=0.21\times 10^6\, D^{-0.35} \qquad (4)$$

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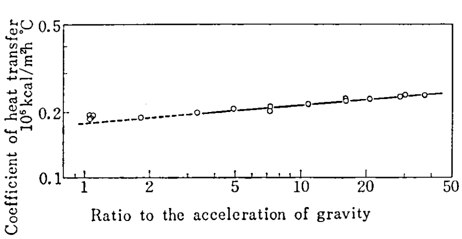


Fig. 3 Heat transfer coefficient *vs.* acceleartion

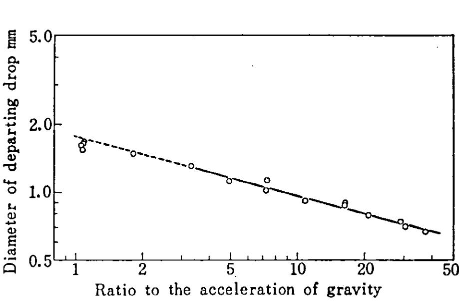


Fig. 4 Critical size *vs.* acceleration

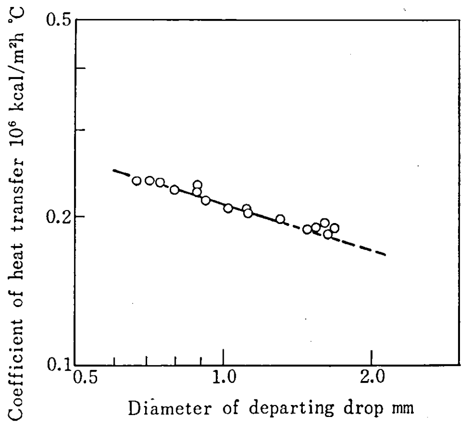


Fig. 5 Heat transfer coefficient *vs.* critical size

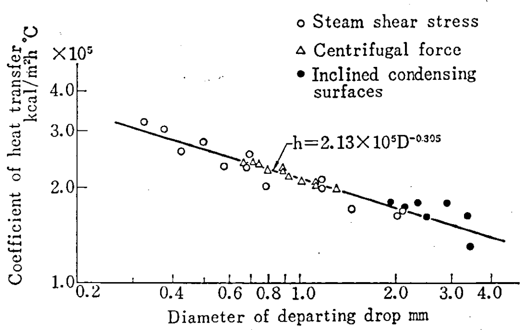
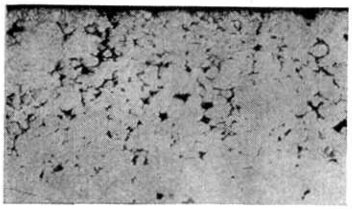
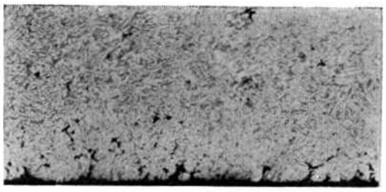


Fig. 6 Heat transfer coefficient *vs.* critical sive

(29 ϕ, 760°C, 3 Secs.)

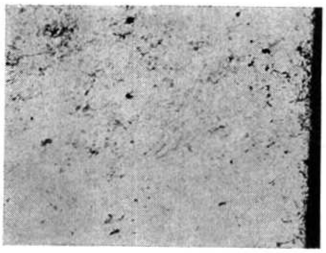


Top



Bottom

0. 1mm



Side

Fig. 14 Surface pores obtained in case of F→S specimen

However, even in ordinary powder compaction and cold coining, similar pores are found and hence this tendency is not due to thermal effect only.

The depths of surface pores in the case of F→S are small on the top surface and almost nil on the side and bottom as shown in Fig. 14 in spite of its low average density. From this fact it is obvious that these surface pores decrease during sintering. So, re-heating of the product possessing surface pores is effective in decreasing pores.

4. Conclusion

The surface pores of the product are affected by preform temperature and its cooling during handling which results in the oxidation of surface in contact with air. In this experiment, particularly the differences in the depth of surface pores on the top and bottom are given more importance whereas many factors still left for explanation.

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A little difference can be found between the exponents to D. However, the result of error analysis revealed that there did not exist any significant difference between the values of these two exponents provided the confidence limits of 95% were assumed.

In Fig. 6 the data from Figs. 4 and 5 are plotted together and, simultaneously, the data obtained for the inclined surfaces[2] are added. For these whole points the relation between h and D becomes

$$h=0.21\times10^{6}\,D^{-0.31} \qquad (5)$$

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References

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