Effect of Blade Thickness on the Two-Dimensional Cascade Performance
(Correcting Method for Design Camber and Stagger*)

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According to a potential flow analysis, the variation of blade thickness affects not only the circulation of the axial blade row, but also the optimum inflow condition. From this point of view, a calculating method has been proposed, by which the design camber and stagger are corrected theoretically so as to operate at the optimum condition when the thickness deviates from the basic profile. The method has been applied to NACA 65-series compressor blades, and compared with some classical theories. Correcting diagrams for the camber and the stagger are prepared by use of the carpet plotting technique. The necessity of further experimental studies by considering the variation of loss coefficient is suggested.

1. Introduction

In the design of blade sections of the axial compressor, experimental data of two-dimensional cascade are widely used because of their high reliability. The cascade performance, however, is influenced by many variables such as camber, blade thickness, stagger, solidity etc. It is almost impracticable to carry out the cascade performance tests for numerous combinations of these parameters. Therefore, the effect of blade thickness which is comparatively weak has been investigated for a particular cascade geometry, and the results have been applied to arbitrary cases as a correcting method for the blade thickness variation. For instance, classical methods by Rudden (1), Raabe (2), Shimoyama (3) and Stanitz (4) are all based on the theoretical investigation for non-cambered blade, and the correction in the NACA design method (5) is derived from the experimental investigation for NACA 65-1210 compressor blade (6).

According to a potential flow theory, however, the effect of blade thickness on the performance and the optimum inflow condition varies depending on camber, solidity and stagger. In this paper, a rational method is presented to correct the design camber and stagger theoretically for the thickness variation so as to obtain not only the required performance but also the optimum inflow condition for an arbitrary cascade geometry. The method has been applied to NACA 65-series compressor blades and compared with the previous methods. As a result, the correcting diagrams for camber and stagger are prepared to facilitate the selection of cascade geometry by use of a carpet plotting technique.

2. Nomenclature

\[ \sigma_{12} : \text{camber} \]
\[ \gamma : \text{circulation parameter} \]
\[ \phi = \tan \beta_1 - \tan \beta_2 : \text{angle of attack} \]
\[ \alpha : \text{angle of attack} \]
\[ \beta_1 : \text{inlet flow angle} \]
\[ \beta_2 : \text{outlet flow angle} \]
\[ \gamma : \text{stagger} \]
\[ \psi : \text{turning angle} \]
\[ C_\text{p} : \text{total pressure loss coefficient} \]
\[ C_\text{d} : \text{referred to the dynamic pressure corresponding to axial velocity} \]
\[ \eta_{b} : \text{blade element efficiency} \]
\[ \eta_{f} : \text{efficiency of fan} \]
\[ \nu : \text{inlet angle of blade} \]
\[ \sigma : \text{solidity} \]
\[ \tau : \text{thickness ratio} \]
\[ \phi_{b} : \text{flow coefficient for blade element} \]
\[ \delta : \text{equivalent camber angle as circular-arc} \]
\[ \psi : \text{pressure rise coefficient of fan} \]
\[ \psi_{b} : \text{pressure rise coefficient of blade element} \]

Prefix
\[ \delta : \text{difference between a previous correcting method and the present method} \]
\[ \Delta : \text{variation due to change in the blade thickness} \]

**Suffix**

* : optimum inlet flow condition or impact free inlet condition

\( \circ \) : value associated with the reference thickness

3. Correction of design camber and stagger for the variation of blade thickness

With a variation of blade thickness, the pressure rise and the efficiency of axial impeller vary corresponding to changes in the circulation and the profile loss of blade elements. The variation can be estimated as follows: The pressure rise coefficient and the efficiency of the blade element at arbitrary radius are represented by

\[ \psi_B = 2\eta_B \phi_B \zeta B \]  
\[ \eta_B = 1 - (\phi_B \zeta B / 2f) \]  

In case of a constant flow rate, then, the variations of \( \psi_B \) and \( \eta_B \) due to a change in blade thickness are given approximately by the following relations\(^{(1)}\)

\[ \frac{\Delta \psi_B}{\psi_B} = \frac{\Delta f}{f} + \Delta \eta_B / \eta_B \]  
\[ \frac{\Delta \eta_B}{\eta_B} = 1 - \eta_B \left( \frac{\Delta f}{f} - \frac{\Delta \sigma_2}{\sigma_2} \right) \]  
\[ = \frac{\phi_B \zeta B - \phi_B \zeta}{2f - \phi_B \zeta} - \frac{\Delta \sigma_2}{\eta_B} \]  

