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Theoretical and Experimental Investigation on the Centrifugal and Mixed-flow Impellers with Particular Reference to the Slip Factor of Impellers

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In designing centrifugal or mixed-flow impeller, the slip factor which gives relation between the number of blades and the delivery head, is employed as an important factor. Methods to estimate the slip factor of centrifugal and mixed-flow impellers have already been derived by several authors. Because of the difference of derivation, the expression of the slip factor derived by these authors does not coincide well. Also, in the range of smaller number of blades, the slip factor evaluated by these expressions give lower values than the experimental results.

The author derived theoretically a formula of slip factor of centrifugal and mixed-flow impellers which showed fair coincidence with the experimental results even at the range of smaller number of blades. Relation between the slip factors of impellers and the performance characteristics of compressors are also clearly explained.

In chapter 1 the definition of the slip factor and formulae for slip factor which have already been derived by several authors are shown. Also, the method of theoretical analysis by the author is shown.

In chapter 2 the experimental investigation of the slip factor of centrifugal and mixed-flow impellers is described.

In chapter 3 the slip factors of these impellers are evaluated by the analysis of potential flow. Although the actual flow pattern in the mixed-flow impeller is of three dimensional, the author analysed the flow on conical surface as two dimensional, because the three dimensional analysis of turbomachinery is not established up to the present stage. The results of this analysis showed lower values than the experimental ones. It is conceivable that the deviation depends on the choice of boundary condition in the theoretical analysis. Analysis of this chapter is assumed that the relative eddy is enclosed wholly within the impeller channel, but it is considerable that the relative eddy passes over the exit periphery of impeller.

In chapter 4 the author observed the boundary of the relative eddy formed within the impeller channel by photographic method and showed that the outermost boundary of the relative eddy near the impeller exit lied out of the exit periphery of the impeller channel and further found the deviation of the utmost

boundary of the relative eddy is primarily influenced by the number of impeller blades.

In chapter 5 the relative flow in the rotating impeller channel are experimentally examined. By this experiment it is ascertained that the slip factor depends on the strength of relative eddy. The viscosity, compressibility and the secondary flow have small influence on the slip factor.

In chapter 6 theoretical calculations of slip factor of radial bladed centrifugal and mixed-flow impellers are shown. By this calculation, the boundary conditions derived in chapter 4 is used. These calculations need much time for computation, so that the formulation of these consequence of calculation seems practically significant. The analytical consequence of slip factor is formulated as

$$\mu = 1 - \frac{2.4}{z+3} \left(1 - \frac{0.83}{z} \right) \sin \gamma$$

where z is number of blades and γ is angle between rotating axis and conical surface. This formula shows fair coincidence with the experimental results even at smaller number of impeller blades.

In chapter 7 the relations between slip factors of impellers and the characteristics of compressors are shown.

Chapter 8 is the conclusion and the results of this investigations are summarized.