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EFFECT OF TRAILING-EDGE GEOMETRY AND THICKNESS ON THE PERFORMANCE OF CERTAIN TURBINE STATOR BLADING

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16. Abstract

The investigation does not consider the effect of trailing-edge coolant ejection. The experimental and analytical investigation included solid blades with five different trailing-edge thicknesses and four different trailing-edge geometries. One of the geometries was round, one was square, one was tapered from the suction surface, and the other tapered from the pressure surface. One of the trailing-edge thicknesses was sharp edged; the other four thicknesses were equivalent to about 5, 11, 16, and 20 percent of the blade throat width. The experimental results show increased efficiency loss for increased trailing-edge thickness for all trailing-edge geometries. The blade with round trailing edge, equal to about 11 percent of the blade throat width, had 60 percent more loss than the sharp-edged blade. For the same trailing-edge thickness, square trailing edges caused more loss than round trailing edges, and the tapered trailing edges caused about the same loss as the round trailing edges.

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SUMMARY

An experimental and analytical investigation of the effect of trailing-edge geometry and thickness on the efficiency of particular solid turbine stator blading was conducted. The effect of trailing-edge coolant flow is not considered. Five trailing-edge thicknesses and four trailing-edge geometries were included. One of the trailing-edge geometries was round, one was square, one had a flat trailing-edge surface that was tapered from the blade pressure surface, and the other had a flat trailing-edge surface that was tapered from the blade suction surface. One of the trailing-edge thicknesses investigated was essentially sharp-edged. The other four trailing-edge thicknesses investigated were equivalent to about 5, 11, 16, and 20 percent of the blade throat width.

The results showed the trailing-edge loss to increase with increased trailing-edge thickness for the four trailing-edge geometries investigated. In the range of critical velocities between 0.5 to 0.8, the round trailing edge having a thickness equal to about 11 percent of the blade throat width caused an additional efficiency loss of about 0.9 percentage points relative to the sharp-edged blade. This is an increase in loss of about 60 percent relative to a sharp-edged blade. For the three larger trailing-edge thicknesses investigated, the square trailing edge caused significantly more loss than the round trailing edge. For a trailing-edge thickness equal to about 11 percent of the blade throat width and between critical velocity ratios of 0.5 and 0.8, the average efficiency loss for the round trailing edge is indicated to be about 0.4 to 0.5 percentage point larger than for the two tapered trailing edges. At other trailing-edge thicknesses, the two tapered trailing edges are indicated to have about the same loss as the round trailing edge.

A comparison between experimental and analytical results shows good agreement for some trailing-edge geometries and thicknesses and rather poor agreement for others.

INTRODUCTION

In cooled turbines, blades with thicker than normal profiles, including trailing-edge thicknesses, are generally required to accommodate the internal passages needed for the coolant flow. The effect of these thicker profiles on the aerodynamic performance of blading is being investigated at the NASA-Lewis Research Center (e.g., refs. 1 to 3).

This investigation concerns how the performance of a particular design of turbine stator blading is affected by different trailing-edge thicknesses and different trailing-edge geometries. The effect of trailing-edge coolant ejection, which influences the trailing-edge loss, was not included in this study.

The basic stator blading used is described in reference 1. The size of the blading is indicated by a height of 10.16 centimeters (4.0 in.), a chord of 5.74 centimeters (2.26 in.), and a pitch of 4.14 centimeters (1.63 in.). The trailing-edge thickness is 0.178 centimeter (0.070 in.). The nominal turning angle of the blading is about 67° with axial flow at the inlet.

Five different trailing-edge thicknesses and four different trailing-edge geometries were investigated. The trailing-edge thicknesses included were 0.0127, 0.089, 0.178, 0.254, and 0.330 centimeter (0.005, 0.035, 0.070, 0.100, and 0.130 in.). In terms of percentage of blade throat width, these thicknesses represent approximately 1 (sharp-edged), 5, 11, 16, and 20 percent, respectively, of the test blade throat width. The trailing-edge geometries considered were round, square, and tapered. Two tapered trailing-edge geometries were included. In one of these, the flat trailing-edge surface makes an angle of 35° at the tip of the trailing edge with the blade suction surface. In the other, the flat trailing-edge surface makes an angle of 35° at the tip of the trailing edge with the blade pressure surface.

Data used for determining the experimental performance were obtained from pressure loss surveys conducted in a two-dimensional cascade. The range of critical velocity ratios covered was from about 0.5 to 0.9.

Included in the results are the effects of the different trailing-edge thicknesses and geometries considered on the kinetic energy loss of the subject stator blading. (Kinetic energy loss coefficients relate the loss in kinetic energy of the blading to the ideal kinetic energy of the actual flow through the blading.) Also included in the results is a comparison between experimental losses and analytical losses computed using the semi-empirical method of reference 4.

SYMBOLS

c_D independent drag coefficient

$\bar{e}_m$ two-dimensional aftermix kinetic energy loss coefficient

t trailing-edge thickness, m; ft

V gas velocity, m/sec; ft/sec

w blade throat width, m; ft

δ_{full} full boundary-layer thickness, m; ft

Subscripts:

cr conditions at Mach 1

i ideal conditions corresponding to isentropic process

m station after complete mixing occurs

tot sum of blade suction and pressure surface quantities

te blade trailing edge

APPARATUS AND PROCEDURE

Cascade

The experimental investigation was conducted in a simple two-dimensional cascade shown in the photograph of figure 1. Details of this cascade are described in reference 5. The subject cascade contained 12 blades. To minimize entrance and exit guide wall effects, only the channels corresponding to the center three blades were included in the testing.

Blading

The basic solid blading used in this investigation, which is of constant section, is shown in figure 2. In figure 3 a cross-sectional sketch, which indicates the flow path and profile of this blading, is presented. The profile and flow path are the same as that of the mean section of the stator blading described in detail in reference 1. The profile of the blading is quite thick, including the trailing-edge thickness which is equal to about 11 percent of the throat width. The thickened profile results from the blading having been designed to have a profile representative of a cooled blade. All blades investigated are modifications of this blading.

Blades having five different trailing-edge thicknesses and four different trailing-edge geometries were investigated. Figure 4 shows the details of the different trailing-edge geometries, and table I summarizes the 17 different blade configurations with different trailing-edge thicknesses and geometries used in the investigation.