It will be most desirable to correct the blade geometry so as to keep the relation of \( \Delta \psi_B / \psi_B = 0 \), if possible. However, such a correction is complicated since \( \Delta \eta_B / \eta_B \) depends not only on the parameters \( f \) and \( \sigma_2 \) associated with cascade performance, but also on the design parameter \( \phi_B \). As evident from Eq. (3), therefore, conventional correction is made to keep \( \Delta f / f = 0 \) (namely, not to change the velocity diagram), and as to the variation of blade efficiency, consideration is made when the theoretical pressure rise coefficient \( (\psi_B \phi_B \zeta_B) / (\psi_B \phi_B \zeta_B) \) or the velocity diagram is determined.

Such correcting methods were proposed by several workers using approximate potential flow theories.\(^{(3)-(6)}\) As shown in Fig.1, however, there are considerable differences in the correcting values of stagger calculated from these methods. The main reason for the difference may be that the shape of blade varies with an assumption in each theory. Therefore, these methods appear not to be proper for an accurate design.

In this paper, a rational method is presented taking into consideration the blade geometry, where the correcting values of camber and stagger are obtained to satisfy the required velocity diagram with the optimum inlet flow condition. The potential flow theory may be available for such a method on account of the following facts.

[A] Although the difference of the performances between real flow and potential flow is considerable for compressor cascade, the difference in the variations of the optimum inlet flow angle and turning angle caused by a change in blade thickness is negligibly small, since the variations themselves are small in general.

[B] The variations of the optimum inlet angle with the blade thickness change can be assumed to be identical to those of impact-free inlet angle in the potential flow. Figure 2 shows a comparison between the optimum and the impact-free angles of attack for NACA 65-series compressor blades, in which the former is obtained from the semi-empirical relation by authors\(^{(3)}\) and the latter is calculated by Schlichting's three-terms method. In Schlichting's method, blade row is replaced by distributed vortices and sources which are represented by the Blauert series and the coefficients of these series are so decided as to satisfy the boundary conditions only at three points on the blade. Such replacement makes the slope of camber line gentle near the leading

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**Fig.1** Correction values of design stagger for the infinitely thin blade

**Fig.2** Comparison of the optimum design angle of attack with the impact-free inlet angle for NACA 65-series cascade
edge, while it is rather steep for NACA 65-series profile. Thus, the impact-free angles of attack by Schlichting's method are considerably smaller than the optimum angles of attack. However, the qualitative tendency of variations with camber and inlet flow angle is similar at both angles of attack. This fact indicates that the above assumption is proper.

For these reasons, the correcting values of stagger and camber have been calculated by the potential flow theory in the following procedure.

The inlet flow angle $\beta_0^*$ and the turning angle $\epsilon^*$ at impact-free inlet condition are represented as functions of camber angle $\theta$, thickness ratio $\tau$, solidity $\sigma$ and stagger $\gamma$. When the blade thickness changes from the reference value $\tau_0$ to an arbitrary one $\tau$ providing that $\theta$, $\sigma$ and $\gamma$ are constant, the impact-free inlet flow angle and the turning angle change from $\beta_0^*$ and $\epsilon^*$ to $\beta^*$ and $\epsilon^*$ respectively. In order to keep the turning angle equal to the reference value $\epsilon^*$, it is necessary to change the camber. In the first approximation, the correcting values of the camber are

$$\Delta \theta^{[1]} = - (\epsilon^* - \epsilon^0)$$  (4)

And to keep the inlet flow angle $\beta_0^*$, the change in inlet blade angle may be

$$\Delta \upsilon^{[1]} = \beta_0^* - \beta^*$$  (5)

