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HEAT DISTRIBUTION ON 10 PERCENT
SCALE MODEL NIMBUS B SENSORY RING
AND SNAP 19 GENERATOR AT MACH 10

MND-3607-95

January 1967

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FOREWORD

This report is submitted by the Martin Company in compliance with the United States Atomic Energy Commission Contract AT(30-1)-3607. It constitutes an investigation of the aerodynamic heating rates to the surfaces of a model of the Nimbus B sensory ring and SNAP 19 generator in hypersonic flow. It represents Test Item 4(1)e of the SNAP 19 Experimental Safety Program.

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CONTENTS

	Page
Legal Notice	ii
Foreword	iii
Contents	v
Summary	vii
Symbols and Definitions	ix
I. Introduction	1
II. Facility Description	5
III. Model Description	7
IV. Test Procedures	9
A. General Procedures	9
B. Instrumentation and Data Taking	9
V. Accuracy of Data	61
VI. Data Presentation	63
A. Data Processing	63
VII. Discussion of Results	65
A. Sensory Ring	65
B. The Separator--Nimbus Sensory Ring	67
C. The Generator	68
D. Effect of Phase Change Coating	71
VIII. Conclusions and Recommendations	73
A. Conclusions	73
B. Recommendations	73
IX. References	75

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SUMMARY

The purpose of this test was to obtain aerodynamic heating rate profiles at $M = 10$, over the surfaces of a 10% scale model of the Nimbus B sensory ring and SNAP 19 generator at angles of attack from -90 to $+90$ degrees and at angles of roll of 0 , 45 , 90 and -45 degrees.

The test was conducted at the Ames 3.5-foot Hypersonic Wind Tunnel at Moffett Field, California from August 30 to September 9, 1966. The model was constructed of thin skin Inconel 600, had four sting mounting locations to minimize sting interference, and was instrumented with 107 thermocouples--87 in the sensory ring, 19 in the generator and 1 in the generator standoff support.

The nominal test conditions in the wind tunnel were:

$$M = 10.4$$

$$P_0 = 400 \text{ psia}$$

$$T_0 = 2100^\circ \text{ R}$$

$$R_N = 0.4 \times 10^5$$

$$R_\ell = 2.28 \times 10^5$$

The data accuracy is approximately $\pm 10\%$.

The data collected were reduced to a non-dimensionalized set of values which consisted of the ratio of the heat transfer rate at the model wall to a reference heat transfer rate at the wind tunnel conditions for each run.

From the results of the test, the following conclusions were made:

- (1) The sensory ring reduced the aerodynamic heating of the generator to as low as $1/10$ to $1/20$ the level at angles of attack near ± 90 degrees when the model was at angles of attack between -75 and $+75$ degrees (passing through zero) and at all angles of roll tested; that is, when the generator was in the wake of the sensory ring.
- (2) The portion of the sensory ring which received the most overall aerodynamic heating, when averaged over the angle of attack range tested, was the A frame and the area which contained the TV camera, the HDRSS electronics and the multiplexers.

- (3) The sensory ring received the greatest aerodynamic heating at angles of attack near zero degrees.
- (4) The generator received the highest aerodynamic heating at angles of attack near ± 90 degrees.
- (5) The overall heating rate to the outside of the separator was approximately twice the heating rate to the inside. However, when the holes of the separator were located so that maximum flow through them occurred, the inside of the separator received considerable aerodynamic heating.

SYMBOLS AND DEFINITIONS

<u>Symbol</u>	<u>Definition</u>	<u>Units</u>
α	Angle of attack (see Fig. 15)	degrees
ϕ	Angle of roll (see Fig. 15)	degrees
$\dot{q}$	Heat transfer rate, dq/dt	Btu/ft ² -sec
ρ	Density	slugs/ft ³ or lb/ft ³
τ	Skin thickness	ft or in.
C_p	Specific heat	Btu/lb-°F
T	Temperature	°R
M	Mach number	
P	Pressure	psia
R_N	Reynolds number per inch, $\rho V_\infty / \mu_\infty$	1/in.
R_ℓ	Reynolds number based on reference length, $\rho V_\infty \ell / \mu_\infty$	
μ_∞	Coefficient of viscosity, free stream	
ℓ	Reference length, 5.712 inches (diameter of sensory ring)	in.
r	Radius	ft
γ	Angle with respect to the generator body centerline	degrees
N	Number of cases for averaging	
V_∞	Velocity, free stream	fps
t	Time	sec

Subscripts:

0	Conditions in tunnel stagnation chamber
wall	Model wall

ref	Reference
ave	Average
body	Body of SNAP 19 generator
fins	Fins of SNAP 19 generator
SL	Sea level
HDRSS	High data rate transmission system
HRIR	High resolution infrared radiometer
IDCS	Image dissector camera system
MRIR	Medium resolution infrared radiometer
SIRS	Satellite infrared spectrometer

I. INTRODUCTION

The SNAP 19 radioisotope-fueled thermoelectric generator has been designed for use on the Nimbus B satellite. It is required to establish and confirm the safety of the system from fueling to possible re-entry of the fuel capsule from orbit into the Earth's atmosphere.

Calculations performed at Martin and Sandia indicate the potential existence of aerodynamic and aerothermodynamic conditions which would create hazardous conditions because of the resultant size of the fuel particles which may reach the lower atmosphere and the surface of the Earth. This potential hazard re-emphasized the need for an accurate description of the aerodynamic and aerothermodynamic properties of all systems and subsystems housing the fuel or attached to the SNAP 19 RTG at the time of re-entry.

The aerodynamic and burnup analyses of the SNAP 19 RTG, mounted in the Nimbus B satellite, involve configurations such as the sensory ring, generator and fuel capsules, which are difficult to analyze for aerodynamic characteristics and aeroheating distributions. The various theoretical methods available for use in analysis are basically applied to more conventional shapes. Extrapolation of these methods to the Nimbus B sensory ring and SNAP 19 RTG configurations does not give results which are accurate enough. Experimental data are necessary to supplement the theoretical methods.

The testing facilities available and the time and expenses involved do not make it practical to test at the different Mach numbers in the many possible re-entry flight trajectories. Mach 10 was selected as a representative hypersonic velocity and provides good test points for application to other parts of the re-entry trajectories.

Since, in the event of re-entry of the satellite, the SNAP 19 RTG will not be ejected as was intended earlier in the program, the entire spacecraft will begin the re-entry. It is probable that the struts connecting the upper portion of the spacecraft to the sensory ring will fail because of low thermal capacity and allow the sensory ring with the attached SNAP 19 RTG to continue the flight. It is this configuration which was tested.

Previous aerodynamic force tests, described in Refs. 1 and 2, showed that the sensory ring and SNAP 19 RTG combination could achieve steady flight with the generator trailing. This means that the generator could be shielded from direct aerodynamic heating effects by the sensory ring. It was the purpose of this test to measure the heat distribution on the sensory ring and generator at Mach 10 for flight attitudes that provide partial or complete shielding of the generator.

From August 30 to September 9, 1966, a 10% scale model of the Nimbus B sensory ring and SNAP 19 RTG was tested at Mach 10.4 in the NASA-Ames 3.5-foot Hypersonic Wind Tunnel.

The nominal test conditions in the wind tunnel were as follows:

$$M = 10.4$$

$$P_0 = 400 \text{ psia}$$

$$T_0 = 2100^\circ \text{ R}$$

Table 1 shows the run program as it was performed, and Table 3 shows the actual test conditions for each run.

TABLE 1

**Actual Run Program of 10% Scale Heat Transfer
Model of Nimbus B Sensory Ring and SNAP 19 Generator
in NASA-Ames 3.5-Foot Hypersonic Wind Tunnel**

Actual Run No.	Planned Run No.	Angle of Attack, α (deg)	Angle of Roll, ϕ (deg)	Remarks
1	1	0	0	Run had to be repeated because of wiring difficulties
2	1	0	0	
3	7	-15	0	
4	8	-15	45	
5	6	-15	-45	Model painted with 250 deg phase change paint
6	9	-15	90	
7	2	15	0	
8	2	15	0	
9	4	15	90	Repeat of runs
10	3	15	45	
11	5	-15	-45	
12	10	30	0	
13	11	30	45	With phase change paint Repeat of Run 5
14	12	30	90	
15	13	30	-45	
16	14	-30	0	
17	15	-30	45	MRIR came loose and peeled back Repeated planned Run 18 with MRIR secured in position
18	15	-30	45	
19	17	30	-45	
20	16	-30	90	
21	18	45	0	No oscillograph record on this run
22	18	45	0	
23	19	60	0	
24	20	45	45	
25	21	60	45	Thermocouple switching not carried out as planned Thermocouple switching not carried out as planned
26	22	45	90	
27	23	60	90	
28	25	60	-45	
29	24	45	-45	Changed sting mount from SIRS to side of ring
30	26	75	0	
31	27	90	0	
32	28	90	45	
33	29	75	45	Sting mount collapsed MRIR peeled back, repaired model Changed to different sting mount and reinforced model
34	30	75	90	
35	31	90	90	
36	32	90	-45	
37	33	75	-45	With phase change paint
38	34	-75	-45	
40	36	-45	-45	
41	37	-60	-45	
42	38	-60	0	Repeat of actual Run 47 with sting mount repaired and reinforced
43	39	-45	0	
44	40	-75	0	
45	41	-90	0	
46	42	-90	45	
47	43	-75	45	
48	49	-90	90	
49	48	-75	90	
50	48	-75	90	
51	51	-45	90	
52	46	-60	90	
53	43	-75	45	
54	44	-45	45	
55	45	-60	45	

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II. FACILITY DESCRIPTION

The NASA-Ames 3.5-foot Hypersonic Wind Tunnel is a blowdown type of facility. Figures 1 and 2 are photographs of models of it. Cylindrical vessels upstream of the heater are pressurized and very large spherical containers downstream of the test section are evacuated so that the necessary pressure ratio across the nozzle can be obtained and maintained long enough to establish stable hypersonic flow for model testing. Stagnation temperatures from 1160° to about 2300° R are achieved by passing the air through a pebble bed heater illustrated in Figs. 2 and 3. The heater contains about 150 tons of aluminum oxide spheres. A propane-fired furnace burner heats the spheres to stagnation temperature at the top, where the working gas exits from the pebble bed. A forced draft through the heater draws the hot gas down through the pebble bed until the desired temperature is reached, then the burner and the forced draft are shut off and the air from the high pressure tanks is allowed to pass through the heater to the nozzle where it goes supersonic and expands into the test section where hypersonic flow is established and, thence, into the huge vacuum tanks. The run is usually terminated before the pressure ratio across the nozzle becomes too small to maintain hypersonic flow in the test section. The maximum running time at Mach 10 is about two minutes. There are three nozzles shown in Figs. 1 and 2 which operate the tunnel at nominal Mach numbers 7, 10 and 14. The smallest parts of the nozzles (throats) are cooled by admitting helium through an annular slot into the boundary layer next to the wall just upstream of the nozzle throat. The helium inlet is shown in Fig. 3. About 95% of the helium used in each run is recovered and stored to be used again.

For this test the model was mounted on a sting which in turn was secured to a movable strut which lay horizontal and was retractable into a large sealed container from which it was inserted quickly into the test section, kept there for a prescribed time and quickly withdrawn again. Sliding doors in the test section walls opened to admit the model and closed again after the model was withdrawn. Figures 4, 5 and 6 show the test section and part of the quick insertion system.

Tunnel stagnation pressures range from 50 to 1800 psia, allowing a Reynolds No. range from 0.157×10^6 to 6.31×10^6 per foot.

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III. MODEL DESCRIPTION

A 10% scale model of the Nimbus B sensory ring and SNAP 19 generator was built for the wind tunnel test. The model was constructed of Inconel 600 which was selected because it is a high strength metal which has low conductivity and has thermal properties which are well known and consistent from batch to batch. Thin skins of approximately 0.010, 0.020 and 0.030 inch were used to further reduce heat conduction effects and yet meet the strength requirements at the anticipated airloads and temperatures. An effort was made to prevent large masses of metal from being too near the thermocouples and acting as heat sinks. Bolted and spot-welded points were used as much as possible because such joining provides poorer heat paths than seam welding or brazing. However, some seam welding and brazing were necessary for strength considerations even at the cost of providing a few undesirable heat paths and heat sinks.

Figures 7 to 11 are photographs of the model before and after assembly. Figures 317a to 317e are the engineering drawings of the model. Figure 7 shows two views of the model with details of the components on the bottom surface of the sensory ring and a view showing the generator. Figure 8 shows the model partially disassembled and includes the sting and sting adapters and other parts of the model. Figure 9 shows the model with a sting adapter mounted in the side of the model. Figure 10 shows the model with a sting adapter mounted in the SIRS. Figures 10 and 11 show the wire routing through the model. Figure 11 shows labeled parts of the model before it was assembled.

Thermocouples were installed in the model skin according to the method described in Ref. 3. In essence, this method provides that the thermocouple wires be strung through a two-holed ceramic bead, then twisted together and inserted through a hole in the model skin which is slightly larger than the combined diameters of the two wires. The ceramic bead is drawn tight against the inside of the model skin. Then the insulated pair of wires is secured to the inside of the skin by a strap of shim stock which is spot welded to the skin so that the wire pair can be pulled without loading the wire near the thermocouple junction. The model or model part was then put in an evacuated box and the thermocouple wires protruding through the sensing skin were melted down to the surface so that there was a small bead blended into the surface. This bead was filed off flush with the surface. All wire bundles were tied together at intervals and secured to the structure inside the model to eliminate long unsupported spans of wire which could vibrate harmoniously with the very high frequency-high energy oscillations encountered in the wind tunnel. The wires which passed from the components in the A frame to the sensory ring in regions where flow through would cause severe aerodynamic heating were either passed through stainless steel tubes or covered with Inconel shields.

Figure 12 shows the arrays of thermocouples on the sensory ring on the bottom surface and identifies the sections. The thermocouple locations on the generator are shown in Fig. 317d.

The model was sting mounted through the SIRS for the first 37 runs, then the top side of the SIRS was capped and the wires were divided into two bundles and routed through the sensory ring to one of four sting mounts through the outside wall of the sensory ring for roll angles of 0, 45, 90 and -45 degrees. Figures 8, 9 and 10 show the wire bundles routed both ways. This system of sting mounting made it possible to obtain all of the desired model attitudes with a minimum of sting interference, especially to the SNAP 19 generator. Figures 4, 5 and 7 to 10 show the sting mounted into the SIRS and into the side of the sensory ring. Three split sting adapters were used which had bend angles of 0, 40 and 70 degrees. This made it possible to obtain the angles of attack from -90 to +90 degrees in 15-degree increments with a wind tunnel strut angle of attack range of 20 degrees. The model attitude changes and all model repairs were made without pulling the thermocouple wires through the sting. This was made possible through the use of the split sting adapters.