In modifying the basic blading to obtain the blading with different trailing-edge thicknesses, it was desired that all blading have the same surface friction loss so that the trailing-edge loss would be isolated. For given flow conditions, the surface friction loss of blading remains constant if the flow path between the suction and pressure surfaces of the blading is unchanged. Excluding the flow path at the leading edge, the same flow path for blading with different trailing-edge thicknesses was achieved by modifying the basic blading as follows. First, the suction and pressure side curvatures and surface lengths of all blades were kept the same as that of the basic blade. Next, the profile thicknesses of the blades were adjusted to provide for the different trailing-edge thicknesses. Finally, the pitch of each blade configuration with different trailing-edge and profile thickness was adjusted so that its flow path was the same as that of the basic blading.

A cross section of the profiles and flow paths of the different blading with round trailing edges of different thicknesses is shown in figure 5 after having been modified as described. As shown, three blades were modified. Except at the leading edge, all the center blades, which are the tested blades, have the same adjoining flow paths up to the trailing edge. The differences in flow paths at the leading edge resulting from the differences in leading-edge radii are believed to cause negligible difference in surface friction loss since the flow velocities around the leading edges are quite low. Even if the differences in loss caused by different leading-edge radii are not negligible, different trailing-edge thicknesses practically require different leading-edge radii. Therefore, any change in surface friction loss caused by having to increase the leading-edge radii so as to thicken the trailing edge may be considered an inherent part of the increased loss of the thicker trailing edge.

It will be noted in figure 5 that each tested blade except the blade with a sharp trailing edge was adjacent to a blade having the same profile. The low loss obtained for the sharp-edged blade indicated that this exception did not result in a significantly adverse effect on its performance.

Instrumentation

Exit-flow conditions for the cascade investigation were measured with a calibrated multipuprose survey probe of the same type as that shown in figure 6. Details of the probe are described in reference 5. The probe is equipped to measure static pressure, total pressure, and flow angle. Calibrated strain-gage transducers were used to measure the pressures corresponding to these measurements.

Test and Calculations Procedure

Atmospheric air was caused to flow through the cascade by use of the laboratory altitude exhaust system. With atmospheric inlet conditions, desired pressure ratios across the blading were set by regulating an exhaust control valve. With the desired pressure ratio setting and with the survey probe fixed at the average exit-flow angle, surveys of total pressure loss, angle, and static pressure were conducted for approximately one blade pitch by use of a power driven probe actuator shown in figure 1. Most of the data were measured with the probe sensing elements approximately 3.0 centimeters (1.2 in.) downstream of the blading in the direction of flow. Some of the data were checked, by measurements 1.27 centimeters (0.5 in.) downstream of the blading in the direction of flow. Loss coefficients obtained from data measured at the two locations were in close agreement and are included in the results.

During testing, data obtained from the multipurpose probe was monitored as a function of probe position on three x-y recorders. At the same time, the data were also recorded on magnetic tape at the laboratory central data processing center.

At the data processing center, a computer was used to convert the survey data to kinetic energy loss coefficients. The calculation procedure used was a modification of that described in reference 5.

RESULTS AND DISCUSSION

An experimental and analytical investigation of the effect of trailing-edge thickness and geometry on the performance of a particular stator blade was conducted. Five trailing-edge thicknesses and four trailing-edge geometries were included. One of the four trailing-edge geometries was round, one was square, one had a flat trailing-edge surface that made an angle of 35° at the tip of the trailing edge with the suction surface of the blade (see fig. 4), and the other had a flat trailing-edge surface that made an angle of 35° at the tip of the trailing edge with the pressure surface of the blade. In terms of percent of blade throat width, the thicknesses investigated were about 1 (sharp-edged), 5, 11, 16, and 20 percent of the throat width of the tested blading.

The results are presented in three sections. In the first section, the experimental results are presented. In the second section, the experimental results are compared to show the effects of both trailing-edge thickness and trailing-edge geometry on the blade performance. In the last section, the experimental results are compared with analytical results obtained from the semi-empirical method of reference 4.

All results are presented in terms of two-dimensional aftermix kinetic energy loss coefficients $\bar{e}_m$ as functions of ideal aftermix critical velocity ratio $(V/V_{cr})_{i,m}$. The ideal aftermix critical velocity ratio indicates the ideal velocity (and consequently ideal kinetic energy) at a hypothetical downstream location where the flow is fully mixed. The two-dimensional aftermix loss coefficients contain all the losses of the blading, including mixing, except end-wall losses. Values of these loss coefficients are equivalent to loss in efficiency on a kinetic energy basis.

Experimental Results

The experimental results are presented in figure 7 for each of the 17 different bladings investigated. This was done because the data points for the different bladings would have overlapped and been confusing if they had been combined on fewer plots. The data points show test scatter of generally not more than about ±0.25 percentage points in efficiency. Faired curves have been drawn through the data points to represent the average level of loss as a function of critical velocity ratio. These faired curves are used in the next two sections of the report to directly compare the losses of the different blades.

In figure 7, the faired curves through the test results indicate that the loss level for most of the blades did not vary greatly in the range of critical velocity ratios from 0.5 to about 0.8 or 0.85. At critical velocity ratios between about 0.8 and 0.9, there is a sharp increase in loss for most blades. This sharp increase in loss is attributed to flow separation.

The results show a general trend of increased loss with increased trailing-edge thickness. This trend is discussed in the next section where the same results are presented in a manner that allows easier comparison of the losses.

Comparison of Experimental Results

Figure 8 shows the effect of trailing-edge thickness on the loss of the subject blade for each of the four trailing-edge geometries investigated. The faired curves through the test points shown in the previous section have been terminated at a critical velocity ratio of 0.8. This was done because, as pointed out in the previous section, with further increase in velocity above this approximate velocity ratio, there is evidence of flow separation.

In general, the results of figure 8 show increased loss with increased trailing-edge thickness for the four trailing-edge geometries investigated, and the blading with square trailing edges shows the largest increase in loss with increased trailing-edge thickness.

It will be noted that the results for the 0.0127-centimeter (0.005-in.) round trailing-edge blading, which is essentially a sharp-edged blade, are included on all curves of figure 8. This was done so the loss for the blading with different trailing-edge thicknesses could be compared with the loss of a blade having negligible trailing-edge loss. Also, the additional loss caused by the particular trailing edge can be obtained by subtracting the loss coefficient of the sharp-edged blade from the loss coefficient of the blade having that particular trailing edge.

The two-dimensional efficiency loss for the sharp-edged blade is quite small, decreasing a small amount from about 1.6 percent at a critical velocity ratio of about 0.5 to about 1.4 percent at a critical velocity ratio of 0.8.

