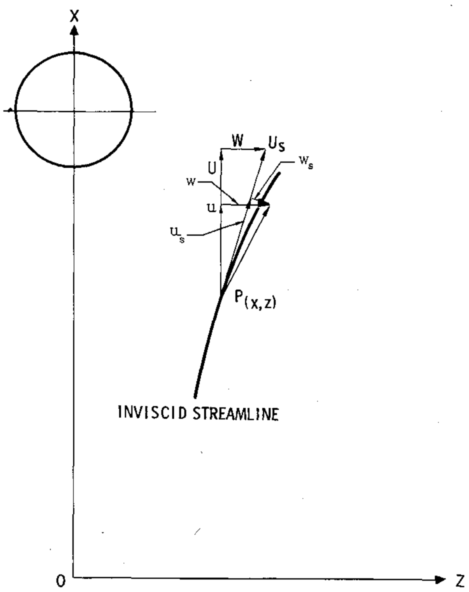

Fig. 1 Velocity components of inviscid and viscous flows at point P.

Consequently, its approximation as given in Ref. 2 will be more effective for computation using the streamline coordinate system. This conclusion is further strengthened by the results of Ref. 1. It can be seen that the inviscid velocity component w increases with increasing ζ according to the solution for potential flow. This leads directly to an increase in the viscous velocity component w; which in turn causes the approximation to deteriorate, as shown in the numerical results. On the other hand, use of the streamline coordinate will limit this increase in the value of w, and thereby retain the effectiveness of approximation.

One of the reasons that motivated the present author to select the streamline coordinate system was its better representation of the physical behavior of boundary-layer flow. The comparative study of both exact and approximate methods in Ref. 1 has independently confirmed its effectiveness and applicability.

References

[1] Fillo, J. A. and Burbank, R., "Calculation of Three-Dimensional Laminar Boundary-Layer Flows," *AIAA Journal*, Vol. 10, No. 3, March 1972, pp. 353–355.

[2] Wang, K. K., "An Effective Approximation for Computing the Three-Dimensional Laminar Boundary-Layer Flows," *AIAA Journal*, Vol. 9, No. 8, Aug. 1971, pp. 1649–1651.

Reply by Authors to K. K. Wang

J. A. Fillo* and R. Burbank†

University of Massachusetts, Amherst, Mass.

In the preceding Comment on Ref. 1, Wang emphasizes the role of streamline coordinates in his approximating scheme. Whereas it is true that certain terms, in general, may be 'smaller' computed in a streamline coordinate system compared with Cartesian coordinates, there still remains the question of which terms are important in governing certain flow phenomena such as flow reversal. Near flow reversal inertial terms are important and, consequently, even in streamline coordinates the approximations of Ref. 2 may not be adequate. This observation is what is referred to in Ref. 1 when we said that "Wang's approximation may not be valid in some... particular region of a flowfield."

Aside from the question of streamline coordinates, the primary deficiency of the approximation in Ref. 1 was its failure to predict flow reversal at a particular distance from the line of symmetry. To see what effect alternative ways of approximating the z or ζ derivatives would have on flow reversal predictions, two additional approximations have been investigated for the problem in Ref. 1

$$u_z \sim U_z = U_\zeta, \qquad w_z \sim W_z = W_\zeta, \qquad g_\zeta = 0 \qquad \text{(A)}$$

The derivatives of velocity are approximated before the transformations

$$F_\zeta = 0, \qquad G_\zeta = 0, \qquad g_\zeta = 0 \qquad \text{local similarity in the } \zeta\text{-direction} \qquad \text{(B)}$$

Tables 1 and 2 are a comparison between approximations (A) and (B) of F_η and G_η at $\eta = 0$.

Again, for small z or ζ values, the approximate calculations predict flow reversal in the u component, the approximate methods predicting flow reversal further downstream from the leading edge than the full three-dimensional calculations. At larger ζ values the full three-dimensional calculations predict flow reversal whereas the approximate methods do not. The same