IV. TEST PROCEDURE

A. GENERAL PROCEDURE

Preparation for each run consisted of setting the model at the prescribed angles of attack and roll and switching the thermocouples listed in Table 2 according to a pre-arranged plan shown in Table 4 of Ref. 4. Figure 316 defines the model attitudes.

At the same time the facility personnel prepared the wind tunnel for the next run.

Before each run a picture was taken of the model in the attitude and configuration in which it was to be run. Some of these photographs are shown in Fig. 5.

Just prior to each run a listing was made which monitored all of the thermocouples which were routed through the Beckman system. If a thermocouple was not reading for any reason such as open circuits at the junction, or open or reversed wires in the circuit, or because of a malfunction in the Beckman system, it showed up at this time. It usually could be corrected before the run was made.

Tunnel conditions were maintained as nearly the same as possible for each run. The tunnel stagnation pressure was about 400 psia and the stagnation temperature was about 2100° R. Table 3 shows these conditions for each run.

Flow was established in the tunnel while the model was stored in the quick insertion box. When the tunnel conditions were right, the model was injected into the test section for a period of three to five seconds. Data taking and motion picture filming proceeded as soon as the insertion mechanism was activated.

When the model was withdrawn, the tunnel was shut down so that there would be as little air in the vacuum tanks as possible, since evacuation of these tanks usually took the longest time of all the steps necessary to prepare for a run.

B. INSTRUMENTATION AND DATA TAKING

The model was instrumented with 107 chromel-alumel thermocouples which consisted of pairs of 30 gage wire, each 0.010 inch in diameter, welded together to form a thermocouple junction in the heat sensing surfaces of the model. These wires were connected to either a Beckman system computer or to an oscillograph. In general, the higher

TABLE 2
Tabulated Data

$\phi = 0^\circ$
 $\alpha = -90^\circ$
Run 45

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.466	0.103	28	9.9	2.19	55	0.015	0.003	82	3.81	0.842
2	0.337	0.075	29	3.38	0.748	56	0.534	0.118	83	0.378	0.084
3	1.318	0.292	30	6.18	1.367	57	0.391	0.087	84	0.453	0.100
4	1.405	0.311	31	7.95	1.76	58	0.175	0.039	85	0.857	0.190
5	0.149	0.032	32	7.53	1.66	59	-0.006	-0.001	86	5.04	1.115
6	--	0.910	33	10.21	2.259	60	0.110	0.0243	87	1.063	0.235
7	0.244	0.054	34	8.22	1.819	61	0.039	0.0086	88	1.462	0.323
8	0.355	0.079	35	3.87	0.856	62	-0.100	-0.022	89	1.116	0.247
9	2.097	0.464	36	3.78	0.836	63	-0.017	-0.0037	90	0.334	0.074
10	7.00	1.55	37	1.338	0.296	64	0.393	0.087	91	0.008	0.002
11	2.27	0.502	38	1.455	0.322	65	0.196	0.0434	92	--	0.127
12	2.72	0.602	39	2.55	0.564	66	0.197	0.043	93	--	0.454
13	3.45	0.763	40	3.52	0.779	67	0.114	0.025	94	--	0.129
14	2.33	0.515	41	3.14	0.695	68	0.572	0.127	95	--	0.042
15	2.15	0.476	42	--	0.114	69	0.501	0.111	96	--	1.324
16	1.66	0.367	43	--	0.086	70	0.606	0.134	97	--	2.20
17	--	0.199	44	--	0.097	71	1.654	0.366	98	--	0.581
18	--	0.111	45	--	0.057	72	5.75	1.05	99	--	0.681
19	--	0.085	46	1.092	0.242	73	1.303	0.290	100	--	0.302
20	--	0.135	47	1.324	0.293	74	0.812	0.180	101	--	3.85
21	1.45	0.321	48	1.614	0.357	75	1.204	0.266	102	--	4.19
22	0.960	0.212	49	0.994	0.220	76	0.902	0.200	103	--	0.599
23	1.187	0.262	50	0.463	0.102	77	0.961	0.213	104	7.02	1.553
24	3.61	0.799	51	0.383	0.085	78	0.955	0.211	105	0.273	0.060
25	2.42	0.535	52	0.946	0.209	79	0.449	0.099	106	--	0.836
26	1.685	0.373	53	0.291	0.065	80	0.664	0.147	107	--	0.441
27	12.40	2.75	54	-0.051	-0.011	81	1.134	0.251			

TABLE 2 (continued)

$\phi = 0^\circ$
 $\alpha = -75^\circ$
 Run 44

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.252	0.279	28	9.80	2.19	55	0.948	0.211	82	0.651	0.145
2	1.186	0.264	29	6.62	1.474	56	1.854	0.413	83	1.728	0.385
3	3.42	0.762	30	5.89	1.312	57	1.665	0.371	84	2.40	0.535
4	2.26	0.503	31	7.71	1.72	58	2.27	0.506	85	2.43	0.541
5	0.475	0.1057	32	7.83	1.74	59	4.28	0.953	86	8.13	1.811
6	--	0.046	33	9.10	2.027	60	0.032	0.0071	87	1.312	0.292
7	0.613	0.137	34	8.35	1.860	61	0.071	0.0158	88	0.088	0.020
8	0.978	0.218	35	4.36	0.971	62	0.306	0.068	89	0.126	0.028
9	2.12	0.472	36	4.23	0.942	63	0.889	-0.0008	90	-0.038	-0.008
10	4.76	1.060	37	1.36	0.303	64	0.099	0.022	91	0.071	0.016
11	2.56	0.570	38	2.91	0.648	65	0.246	0.055	92	--	0
12	3.16	0.704	39	5.08	1.131	66	0.477	0.106	93	--	0
13	2.82	0.629	40	4.34	0.967	67	1.461	0.325	94	--	0
14	2.11	0.470	41	2.85	0.635	68	1.41	0.314	95	--	0
15	2.02	0.450	42	--	0.115	69	1.16	0.258	96	--	0.276
16	1.78	0.397	43	--	0.108	70	1.50	0.334	97	--	0
17	--	0.261	44	--	0.097	71	3.67	0.817	98	--	0.135
18	--	0.140	45	--	0.087	72	14.0	3.12	99	--	0.129
19	--	0.142	46	1.092	0.242	73	1.328	0.296	100	--	0.827
20	--	0.245	47	1.324	0.293	74	0.634	0.141	101	--	0.299
21	2.44	0.544	48	1.614	0.357	75	1.712	0.381	102	--	0.736
22	1.551	0.347	49	0.994	0.220	76	1.412	0.314	103	--	0.259
23	1.301	0.290	50	0.463	0.102	77	1.234	0.275	104	1.616	0.360
24	1.147	0.256	51	0.754	0.168	78	0.810	0.180	105	0.117	0.026
25	3.62	0.806	52	0.335	0.075	79	6.67	1.485	106	--	0.138
26	5.51	1.23	53	1.039	0.231	80	2.58	0.575	107	--	0.121
27	13.6	3.04	54	1.121	0.250	81	7.76	1.728			

TABLE 2 (continued)

$\phi = 0^\circ$
 $\alpha = -60^\circ$
 Run 42

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.121	0.245	28	15.0	3.28	55	1.547	0.338	82	1.557	0.341
2	1.731	0.379	29	7.96	1.742	56	2.75	0.602	83	3.83	0.838
3	3.870	0.847	30	4.60	1.006	57	2.45	0.536	84	3.80	0.831
4	3.11	0.068	31	7.33	1.60	58	3.33	0.729	85	3.00	0.656
5	1.816	0.397	32	9.48	2.07	59	7.85	1.72	86	13.04	2.853
6	--	0.092	33	8.16	1.785	60	0.183	0.040	87	1.04	0.408
7	0.383	0.084	34	11.7	2.56	61	0.293	0.0641	88	1.867	0.014
8	0.532	0.116	35	6.88	1.505	62	0.629	0.137	89	0.064	0.018
9	3.84	0.840	36	6.11	1.337	63	1.817	0.402	90	0.080	0.004
10	4.03	0.882	37	4.27	0.934	64	0.392	0.086	91	0.019	0.026
11	2.53	0.554	38	3.80	0.831	65	0.596	0.130	92	0.117	0
12	3.64	0.796	39	4.31	0.943	66	1.238	0.270	93	--	0
13	4.13	0.903	40	5.37	1.175	67	3.065	0.670	94	--	0
14	3.34	0.731	41	3.00	0.656	68	1.43	0.313	95	--	0
15	4.81	1.051	42	--	0.0847	69	0.998	0.218	96	--	0.1354
16	3.80	0.847	43	--	0.0639	70	1.362	0.298	97	--	0.130
17	--	0.428	44	--	0.0322	71	3.95	0.864	98	--	0.088
18	--	0.165	45	--	0.0284	72	9.00	1.97	99	--	0.042
19	--	0.111	46	2.82	0.617	73	2.13	0.466	100	--	0.271
20	--	0.130	47	4.19	0.917	74	0.851	0.186	101	--	0.209
21	3.54	0.774	48	2.87	0.628	75	1.677	0.367	102	--	0.316
22	0.999	0.218	49	0.284	0.062	76	1.162	0.254	103	--	0.169
23	1.781	0.390	50	0.668	0.146	77	0.947	0.207	104	0.804	0.176
24	0.306	0.067	51	1.215	0.266	78	0.499	0.109	105	0.076	0.017
25	4.09	0.895	52	0.626	0.137	79	12.00	2.63	106	--	0.068
26	4.46	0.975	53	1.059	0.232	80	3.43	0.750	107	--	0.040
27	4.90	1.072	54	1.249	0.273	81	7.24	1.584			

TABLE 2 (continued)

$\phi = 0^\circ$
 $\alpha = -45^\circ$
 Run 43

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.794	0.400	28	11.7	2.61	55	2.81	0.626	82	3.19	0.710
2	1.461	0.325	29	5.72	1.274	56	3.93	0.875	83	7.50	1.670
3	6.33	1.410	30	8.75	1.949	57	3.26	0.726	84	5.99	1.334
4	2.88	0.641	31	5.54	1.23	58	4.29	0.955	85	11.90	2.65
5	0.626	0.139	32	7.95	1.77	59	10.08	2.245	86	13.38	2.980
6	--	0.138	33	6.16	1.372	60	0.700	0.156	87	2.52	0.561
7	0.701	0.156	34	3.45	0.768	61	0.695	0.155	88	0.182	0.041
8	1.230	0.274	35	2.04	0.454	62	0.596	0.133	89	0.005	0.001
9	6.25	1.392	36	1.783	0.397	63	2.975	0.660	90	-0.093	-0.021
10	4.66	1.038	37	0.941	0.210	64	0.855	0.190	91	0.048	0.011
11	3.41	0.759	38	6.28	1.399	65	1.034	0.230	92	--	0
12	4.68	1.042	39	5.07	1.129	66	2.182	0.486	93	--	0
13	4.19	0.934	40	6.07	1.351	67	5.778	1.29	94	--	0
14	3.41	0.760	41	4.42	0.984	68	2.88	0.641	95	--	0
15	2.12	0.472	42	--	0.173	69	2.45	0.546	96	--	0
16	2.93	0.640	43	--	0.130	70	3.15	0.706	97	--	0
17	--	0.202	44	--	0.065	71	7.08	1.577	98	--	0.045
18	--	0.194	45	--	0.087	72	6.82	1.52	99	--	0.043
19	--	0.142	46	2.64	0.588	73	3.08	0.685	100	--	0.046
20	--	0.030	47	5.21	1.160	74	2.04	0.454	101	--	0.043
21	3.33	0.742	48	5.90	1.314	75	1.884	0.420	102	--	0.092
22	1.12	0.250	49	0.543	0.121	76	1.066	0.237	103	--	0.086
23	3.30	0.735	50	1.212	0.270	77	0.647	0.144	104	0.182	0.041
24	1.01	0.227	51	1.707	0.380	78	0.463	0.103	105	0.081	0.018
25	9.60	2.14	52	2.08	0.463	79	15.9	3.54	106	--	0.028
26	4.47	0.995	53	4.72	1.051	80	5.04	1.122	107	--	0.081
27	12.2	2.72	54	3.42	0.762	81	17.6	3.92			

TABLE 2 (continued)

$\phi = 0^\circ$
 $\alpha = -30^\circ$

Run 16

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	4.08	0.893	28	19.96	4.367	55	6.74	1.475	82	12.58	2.753
2	5.91	1.116	29	13.06	2.858	56	8.09	1.770	83	18.50	4.048
3	10.19	2.230	30	11.81	2.584	57	7.04	1.540	84	12.97	2.838
4	8.64	1.891	31	12.08	2.64	58	8.99	1.967	85	25.5	5.579
5	2.43	0.532	32	15.00	3.28	59	20.7	4.529	86	34.9	7.636
6	--	0.406	33	9.03	1.976	60	2.38	0.521	87	6.05	1.324
7	1.710	0.347	34	7.42	1.623	61	1.624	0.356	88	0.200	0.044
8	1.690	0.370	35	5.55	1.214	62	2.13	0.466	89	0.077	0.017
9	7.97	1.744	36	5.37	1.175	63	5.51	1.21	90	0.108	0.024
10	0.003	0.001	37	3.91	0.856	64	3.52	0.770	91	0.072	0.016
11	-0.003	-0.001	38	8.96	1.961	65	3.42	0.749	92	--	0
12	11.16	2.442	39	11.97	2.619	66	4.62	1.01	93	--	0
13	11.34	2.48	40	13.61	2.978	67	9.691	2.12	94	--	0
14	6.20	1.36	41	14.52	3.177	68	8.24	1.803	95	--	0.041
15	5.67	1.24	42	--	1.128	69	6.40	1.400	96	--	0.136
16	6.12	1.34	43	--	0.658	70	7.82	1.711	97	--	0.044
17	--	1.52	44	--	0.926	71	20.3	4.442	98	--	0.022
18	--	0.80	45	--	1.136	72	15.45	3.36	99	--	0.338
19	--	0.70	46	8.16	1.785	73	9.11	1.99	100	--	0.226
20	--	0.80	47	8.13	1.779	74	6.05	1.32	101	--	0.168
21	6.36	1.39	48	10.99	2.405	75	6.17	1.35	102	--	0.271
22	5.14	1.13	49	1.353	0.296	76	5.76	1.26	103	--	0.382
23	3.85	0.821	50	2.78	0.608	77	4.71	1.031	104	1.183	0.259
24	1.112	0.245	51	4.95	1.083	78	4.09	0.895	105	0.268	0.059
25	9.44	2.065	52	8.17	1.788	79	30.9	6.76	106	--	0.216
26	6.84	1.50	53	8.20	1.794	80	12.84	2.809	107	--	0.317
27	19.94	4.363	54	5.87	1.284	81	33.6	7.352			

TABLE 2 (continued)