In figures 8(a) and (d) for the lower critical velocity ratios, the results for the two blades having a 0.089-centimeter (0.035-in.) trailing-edge thickness with round trailing-edge geometry and tapered pressure surface trailing-edge geometry indicate that these blades had about the same loss as the sharp-edged blade. (The slightly smaller loss shown for the 0.089-cm (0.035-in.) tapered trailing edge than for the sharp trailing edge is attributed to data scatter.)

Referring to figure 8(a), which indicates the loss for round trailing edges, the losses for particular thicknesses are shown to vary somewhat with velocity ratio. In the critical velocity range shown, the average additional efficiency loss caused by round trailing edges having different thicknesses was about 0.25 percent for the 0.089-centimeter (0.035-in.) thickness (equal to about 5 percent of the blade throat width), about 0.9 percent for the 0.178-centimeter (0.070-in.) thickness (equal to about 11 percent of the blade throat width), about 1 percent for the 0.254-centimeter (0.100-in.) thickness (equal to about 16 percent of the blade throat width), and about 1.70 percent for the 0.330-centimeter (0.130-in.) thickness (equal to about 20 percent of the blade throat width).

The loss for the blading having a round trailing-edge thickness equal to about 11 percent of the blade throat width is noteworthy since this blade configuration is considered to be representative of cooled stator blading. In the range of critical velocities between 0.5 and 0.8, the average efficiency loss for this blade is about 2.4 percent; the average efficiency loss for the sharp-edged blade is about 1.5 percent. This difference represents an increase in loss for the round-edged blade of about 60 percent relative to the sharp-edged blade. It is therefore shown that trailing-edge configurations required for cooled blades can cause significant loss relative to blading with sharp trailing edges.

In figure 9, the same results as shown in figure 8 are rearranged to better show the effect of trailing-edge geometry on blade loss for each of the five trailing-edge thicknesses.

These results clearly show that, for the three larger trailing-edge thicknesses, the loss for square-edged geometry is significantly larger than for the other trailing-edge geometries. For instance, figure 9(b) for a trailing-edge thickness of 0.178 centimeter (0.070 in.) shows the square trailing edge to cause about 0.5 percentage points more efficiency loss than the round trailing edge in the critical velocity ratio range between about 0.5 and 0.7. At critical velocity ratios above about 0.7 for this thickness, the difference in loss between the square and the round trailing edge decreases, and at a critical velocity ratio of 0.8, the efficiency loss of the square-edged blade relative to the round is about 0.25 percentage points. At the smallest thickness investigated (see fig. 9(a)), the square trailing-edge geometry shows a little more loss than the other geometries except at the higher critical velocity ratios where the losses are about the same.

In figure 9(b) for trailing-edge thicknesses equal to about 11 percent of the blade throat width, the loss for the tapered trailing edges is significantly less than the loss for the round trailing edge, the difference in loss increasing with increased critical velocity ratio. For the range of critical velocity ratios shown and for this trailing-edge thickness, the average efficiency loss for the round trailing edge is indicated to be about 0.4 to 0.5 percentage points larger than for the two tapered trailing edges. This performance improvement for the tapered trailing edge is significant if such a geometry is practical from cooling and stress standpoints and if the gain can be realized in a turbine stage.

In figures 9(a), (c), and (d), for trailing-edge thicknesses other than 0.178 centimeter (0.070 in.), the tapered-suction-surface trailing edge is indicated to have the same or a little more loss than the round trailing edge, and the tapered-pressure-surface trailing edge is indicated to have the same or a little less loss than the round.

Concerning the reasons for the difference in loss between the round and the tapered trailing edges, the tapered-pressure-surface trailing edge might be expected to have less loss than either the round trailing edge or the tapered-suction-surface trailing edge since it provides a comparatively smooth, divergent flow path from the pressure side to the suction side of the blading. The reasons why the differences in loss between the round and tapered trailing edges vary, as shown with different trailing-edge thicknesses, is not understood.

Comparison of Experimental and Analytical Results

The stator blade trailing-edge losses $\bar{e}_{te}$ were also computed using a modification of the semi-empirical equation of reference 4 (chap. 5, p. 6, eq. 10). This equation results from an analysis of the drag caused by boundary-layer flow over thin surface discontinuities having different geometries. The reference equation was modified such that the drag is converted to blade efficiency loss in terms of blade geometry. The following equation was evolved:

$$\bar{e}_{te} = 0.675 \left(\frac{t}{\delta_{full,tot}}\right)^{1/3} \frac{t}{w} c_D \tag{1}$$

where

$\bar{e}_{te}$	efficiency loss caused by trailing edge
t	trailing-edge thickness
$\delta_{full,tot}$	full boundary-layer heights due to frictional flow over both suction and pressure surfaces of blading
w	throat width of blading
c_D	independent drag coefficient dependent on geometry of trailing edge

The value of $\delta_{full,tot}$ used in equation (1) was determined experimentally by measuring the boundary-layer thickness on both surfaces of the blade just preceding the blade trailing edge by use of a total pressure probe. Values of c_D for the four trailing-edge geometries were computed from equation (1). These were computed using average values of experimental trailing-edge loss from figure 8 for a trailing-edge thickness of 0.178 centimeter (0.070 in.) and for critical velocity ratios between 0.5 and 0.8. The following average values of c_D were obtained:

Trailing-edge geometry	c_D
Round	0.130
Square	.200
Tapered from suction surface	.073
Tapered from pressure surface	.066

These values of c_D were then applied in equation (1) to compute the trailing-edge loss for the other three trailing-edge thicknesses.

A comparison of the experimental results with the results obtained using the analytical procedure described in the preceding paragraphs is presented in figure 10. As explained, the analytical results have been normalized to agree with experimental results for trailing-edge thicknesses of 0.178 centimeter (0.070 in.). Comparing, then, the analytical and experimental results in figure 10 for thicknesses other than 0.178 centimeter (0.070 in.) reveals good agreement in loss for some trailing-edge geometries and thicknesses and rather poor agreement for others. Nevertheless, even though the agreement is not as good as desired, the method may be useful if an estimate of the trailing-edge loss of stator blading is required.

SUMMARY OF RESULTS

An experimental and analytical investigation of the effect of trailing-edge geometry and trailing-edge thickness on the performance of a particular turbine stator blade was conducted. The investigation did not include the effect of trailing-edge coolant ejection, which influences the trailing-edge loss.