Table 1 Approximate three-dimensional boundary-layer calculations of $F_n(0)$

	$\zeta = 3.05$		$\zeta = 6.10$		$\zeta = 7.32$		$\zeta = 9.15$	
ξ-cm	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)
0	0.4696	0.4696	0.4696	0.4696	0.4696	0.4696	0.4696	0.4696
0.61	0.4677	0.4677	0.4677	0.4677	0.4678	0.4678	0.4679	0.4679
3.66	0.4631	0.4631	0.4637	0.4637	0.4640	0.4640	0.4646	0.4646
7.93	0.4508	0.4508	0.4529	0.4529	0.4541	0.4541	0.4560	0.4560
10.37	0.4408	0.4408	0.4444	0.4445	0.4464	0.4465	0.4497	0.4497
13.42	0.4231	0.4232	0.4301	0.4302	0.4337	0.4339	0.4398	0.4400
17.69	0.3819	0.3821	0.3990	0.3996	0.4077	0.4084	0.4215	0.4224
20.13	0.3429	0.3433	0.3725	0.3737	0.3869	0.3884	0.4092	0.4109
23.79	0.2398	0.2414	0.3132	0.3179	0.3457	0.3511	0.3920	0.3976
24.40	0.2132	0.2153	0.3002	0.3063	0.3377	0.3445	0.3902	0.3970
25.01	0.1818	0.1848	0.2801	0.2939	0.3295	0.3380	0.3889	0.3972
25.62	0.1442	0.1483	0.2707	0.2809	0.3211	0.3318	0.3885	0.3986
26.23	0.0964	0.1026	0.2541	0.2674	0.3127	0.3263	0.3891	0.4014
26.84			0.2360	0.2535	0.3045	0.3217	0.3910	0.4060
27.45			0.2163	0.2396	0.2967	0.3185	0.3946	0.4128
28.06			0.1948	0.2262	0.2895	0.3172	0.4003	0.4222
28.67			0.1712	0.2138	0.2834	0.3187	0.4086	0.4350
29.28			0.1447	0.2037	0.2789	0.3237	0.4200	0.4517
29.89			0.1142	0.1972	0.2767	0.3335	0.4351	0.4730
30.50			0.0757	0.1962	0.2776	0.3492	0.4549	0.4997
31.11				0.2029	0.2827	0.3724	0.4800	0.5328

Table 2 Approximate three-dimensional boundary-layer calculations of $G_n(0)$

	$\zeta = 3.05$		$\zeta = 6.10$		$\zeta = 7.32$		$\zeta = 9.15$	
ξ-cm	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)
0	0.4696	0.4696	0.4696	0.4696	0.4696	0.4696	0.4696	0.4696
0.61	0.5307	0.5308	0.5295	0.5297	0.5289	0.5290	0.5277	0.5278
3.66	0.8555	0.8566	0.8477	0.8487	0.8433	0.8442	0.8353	0.8361
7.93	1.351	1.354	1.330	1.333	1.318	1.321	1.297	1.299
10.37	1.664	1.669	1.632	1.636	1.614	1.618	1.582	1.585
13.42	2.094	2.101	2.044	2.049	2.015	2.020	1.965	1.969
17.69	2.798	2.807	2.703	2.711	2.650	2.657	2.559	2.564
20.13	3.278	3.286	3.139	3.146	3.064	3.070	2.935	2.939
23.79	4.172	4.164	3.909	3.906	3.774	3.772	3.552	3.551
24.40	4.351	4.337	4.055	4.048	3.904	3.900	3.660	3.658
25.01	4.543	4.520	4.207	4.195	4.039	4.031	3.770	3.766
25.62	4.750	4.715	4.366	4.348	4.178	4.166	3.881	3.874
26.23	4.973	4.922	4.532	4.507	4.321	4.304	3.993	3.983
26.84			4.706	4.672	4.468	4.445	4.105	4.092
27.45			4.890	4.843	4.620	4.588	4.217	4.200
28.06			5.084	5.021	4.776	4.735	4.329	4.306
28.67			5.290	5.205	4.936	4.882	4.438	4.411
29.28			5.509	5.396	5.100	5.031	4.545	4.511
29.89			5.744	5.593	5.267	5.179	4.648	4.608
30.50			5.992	5.793	5.435	5.326	4.746	4.698
31.11				5.994	5.605	5.467	4.836	4.780

Received July 14, 1972.

Index category: Boundary Layers and Convective Heat Transfer—Laminar.

* Associate Professor; now Department of Mechanical Engineering, University of Texas at El Paso, El Paso, Texas. Member AIAA.

† Graduate Research Assistant, Dept. of Mechanical and Aerospace Engineering. Associate Member AIAA.

behavior of the approximation in Ref. 1 is observed in the present results, namely $F_\eta(0)$ reaches a minimum and then increases with ξ. The minimum points shifts to smaller ξ values as ζ increases. The calculations of $G_\eta(0)$ by both approximate methods, and for all ζ values, even in the region where the approximate methods fail to predict flow reversal, again show good agreement.

Of the three approximations, that of Ref. 1 is in better agreement with the full three-dimensional calculations. The boundary-layer calculations for the problem in Ref. 1 should now be carried out in transformed streamline coordinates in order to complete the discussions of Wang's approximation.

References

[1] Fillo, J. A. and Burbank, R., "Calculation of Three-Dimensional Laminar Boundary-Layer Flows," *AIAA Journal*, Vol. 10, No. 3, March 1972, pp. 353–355.

[2] Wang, K. K., "An Effective Approximation for Computing the Three-Dimensional Laminar Boundary-Layer Flows," *AIAA Journal*, Vol. 9, No. 8, Aug. 1971, pp. 1645–1651.

Comment on "Wind-Tunnel Interference Reduction by Streamwise Porosity Distribution"

M. Mokry*
National Research Council, Ottawa, Ontario, Canada

FROM the theoretical point of view, the walls of constant porosity do not behave necessarily as bas as the recent paper[1] suggests. The comparison with the "optimum" porosity (closed walls in the two-dimensional case) which produces the lift interference factor of small absolute value, but of a large gradient at the model position, seems to be irrelevant in the context.