$\phi = 0^\circ$
 $\alpha = -15^\circ$
 Run 3

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	q_w	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	2.55	0.562	28	9.18	2.022	55	4.17	0.918	82	6.10	1.344
2	3.18	0.700	29	6.70	1.476	56	4.07	0.896	83	14.92	3.286
3	6.65	1.465	30	3.91	0.861	57	3.66	0.806	84	7.99	1.760
4	3.38	0.744	31	2.52	0.555	58	5.11	1.126	85	24.6	5.418
5	1.449	0.319	32	1.655	0.364	59	31.7	6.982	86	30.1	6.630
6	--	0.27	33	3.00	0.661	60	1.515	0.334	87	5.58	1.229
7	0.663	0.146	34	2.62	0.577	61	0.938	0.207	88	-0.070	-0.015
8	1.054	0.232	35	2.18	0.480	62	1.523	0.336	89	-0.042	-0.009
9	2.89	0.637	36	1.74	0.383	63	6.483	1.43	90	0.125	0.028
10	4.03	0.888	37	1.14	0.251	64	2.414	0.530	91	-0.057	-0.013
11	4.62	1.018	38	2.91	0.641	65	2.378	0.520	92	--	0
12	8.19	1.804	39	4.86	1.070	66	4.327	0.954	93	--	0
13	3.757	0.827	40	5.67	1.249	67	7.169	1.58	94	--	0.043
14	1.576	0.347	41	9.15	2.015	68	4.44	0.978	95	--	0.041
15	0.964	0.213	42	--	0.80	69	3.38	0.744	96	--	0.046
16	1.46	0.322	43	--	0.36	70	4.20	0.925	97	--	0.044
17	--	0.48	44	--	0.52	71	9.44	2.079	98	--	0.133
18	--	0.50	45	--	0.37	72	5.24	1.15	99	--	0.042
19	--	0.45	46	3.56	0.784	73	5.39	1.19	100	--	0.046
20	--	0.68	47	5.53	1.218	74	4.03	0.89	101	--	0
21	3.80	0.837	48	7.70	1.696	75	2.55	0.562	102	--	0.137
22	2.45	0.540	49	0.705	0.155	76	1.605	0.354	103	--	0.062
23	1.662	0.366	50	1.723	0.380	77	1.485	0.327	104	0.305	0.067
24	0.328	0.0724	51	3.22	0.709	78	1.816	0.400	105	0.137	0.030
25	13.8	3.040	52	5.98	1.317	79	17.18	3.784	106	--	0.019
26	6.83	1.51	53	5.32	1.172	80	9.03	1.989	107	--	0.052
27	9.68	2.132	54	4.18	0.921	81	19.48	4.291			

TABLE 2 (continued)

 $\phi = 0^\circ$ $\alpha = 0^\circ$

Run 2

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	6.33	1.455	28	24.3	5.59	55	15.9	3.66	82	21.97	5.050
2	12.23	2.811	29	23.4	5.38	56	11.38	2.616	83	27.52	6.326
3	17.40	4.00	30	9.57	2.20	57	8.81	2.025	84	20.1	4.621
4	14.40	3.31	31	12.56	2.89	58	11.17	2.568	85	31.6	7.264
5	4.27	0.982	32	6.41	1.44	59	44.6	10.27	86	46.4	10.666
6	--	0.849	33	9.05	2.08	60	--	2.30	87	12.96	2.979
7	2.45	0.563	34	7.95	1.828	61	--	0.910	88	1.423	0.327
8	2.48	0.570	35	7.62	1.752	62	--	1.60	89	0.537	0.123
9	24.60	5.66	36	6.58	1.513	63	--	2.92	90	0.313	0.072
10	17.90	4.11	37	4.67	1.074	64	--	2.09	91	0.367	0.084
11	26.4	6.07	38	21.8	5.01	65	--	1.86	92	0.324	0.0745
12	24.0	5.52	39	22.8	5.25	66	--	2.07	93	0.118	0.0270
13	9.542	2.192	40	46.4	6.07	67	--	5.10	94	--	0.1400
14	4.111	0.944	41	29.6	6.80	68	10.50	2.414	95	--	0.044
15	2.663	0.613	42	--	2.44	69	12.60	2.90	96	--	0.048
16	5.404	1.241	43	--	1.67	70	14.10	3.24	97	--	0.045
17	--	2.19	44	--	1.99	71	20.30	4.67	98	--	0.094
18	--	1.94	45	--	2.34	72	12.48	2.87	99	--	0.042
19	--	1.58	46	7.73	1.777	73	14.60	3.36	100	0.969	0.223
20	--	2.40	47	17.30	3.98	74	12.15	2.88	101	0.260	0.060
21	10.0	2.30	48	19.1	4.39	75	7.60	2.24	102	2.265	0.520
22	7.07	1.59	49	2.67	0.614	76	13.70	3.15	103	3.13	0.720
23	4.567	1.03	50	4.80	1.103	77	11.96	2.749	104	1.193	0.274
24	0.901	0.207	51	7.62	1.752	78	14.58	3.352	105	0.636	0.146
25	19.53	4.490	52	19.10	4.39	79	56.90	13.09	106	0.664	0.153
26	10.38	2.38	53	14.9	3.34	80	13.51	3.106	107	1.97	0.454
27	27.0	6.21	54	14.70	3.38	81	44.9	10.32			

TABLE 2 (continued)

$\phi = 0^\circ$
 $\alpha = 15^\circ$
 Run 7

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.928	0.403	28	6.87	1.437	55	4.73	0.990	82	4.47	0.935
2	4.13	0.864	29	6.89	1.441	56	5.47	1.144	83	10.47	2.190
3	5.71	1.195	30	3.11	0.651	57	3.53	0.738	84	8.92	1.866
4	4.34	0.908	31	3.35	0.701	58	3.66	0.766	85	21.92	4.586
5	0.283	0.059	32	1.60	0.335	59	5.69	1.190	86	26.04	5.448
6	0.240	0.050	33	2.68	0.561	60	--	0.444	87	7.73	1.617
7	0.118	0.025	34	2.04	0.427	61	--	0.132	88	3.01	0.630
8	0.811	0.170	35	1.836	0.384	62	--	0.142	89	0.623	0.130
9	3.26	0.682	36	1.999	0.418	63	--	0.187	90	0.283	0.059
10	4.40	0.920	37	1.273	0.266	64	--	0.558	91	0.146	0.031
11	4.54	0.950	38	5.49	1.149	65	--	0.469	92	0.566	0.119
12	9.27	1.939	39	7.45	1.559	66	--	0.396	93	0.016	0.0033
13	--	0.474	40	7.57	1.584	67	--	0.258	94	0.003	0.00063
14	--	0.133	41	9.90	2.071	68	4.49	0.939	95	0.148	0.031
15	--	0.086	42	4.434	0.926	69	3.20	0.669	96	--	0.040
16	--	0.306	43	2.193	0.458	70	3.40	0.711	97	--	0.087
17	2.92	0.611	44	2.914	0.610	71	4.67	0.977	98	--	0.080
18	1.72	0.360	45	2.610	0.546	72	3.54	0.74	99	--	0.043
19	2.50	0.524	46	2.25	0.471	73	4.19	0.876	100	--	0.040
20	2.71	0.568	47	5.36	1.121	74	7.21	1.51	101	--	0
21	--	1.243	48	7.64	1.598	75	3.14	0.657	102	--	0.116
22	--	0.795	49	0.797	0.167	76	3.03	0.634	103	0.519	0.109
23	--	0.469	50	1.974	0.413	77	3.58	0.749	104	0.270	0.056
24	--	0.135	51	4.19	0.877	78	6.68	1.397	105	0.481	0.101
25	10.08	2.109	52	3.54	0.741	79	13.75	2.877	106	0.188	0.0394
26	4.91	1.03	53	6.73	1.408	80	6.67	1.395	107	0.655	0.137
27	9.64	2.017	54	4.71	0.985	81	16.24	3.397			

TABLE 2 (continued)

 $\phi = 0^\circ$ $\alpha = 30^\circ$

Run 12

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.748	0.386	28	5.47	1.208	55	3.07	0.678	82	3.91	0.863
2	2.41	0.532	29	5.62	1.241	56	6.09	1.344	83	9.94	2.194
3	5.55	1.225	30	2.95	0.651	57	3.33	0.735	84	12.68	2.799
4	4.48	0.989	31	3.24	0.716	58	3.15	0.695	85	18.75	4.139
5	0.347	0.077	32	0.846	0.187	59	3.79	0.837	86	26.00	5.740
6	0.083	0.018	33	1.855	0.409	60	--	0.219	87	7.91	1.746
7	0.172	0.038	34	1.499	0.331	61	--	0.132	88	6.05	1.336
8	0.936	0.207	35	1.661	0.367	62	--	0.059	89	4.86	1.073
9	-0.004	-0.001	36	1.862	0.411	63	--	0.056	90	3.26	0.720
10	-0.006	-0.001	37	1.280	0.283	64	--	0.411	91	0.744	0.164
11	-0.008	-0.002	38	3.39	0.748	65	--	0.290	92	2.30	0.508
12	8.37	1.848	39	4.68	1.033	66	--	0.253	93	0.671	0.148
13	1.068	0.236	40	6.37	1.406	67	--	0.216	94	0.792	0.175
14	--	0.0910	41	9.49	2.095	68	4.74	1.046	95	0.148	0.031
15	--	0.047	42	--	0.305	69	2.98	0.658	96	--	0.040
16	1.021	0.226	43	--	0.281	70	2.75	0.607	97	--	0.087
17	0.702	0.155	44	--	0.594	71	3.61	0.797	98	--	0.080
18	0.669	0.148	45	--	0.882	72	2.25	0.496	99	--	0.043
19	1.231	0.272	46	2.46	0.543	73	3.34	0.739	100	--	0.040
20	3.164	0.700	47	4.71	1.040	74	8.32	1.84	101	--	0
21	3.964	0.876	48	6.35	1.402	75	2.44	0.539	102	--	0.086
22	2.43	0.538	49	0.691	0.153	76	2.27	0.501	103	--	0.085
23	1.475	0.326	50	1.737	0.383	77	2.20	0.486	104	0.171	0.038
24	0.269	0.060	51	4.01	0.885	78	3.16	0.698	105	0.917	0.202
25	6.30	1.391	52	1.703	0.376	79	14.86	3.280	106	0.288	0.064
26	2.85	0.630	53	6.16	1.360	80	6.65	1.468	107	--	0.160
27	7.02	1.550	54	4.18	0.923	81	16.49	3.640			

TABLE 2 (continued)

$\phi = 0^\circ$
 $\alpha = -45^\circ$
 Run 22

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.491	0.332	28	4.79	1.067	55	2.10	0.468	82	4.99	1.111
2	2.46	0.548	29	4.52	1.007	56	8.75	1.949	83	8.29	1.846
3	7.40	1.648	30	3.68	0.820	57	3.33	0.742	84	17.3	3.85
4	7.60	1.693	31	--	0.477	58	2.94	0.655	85	23.1	5.144
5	0.633	0.141	32	--	0.342	59	3.10	0.690	86	36.0	8.017
6	0.651	0.145	33	5.07	1.129	60	--	0.7078	87	10.06	2.240
7	0.262	0.058	34	1.566	0.349	61	--	0.1797	88	7.29	1.624
8	1.191	0.265	35	1.974	0.440	62	--	0.057	89	8.30	1.848
9	1.856	0.413	36	2.17	0.483	63	--	0.0612	90	9.80	2.183
10	1.881	0.419	37	1.604	0.357	64	--	0.2312	91	1.343	0.299
11	2.23	0.497	38	3.78	0.841	65	--	0.149	92	4.16	0.926
12	8.55	1.904	39	5.29	1.178	66	--	0.1755	93	1.61	0.358
13	--	0.2294	40	5.11	1.138	67	--	0.1158	94	1.37	0.305
14	--	0.0944	41	4.66	1.038	68	5.18	1.154	95	0.895	0.199
15	--	0.0454	42	0.636	0.142	69	2.44	0.543	96	0.164	0.0365
16	--	0.089	43	0.368	0.082	70	1.942	0.432	97	0.077	0.0171
17	--	0.164	44	1.163	0.259	71	2.50	0.557	98	0.245	0.0546
18	--	0.110	45	1.721	0.384	72	0.864	0.192	99	0.191	0.0425
19	--	0.151	46	1.99	0.443	73	2.10	0.468	100	0.013	0.0029
20	--	0.391	47	3.77	0.840	74	8.71	1.94	101	0.022	0.0049
21	--	0.435	48	3.85	0.857	75	2.10	0.468	102	0.125	0.028
22	--	0.2033	49	0.757	0.169	76	1.817	0.405	103	0.124	0.028
23	--	0.1452	50	1.728	0.385	77	1.428	0.318	104	0.214	0.048
24	--	0	51	0.367	0.082	78	1.479	0.329	105	1.912	0.426
25	5.70	1.269	52	1.270	0.283	79	28.85	6.425	106	0.348	0.077
26	1.908	0.425	53	5.86	1.305	80	7.34	1.635	107	--	0.088
27	5.55	1.236	54	3.15	0.702	81	21.63	4.817			

TABLE 2 (continued)

$\phi = 0^\circ$

$\alpha = 60^\circ$

Run 23

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.467	0.308	28	3.67	0.771	55	1.98	0.416	82	2.33	0.489
2	3.98	0.836	29	2.85	0.599	56	8.34	1.752	83	5.29	1.111
3	4.22	0.887	30	5.86	1.231	57	1.515	0.318	84	25.0	5.252
4	3.74	0.786	31	--	1.502	58	2.76	0.580	85	12.49	2.624
5	0.852	0.179	32	--	0.511	59	5.63	1.182	86	16.47	3.460
6	0.557	0.117	33	1.243	0.261	60	--	0.502	87	1.747	0.367
7	1.042	0.219	34	2.63	0.553	61	--	0.1729	88	12.76	2.681
8	0.912	0.192	35	3.40	0.714	62	--	0.081	89	5.82	1.223
9	1.021	0.214	36	3.19	0.670	63	--	0.087	90	8.27	1.737
10	1.934	0.406	37	2.20	0.462	64	--	0.082	91	4.62	0.971
11	2.11	0.443	38	1.961	0.412	65	--	0.029	92	5.93	1.25
12	6.34	1.332	39	2.62	0.550	66	--	0.028	93	2.69	0.565
13	--	0.0868	40	2.92	0.613	67	--	0.027	94	3.07	0.645
14	--	0.0891	41	3.43	0.721	68	4.90	1.029	95	3.804	0.800
15	--	0.1300	42	0.311	0.0654	69	2.16	0.454	96	0.270	0.0568
16	--	0.0876	43	0.392	0.0824	70	1.538	0.323	97	0.685	0.144
17	--	0.0256	44	0.675	0.142	71	1.696	0.356	98	0.527	0.111
18	--	0.1086	45	0.839	0.176	72	0.935	0.196	99	0.328	0.077
19	--	0.0815	46	2.37	0.498	73	2.66	0.560	100	-0.013	-0.0027
20	--	0.2773	47	3.19	0.670	74	15.20	3.20	101	0.185	0.039
21	--	0.2416	48	2.39	0.502	75	2.58	0.542	102	0.172	0.036
22	--	0.229	49	0.592	0.124	76	2.53	0.532	103	0.317	0.0666
23	--	0.137	50	0.782	0.164	77	1.678	0.353	104	0.243	0.051
24	--	0	51	0.984	0.207	78	1.182	0.248	105	2.23	0.468
25	4.67	0.981	52	1.018	0.214	79	14.78	3.105	106	0.498	0.105
26	1.384	0.292	53	6.76	1.420	80	10.09	2.120	107	--	0.038
27	4.89	1.027	54	2.09	0.439	81	13.71	2.880			