Thus, the change in the stagger must be

$$\Delta \gamma^{[1]} = - \Delta \theta^{[1]}/2 + \Delta \upsilon^{[1]}$$  (6)

since $\upsilon = \gamma + \theta/2$ referring to Fig.3. In the second approximation, the optimum condition of $\beta_0^*$ and $\epsilon^*$ is calculated for the cascade geometry of $\theta^{[1]} = \theta + \Delta \theta^{[1]}$ and $\gamma^{[1]} = \gamma + \Delta \gamma^{[1]}$ by the potential flow theory. Then,

$$\Delta \theta^{[2]} = - (\epsilon^* - \epsilon^0)$$

$$\Delta \upsilon^{[2]} = \beta_0^* - \beta^*$$

$$\Delta \gamma^{[2]} = - \Delta \upsilon^{[2]}/2 + \Delta \upsilon^{[1]}$$

In a similar way, the camber angle and stagger for the $n$-th approximation are

$$\theta^{[n]} = \theta^{[n-1]} + \Delta \theta^{[n]}$$

$$\gamma^{[n]} = \gamma^{[n-1]} - (\Delta \theta^{[n]}/2) + \Delta \upsilon^{[n]}$$  (7)

Iterating the above procedure until $\Delta \theta^{[n]}$ and $\Delta \upsilon^{[n]}$ are regarded as vanished, the correcting values become

$$\Delta \theta = \theta^{[n]} - \theta = \Delta \theta^{[1]} + \Delta \theta^{[2]} + \ldots + \Delta \theta^{[n]}$$

$$\Delta \gamma = \gamma^{[n]} - \gamma = \Delta \gamma^{[1]} + \Delta \gamma^{[2]} + \ldots + \Delta \gamma^{[n]}$$  (8)

Rapid convergence is obtained by the above procedure.

Although there are several calculating methods of potential flow to carry out the procedure, the difference in the correcting values caused by the method is ignored for the similar reason stated in [A]. Therefore, Schlichting's method was adopted in which the impact-free inlet condition was easily found by putting as zero the first term of Glauert series for vortex distribution. In the iterating procedure, the stagger angle varies in turn, and the computation of the coefficients of influence for various stagger takes enormous time. Therefore, it is convenient to compute the coefficients at every five degrees of stagger beforehand, and estimate the value for an arbitrary stagger by interpolation.

4. Discussion on the calculating results

4.1 Correction for NACA-65 series compressor blades

The described method is to be applied to the case when the cascade data of the blades with the reference thickness have been prepared and it is intended to change the thickness. In this investigation, therefore, NACA 65-series compressor blades have been selected as calculating examples, since systematic data are available on these blades with thickness ratio of 10%, and are used widely in practical design. In these profiles, 0 is replaced by an equivalent camber angle which is defined as the center angle of a circular arc passing through the leading and trailing edges and the point of maximum camber at the mid-chord position. Hence, with the relation of

$$\theta = 4\tan^{-1}(0.1103\sigma_{z_0})$$  (9)

to the correcting values of $\theta$ can be converted to those of $\sigma_{z_0}$.

At first, the effect of stagger $\gamma$ on the correcting values of camber $\Delta \theta_{z_0}$ and stagger $\Delta \gamma$ has been examined in Fig.4, taking the thickness ratio $\tau$ as parameter in the case of $\sigma = 1.5$ and $\sigma_{z_0} = 1.8$. In the low stagger region, the optimum inlet condition is obtained by positive correction of camber for thinner profile and negative for thicker one. For constant thickness, the correcting value $\Delta \theta_{z_0}$ changes little with the stagger in this region, but it approaches zero as the
stagger becomes a certain medial value, and opposite correction is necessary in the high stagger region.

As to the correction of stagger, $\Delta \gamma$ is positive for thicker blade in the same manner as the classical method. For constant thickness, the absolute value of $\Delta \gamma$ changes little with stagger in the high stagger region, reduces with a decreasing stagger, and falls to zero at a certain negative value of $\gamma$.

The effect of camber is shown in Fig. 5, where $\Delta \sigma_{LO}$ and $\Delta \gamma$ for $\sigma = 1.0$ and $\tau = 0.06$ are plotted taking the camber of the reference profile as parameter. The correcting value changes with the camber, while it does not in the conventional correcting methods. It is also seen that the values of stagger, where the sign of $\Delta \sigma_{LO}$ turns to opposite and $\Delta \gamma$ becomes zero as shown in Fig. 4, decrease as the camber increases.

Figure 6 indicates the correcting values as functions of $\tau$ and $\gamma$. Both $\Delta \sigma_{LO}$ and $\Delta \gamma$ have linear relations with the thickness, which are available to make correcting diagrams as will be described in Section 5.