Four trailing-edge geometries and five trailing-edge thicknesses were included. One of the four trailing-edge geometries was round; one was square; one had a flat trailing-edge surface that made a 35° angle with the suction surface of the blade (see fig. 4); and the other had a flat trailing-edge surface that made a 35° angle with the blade pressure surface. In terms of percent of blade throat width, the thicknesses investigated were about 1 (sharp-edged), 5, 11, 16, and 20 percent of the throat width of the tested blading.

The experimental investigation was conducted over a range of critical velocity ratios from about 0.5 to 0.9, but comparative results are reported only for the range of critical velocity ratios between 0.5 and 0.8 because of the evidence of flow separation above about 0.8 critical velocity ratio.

It is noted that the reported differences in efficiency loss for the blades may in some cases be in error as much as about ±0.25 percentage points because of data scatter. Also, the reported losses are for a particular turbine stator blade configuration, and these losses may vary somewhat with different basic blade geometries.

The results are summarized as follows:

1. For the four trailing-edge geometries investigated, the trailing-edge loss increased with increased trailing-edge thickness.

2. For the range of critical velocity ratios between 0.5 and 0.8, the round trailing edge with thickness equal to about 11 percent of the blade throat width causes an additional loss in efficiency of about 0.9 percentage points relative to the sharp-edged blade. This represents an increase in loss for the round-edged blade of about 60 percent relative to the sharp-edged blade.

3. For the three larger trailing-edge thicknesses investigated, the square trailing edge caused significantly more loss than the round trailing edge. For instance, for a trailing-edge thickness equal to about 11 percent of the blade throat width in the critical velocity ratio range between about 0.5 and 0.7, the square trailing edge causes about 0.5 percentage points more efficiency loss than the round trailing edge.

4. Comparing the loss for the round trailing edge with the loss for the two tapered trailing edges at a trailing-edge thickness equal to about 11 percent of the blade throat

width, between critical velocity ratios of 0.5 and 0.8, shows that the average efficiency loss for the round trailing-edge is about 0.4 to 0.5 percentage points larger than for the two tapered trailing edges. At other trailing-edge thicknesses investigated the two tapered trailing edges are indicated to have about the same loss as the round trailing edge.

5. A comparison between experimental and analytical results shows good agreement for some trailing-edge geometries and thicknesses and rather poor agreement for others.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, November 5, 1971,
764-74.

REFERENCES

1. Whitney, Warren J.; Szanca, Edward M.; Moffitt, Thomas P.; and Monroe, Daniel E.: Cold-Air Investigation of a Turbine For High-Temperature-Engine Application. I - Turbine Design and Overall Stator Performance. NASA TN D-3751, 1967.
2. Whitney, Warren J.; Szanca, Edward M.; Moffitt, Thomas P.; and Monroe, Daniel E.: Cold-Air Investigation of a Turbine for High-Temperature-Engine Application. III - Overall Stage Performance. NASA TN D-4389, 1968.
3. Moffitt, Thomas P.; Prust, Herman W., Jr.; and Bider, Bernard: Effect of Variable Stator Area on Performance of a Single-Stage Turbine Suitable For Air Cooling. II - Stator Detailed Losses With 130 Percent Design Area. NASA TM X-1635, 1968.
4. Hoerner, Sighard F.: Fluid-Dynamic Drag. Midland Part, N. J., 1965.
5. Stabe, Roy G.: Design and Two-Dimensional Cascade Test of Turbine Stator Blade With Ratio of Axial Chord to Spacing of 0.5. NASA TM X-1991, 1970.

TABLE I. - TRAILING-EDGE THICKNESSES AND GEOMETRIES CONSIDERED

Trailing-edge thickness, cm	Trailing-edge thickness, in.	Round	Trailing-edge geometry: Square	Trailing-edge geometry: Tapered suction surface	Trailing-edge geometry: Tapered pressure surface
0.0127	0.005	×			
.089	.035	×	×	×	×
.178	.070	×	×	×	×
.254	.100	×	×	×	×
.330	.130	×	×	×	×

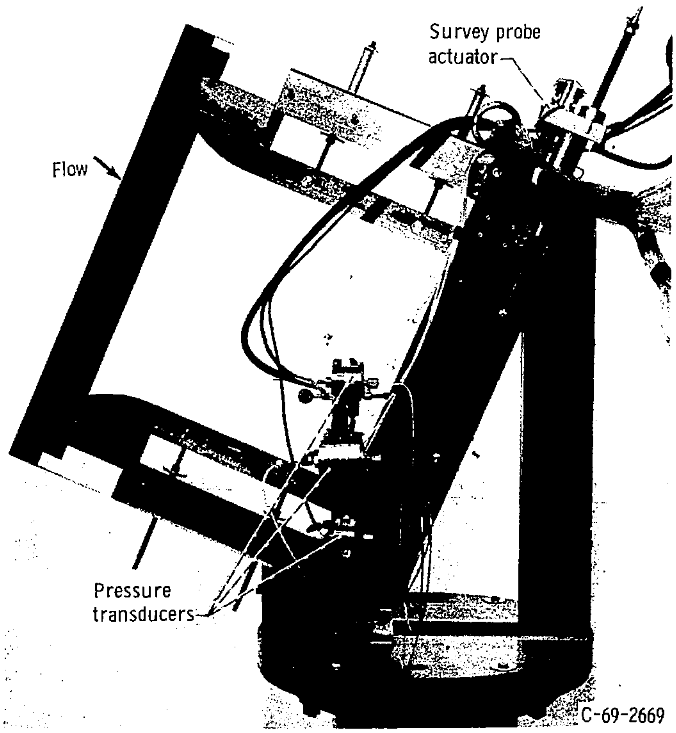


Figure 1. - Stator blade cascade.

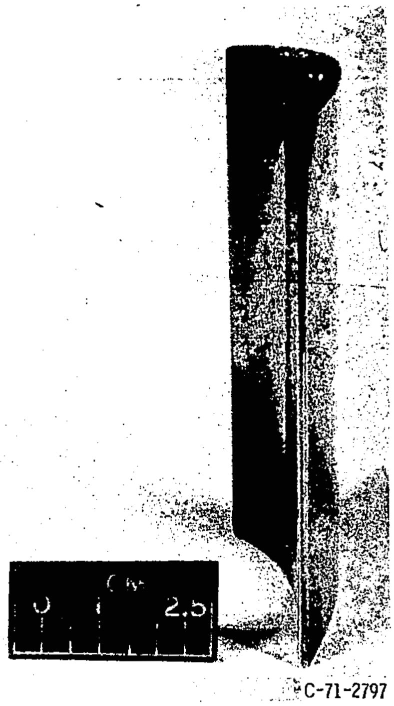


Figure 2. - Basic stator blading.