TABLE 2 (continued)

$\phi = 0^\circ$
 $\alpha = 75^\circ$
 Run 30

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	3.39	0.717	28	3.07	0.649	55	2.17	0.459	82	2.15	0.455
2	3.19	0.674	29	2.50	0.529	56	4.90	1.036	83	3.00	0.634
3	1.45	0.307	30	1.256	0.266	57	2.11	0.446	84	12.8	2.705
4	1.708	0.361	31	--	0.177	58	2.22	0.469	85	8.11	1.714
5	0.126	0.027	32	--	0.097	59	2.74	0.579	86	12.46	2.634
6	0.390	0.0864	33	0.711	0.150	60	--	0.409	87	2.21	0.467
7	0.449	0.095	34	0.383	0.081	61	--	0.0887	88	13.14	2.778
8	1.498	0.317	35	0.636	0.134	62	--	0.085	89	13.34	2.820
9	1.166	0.246	36	0.533	0.113	63	--	0.091	90	16.86	3.564
10	1.547	0.327	37	0.360	0.076	64	--	0.115	91	7.47	1.579
11	2.09	0.442	38	1.389	0.294	65	--	0.062	92	6.93	1.46
12	6.18	1.306	39	2.19	0.463	66	--	0.029	93	6.91	1.46
13	--	0	40	2.24	0.474	67	--	0.087	94	6.40	1.35
14	--	0	41	2.15	0.455	68	1.31	0.277	95	4.61	0.976
15	--	0.139	42	0.095	0.0201	69	0.670	0.142	96	1.74	0.370
16	--	0.093	43	0.188	0.0399	70	1.260	0.266	97	1.46	0.310
17	--	0.082	44	0.162	0.0242	71	2.43	0.514	98	0.509	0.108
18	--	0.199	45	0.252	0.0534	72	0.565	0.120	99	0.443	0.094
19	--	0.386	46	1.801	0.381	73	1.66	0.351	100	2.92	0.620
20	--	0.161	47	2.61	0.552	74	12.40	2.62	101	0.773	0.164
21	--	0.127	48	4.78	1.010	75	0.844	0.178	102	0.659	0.140
22	--	0.0406	49	0.304	0.064	76	0.657	0.139	103	0.452	0.096
23	--	0	50	0.424	0.090	77	0.446	0.094	104	0.539	0.114
24	--	0.1228	51	0.594	0.126	78	0.315	0.067	105	3.11	0.657
25	4.74	1.002	52	0.384	0.081	79	16.5	3.488	106	0.721	0.153
26	0.896	0.190	53	3.68	0.778	80	3.52	0.744	107	--	0.1206
27	3.93	0.831	54	2.78	0.588	81	5.80	1.226			

TABLE 2 (continued)

$\phi = 0^\circ$
 $\alpha = 90^\circ$
 Run 31

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.678	0.380	28	0.371	0.084	55	2.214	0.501	82	0.730	0.165
2	0.957	0.217	29	0.257	0.058	56	4.14	0.937	83	2.74	0.620
3	0.437	0.099	30	0.203	0.046	57	1.479	0.335	84	9.20	2.081
4	2.31	0.523	31	--	0.084	58	1.378	0.312	85	3.60	0.814
5	0.179	0.040	32	--	0.093	59	2.011	0.455	86	6.52	1.475
6	0.498	0.112	33	0.431	0.098	60	--	0.0801	87	0.906	0.205
7	0.482	0.109	34	0.043	0.010	61	--	0.0854	88	6.92	1.566
8	0.797	0.180	35	0.047	0.011	62	--	0.027	89	6.37	1.441
9	0.397	0.099	36	-0.019	-0.004	63	--	0.029	90	7.35	1.663
10	0.671	0.152	37	-0.042	-0.010	64	--	0.055	91	5.53	1.251
11	0.572	0.129	38	0.277	0.063	65	--	0.060	92	5.73	1.29
12	0.431	0.098	39	0.519	0.117	66	--	0.056	93	3.65	0.825
13	--	0	40	0.372	0.084	67	--	0.053	94	3.79	0.86
14	--	0	41	0.253	0.057	68	1.075	0.243	95	4.83	1.09
15	--	0	42	0.198	0.0448	69	0.417	0.094	96	0.058	0.131
16	--	0.309	43	0.169	0.0382	70	0.517	0.117	97	0.862	0.195
17	--	0.026	44	-0.042	-0.0095	71	1.384	0.313	98	0.516	0.117
18	--	0.027	45	-0.013	-0.0029	72	0.207	0.0488	99	0.294	0.0565
19	--	0.021	46	0.931	0.211	73	0.768	0.174	100	0.924	0.209
20	--	0.062	47	1.658	0.375	74	7.23	1.63	101	0.295	0.0668
21	--	0.040	48	3.03	0.686	75	0.141	0.032	102	0.499	0.103
22	--	0.0387	49	0.706	0.160	76	0.160	0.036	103	0.521	0.118
23	--	0.0345	50	0.284	0.064	77	0.130	0.029	104	0.226	0.051
24	--	0.0389	51	0.408	0.092	78	0.091	0.021	105	3.74	0.846
25	2.93	0.663	52	0.553	0.125	79	12.50	2.828	106	0.648	0.146
26	0.218	0.0493	53	2.275	0.515	80	1.735	0.393	107	--	0.077
27	0.702	0.159	54	0.479	0.108	81	3.61	0.817			

TABLE 2 (continued)

 $\phi = 45^\circ$ $\alpha = -90^\circ$

Run 46

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	2.318	0.495	28	2.761	0.590	55	0.173	0.037	82	0.712	0.152
2	3.178	0.679	29	3.606	0.783	56	0.317	0.068	83	0.891	0.190
3	2.352	0.502	30	3.687	0.788	57	0.255	0.054	84	1.212	0.259
4	2.433	0.520	31	3.178	0.691	58	0.147	0.031	85	0.678	0.145
5	2.784	0.595	32	3.872	0.842	59	0.181	0.039	86	1.563	0.334
6	--	0.528	33	2.771	0.592	60	2.608	0.567	87	0.438	0.094
7	2.130	0.455	34	1.983	0.424	61	0.317	0.069	88	1.796	0.384
8	1.814	0.388	35	3.419	0.731	62	0.297	0.065	89	4.825	1.031
9	1.660	0.355	36	2.191	0.468	63	0.329	0.072	90	1.938	0.414
10	0.974	0.208	37	1.257	0.269	64	2.836	0.617	91	0.233	0.050
11	1.251	0.267	38	0.940	0.201	65	1.801	0.392	92	--	1.226
12	2.215	0.473	39	1.196	0.256	66	1.133	0.246	93	--	2.739
13	8.629	1.876	40	1.697	0.363	67	0.637	0.138	94	--	0.372
14	6.751	1.468	41	2.235	0.478	68	1.319	0.282	95	--	0.282
15	5.036	1.095	42	--	0.274	69	1.311	0.280	96	--	0.466
16	3.333	0.725	43	--	0.208	70	0.808	0.173	97	--	7.874
17	--	0.083	44	--	0.312	71	0.866	0.185	98	--	3.669
18	--	0.054	45	--	0.276	72	2.197	0.478	99	--	1.810
19	--	0.081	46	-0.017	-0.004	73	1.608	0.350	100	--	2.688
20	--	0.157	47	0.460	0.098	74	0.648	0.141	101	--	6.449
21	1.789	0.389	48	1.209	0.258	75	3.154	0.674	102	--	9.530
22	1.702	0.370	49	2.162	0.462	76	1.339	0.286	103	--	0.8996
23	1.372	0.298	50	1.038	0.222	77	1.394	0.298	104	22.45	4.80
24	3.402	0.740	51	0.518	0.111	78	1.356	0.290	105	0.087	0.019
25	2.911	0.622	52	0.147	0.031	79	0.824	0.176	106	--	2.643
26	3.409	0.741	53	0	0	80	1.818	0.388	107	--	0.813
27	3.705	0.792	54	0.345	0.074	81	3.263	0.697			

TABLE 2 (continued)

$\phi = 45^\circ$
 $\alpha = -75^\circ$
 Run 53

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	4.020	0.865	28	6.20	1.35	55	1.740	0.374	82	1.118	0.240
2	4.447	0.956	29	3.527	0.758	56	1.753	0.377	83	0.927	0.199
3	4.538	0.976	30	0.922	0.198	57	1.739	0.374	84	1.531	0.329
4	2.248	0.483	31	3.986	0.867	58	2.331	0.501	85	1.544	0.332
5	2.042	0.439	32	2.523	0.548	59	6.25	1.36	86	7.521	1.617
6	--	0.403	33	3.871	0.832	60	0.161	0.0550	87	1.356	0.292
7	2.160	0.465	34	2.540	0.546	61	0.167	0.0563	88	0.156	0.034
8	2.724	0.586	35	4.0	0.87	62	0.548	0.119	89	0.298	0.064
9	2.028	0.436	36	1.271	0.273	63	1.429	0.311	90	0.603	0.130
10	1.641	0.353	37	0.474	0.102	64	-0.076	-0.017	91	-0.009	0.002
11	2.269	0.488	38	2.152	0.463	65	0.262	0.057	92	--	0.332
12	3.781	0.813	39	2.573	0.553	66	0.917	0.199	93	--	0.260
13	6.339	1.378	40	3.242	0.697	67	3.097	0.673	94	--	0.042
14	3.926	0.854	41	2.820	0.606	68	1.035	0.223	95	--	0.041
15	4.345	0.945	42	--	0.056	69	0.601	0.129	96	--	1.62
16	3.725	0.810	43	--	0.064	70	1.137	0.245	97	--	2.25
17	--	0.619	44	--	0	71	1.779	0.383	98	--	1.40
18	--	0.164	45	--	0	72	3.054	0.664	99	--	0.711
19	--	0.166	46	0.466	0.100	73	2.478	0.550	100	--	1.30
20	--	0.187	47	1.888	0.406	74	0.859	0.187	101	--	0.830
21	1.354	0.294	48	2.316	0.498	75	1.364	0.293	102	--	2.467
22	1.211	0.263	49	0.205	0.044	76	0.828	0.178	103	--	0.249
23	0.597	0.1293	50	0.815	0.175	77	1.042	0.224	104	5.303	1.140
24	0.784	0.170	51	0.962	0.207	78	0.659	0.142	105	0.044	0.009
25	4.357	0.937	52	0.610	0.131	79	5.823	1.252	106	--	0.499
26	4.295	0.934	53	-0.011	-0.002	80	4.197	0.903	107	--	0.158
27	4.357	0.937	54	1.650	0.355	81	8.051	1.731			

TABLE 2 (continued)

$\phi = 45^\circ$
 $\alpha = -60^\circ$
 Run 55

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	9.80	2.04	28	18.60	3.88	55	3.080	0.642	82	7.67	1.60
2	9.40	1.96	29	8.532	1.777	56	6.379	1.329	83	11.33	2.36
3	9.593	1.999	30	8.00	1.67	57	5.675	1.182	84	11.02	2.30
4	6.518	1.358	31	13.597	2.833	58	7.384	1.538	85	24.00	5.00
5	9.30	1.94	32	18.068	3.764	59	46.00	9.59	86	30.00	6.25
6	--	0.403	33	8.30	1.73	60	0.161	0.0550	87	4.40	0.92
7	6.60	1.38	34	7.186	1.497	61	0.167	0.0563	88	0.442	0.092
8	4.40	0.92	35	9.246	1.926	62	0.548	0.119	89	0.220	0.046
9	8.50	1.77	36	8.219	1.712	63	5.706	1.189	90	0.001	0
10	8.00	1.67	37	6.322	1.317	64	-2.530	-0.527	91	0.114	0.024
11	7.60	1.58	38	6.028	1.256	65	2.141	0.446	92	--	0.279
12	8.642	1.800	39	7.399	1.541	66	3.322	0.692	93	--	0.179
13	6.339	1.378	40	7.40	1.54	67	15.00	3.13	94	--	0.081
14	3.926	0.854	41	8.038	1.675	68	6.043	1.259	95	--	0.078
15	4.345	0.945	42	--	0.483	69	4.252	0.886	96	--	0.516
16	14.9	3.11	43	--	0.064	70	4.618	0.962	97	--	1.205
17	--	2.577	44	--	0	71	9.00	1.88	98	--	0.379
18	--	0.993	45	--	0	72	12.90	2.69	99	--	0.321
19	--	0.848	46	2.372	0.494	73	12.20	2.54	100	--	0.516
20	--	0.713	47	10.60	2.21	74	4.071	0.848	101	--	0.319
21	4.760	0.992	48	12.00	2.50	75	8.821	1.838	102	--	1.377
22	4.281	0.892	49	0.982	0.205	76	6.792	1.415	103	--	0.242
23	3.056	0.637	50	2.206	0.460	77	5.617	1.170	104	1.80	0.375
24	1.741	0.363	51	3.601	0.750	78	3.697	0.770	105	0.40	0.083
25	9.00	1.88	52	6.50	1.36	79	46.00	9.59	106	--	0.283
26	5.440	1.133	53	0.003	0.001	80	7.733	1.611	107	--	0.416
27	33.00	6.88	54	3.609	0.752	81	37.0	7.71			

TABLE 2 (continued)