4.2 Comparison with the experimental data

In Fig. 7, the design points obtained from the present method are shown on the $c - \alpha$ plane with the experimental data for various thickness ratios ($\sigma$). The design points for blade thickness ratios other than 10% have been estimated by correcting the optimum design points of NACA 65 (c_{LO}A_{10}) profile (shown by @ mark in the figure). As is evident from the figure, the calculated design points coin-

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![Figure 4](image1)

**Fig. 4** Correcting values of design camber and stagger ($\sigma = 1.5$, $\sigma_{LO} = 1.8$)

![Figure 5](image2)

**Fig. 5** Correcting values of design camber and stagger ($\sigma = 1.0$, $\tau = 0.06$)

![Figure 6](image3)

**Fig. 6** Correcting values of design camber and stagger ($\sigma = 1.5$, $\sigma_{LO} = 1.8$)

![Figure 7](image4)

**Fig. 7** Calculated design point and experimental data
cide with the experimental performances except in the case of $\beta_1 = 60^\circ$ and $\tau = 0.15$ where the calculated turning angle is somewhat larger than the experimental one. There are no available experimental data except those quoted in Fig. 7. Although it is not concluded so far whether the present method is applicable for other cascade geometry, the method will be useful unless the inlet flow angle and the thickness ratio are extremely large.

4.3 Comparison with the previous correcting methods

Firstly, comparison has been made with the correction by Lieblein which is adopted in the NACA design method. As shown in Figs. 8(a) and (b), the correcting values by Lieblein are independent of camber, and agree fairly well with the present method both at a low inlet flow angle for $\sigma_{20} = 0.0$ and at an inlet flow angle of about $60^\circ$ for medial camber. This fact is reasonable since Lieblein's correction was derived from the classical analysis by Stanitz for non-cambered blade and the correlations of the experimental results for $\beta_1 = 45^\circ$, $60^\circ$, and $\sigma_{20} = 1.2$ (Fig. 7). The deviation in the optimum inlet flow angle is out of the question, since the correcting values of stagger $\delta y$ never exceed $1^\circ$ even when they become maximum at a low inlet flow angle for a high cambered blade. However, the difference of cascade performance caused by the disagreement of $\Delta \theta_{20}$ and $\delta y$ in both methods is significant in practical design. The difference is represented by the variations of circulation parameter $\delta \psi / \psi$ and outlet flow angle $\delta \beta_2$. The calculating results for $\tau = 0.06$ and $\sigma = 1.5$ are plotted in Fig. 9, taking $\psi$ as abscissa, where $\delta \psi / \psi$ and $\delta \beta_2$ are estimated by Schlichting's method. For the inlet flow angle lower than $60^\circ$, $\delta \beta_2$ and $\delta \psi / \psi$ are less than 0.2° and 0.01 respectively at ordinary design value of $\psi$. In the case of $\beta_1 = 70^\circ$, however, the difference of outlet flow angle amounts to $0.5^\circ$, and $\psi$ varies remarkably with a small change in the outlet flow angle so that the variation of impeller performance may be considerable.

Secondly, the present method has been compared with the classical methods by Ruden, Raabe and Stanitz, which are based on the approximate potential flow theories. In their methods the design angles of attack do not coincide with the optimum angles since the corrections are made only for stagger. However, the deviation from the optimum angle of attack is smaller than $1.5^\circ$ and is out of consideration in practical design. The deviation of cascade performance may rather cause trouble. Again, Schlichting's method was used to estimate the deviations $\delta \beta_2$ and $\delta \psi / \psi$ when the thickness ratio varied from 0.1 to 0.06 and to 0.15 for various inlet flow angles. The results for $\sigma_{20} = 1.2$ and $\sigma = 1.5$ are tabulated in Table 1. In general,
the larger deviations can be observed than those of Lieblein's correction. Especially the deviations of Ruden's and Stanitz's corrections are remarkable at low inlet flow angles, and those of Raabe's correction at high inlet flow angles. Further, the calculation showed that the deviation becomes larger with an increasing solidity for Ruden's correction and vice versa for Raabe's of which the results are omitted in the table. For these corrections, the similar tendency has been obtained in the comparison with the experimental cascade performance of flat-plates by the authors. This fact may suggest the propriety of the present method as well as the limitation of the correction by approximate potential flow theory.