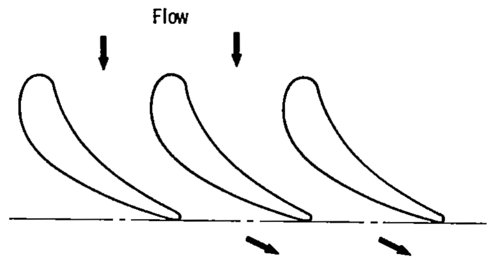


Figure 3. - Profile and flow path of basic stator blading.

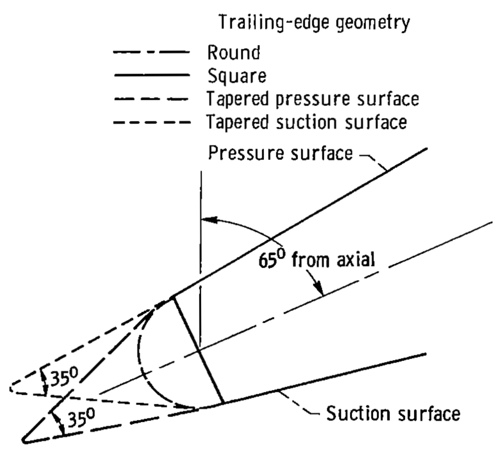


Figure 4. - Blade trailing-edge geometry (from x10 enlargements of actual blade profiles).

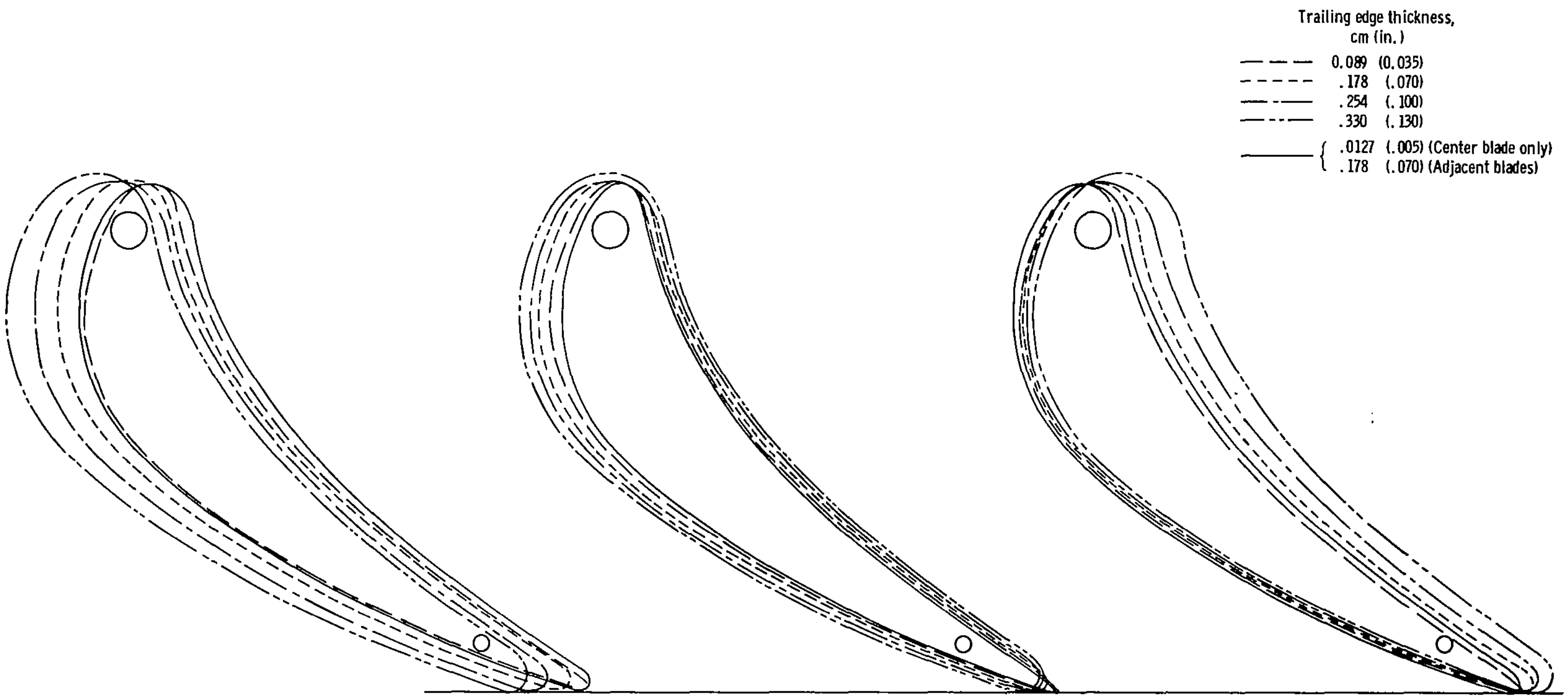


Figure 5. - Profile and flow path of blading having round trailing edges of different thicknesses.