$\alpha = 45^\circ$
 $\phi = -45^\circ$
 Run 54

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	31.668	7.181	28	7.906	1.793	55	1.685	0.382	82	5.488	1.244
2	5.241	1.188	29	4.207	0.954	56	5.230	1.186	83	7.228	1.639
3	5.250	1.190	30	2.734	0.620	57	4.883	1.107	84	6.595	1.495
4	3.396	0.770	31	5.746	1.302	58	5.872	1.331	85	10.90	2.48
5	3.892	0.883	32	2.853	0.647	59	25.0	5.67	86	14.00	3.18
6	--	0.654	33	4.270	0.968	60	1.877	0.426	87	3.464	0.785
7	2.800	0.635	34	1.473	0.334	61	1.139	0.258	88	0.155	0.035
8	2.773	0.629	35	1.906	0.432	62	1.444	0.327	89	0.043	0.010
9	4.446	1.008	36	2.017	0.457	63	4.742	1.075	90	0.561	0.127
10	4.192	0.951	37	1.273	0.289	64	-1.372	-0.311	91	0.057	0.013
11	3.601	0.817	38	3.522	0.799	65	1.388	0.315	92	--	0.044
12	4.339	0.984	39	4.120	0.934	66	2.828	0.641	93	--	0
13	12.516	2.838	40	5.291	1.200	67	11.70	2.66	94	--	0
14	5.989	1.358	41	6.206	1.407	68	4.422	1.003	95	--	0
15	5.802	1.316	42	--	0.146	69	2.508	0.569	96	--	0.047
16	2.956	0.670	43	--	0.110	70	2.674	0.606	97	--	0.045
17	--	0.467	44	--	0.066	71	6.074	1.377	98	--	0.046
18	--	0.312	45	--	0.059	72	4.202	0.953	99	--	0
19	--	0.115	46	1.234	0.280	73	5.068	1.149	100	--	0.047
20	--	0.277	47	6.023	1.366	74	2.865	0.650	101	--	0
21	3.121	0.708	48	7.205	1.634	75	2.577	0.584	102	--	0.094
22	1.710	0.388	49	0.348	0.079	76	2.109	0.478	103	--	0.088
23	1.215	0.276	50	1.081	0.245	77	1.706	0.387	104	0.121	0.027
24	0.567	0.129	51	1.898	0.430	78	1.330	0.301	105	0.178	0.040
25	8.00	1.81	52	5.842	1.325	79	18.80	4.26	106	--	0.028
26	2.831	0.642	53	0.005	0.001	80	5.634	1.278	107	--	0.040
27	20.9	4.74	54	2.580	0.585	81	21.8	4.94			

TABLE 2 (continued)

$\phi = 45^\circ$

$\alpha = -30^\circ$

Run 17

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	3.120	0.678	28	6.701	1.457	55	4.315	0.938	82	7.679	1.669
2	2.130	0.463	29	4.341	0.944	56	5.139	1.117	83	9.902	2.153
3	12.315	2.677	30	4.170	0.907	57	4.196	0.912	84	7.396	1.602
4	3.526	0.767	31	3.090	0.672	58	5.386	1.171	85	16.574	3.603
5	2.589	0.563	32	3.274	0.712	59	25.637	5.573	86	23.686	5.149
6	--	0.537	33	3.632	0.790	60	1.753	0.381	87	5.695	1.238
7	2.560	0.557	34	0.895	0.195	61	0.960	0.209	88	0.153	0.033
8	2.029	0.441	35	0.543	0.118	62	1.139	0.248	89	0.046	0.010
9	15.477	3.365	36	0.762	0.166	63	5.803	1.262	90	-0.130	-0.003
10	11.767	2.558	37	0.679	0.148	64	2.135	0.464	91	0.056	0.012
11	4.599	1.000	38	3.617	0.786	65	2.497	0.543	92	--	0.332
12	6.916	1.503	39	4.555	0.990	66	4.098	0.891	93	--	0.260
13	9.720	2.113	40	5.309	1.154	67	10.289	2.237	94	--	0.042
14	3.127	0.680	41	7.301	1.587	68	3.458	0.752	95	--	0.041
15	2.473	0.538	42	--	0.392	69	2.840	0.618	96	--	0.045
16	3.882	0.844	43	--	0.189	70	3.759	0.817	97	--	0.043
17	--	0.645	44	--	0.190	71	8.801	1.913	98	--	0.044
18	--	0.409	45	--	0.367	72	15.803	3.435	99	--	0.042
19	--	0.166	46	1.262	0.274	73	2.478	0.550	100	--	0.045
20	--	0.186	47	5.679	1.235	74	0.859	0.187	101	--	0.042
21	3.303	0.718	48	8.579	1.865	75	2.424	0.527	102	--	0.089
22	2.006	0.436	49	0.583	0.127	76	2.158	0.469	103	--	0.084
23	1.641	0.357	50	1.430	0.311	77	2.318	0.504	104	0.262	0.057
24	0.520	0.113	51	2.976	0.647	78	2.614	0.568	105	0.072	0.016
25	11.297	2.456	52	5.627	1.223	79	22.623	4.918	106	--	0.040
26	2.673	0.581	53	8.367	1.819	80	6.826	1.484	107	--	0.012
27	9.186	1.997	54	8.551	1.859	81	21.892	4.759			

TABLE 2 (continued)

$\phi = 45^\circ$
 $\alpha = -15^\circ$
 Run 4

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	4.239	0.900	28	12.081	2.565	55	9.946	2.112	82	3.804	0.808
2	1.938	0.411	29	11.580	1.459	56	4.202	0.892	83	7.436	1.579
3	7.665	1.627	30	2.557	0.543	57	3.801	0.807	84	5.023	1.066
4	4.640	0.985	31	0.726	0.154	58	4.945	1.050	85	24.309	5.161
5	2.471	0.525	32	1.485	0.315	59	25.851	5.488	86	27.635	5.867
6	--	0.263	33	1.458	0.310	60	1.382	0.293	87	6.777	1.439
7	0.483	0.103	34	1.572	0.334	61	0.805	0.171	88	0.128	0.027
8	0.482	0.102	35	1.101	0.234	62	1.841	0.391	89	0.070	0.015
9	18.232	3.871	36	0.782	0.166	63	5.880	1.248	90	-0.031	-0.007
10	17.509	3.717	37	0.535	0.114	64	1.615	0.343	91	0.103	0.022
11	10.299	2.187	38	4.491	0.953	65	2.467	0.524	92	--	0
12	12.731	2.703	39	6.148	1.305	66	4.356	0.925	93	--	0
13	3.557	0.755	40	7.155	1.519	67	5.840	1.240	94	--	0
14	1.038	0.220	41	9.420	2.000	68	9.190	1.951	95	--	0
15	0.357	0.076	42	--	0.604	69	9.850	2.091	96	--	0
16	1.239	0.263	43	--	0.289	70	9.826	2.086	97	--	0
17	--	0.050	44	--	0.248	71	7.129	1.514	98	--	0.086
18	--	0.545	45	--	0.447	72	5.273	1.120	99	--	0
19	--	0.379	46	1.316	0.279	73	6.418	1.363	100	--	0
20	--	0.390	47	5.488	1.165	74	2.519	0.535	101	--	0
21	4.990	1.059	48	6.775	1.438	75	2.452	0.521	102	--	0.131
22	2.140	0.454	49	0.605	0.128	76	2.525	0.536	103	--	0.165
23	1.697	0.360	50	1.856	0.394	77	3.013	0.640	104	0.384	0.082
24	0.181	0.038	51	3.891	0.826	78	1.789	0.380	105	0.134	0.028
25	13.437	2.853	52	6.448	1.369	79	18.949	4.023	106	--	0.065
26	2.142	0.455	53	6.880	1.461	80	6.446	1.368	107	--	0.115
27	15.518	3.294	54	7.673	1.629	81	16.319	3.465			

TABLE 2 (continued)

 $\phi = 45^\circ$ $\alpha = 15^\circ$

Run 10

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.624	0.358	28	7.471	1.649	55	3.522	0.777	82	4.008	0.885
2	2.239	0.494	29	5.671	1.252	56	6.736	1.487	83	12.064	2.663
3	4.976	1.098	30	2.952	0.431	57	4.996	1.102	84	7.652	1.689
4	4.517	0.997	31	2.542	0.561	58	5.346	1.180	85	22.480	4.962
5	0.481	0.106	32	1.582	0.349	59	8.254	1.822	86	26.372	5.822
6	--	0.263	33	3.211	0.709	60	--	0.413	87	7.698	1.699
7	0.329	0.073	34	2.728	0.602	61	--	0.204	88	2.002	0.442
8	0.511	0.113	35	2.466	0.544	62	--	0.240	89	0.496	0.109
9	0.019	0.004	36	1.639	0.362	63	--	0.691	90	0.283	0.062
10	0.029	0.006	37	1.090	0.241	64	--	0.571	91	0.105	0.023
11	0.016	0.004	38	5.630	1.243	65	--	0.457	92	0.200	0.044
12	9.348	2.064	39	7.577	1.673	66	--	0.409	93	--	0
13	3.557	0.755	40	7.518	1.660	67	--	0.522	94	--	0
14	1.038	0.220	41	9.426	2.081	68	3.977	0.878	95	--	0
15	0.357	0.076	42	--	0.969	69	2.858	0.631	96	--	0.045
16	1.239	0.263	43	--	0.544	70	3.361	0.741	97	--	0.043
17	2.699	0.596	44	--	0.525	71	5.277	1.165	98	--	0.046
18	1.766	0.390	45	--	0.280	72	3.919	0.865	99	--	0.042
19	2.558	0.565	46	1.242	0.274	73	4.634	1.023	100	--	0.046
20	2.942	0.649	47	5.516	1.218	74	6.975	1.540	101	--	0.043
21	2.582	0.570	48	7.784	1.718	75	2.829	0.625	102	--	0.127
22	2.302	0.508	49	0.776	0.171	76	3.197	0.706	103	--	0.162
23	1.951	0.431	50	1.857	0.410	77	4.092	0.903	104	0.295	0.065
24	0.294	0.065	51	4.855	1.072	78	4.815	1.063	105	0.565	0.125
25	10.003	2.208	52	1.926	0.425	79	18.781	4.146	106	0.191	0.042
26	2.706	0.597	53	4.816	1.063	80	6.491	1.433	107	0.653	0.144
27	11.726	2.589	54	3.730	0.823	81	16.021	3.537			

TABLE 2 (continued)

 $\phi = 45^\circ$ $\alpha = 30^\circ$

Run 13

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.968	0.210	28	6.644	1.444	55	2.903	0.631	82	4.990	1.085
2	3.466	0.753	29	6.523	1.418	56	5.579	1.213	83	9.529	2.072
3	4.933	1.072	30	3.619	0.787	57	4.623	1.005	84	9.754	2.120
4	5.516	1.199	31	3.516	0.764	58	6.859	1.491	85	21.319	4.635
5	0.298	0.065	32	1.480	0.322	59	5.547	1.206	86	27.324	5.940
6	0.224	0.049	33	3.714	0.807	60	--	0.149	87	7.170	1.559
7	0.105	0.023	34	2.677	0.582	61	--	0.194	88	6.695	1.455
8	0.353	0.077	35	2.599	0.565	62	--	0.136	89	3.135	0.682
9	-0.005	-0.001	36	1.998	0.434	63	--	0.089	90	1.559	0.339
10	-0.005	-0.001	37	1.284	0.279	64	--	0.382	91	0.361	0.078
11	0	0	38	4.446	0.967	65	--	0.029	92	-0.079	-0.017
12	11.147	2.423	39	6.526	1.419	66	--	0.227	93	-0.186	-0.040
13	--	0	40	6.051	1.315	67	--	0.334	94	-0.007	-0.002
14	--	0.184	41	9.614	2.090	68	4.046	0.880	95	0.017	0.004
15	--	0.135	42	2.325	0.505	69	3.213	0.698	96	0.170	0.037
16	--	0.318	43	1.386	0.301	70	3.957	0.860	97	0.046	0.010
17	1.165	0.253	44	2.059	0.448	71	5.552	1.207	98	0.116	0.025
18	1.121	0.244	45	--	0.297	72	2.929	0.637	99	0.044	0.010
19	1.930	0.420	46	13.010	2.828	73	3.515	0.764	100	--	0.083
20	4.704	1.023	47	5.819	1.265	74	8.832	1.920	101	--	0.045
21	--	0.625	48	7.481	1.626	75	3.190	0.693	102	--	0.084
22	--	0.460	49	0.748	0.163	76	3.279	0.713	103	--	0.083
23	--	0.435	50	1.735	0.377	77	5.175	1.125	104	0.187	0.041
24	--	0.093	51	2.687	0.584	78	4.138	0.900	105	1.644	0.357
25	10.015	2.177	52	0.953	0.207	79	30.104	6.544	106	0.161	0.035
26	--	0.550	53	5.620	1.222	80	8.416	1.830	107	--	0.118
27	10.084	2.192	54	3.121	0.678	81	15.966	3.471			

TABLE 2 (continued)

 $\phi = 45^\circ$ $\alpha = 45^\circ$

Run 24

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.987	0.208	28	5.407	1.141	55	2.893	0.610	82	2.586	0.546
2	3.021	0.637	29	5.519	1.164	56	7.198	1.519	83	7.830	1.652
3	7.393	1.559	30	2.540	0.536	57	3.635	0.767	84	8.438	1.780
4	6.733	1.420	31	2.775	0.585	58	3.094	0.653	85	20.295	4.282
5	0.314	0.066	32	0.674	0.142	59	3.023	0.638	86	22.469	4.740
6	0.013	0.003	33	2.373	0.501	60	--	0.133	87	6.839	1.443
7	0.091	0.019	34	1.521	0.321	61	--	0.140	88	17.305	3.651
8	0.345	0.073	35	1.647	0.347	62	--	0.105	89	9.336	1.970
9	3.272	0.690	36	1.287	0.272	63	--	0.064	90	4.585	0.967
10	3.965	0.836	37	0.911	0.192	64	--	0.230	91	1.031	0.218
11	3.856	0.814	38	2.863	0.604	65	--	0.164	92	0.825	0.174
12	6.289	1.327	39	4.101	0.865	66	--	0.147	93	0.381	0.080
13	--	0.350	40	4.592	0.969	67	--	0.166	94	-0.070	0.015
14	--	0.134	41	5.895	1.244	68	3.271	0.690	95	--	0.040
15	--	0.131	42	0.427	0.090	69	2.116	0.446	96	--	0.087
16	--	0.133	43	0.797	0.168	70	2.735	0.577	97	--	0.420
17	0.700	0.148	44	1.463	0.309	71	5.424	1.144	98	--	0
18	0.590	0.124	45	1.345	0.284	72	2.272	0.479	99	--	0.162
19	0.965	0.204	46	25.935	5.472	73	0.009	0.002	100	--	0.044
20	0.882	0.186	47	4.435	0.936	74	8.407	1.774	101	--	0.121
21	2.747	0.580	48	8.368	1.765	75	2.299	0.485	102	--	0.087
22	1.842	0.389	49	0.644	0.136	76	1.989	0.420	103	--	0.082
23	1.743	0.368	50	1.585	0.334	77	3.400	0.717	104	0.156	0.033
24	0.085	0.018	51	3.595	0.758	78	2.900	0.612	105	4.347	0.917
25	7.102	1.498	52	1.007	0.212	79	27.038	5.704	106	--	0.026
26	3.280	0.692	53	7.013	1.480	80	6.999	1.477	107	--	0.077
27	9.079	1.915	54	3.865	0.815	81	15.264	3.222			

TABLE 2 (continued)