5. The correcting diagrams for the design camber and stagger

It is found that Eq. (8) gives the rational correction of the design camber and stagger for arbitrary thickness ratio when the available design data have been prepared for the reference thickness ratio. For practical design, however, it is more convenient to present the correcting values as design charts beforehand. Such charts are made in the following manner. Considering the fact that \( \Delta \sigma_{\Delta \gamma} \) and \( \Delta \gamma \) have the linear relations with \( \tau \) (Fig. 6), the following formulae hold for a considerable change in the blade thickness:

\[
\sigma_{\Delta \gamma} = (\sigma_{\Delta \gamma})_0 + \frac{\partial (\Delta \sigma_{\Delta \gamma})}{\partial \tau} (\tau - \tau_0)
\]

\[
\gamma = \gamma_0 + \frac{\partial (\Delta \gamma)}{\partial \tau} (\tau - \tau_0)
\]

The gradients \( \frac{\partial (\Delta \sigma_{\Delta \gamma})}{\partial \tau} \) and \( \frac{\partial (\Delta \gamma)}{\partial \tau} \) are evaluated by the potential flow theory as functions of \( (\sigma_{\Delta \gamma})_0 \), \( \gamma_0 \) and \( \sigma \):

\[
\frac{\partial (\Delta \sigma_{\Delta \gamma})}{\partial \tau} = F(\sigma, (\sigma_{\Delta \gamma})_0, \gamma_0)
\]

\[
\frac{\partial (\Delta \gamma)}{\partial \tau} = G(\sigma, (\sigma_{\Delta \gamma})_0, \gamma_0)
\]

The calculating results of Eq. (11) for NACA 65-series compressor blades are presented in Fig. 10 using the carpet plotting technique, which is available as correcting diagrams of the well known design camber and angle of attack selection charts for NACA 65 (\( \sigma_{\Delta \gamma}A_1 \)). But, it is more recommendable to use together with it the improved and extended selection charts by the authors in order to perform the optimum design. Namely, \( (\sigma_{\Delta \gamma})_0 \) and \( \gamma_0 \) which satisfy the required velocity diagram at the optimum condition are found by the selection charts for \( \tau_0 = 10\% \) at first, and \( \frac{\partial (\Delta \sigma_{\Delta \gamma})}{\partial \tau} \) and \( \frac{\partial (\Delta \gamma)}{\partial \tau} \) are selected corresponding to \( (\sigma_{\Delta \gamma})_0 \) and \( \gamma_0 \) on

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Table 1 Deviation of cascade performances at design point for various classical methods

<table>
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<tr>
<th>( \sigma )</th>
<th>30°</th>
<th>45°</th>
<th>60°</th>
<th>70°</th>
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<tr>
<td>( f )</td>
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<td>0.589</td>
<td>0.695</td>
<td>1.490</td>
</tr>
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<td>Ruden</td>
<td>( \delta )</td>
<td>0.76°</td>
<td>0.96°</td>
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<td>( f/f )</td>
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<td>-1.31</td>
<td>-1.6</td>
<td>-1.6</td>
</tr>
<tr>
<td>Stanitz</td>
<td>( \delta )</td>
<td>0.5°</td>
<td>0.96°</td>
<td>0.6°</td>
</tr>
<tr>
<td>( f/f )</td>
<td>-1.29</td>
<td>-1.6</td>
<td>-1.6</td>
<td>-1.6</td>
</tr>
<tr>
<td>Raabe</td>
<td>( \delta )</td>
<td>-0.06°</td>
<td>-0.06°</td>
<td>-1.2°</td>
</tr>
<tr>
<td>( f/f )</td>
<td>1.1</td>
<td>0.6</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Stanitz</td>
<td>( \delta )</td>
<td>0.8°</td>
<td>0.96°</td>
<td>0.6°</td>
</tr>
<tr>
<td>( f/f )</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
</tr>
<tr>
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<td>( \delta )</td>
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<td>0.14°</td>
<td>-1.1°</td>
</tr>
<tr>
<td>( f/f )</td>
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<td>-0.5</td>
<td>3.6</td>
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<tr>
<td>Stanitz</td>
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<td>( f/f )</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
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</tbody>
</table>

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Fig. 10 Carpet diagrams of correcting design camber and stagger for the change in thickness of NACA 65-series blades

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the correcting diagrams of Fig. 10. Then, the optimum design values of camber and stagger are calculated from Eq. (10) for an arbitrary thickness.