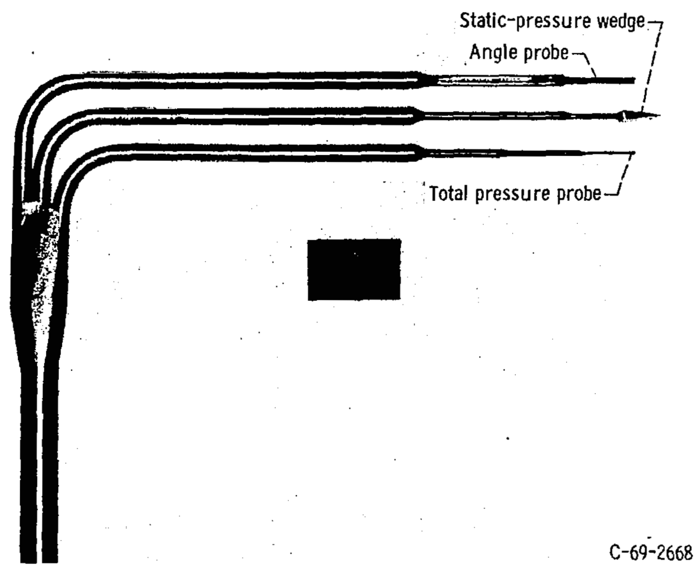
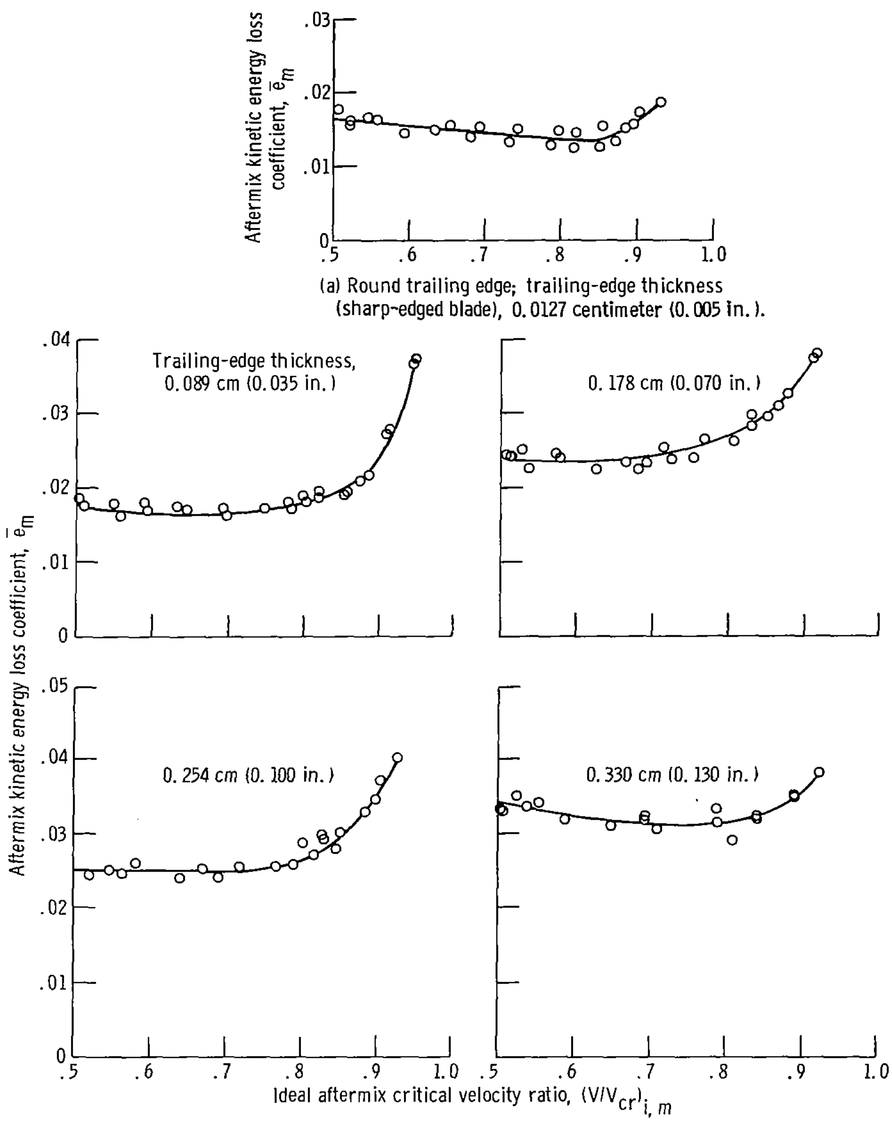


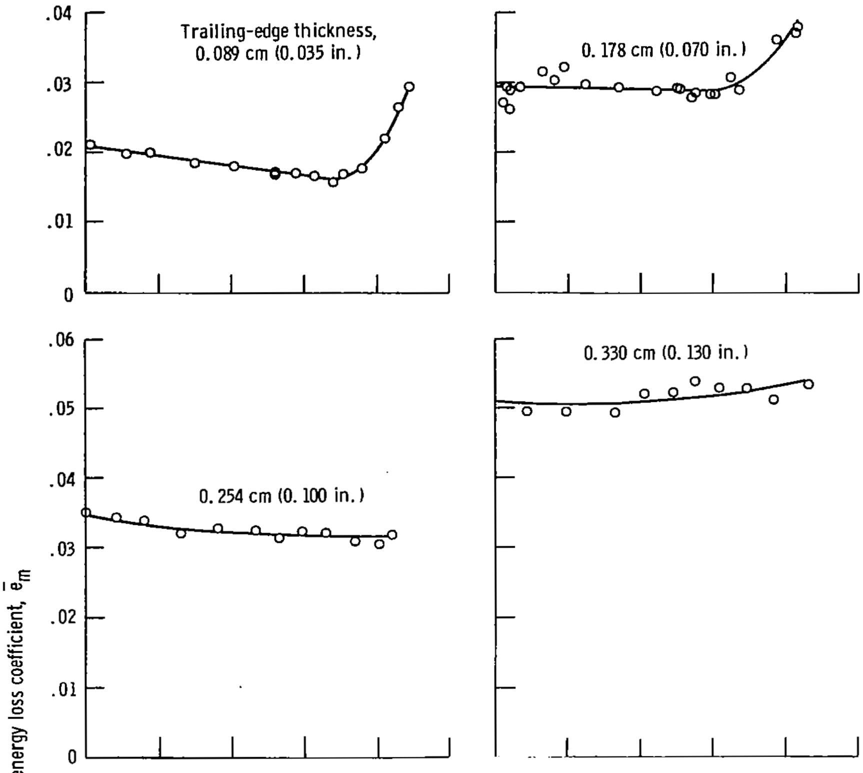
Figure 6. - Multipurpose survey probe.