 $\phi = 45^\circ$ $\alpha = 60^\circ$

Run 25

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.982	0.207	28	5.382	1.133	55	9.246	1.946	82	1.493	0.314
2	1.574	0.332	29	5.003	1.053	56	8.020	1.688	83	3.773	0.794
3	6.809	1.433	30	0.358	0.075	57	3.130	0.659	84	6.085	1.281
4	4.724	0.994	31	0.964	0.203	58	2.122	0.467	85	15.424	3.247
5	0	0	32	0.166	0.035	59	2.059	0.433	86	25.303	5.327
6	0.127	0.027	33	1.539	0.324	60	--	0.132	87	10.554	2.222
7	0.087	0.018	34	0.138	0.029	61	--	0.083	88	10.461	2.202
8	0.575	0.121	35	0.129	0.027	62	--	0.084	89	5.090	1.072
9	1.111	0.234	36	0.183	0.039	63	--	0.063	90	6.825	1.437
10	1.764	0.372	37	0.054	0.011	64	--	0.086	91	3.992	0.840
11	1.697	0.357	38	2.522	0.531	65	--	0.082	92	0.468	0.099
12	5.174	1.089	39	3.344	0.704	66	--	0.073	93	0.327	0.069
13	--	0	40	3.095	0.652	67	--	0.083	94	0.421	0.089
14	--	0	41	2.784	0.586	68	2.686	0.565	95	--	0.079
15	--	0	42	0.158	0.033	69	1.798	0.379	96	--	0.043
16	--	0.044	43	0.002	0	70	1.518	0.320	97	--	0.363
17	0.298	0.061	44	0.384	0.081	71	2.347	0.494	98	--	0.043
18	0.331	0.070	45	0.674	0.142	72	0.543	0.114	99	--	0.162
19	0.731	0.154	46	17.721	3.730	73	-0.007	-0.001	100	--	0.044
20	1.368	0.288	47	4.659	0.981	74	6.658	1.402	101	--	0.040
21	1.157	0.244	48	4.950	1.042	75	0.954	0.201	102	--	0.087
22	0.852	0.179	49	0.550	0.116	76	0.936	0.197	103	--	0.082
23	0.610	0.128	50	0.983	0.207	77	1.334	0.281	104	0.138	0.029
24	0.260	0.055	51	2.065	0.435	78	1.119	0.236	105	6.497	1.368
25	4.751	1.000	52	2.920	0.615	79	19.260	4.055	106	--	0.039
26	2.192	0.461	53	5.865	1.235	80	6.494	1.367	107	--	0.037
27	6.142	1.293	54	1.881	0.396	81	9.124	1.921			

TABLE 2 (continued)

$\phi = 45^\circ$

$\alpha = 75^\circ$

Run 33

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.402	0.082	28	1.284	0.261	55	3.571	0.726	82	1.230	0.250
2	0.985	0.200	29	0.742	0.151	56	4.446	0.904	83	1.766	0.359
3	1.780	0.362	30	-0.008	-0.002	57	2.813	0.572	84	3.650	0.742
4	3.346	0.680	31	0.283	0.058	58	5.60	1.14	85	8.967	1.823
5	-0.020	-0.004	32	0.056	0.011	59	2.852	0.580	86	19.33	3.929
6	0.184	0.037	33	0.936	0.188	60	--	0.076	87	5.707	1.160
7	0.146	0.030	34	0.075	0.015	61	--	0.027	88	20.275	4.121
8	0.230	0.047	35	0.018	0.004	62	--	0.020	89	20.743	4.216
9	1.231	0.250	36	-0.021	-0.004	63	--	0.061	90	11.260	2.289
10	1.770	0.360	37	0.071	0.014	64	--	0.055	91	6.589	1.339
11	1.467	0.298	38	1.122	0.228	65	--	0.053	92	0.965	0.196
12	2.769	0.563	39	1.868	0.380	66	--	0.047	93	1.418	0.288
13	--	0	40	1.817	0.369	67	--	0.107	94	2.162	0.439
14	--	0	41	0.932	0.189	68	1.782	0.362	95	--	0.228
15	--	0.042	42	0.128	0.026	69	1.540	0.313	96	--	0.796
16	--	0.043	43	0.130	0.026	70	1.746	0.355	97	--	0.243
17	0.107	0.022	44	0.164	0.033	71	2.917	0.593	98	--	0.166
18	0.147	0.030	45	0.199	0.040	72	0.092	0.019	99	--	0.118
19	0.261	0.053	46	9.000	1.829	73	1.167	0.237	100	--	0.461
20	0.332	0.067	47	2.109	0.429	74	6.734	1.368	101	--	0.196
21	0.062	0.013	48	5.555	1.129	75	0.577	0.117	102	--	0.168
22	0.198	0.040	49	1.303	0.265	76	0.297	0.060	103	--	0.158
23	0.294	0.060	50	0.998	0.203	77	0.248	0.050	104	0.337	0.068
24	0.154	0.031	51	1.988	0.404	78	0.241	0.049	105	6.812	1.385
25	4.40	0.894	52	1.681	0.342	79	16.88	3.43	106	--	0.038
26	0.373	0.076	53	5.457	1.109	80	3.258	0.662	107	--	0.221
27	2.643	0.537	54	2.631	0.535	81	4.180	0.850			

TABLE 2 (continued)

 $\phi = 45^\circ$ $\alpha = 90^\circ$

Run 32

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.193	0.044	28	0.246	0.056	55	2.103	0.476	82	2.328	0.527
2	0.629	0.142	29	0.178	0.040	56	1.752	0.396	83	1.473	0.333
3	0.575	0.130	30	0.188	0.043	57	0.688	0.156	84	0.732	0.166
4	2.021	0.457	31	0.107	0.024	58	3.80	0.86	85	2.425	0.549
5	0.191	0.043	32	0.148	0.033	59	2.213	0.501	86	6.436	1.456
6	0.073	0.017	33	0.038	0.009	60	--	0.113	87	0.998	0.226
7	0.141	0.032	34	0.045	0.010	61	--	0.030	88	6.902	1.562
8	0.111	0.025	35	0.020	0.005	62	--	0.022	89	7.528	1.703
9	0.510	0.115	36	0.032	0.007	63	--	0.034	90	7.202	1.629
10	0.485	0.110	37	0.132	0.030	64	--	0	91	15.913	3.600
11	0.288	0.065	38	0.891	0.202	65	--	0	92	0.772	0.175
12	0.344	0.078	39	0.692	0.157	66	--	0	93	0.254	0.057
13	--	0.047	40	0.761	0.172	67	--	0	94	0.191	0.043
14	--	0.048	41	0.773	0.175	68	0.311	0.070	95	--	0.212
15	--	0.047	42	3.379	0.764	69	0.526	0.119	96	--	0.140
16	--	0.048	43	0.710	0.161	70	1.68	0.38	97	--	0.360
17	-0.043	-0.010	44	0.081	0.018	71	1.202	0.272	98	--	0.091
18	-0.056	-0.013	45	0.221	0.050	72	0.318	0.072	99	--	0.087
19	-0.069	-0.016	46	9.30	2.10	73	0.563	0.127	100	--	0.280
20	0.093	0.021	47	0.810	0.183	74	2.957	0.669	101	--	0.173
21	0.668	0.151	48	1.484	0.336	75	0.353	0.080	102	--	0.466
22	0.177	0.040	49	0.473	0.107	76	0.428	0.097	103	--	0
23	0.078	0.018	50	0.361	0.082	77	0.460	0.104	104	0.471	0.107
24	0.247	0.056	51	0.589	0.133	78	0.339	0.077	105	3.850	0.871
25	0.78	0.18	52	0.756	0.171	79	7.90	1.79	106	--	0.084
26	0.149	0.034	53	3.288	0.744	80	1.174	0.266	107	--	0.205
27	0.117	0.026	54	1.053	0.238	81	0.649	0.147			

TABLE 2 (continued)

$\phi = 90^\circ$
 $\alpha = -90^\circ$
 Run 48

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	6.36	1.381	28	2.31	0.524	55	0.106	0.023	82	0.608	0.132
2	6.27	1.364	29	2.80	0.609	56	0.499	0.109	83	0.855	0.186
3	1.107	0.240	30	0.642	0.140	57	0.544	0.118	84	1.181	0.394
4	1.63	0.354	31	0.527	0.115	58	0.764	0.166	85	0.359	0.078
5	4.00	0.870	32	0.323	0.071	59	0.966	0.210	86	0.704	0.152
6	3.54	0.770	33	0.849	0.185	60	--	0.040	87	0.168	0.037
7	4.13	0.896	34	0.235	0.051	61	--	0.030	88	1.861	0.405
8	3.77	0.820	35	0.309	0.067	62	--	0.028	89	2.570	0.560
9	0.695	0.151	36	0.297	0.065	63	--	0.029	90	3.230	0.702
10	0.498	0.108	37	0.345	0.075	64	--	0.340	91	1.876	0.408
11	0.674	0.146	38	0.242	0.053	65	--	0.213	92	12.13	2.64
12	1.144	0.249	39	0.744	0.162	66	--	0.282	93	14.12	3.07
13	4.29	0.934	40	0.689	0.148	67	--	0.243	94	29.0	6.30
14	2.825	0.615	41	0.300	0.065	68	1.371	0.298	95	12.27	2.67
15	3.01	0.654	42	0.104	0.023	69	0.501	0.109	96	12.64	2.75
16	1.674	0.364	43	--	0.054	70	0.663	0.144	97	12.06	2.62
17	--	0.328	44	--	0.048	71	2.44	0.530	98	33.0	7.18
18	--	0.084	45	--	0.027	72	--	0.242	99	11.94	2.60
19	--	0.086	46	0.106	0.023	73	--	0.358	100	3.355	0.730
20	--	0.077	47	0.506	0.110	74	--	0.153	101	3.58	0.778
21	--	0.353	48	0.687	0.150	75	1.578	0.343	102	2.11	0.459
22	--	0.248	49	2.39	0.520	76	0.843	0.183	103	1.869	0.406
23	--	0.081	50	0.394	0.086	77	0.723	0.157	104	1.346	0.292
24	--	0.140	51	0.175	0.038	78	0.799	0.174	105	0.245	0.053
25	3.21	0.700	52	0.034	0.007	79	0.810	0.176	106	12.7	2.76
26	--	0.042	53	-0.005	-0.001	80	1.241	0.270	107	1.534	0.334
27	2.24	0.486	54	0.268	0.058	81	3.911	0.850			

TABLE 2 (continued)

$\phi = 90^\circ$
 $\alpha = -75^\circ$
 Run 49

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	6.02	1.32	28	3.63	0.796	55	0.346	0.076	82	0.902	0.198
2	8.99	1.97	29	3.77	0.826	56	2.51	0.550	83	5.02	1.10
3	2.01	0.441	30	0.700	0.154	57	1.96	0.430	84	3.86	0.846
4	2.01	0.441	31	0.615	0.135	58	2.15	0.471	85	2.02	0.444
5	3.33	0.731	32	1.576	0.346	59	3.42	0.750	86	2.43	0.534
6	3.34	0.734	33	1.827	0.400	60	--	0.136	87	1.47	0.322
7	4.12	0.905	34	0.237	0.052	61	--	0.120	88	1.095	0.240
8	4.22	0.928	35	0.435	0.096	62	--	0.145	89	0.643	0.141
9	1.408	0.308	36	0.563	0.124	63	--	0.322	90	0.471	0.103
10	1.365	0.299	37	0.427	0.094	64	--	0.114	91	0.455	0.100
11	1.343	0.295	38	0.572	0.126	65	--	0.092	92	16.05	3.53
12	1.446	0.317	39	0.865	0.190	66	--	0.085	93	6.77	1.49
13	3.61	0.792	40	0.995	0.218	67	--	0.245	94	5.93	1.30
14	2.80	0.614	41	1.284	0.282	68	2.08	0.456	95	5.20	1.14
15	3.23	0.709	42	0.186	0.041	69	2.06	0.452	96	17.12	3.74
16	2.40	0.526	43	--	0.054	70	2.82	0.619	97	5.56	1.22
17	--	0.192	44	--	0.073	71	1.669	0.366	98	6.32	1.38
18	--	0.028	45	--	0.110	72	--	0.688	99	3.90	0.852
19	--	0.055	46	0.216	0.047	73	--	0.240	100	2.61	0.570
20	--	0.195	47	1.99	0.437	74	--	0.423	101	0.904	0.198
21	--	0.277	48	2.55	0.564	75	0.998	0.219	102	0.405	0.088
22	--	0.250	49	0.134	0.029	76	0.660	0.145	103	0.443	0.097
23	--	0.188	50	0.186	0.041	77	0.796	0.175	104	0.854	0.187
24	--	0.141	51	0.418	0.092	78	1.244	0.274	105	0.161	0.035
25	4.86	1.07	52	0.780	0.171	79	3.30	0.724	106	6.98	1.53
26	--	0.086	53	0	0	80	2.40	0.526	107	0.634	0.139
27	3.99	0.875	54	0.278	0.061	81	5.34	1.17			

TABLE 2 (continued)

 $\phi = 90^\circ$ $\alpha = -60^\circ$

Run 52

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	4.72	1.03	28	5.28	1.15	55	0.917	0.201	82	3.26	0.714
2	5.78	1.26	29	6.29	1.38	56	4.73	1.032	83	10.66	2.33
3	3.89	0.85	30	23.60	5.16	57	3.93	0.860	84	8.34	1.83
4	4.25	0.93	31	1.697	0.370	58	4.43	0.969	85	10.4	2.28
5	7.54	1.65	32	2.22	0.485	59	13.4	2.94	86	15.70	3.44
6	4.53	0.99	33	2.00	0.437	60	--	0.189	87	4.76	1.04
7	7.55	1.65	34	1.457	0.318	61	--	0.239	88	0.525	0.115
8	4.37	0.96	35	2.10	0.460	62	--	0.346	89	0.251	0.055
9	2.64	0.58	36	2.37	0.519	63	--	0.847	90	0.076	0.017
10	4.85	1.06	37	1.65	0.360	64	--	0.171	91	0.046	0.010
11	7.43	1.62	38	2.21	0.484	65	--	0.123	92	7.70	1.68
12	6.73	1.47	39	3.22	0.704	66	--	0.142	93	7.86	1.72
13	5.96	1.30	40	3.90	0.854	67	--	0.367	94	2.10	0.46
14	3.77	0.825	41	5.03	1.10	68	5.15	1.03	95	0.75	0.164
15	4.97	1.09	42	0.915	0.200	69	2.62	0.574	96	8.03	1.75
16	3.23	0.71	43	--	0.135	70	2.30	0.504	97	2.50	0.55
17	--	0.44	44	--	0.242	71	2.98	0.652	98	0.917	0.20
18	--	0.197	45	--	0.329	72	--	0.780	99	0.400	0.087
19	--	0.137	46	0.470	0.103	73	--	0.319	100	0.617	0.135
20	--	0.278	47	5.43	1.19	74	--	0.920	101	0.290	0.063
21	--	0.59	48	5.62	1.23	75	3.37	0.738	102	0.166	0.036
22	--	0.33	49	0.329	0.072	76	1.98	0.434	103	0.185	0.040
23	--	0.34	50	0.805	0.176	77	1.818	0.398	104	0.289	0.063
24	--	0.14	51	1.782	0.390	78	4.14	0.905	105	0.111	0.024
25	4.62	1.01	52	2.72	0.595	79	13.8	3.02	106	1.51	0.330
26	--	0.10	53	0	0	80	5.33	1.17	107	0.426	0.093
27	5.07	1.11	54	1.076	0.235	81	9.87	2.16			