6. Consideration for the variation of total pressure loss coefficient

The method described above is aimed at only satisfying the required velocity diagram. If the camber and stagger are corrected to be $\Delta \beta / \beta = 0$, from Eqs. (2) and (3), it follows that:

$$\frac{\Delta \psi_b}{\psi_b} = \frac{\Delta \eta_b}{\eta_b} = \frac{1 - \eta_b}{\eta_b} \Delta \xi_2$$  \hspace{1cm} (12)

Hence, the efficiency and the pressure rise coefficient of blade element vary due to the change of total pressure loss. In Eq. (12), $\Delta \xi_2 / \xi_2$ varies corresponding to a change in $\tau$, $\gamma$ (or $t_c$) and $\gamma$ in the strict sense. In practical use, however, the variation with $\tau$ and $\gamma$ can be neglected since their minor changes ($\Delta \xi$ and $\Delta \gamma$) affect little the variation of the total pressure loss providing that the circulation parameter $f$ is constant. Therefore $\Delta \xi_2 / \xi_2$ can be replaced by the value corresponding to the thickness variation only.

In Fig. 11, the experimental values of $\Delta \xi_2 / \xi_2$ quoted from Ref. (6) are plotted against the thickness ratio. As the experimental total pressure loss coefficients scatter, they are indicated by the maximum and minimum values in the region of low loss. The figure shows that $\Delta \xi_2 / \xi_2$ changes from -0.2 to 0.3 as the thickness ratio changes from 0.06 to 0.15. Therefore, $\Delta \eta_b / \eta_b$ and $\Delta \eta_b / \eta_b$ may become 1% or less since $(1 - \eta_b) / \eta_b$ is a few percent for the well designed blades. Hence it appears that no correction of the total pressure loss coefficient is required except when an especially accurate design is demanded.

On the other hand, if the camber and stagger are not corrected for the thickness variation, $\Delta \beta$ and $\Delta \xi_2$ have opposite signs in Eq. (3), thus, $\Delta \eta_b / \eta_b$ cannot be ignored. This was confirmed by the rotating cascade tests in a single stage axial fan with hub-tip ratio of 0.6, where the blade profile of Göttingen 436 ($\tau = 11\%$) was varied such that $\tau = 7\%$ and 15% providing the camber line and the stagger were constant. The relative variation of pressure rise coefficient at the design flow rate is compared with the predicted one in Fig. 12. The latter was predicted by

$$\frac{\Delta \psi}{\psi} = \frac{\Delta f}{f} + \frac{\Delta \eta_b}{\eta_b}$$  \hspace{1cm} (13)

where $\Delta f / f$ was calculated by Schlichting's method and the variation of fan efficiency $\Delta \eta_b$ was estimated by the following relation.

$$\Delta \eta_b = (1 - \eta_b) \frac{\Delta f}{f} - \frac{1 - \eta_b}{\Omega} \frac{\Delta \xi_2}{\xi_2}$$  \hspace{1cm} (14)

As to $\Delta \xi_2 / \xi_2$, the relation in Fig. 11 was used approximately since there were no experimental data for Göttingen 436. $\Omega$ is the work done factor which represents the effect of annulus wall boundary layer and is given by $\Omega = \psi / (2 \eta_b \phi_b \phi_f)$. As shown in Fig. 12, the absolute value of $\Delta f / f$ is considerably smaller than the experimental value of $\Delta \psi / \psi$, which suggests the necessity of addition of the second term in the right-hand side of Eq. (13). The predicted value of $\Delta \psi / \psi$ agrees with experimental value in the case of a thicker blade, while it is somewhat overestimated for a thinner blade. This may be caused by the fact that the blade profile was deteriorated by the reduction of thickness and, consequently, the total pressure loss did not decrease as expected in Fig. 11.

As a result, it is found that the variations of pressure rise coefficient with the blade thickness change must be evaluated by taking account of the variation of efficiency especially in the case when the design camber and stagger are not corrected.

7. Conclusions

The results summarised are as follows:

(1) A rational method has been proposed to correct the design camber and stagger for variation of the thickness in the blading of axial turbomachines.

(2) The method was compared with the experimental data and the previous correcting methods in order to confirm its availability.
(3) The correcting diagrams for the design camber and stagger have been prepared by use of the carpet plotting technique.

(4) The effect of a change in the total pressure loss coefficient caused by the thickness variation has been discussed from a standpoint of practical design.

In concluding this paper, the authors would like to emphasize that further experimental investigation is required to clarify the availability of the method and to get more knowledge about the loss. They are now planning the cascade tests for compressor blades with various thickness ratios.

References

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