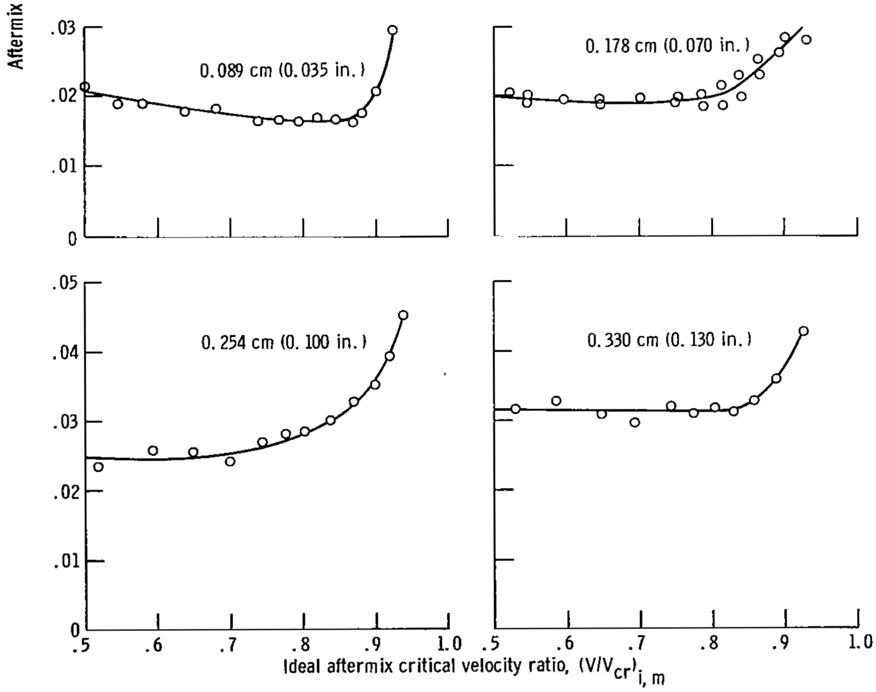
(a) Round trailing edge; trailing-edge thickness (sharp-edged blade), 0.0127 centimeter (0.005 in.).

(b) Round trailing edge.

Figure 7. - Experimental kinetic energy loss for stator blading with different trailing-edge geometries and different trailing-edge thicknesses.

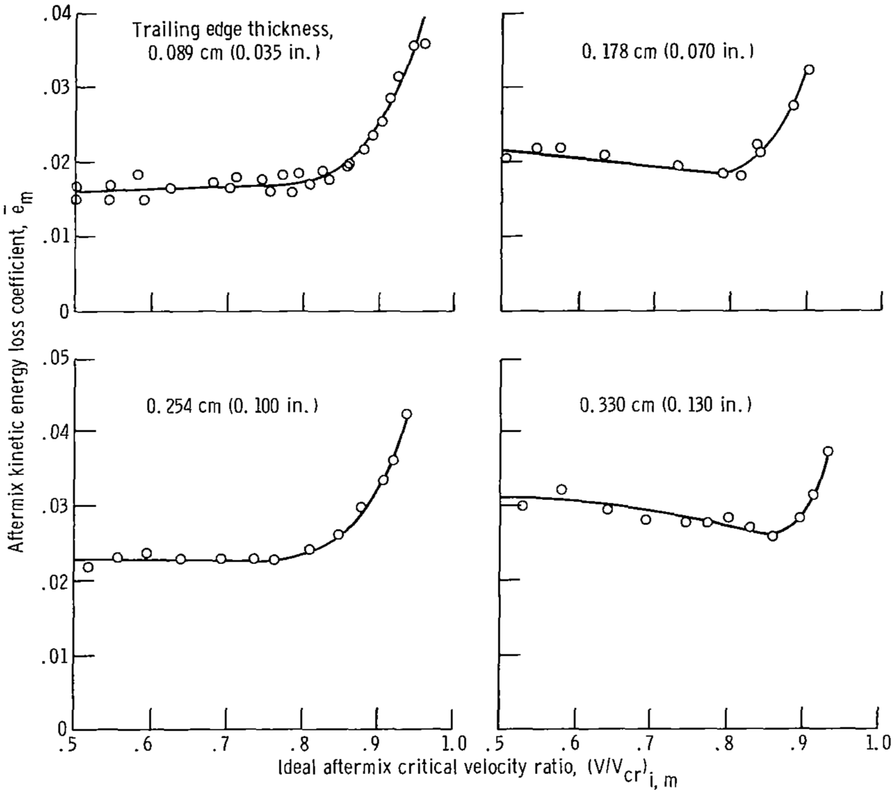


(c) Square trailing edge.



(d) Tapered suction surface trailing edge (see fig. 4).

Figure 7. - Continued.



(e) Tapered pressure surface trailing edge (see fig. 4).

Figure 7. - Concluded.