Using the notation of Ref. 1, and assuming $R(x) = R = \text{constant}$, we find the following closed-form solution for the lift interference factor along the wind-tunnel axis[2] $\delta(x) = 1/2\pi x - \exp[x \tan^{-1}(R/\beta)]/4 \sinh(\pi x/2)$, $0 \leq R < \infty$. The singularity at $x = 0$ is removable;

$$\delta(0) = -\tan^{-1}(R/\beta)/2\pi$$

Letting

$$(d/dx)\delta(x)|_{x=0} = 0$$

we obtain

$$\beta/R = \cot[\pi(3)^{1/2}/6] \cong 0.782$$

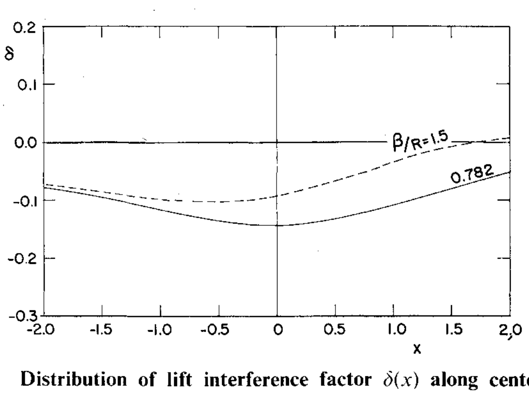

Fig. 1 Distribution of lift interference factor $\delta(x)$ along centerline.

Received June 7, 1972.
Index categories: Aircraft and Component Wind Tunnel Testing; Subsonic and Transonic Flow.

*Assistant Research Officer. Member AIAA.

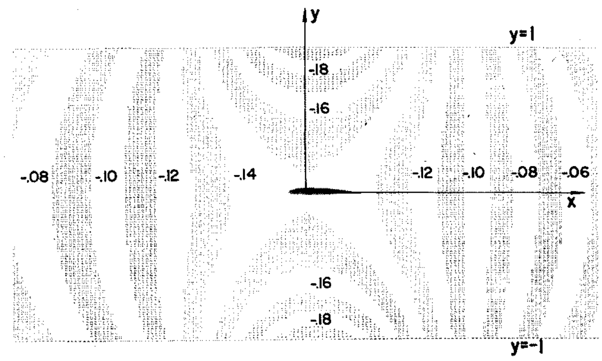

Fig. 2 Distribution of lift interference factor $\tilde{\delta}(x, y)$ for $\beta/R = 0.782$, coordinates $x = X/\beta h$, $y = Y/h$ in same scale.

For a given compressibility factor β, this gives the porosity parameter R about twice that selected in Ref. 1 ($\beta/R = 1.5$).

Figure 1 compares $\delta(x)$ for $\beta/R = 0.782$ and 1.5. The wall induced downwash corresponding to the average of δ over the model is certainly larger in the higher porosity case, but the variations in δ (streamline curvature) near $x = 0$ are roughly of the same magnitude as those obtained by the Gaussian distributions of lower porosity in Ref. 1.

For illustration, a two-dimensional distribution of the lift interference factor

$$\tilde{\delta}(x, y) = Re\{\delta(x + iy)\}$$

was printed in the form of fringes of equal $\tilde{\delta}$ in Fig. 2. In the considered case $\beta/R = 0.782$, a sufficiently small model is seen to lie in the neighborhood of the saddle point of the $\tilde{\delta}$ distribution, and hence in the region of nearly parallel flow. In general, this is a desirable test condition.

Nevertheless, the author Ref. 1 deserves credit for having been able to demonstrate that with the walls of variable porosity, a reasonably parallel flow at the model location can be achieved together with the reduction of the interference downwash.

References

[1] Lo, C. F., "Wind-Tunnel Wall Interference Reduction by Streamwise Porosity Distribution," *AIAA Journal*, Vol. 10, No. 4, April 1972, pp. 547–550.

[2] Mokry, M., "Higher-Order Theory of Two-Dimensional Subsonic Wall Interference in a Perforated Wall Wind Tunnel," LR-553, Oct. 1971, National Research Council of Canada, National Aeronautical Establishment, Ottawa, Ontario, Canada.

Reply by Author to M. Mokry

C. F. Lo*
ARO Inc., Arnold Air Force Station, Tenn.

THE evidence cited in Refs. 1, 5 and 6 of the Note[1] includes theoretical and experimental studies of three-dimensional tunnels in which it has been shown that it is difficult to eliminate pitching moment interference simultaneously with lift interference when using walls with uniformly distributed porosity. Some recent work in connection with the development of walls

Received August 7, 1972.
Index categories: Aircraft and Component Wind Tunnel Testing; Subsonic and Transonic Flow.

* Research Engineer, Propulsion Wind Tunnel Facility. Member AIAA.