Study on the Effects of Flow in the Volute Casing on the Performance of a Sirocco Fan

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The flow at the exit from the runner blade of a centrifugal fan with forward curved blades (a sirocco fan) sometimes separates and becomes unstable. We have conducted many researches on the impeller shape of a sirocco fan, proper inlet and exit blade angles were considered to obtain optimum performance. In this paper, the casing shape were decided by changing the circumferential angle, magnifying angle and the width, 21 sorts of casings were used. Performance tests, inner flow velocity and pressure distributions were measured as well. Computational fluid dynamic calculations were also made and compared with the experimental results. Finally, the most suitable casing shape for best performance is considered.

Keywords: sirocco fan, fan, flow measurement, flow in the casing, CFD.

Performance Test

Shapes of impeller and casings
Table 1 and Fig.1 show the dimensions of the impeller with the best performance in our former research[1]. For the research in this paper, this impeller was used for all volute casing. Table 2 shows the casings used in our experiment. The cross section of the volute casing increases linearly with the circumferential angle taking the origin at the tongue. The relation of the radius of the casing with the circumference angle is:

$$\tan \alpha_c = \frac{r_c - [(D_2/2) + s]}{2\pi[(D_2/2) + s] \frac{\theta_c}{360}}$$

To show the results, coordinate axes are taken in the circumferential direction as u, radial direction as w and axial direction as v, as shown in Fig.2.

Experimental results

Effects of magnifying angle Fig.3 shows the results of the performance tests using casing I ~ IV[11]. The results consist of various values of magnifying angles and equal values of the maximum circumferential angle, inlet port diameter, casing width, and clearance of tongue. In this figure, the performance curve of casing I shows the minimum value of a pressure-discharge curve. This is because the cross area of this casing I is the smallest. Moreover, the flow velocity becomes larger and
friction loss increases. On the contrary, the cross section of casing IV is large and their efficiency is lower than that of casing III. Casing III shows the best characteristics in its pressure discharge and efficiency as compared with the others. The optimum magnifying angle is $\alpha_c = 6.5^\circ$.

**Effects of circumferential angle** In Fig. 4, the effects of the circumferential angle on the performance characteristic curves of casing III, IIIa and IIIb are shown. If a triangular piece is inserted into the throat part, as shown in Fig. 5, then the circumferential angle becomes larger, keeping the other parts of the casing constant. Casing IIIa and IIIb are formed in such a way. If the exit of the impeller is round, then the shape of the volute casing must surround the longer part of the impeller as much as possible. These casings, however, are different in their circumferential angle. In these casings, casing IIIb, (i.e., casing with a larger circumferential angle), has better characteristics with its high pressure and large discharge. The circumference of the volute casing must be as long as possible.

**Effects of casing width** Fig. 6 shows the effects of the casing width, (i.e., effects of casings V, VI, IIIb, VII, VIII, and IX). These casings are different in their casing width. Also, the width increases in the order V, VI, IIIb, VII, VIII and IX. From Fig. 6, the performance increases in the adverse order, for example, from IX to V. According to the results of CFD, Figs. 7(a), (b) shows the difference of velocity distribution for various casing widths. As for a small width of the casing, a vortex cannot be seen in the clearance between the shroud and the side wall. This figure was taken for casing V, and the ratio of casing width to impeller width is 1.2.