TABLE 2 (continued)

$\phi = 90^\circ$
 $\alpha = -45^\circ$
 Run 51

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	4.68	1.03	28	5.14	1.13	55	1.389	0.304	82	5.49	1.20
2	8.20	1.80	29	5.60	1.23	56	4.87	1.07	83	14.0	3.07
3	5.24	1.15	30	6.96	1.53	57	4.78	1.05	84	14.4	3.16
4	5.45	1.19	31	1.765	0.388	58	7.50	1.65	85	15.2	3.33
5	6.47	1.42	32	1.812	0.398	59	25.0	5.48	86	18.6	4.08
6	5.42	1.19	33	2.01	0.440	60	--	0.407	87	5.24	1.15
7	3.15	0.691	34	1.722	0.378	61	--	0.418	88	0.200	0.044
8	2.31	0.506	35	1.915	0.420	62	--	0.433	89	0.129	0.028
9	4.52	0.991	36	1.942	0.426	63	--	1.324	90	0.059	0.013
10	8.30	1.82	37	1.584	0.348	64	--	0.429	91	0.067	0.015
11	13.00	2.85	38	3.79	0.831	65	--	0.306	92	2.88	0.633
12	10.21	2.24	39	5.40	1.19	66	--	0.256	93	1.069	0.234
13	8.43	1.85	40	7.21	1.58	67	--	0.921	94	0.542	0.119
14	5.01	1.10	41	8.37	1.84	68	4.71	1.03	95	0.250	0.055
15	3.55	0.78	42	1.356	0.298	69	2.60	0.570	96	2.09	0.459
16	2.26	0.496	43	--	0.271	70	2.79	0.611	97	0.666	0.146
17	--	0.605	44	--	0.315	71	9.23	2.02	98	0.242	0.053
18	--	0.170	45	--	0.330	72	--	1.296	99	0.093	0.020
19	--	0.138	46	0.696	0.153	73	--	0.999	100	0.234	0.051
20	--	0.251	47	10.00	2.19	74	--	1.115	101	0.023	0.005
21	--	0.395	48	6.81	1.49	75	3.99	0.875	102	0.111	0.024
22	--	0.416	49	0.449	0.098	76	2.46	0.540	103	0.149	0.033
23	--	0.345	50	1.479	0.324	77	2.06	0.452	104	0.143	0.031
24	--	0.188	51	3.17	0.695	78	3.13	0.686	105	0.146	0.032
25	9.20	2.02	52	5.91	1.295	79	24.0	5.26	106	0.758	0.161
26	--	0.057	53	0	0	80	5.54	1.215	107	-0.136	-0.030
27	5.75	0.126	54	2.02	0.443	81	17.21	3.78			

TABLE 2 (continued)

$\phi = 90^\circ$
 $\alpha = -30^\circ$
 Run 20

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	9.40	2.13	28	5.89	1.33	55	1.858	0.420	82	8.32	1.88
2	6.70	1.52	29	6.58	1.49	56	4.59	1.04	83	13.12	2.97
3	5.64	1.28	30	1.648	0.372	57	3.79	0.856	84	9.19	2.08
4	4.90	1.11	31	2.16	0.490	58	5.08	1.15	85	21.4	4.84
5	6.14	1.39	32	1.206	0.273	59	16.50	3.74	86	21.9	4.96
6	3.05	0.690	33	1.873	0.424	60	--	0.364	87	7.13	1.61
7	1.822	0.412	34	0.621	0.140	61	--	0.216	88	0.256	0.058
8	3.43	0.775	35	0.545	0.123	62	--	0.327	89	0.108	0.024
9	4.26	0.964	36	0.443	0.100	63	--	1.028	90	0.078	0.018
10	5.88	1.33	37	0.566	0.128	64	--	0.384	91	0.102	0.023
11	4.93	1.11	38	4.18	0.945	65	--	0.570	92	0.956	0.217
12	10.27	2.32	39	5.92	1.34	66	--	0.411	93	0.391	0.089
13	6.94	1.57	40	6.46	1.46	67	--	0.357	94	0.275	0.062
14	2.73	0.617	41	8.18	1.85	68	7.60	1.72	95	0.113	0.026
15	1.838	0.415	42	2.68	0.607	69	8.89	2.01	96	0.201	0.046
16	1.742	0.394	43	--	0.364	70	7.50	1.70	97	0.382	0.089
17	--	0.766	44	--	0.525	71	5.30	1.20	98	0.282	0.064
18	--	0.466	45	--	0.709	72	--	1.507	99	0.146	0.033
19	--	0.226	46	0.929	0.210	73	--	1.486	100	0.237	0.054
20	--	0.316	47	11.2	2.54	74	--	0.873	101	0.096	0.022
21	--	0.489	48	8.17	1.85	75	2.05	0.464	102	0.333	0.076
22	--	0.300	49	0.602	0.136	76	2.56	0.579	103	0.337	0.076
23	--	0.226	50	1.800	0.407	77	3.60	0.815	104	0.236	0.053
24	--	0.146	51	3.56	0.805	78	2.94	0.665	105	0.234	0.053
25	9.80	2.22	52	5.44	1.23	79	22.6	5.11	106	0.345	0.078
26	--	0.647	53	3.97	0.898	80	5.25	1.19	107	0.102	0.023
27	8.50	1.92	54	2.83	0.640	81	13.53	3.06			

TABLE 2 (continued)

$\phi = 90^\circ$
 $\alpha = -15^\circ$
 Run 6

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.815	0.394	28	8.84	1.92	55	5.04	1.08	82	6.16	1.33
2	2.23	0.485	29	6.75	1.47	56	3.67	0.789	83	9.55	2.05
3	6.05	1.31	30	1.34	0.291	57	2.84	0.610	84	5.98	1.29
4	4.30	0.935	31	1.39	0.302	58	4.06	0.872	85	28.1	6.04
5	2.12	0.461	32	0.376	0.082	59	17.2	3.70	86	25.29	5.44
6	1.57	0.340	33	2.79	0.606	60	--	0.429	87	7.43	1.60
7	1.208	0.262	34	1.589	0.349	61	--	0.237	88	0.139	0.030
8	0.982	0.214	35	0.950	0.206	62	--	0.428	89	0.078	0.017
9	3.65	0.794	36	0.743	0.161	63	--	1.187	90	0.142	0.031
10	4.10	0.890	37	0.716	0.155	64	--	0.538	91	0.064	0.014
11	3.48	0.756	38	5.94	1.29	65	--	0.833	92	0.963	0.209
12	6.57	1.43	39	8.23	1.79	66	--	0.619	93	0.262	0.057
13	1.159	0.252	40	8.46	1.84	67	--	0.820	94	0.099	0.022
14	0.509	0.110	41	9.71	2.11	68	6.05	1.30	95	0.022	0.005
15	0.189	0.041	42	3.71	0.689	69	4.43	0.95	96	0.341	0.074
16	1.354	0.294	43	--	0.430	70	4.82	1.04	97	0.425	0.092
17	--	0.668	44	--	0.384	71	6.93	1.49	98	0.701	0.152
18	--	0.391	45	--	0.544	72	--	1.24	99	0.242	0.053
19	--	0.299	46	0.875	0.190	73	--	1.386	100	0.211	0.046
20	--	0.193	47	6.32	1.36	74	--	1.217	101	0.262	0.057
21	--	0.646	48	6.98	1.50	75	3.34	0.718	102	0.617	0.134
22	--	0.330	49	0.743	0.159	76	3.37	0.724	103	0.700	0.152
23	--	0.297	50	2.03	0.436	77	4.02	0.865	104	0.143	0.031
24	--	0.047	51	3.71	0.796	78	3.53	0.759	105	0.146	0.031
25	13.70	3.98	52	5.74	1.23	79	13.55	2.91	106	0.290	0.062
26	--	0.916	53	6.26	1.34	80	7.40	1.59	107	0.518	0.112
27	12.75	2.77	54	5.50	1.18	81	16.61	3.57			

TABLE 2 (continued)

 $\phi = 90^\circ$ $\alpha = 15^\circ$

Run 9

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.948	0.418	28	8.58	1.84	55	4.15	0.891	82	39.97	8.56
2	3.75	0.804	29	6.73	1.44	56	5.67	1.22	83	12.46	2.67
3	4.94	1.06	30	3.39	0.729	57	4.17	0.896	84	8.81	1.89
4	5.44	1.17	31	2.36	0.506	58	4.88	1.05	85	30.00	6.43
5	0.594	0.128	32	1.484	0.318	59	17.00	3.64	86	29.04	6.25
6	--	0.133	33	3.46	0.742	60	--	0.324	87	8.38	1.80
7	0.399	0.086	34	2.49	0.534	61	--	0.199	88	0.654	0.140
8	0.602	0.129	35	2.71	0.581	62	--	0.321	89	0.164	0.035
9	0	0	36	2.17	0.465	63	--	1.451	90	-0.069	-0.015
10	-0.004	-0.001	37	1.30	0.279	64	--	0.467	91	0.103	0.021
11	0	0	38	4.90	1.05	65	--	0.418	92	-0.008	-0.002
12	8.63	1.85	39	6.23	1.34	66	--	0.618	93	--	0
13	2.86	0.614	40	6.79	1.45	67	--	0.116	94	--	0
14	--	0.228	41	7.82	1.68	68	3.97	0.854	95	--	0
15	--	0.177	42	2.354	0.505	69	3.08	0.661	96	--	0.043
16	--	0.359	43	1.098	0.236	70	3.62	0.779	97	--	0.124
17	2.23	0.479	44	0.787	0.169	71	6.11	1.31	98	--	0.044
18	1.059	0.227	45	1.114	0.245	72	4.114	0.882	99	--	0.041
19	1.630	0.344	46	2.34	0.503	73	4.514	0.969	100	--	0.044
20	4.75	1.02	47	5.83	1.25	74	5.423	1.162	101	--	0.041
21	2.26	0.485	48	7.66	1.65	75	2.76	0.592	102	--	0.123
22	1.797	0.385	49	0.880	0.189	76	3.26	0.700	103	--	0.118
23	2.35	0.504	50	1.923	0.414	77	3.07	0.660	104	0.388	0.083
24	0.294	0.063	51	3.91	0.840	78	1.58	0.340	105	0.545	0.117
25	10.40	2.23	52	4.62	0.992	79	26.8	5.74	106	0.152	0.033
26	3.61	0.774	53	4.85	1.04	80	7.09	1.52	107	0.364	0.078
27	13.60	2.92	54	3.84	0.826	81	16.03	3.44			

TABLE 2 (continued)

 $\phi = 90^\circ$ $\alpha = 30^\circ$

Run 14

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.979	0.216	28	6.69	1.48	55	6.55	1.45	82	6.62	1.46
2	3.67	0.810	29	6.15	1.35	56	6.48	1.43	83	11.14	2.46
3	6.26	1.38	30	1.09	0.240	57	3.47	0.765	84	5.57	1.23
4	5.34	1.18	31	2.32	0.511	58	2.81	0.620	85	16.3	3.60
5	0.633	0.140	32	0.415	0.092	59	9.80	2.16	86	22.04	4.86
6	0.288	0.064	33	2.57	0.566	60	--	0.175	87	5.39	1.21
7	0.141	0.031	34	1.03	0.227	61	--	0.167	88	0.439	0.097
8	0.248	0.055	35	0.961	0.212	62	--	0.274	89	0.161	0.036
9	0.020	0.004	36	0.465	0.103	63	--	0.790	90	0.209	0.046
10	-0.007	-0.002	37	0.400	0.088	64	1.478	0.326	91	0.053	0.012
11	-0.003	-0.001	38	8.52	1.88	65	1.314	0.290	92	0.119	0.026
12	8.01	1.77	39	11.57	2.55	66	2.175	0.480	93	0.287	0.063
13	--	0.955	40	13.12	2.90	67	4.27	0.943	94	0.396	0.087
14	--	0.467	41	11.50	2.54	68	4.65	1.03	95	--	0
15	--	0.091	42	--	0.242	69	3.42	0.754	96	--	0.046
16	--	0.276	43	--	0.170	70	3.71	0.818	97	--	0.044
17	1.114	0.246	44	--	0.106	71	6.09	1.34	98	--	0.089
18	0.845	0.187	45	--	0.193	72	3.19	0.704	99	--	0.043
19	1.685	0.372	46	14.13	3.12	73	3.92	0.865	100	--	0.046
20	2.95	0.651	47	6.82	1.50	74	5.13	1.13	101	--	0.042
21	1.866	0.411	48	8.38	1.85	75	2.72	0.600	102	--	0.091
22	2.31	0.510	49	0.786	0.173	76	1.963	0.434	103	--	0.128
23	2.42	0.534	50	1.612	0.356	77	4.07	0.900	104	0.209	0.046
24	0.434	0.096	51	3.14	0.693	78	3.78	0.826	105	2.35	0.519
25	9.20	2.03	52	2.84	0.625	79	25.2	5.65	106	--	0.055
26	3.14	0.693	53	6.73	1.48	80	7.25	1.60	107	--	0.159
27	13.00	2.87	54	5.57	1.23	81	14.45	3.19			

TABLE 2 (continued)

$\phi = 90^\circ$

$\alpha = 45^\circ$

Run 26

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	2.61	0.590	28	9.96	2.25	55	12.10	2.74	82	14.23	3.20
2	8.34	1.88	29	11.47	2.59	56	9.00	2.04	83	15.88	3.57
3	13.10	2.96	30	2.93	0.663	57	7.34	1.66	84	10.77	3.42
4	14.62	3.30	31	9.53	2.16	58	7.04	1.59	85	21.07	4.74
5	1.675	0.378	32	2.29	0.519	59	15.52	3.52	86	31.8	7.15
6	1.063	0.240	33	6.21	1.40	60	--	--	87	10.84	2.44
7	0.819	0.185	34	3.02	0.682	61	--	--	88	5.16	1.16
8	0.820	0.185	35	2.18	0.484	62	--	--	89	2.06	0.463
9	5.36	1.21	36	1.395	0.316	63	--	--	90	1.611	0.362
10	7.97	1.80	37	1.445	0.327	64	3.23	0.730	91	1.086	0.244
11	9.60	2.17	38	11.16	2.52	65	3.14	0.710	92	1.45	0.328
12	14.54	3.29	39	14.82	3.36	66	3.49	0.790	93	0.718	0.163
13	--	--	40	16.52	3.74	67	6.88	1.56	94	0.178	0.040
14	--	--	41	14.83	3.35	68	7.82	1.77	95	--	--
15	--	--	42	--	--	69	6.10	1.38	96	--	--
16	--	--	43	--	--	70	6.75	1.53	97	--	--
17	4.65	1.05	44	--	--	71	13.45	3.04	98	--	--
18	1.747	0.395	45	--	--	72	6.61	1.50	99	--	--
19	2.021	0.457	46	16.99	3.84	73	8.66	1.96	100	--	--
20	2.32	0.525	47	10.67	2.41	74	9.62	2.18	101	--	--
21	4.52	1.021	48	13.46	3.04	75	8.49	1.92	102	--	--
22	4.93	1.11	49	3.30	0.746	76	5.27	1.19	103	--	--
23	4.30	0.972	50	3.87	0.875	77	8.73	1.87	104	1.382	0.311
24	0.519	0.107	51	7.10	1.61	78	10.50	2.36	105	7.44	1.67
25	14.6	3.30	52	5.93	1.34	79	35.6	8.00	106	--	--
26	5.01	1.13	53	12.25	2.77	80	12.99	2.92	107	--	--
27	14.19	3.21	54	9.93	2.24	81	25.0	5.61			