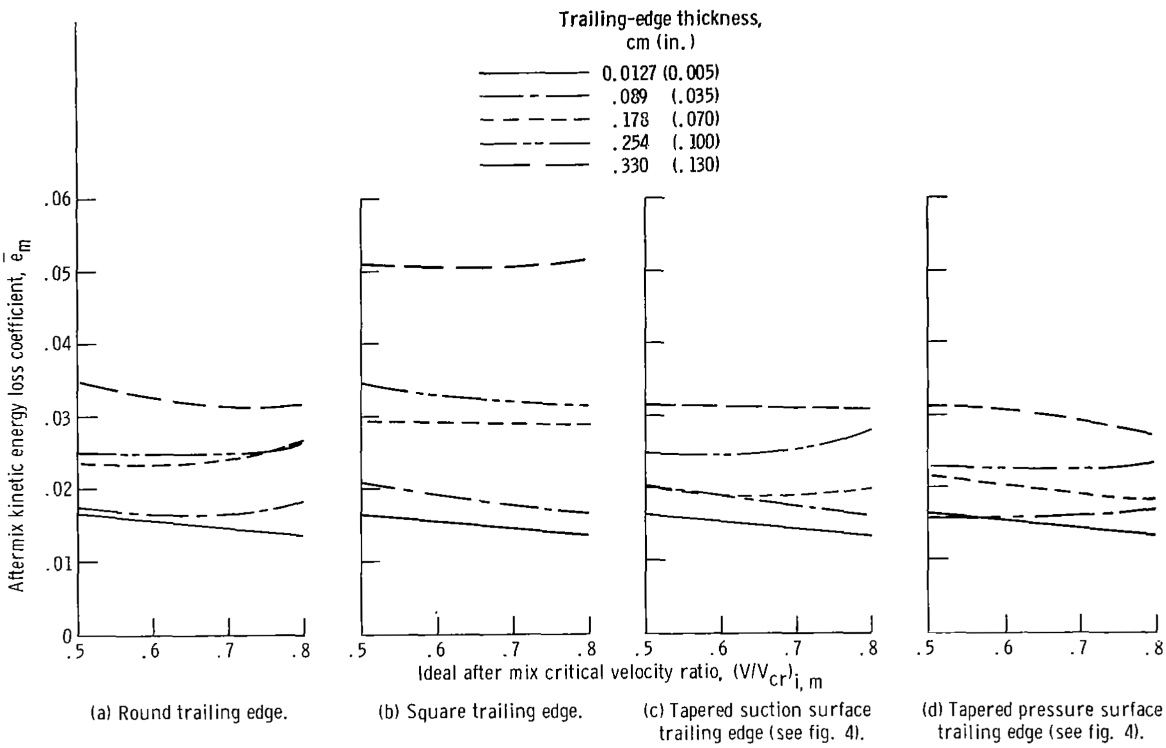
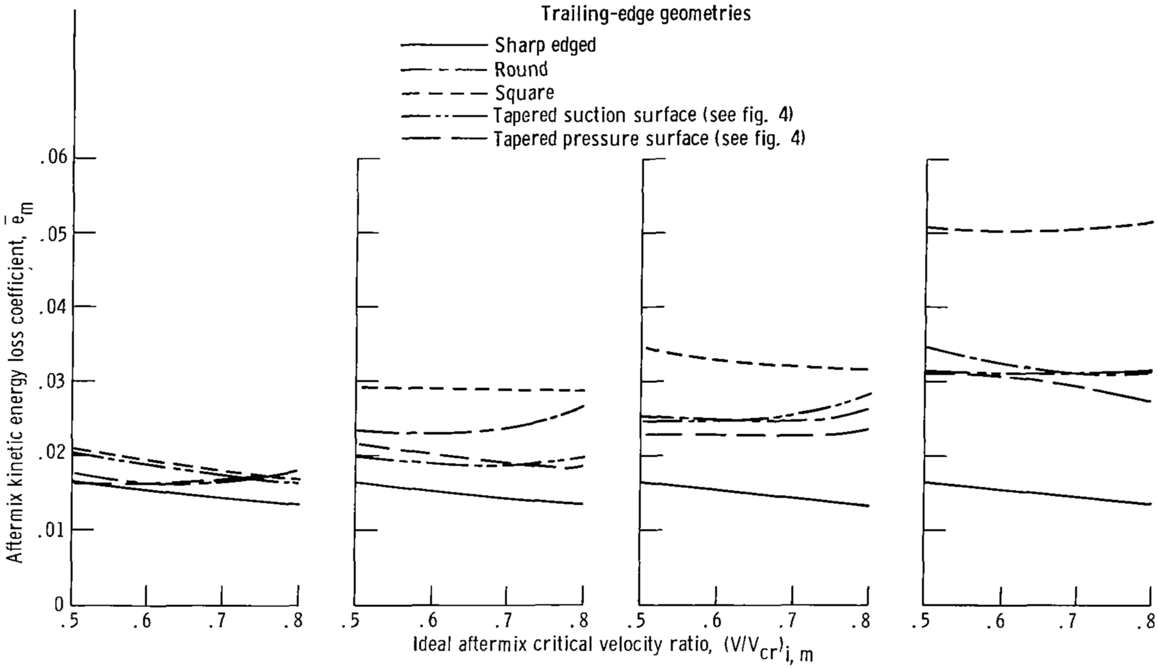


Figure 8. - Comparison of experimental kinetic energy loss for stator blading with same trailing-edge geometries but different trailing-edge thicknesses.



(a) Trailing-edge thickness, 0.089 centimeter (0.035 in.).

(b) Trailing-edge thickness, 0.178 centimeter (0.070 in.).

(c) Trailing-edge thickness, 0.254 centimeter (0.100 in.).

(d) Trailing edge thickness, 0.330 centimeter (0.130 in.).

Figure 9. - Comparison of experimental kinetic energy loss for stator blading with same trailing-edge thickness but different trailing-edge geometries.

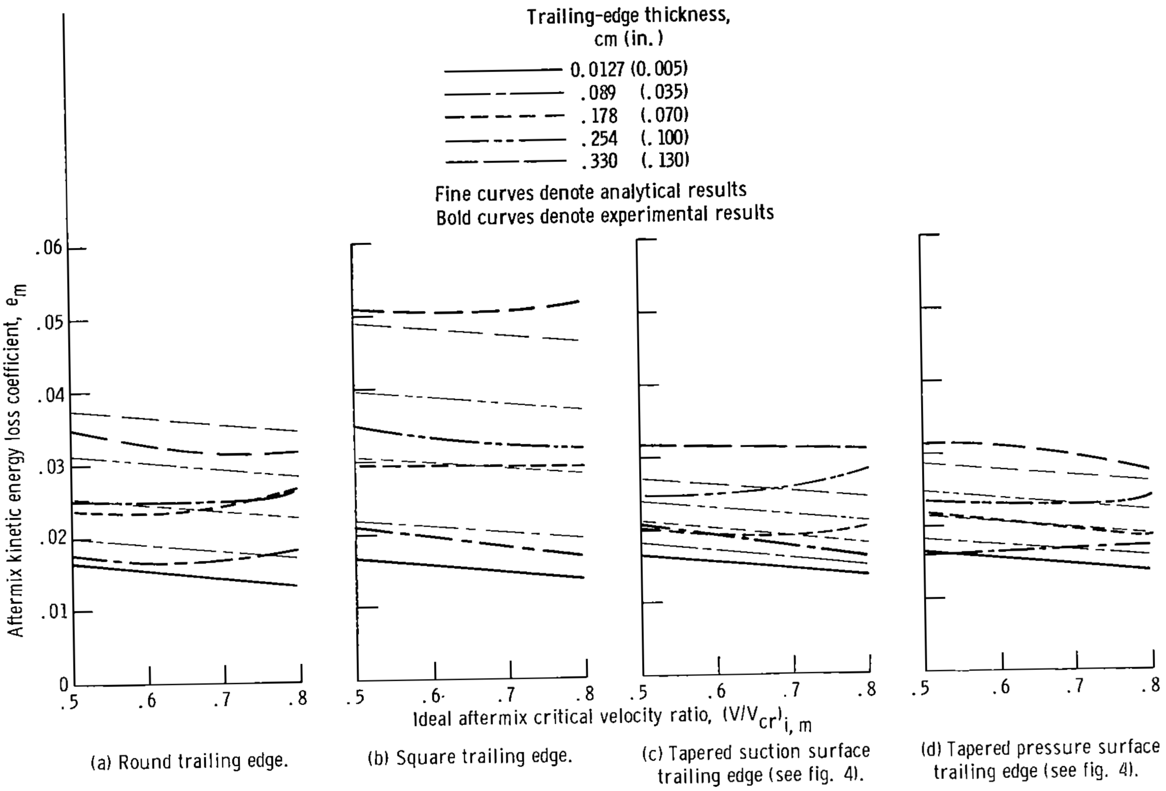


Figure 10. - Comparison of analytical and experimental results.