TABLE 2 (continued)

 $\phi = 90^\circ$ $\alpha = 60^\circ$

Run 27

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.441	0.094	28	4.09	0.870	55	7.35	1.56	82	1.496	0.318
2	2.67	0.568	29	4.49	0.955	56	2.25	0.479	83	3.12	0.664
3	6.05	1.29	30	0.292	0.062	57	0.242	0.052	84	1.639	0.349
4	6.92	1.47	31	3.800	0.810	58	0.411	0.087	85	5.35	1.14
5	0.274	0.058	32	0.287	0.061	59	1.268	0.270	86	8.12	1.73
6	0.088	0.019	33	1.972	0.421	60	--	0	87	3.19	0.680
7	0.096	0.020	34	0.171	0.036	61	--	0	88	1.769	0.376
8	0.092	0.020	35	0.122	0.026	62	--	0	89	0.512	0.108
9	1.92	0.409	36	0.084	0.018	63	--	0.124	90	0.199	0.042
10	3.47	0.739	37	0.218	0.047	64	0.294	0.063	91	0.477	0.102
11	4.10	0.874	38	4.37	0.930	65	0.316	0.067	92	0.215	0.046
12	4.93	1.05	39	4.17	0.889	66	0.412	0.088	93	-0.048	-0.010
13	--	0.526	40	4.67	0.994	67	0.797	0.170	94	-0.317	-0.068
14	--	0.181	41	3.96	0.844	68	2.42	0.515	95	--	0
15	--	0.044	42	--	0.104	69	2.50	0.532	96	--	0.263
16	--	0.135	43	--	0.082	70	3.45	0.734	97	--	0.042
17	1.016	0.216	44	--	0.041	71	4.05	0.862	98	--	0.043
18	0.308	0.066	45	--	0.063	72	3.18	0.878	99	--	0.041
19	0.286	0.061	46	8.06	1.72	73	3.11	0.664	100	--	0.352
20	0.453	0.096	47	2.45	0.521	74	3.76	0.801	101	--	0.082
21	1.193	0.254	48	5.88	1.25	75	1.568	0.334	102	--	0.088
22	1.092	0.233	49	0.798	0.170	76	1.486	0.316	103	--	0.124
23	1.297	0.276	50	1.045	0.222	77	3.29	0.700	104	0.828	0.176
24	0.119	0.025	51	2.15	0.457	78	2.42	0.515	105	4.23	0.900
25	10.00	2.13	52	2.06	0.439	79	11.7	2.49	106	--	0.040
26	1.759	0.375	53	4.83	1.03	80	4.73	1.01	107	--	0.116
27	5.07	1.08	54	3.15	0.670	81	8.40	1.79			

TABLE 2 (continued)

 $\phi = 90^\circ$ $\alpha = 75^\circ$

Run 34

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.203	0.046	28	2.51	0.571	55	2.12	0.482	82	1.326	0.302
2	0.694	0.158	29	3.18	0.724	56	3.00	0.681	83	1.113	0.254
3	2.11	0.480	30	-0.064	-0.015	57	1.925	0.438	84	0.556	0.126
4	3.08	0.700	31	0.231	0.052	58	0.344	0.078	85	3.70	0.841
5	0.172	0.039	32	0.371	0.084	59	0.070	0.016	86	6.69	1.52
6	0.188	0.042	33	0.951	0.216	60	--	0.028	87	2.68	0.610
7	0.205	0.047	34	0.100	0.023	61	--	0	88	1.983	0.450
8	0.103	0.024	35	0.037	0.008	62	--	0	89	0.848	0.193
9	0.575	0.131	36	-0.036	-0.008	63	--	0	90	0.697	0.159
10	0.714	0.162	37	0.042	0.010	64	--	0.031	91	0.971	0.221
11	0.699	0.152	38	2.44	0.555	65	--	0.030	92	1.102	0.249
12	1.623	0.369	39	2.03	0.461	66	--	0.026	93	1.039	0.234
13	--	0.047	40	1.47	0.334	67	--	0.060	94	2.55	0.562
14	--	0.048	41	1.35	0.307	68	1.321	0.300	95	--	0.081
15	--	0.047	42	0.183	0.041	69	1.075	0.344	96	--	0.671
16	--	0.048	43	0.455	0.103	70	1.317	0.299	97	--	0.648
17	0.115	0.026	44	0.486	0.109	71	1.534	0.349	98	--	0.219
18	0.145	0.033	45	0.475	0.107	72	2.19	0.494	99	--	0.125
19	0.161	0.026	46	7.77	1.74	73	1.731	0.391	100	--	0.984
20	0.132	0.030	47	0.879	0.200	74	2.00	0.251	101	--	0.174
21	0.568	0.128	48	3.09	0.703	75	1.233	0.280	102	--	0.141
22	1.381	0.312	49	1.507	0.342	76	0.877	0.299	103	--	0.220
23	0.794	0.179	50	1.255	0.375	77	1.446	0.329	104	0.829	0.188
24	0.223	0.050	51	0.687	0.156	78	0.895	0.204	105	7.54	1.71
25	5.60	1.27	52	0.746	0.170	79	4.57	1.04	106	--	0.014
26	0.307	0.231	53	2.65	0.604	80	1.567	0.356	107	--	0.124
27	2.36	0.536	54	1.951	0.444	81	0.558	0.127			

TABLE 2 (continued)

 $\phi = 90^\circ$ $\alpha = 90^\circ$

Run 35

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.046	0.010	28	2.03	0.440	55	2.34	0.507	82	3.72	0.807
2	0.042	0.009	29	2.21	0.480	56	0.723	0.157	83	0.488	0.104
3	0.254	0.055	30	0.274	0.059	57	0.849	0.184	84	0.140	0.030
4	0.366	0.079	31	0.093	0.020	58	0.615	0.133	85	2.23	0.484
5	0.007	0.002	3	0.037	0.008	59	0.156	0.034	86	3.03	0.656
6	0.124	0.027	33	0.737	0.160	60	--	0.190	87	1.212	0.263
7	0.103	0.022	34	0.182	0.039	61	--	0.028	88	2.03	0.440
8	0.091	0.020	35	0.113	0.025	62	--	0.022	89	4.61	1.00
9	0.233	0.051	36	0.005	0.001	63	--	0.032	90	4.03	0.874
10	0.365	0.079	37	0.121	0.026	64	--	0.041	91	1.535	0.333
11	0.268	0.058	38	0.840	0.182	65	--	0.040	92	2.22	0.490
12	0.272	0.059	39	2.16	0.468	66	--	0	93	6.49	1.43
13	--	0	40	2.24	0.485	67	--	0	94	2.55	0.562
14	--	0	41	1.01	0.219	68	0.659	0.143	95	--	0.081
15	--	0	42	1.337	0.290	69	0.305	0.066	96	--	0.671
16	--	0	43	0.634	0.138	70	0.264	0.057	97	--	0.648
17	0.060	0.013	44	0.255	0.055	71	0.503	0.109	98	--	0.219
18	0.035	0.008	45	0.204	0.045	72	0.437	0.096	99	--	0.125
19	0.074	0.016	46	8.20	1.78	73	1.013	0.223	100	--	0.984
20	-0.107	-0.024	47	1.102	0.239	74	0.389	0.084	101	--	0.540
21	1.973	0.435	48	1.199	0.260	75	1.585	0.344	102	--	0.492
22	1.394	0.307	49	3.62	0.785	76	1.258	0.272	103	--	0.919
23	0.848	0.187	50	3.11	0.674	77	1.233	0.268	104	23.7	5.14
24	0.718	0.156	51	1.18	0.256	78	1.482	0.322	105	15.1	3.27
25	1.885	0.409	52	0.893	0.194	79	2.02	0.438	106	--	0.148
26	1.219	0.264	53	1.505	0.326	80	0.251	0.054	107	--	0.546
27	1.941	0.421	54	1.451	0.315	81	1.373	0.298			

TABLE 2 (continued)

 $\phi = -45^\circ$ $\alpha = -90^\circ$

Run 39

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.052	0.0112	28	4.427	0.952	55	0.349	0.0751	82	1.674	0.361
2	0.259	0.0566	29	4.805	1.032	56	0.426	0.0916	83	0.248	0.0535
3	0.629	0.1353	30	2.796	0.600	57	0.107	0.023	84	0.262	0.0565
4	1.261	0.2714	31	6.614	1.422	58	0.113	0.0243	85	7.70	1.66
5	0.133	0.0286	32	6.368	1.369	59	0.072	0.0155	86	5.557	1.200
6	--	0	33	4.255	0.915	60	0.694	0.149	87	0.926	0.199
7	0.022	0.00473	34	4.298	0.924	61	0.248	0.053	88	1.995	0.429
8	0.020	0.0043	35	1.265	0.272	62	-0.039	-0.008	89	2.327	0.510
9	1.278	0.275	36	1.182	0.254	63	-0.056	-0.012	90	0.714	0.1535
10	0.795	0.171	37	0.695	0.1495	64	0.027	0.006	91	0.892	0.192
11	1.358	0.2921	38	1.444	0.311	65	0.002	0	92	--	0.494
12	1.687	0.363	39	0.626	0.1344	66	-0.180	-0.039	93	--	1.103
13	0.216	0.046	40	1.081	0.232	67	-0.038	-0.008	94	--	0.2501
14	0.377	0.081	41	1.862	0.400	68	0.295	0.0635	95	--	0.080
15	0.513	0.110	42	--	0.166	69	0.299	0.0644	96	--	0.443
16	0.786	0.169	43	--	0.083	70	0.370	0.0795	97	--	0.813
17	--	0.055	44	--	0.125	71	0.391	0.0840	98	--	0.304
18	--	0.162	45	--	0.139	72	2.000	0.430	99	--	0.165
19	--	0.082	46	9.90	2.13	73	0.592	0.127	100	--	2.531
20	--	0.158	47	1.793	0.386	74	-0.094	-0.020	101	--	4.402
21	2.441	0.525	48	1.159	0.249	75	3.369	0.725	102	--	0.769
22	2.053	0.441	49	2.766	0.595	76	1.801	0.388	103	--	1.118
23	1.575	0.339	50	2.335	0.502	77	1.565	0.336	104	14.00	3.01
24	1.957	0.421	51	1.086	0.234	78	2.914	0.626	105	6.315	1.36
25	2.777	0.596	52	0.550	0.1182	79	4.753	1.025	106	--	0.413
26	4.192	0.901	53	1.054	0.227	80	0.166	0.0357	107	--	0.117
27	2.251	0.484	54	0.805	0.1732	81	1.008	0.2158			

TABLE 2 (continued)

 $\phi = -45^\circ$ $\alpha = -75^\circ$

Run 38

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.230	0.0501	28	6.256	1.335	55	1.115	0.238	82	1.559	0.332
2	0.836	0.182	29	4.918	1.049	56	0.706	0.151	83	0.570	0.122
3	2.217	0.483	30	2.724	0.582	57	0.092	0.0196	84	0.333	0.071
4	3.990	0.871	31	6.487	1.383	58	0.183	0.039	85	21.2	4.53
5	0.170	0.0371	32	7.355	1.568	59	0.091	0.0194	86	16.937	3.62
6	--	0	33	5.491	1.23	60	0.279	0.059	87	2.237	0.477
7	0.033	0.00704	34	4.839	1.081	61	0.066	0.014	88	0.449	0.0957
8	0.072	0.01537	35	1.947	0.415	62	-0.074	-0.016	89	0.265	0.0565
9	1.825	0.389	36	1.595	0.340	63	-0.128	-0.027	90	0.656	0.1420
10	1.733	0.370	37	1.379	0.294	64	-0.007	-0.001	91	0.095	0.0203
11	1.660	0.354	38	2.417	0.515	65	0.173	0.037	92	--	0.082
12	2.646	0.565	39	1.567	0.334	66	0.284	0.061	93	--	0.073
13	0.156	0.033	40	2.343	0.500	67	1.032	0.220	94	--	0
14	0.346	0.074	41	4.338	0.925	68	1.495	0.319	95	--	0
15	0.880	0.188	42	--	0.274	69	1.368	0.292	96	--	0.044
16	1.133	0.242	43	--	0.206	70	1.610	0.344	97	--	0.170
17	--	0.082	44	--	0.248	71	1.918	0.410	98	--	0.043
18	--	0.267	45	--	0.249	72	3.832	0.817	99	--	0
19	--	0.081	46	8.839	1.881	73	2.369	0.505	100	--	1.273
20	--	0.182	47	2.778	0.583	74	-0.258	-0.055	101	--	0.611
21	1.954	0.417	48	3.365	0.717	75	2.066	0.441	102	--	0.439
22	1.955	0.417	49	0.318	0.0678	76	2.081	0.444	103	--	0.248
23	1.550	0.330	50	0.351	0.0749	77	2.170	0.463	104	3.535	0.755
24	0.884	0.188	51	0.521	0.1112	78	1.089	0.232	105	2.730	0.583
25	5.80	1.24	52	0.370	0.079	79	14.00	2.99	106	--	0.133
26	9.80	2.09	53	1.653	0.352	80	3.229	0.689	107	--	0.270
27	2.600	0.554	54	1.111	0.237	81	2.94	0.627			

TABLE 2 (continued)

 $\phi = -45^\circ$ $\alpha = -60^\circ$

Run 41

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.623	0.1555	28	6.356	1.589	55	2.22	0.554	82	2.650	0.661
2	1.341	0.292	29	3.741	0.935	56	1.563	0.390	83	3.20	0.798
3	3.074	0.670	30	2.010	0.503	57	0.905	0.2258	84	1.833	0.458
4	3.394	0.740	31	6.149	1.533	58	0.695	0.173	85	11.00	2.75
5	0.004	0.00087	32	11.165	2.784	59	1.285	0.320	86	17.60	4.39
6	--	0	33	6.647	1.651	60	0.106	0.026	87	2.637	0.656
7	0.121	0.0301	34	5.595	1.390	61	0.086	0.021	88	0.092	0.0229
8	0.360	0.0896	35	2.273	0.566	62	-0.095	-0.024	89	-0.032	-0.00799
9	1.241	0.3095	36	1.409	0.350	63	0.244	0.061	90	1.640	0.409
10	1.850	0.461	37	1.278	0.318	64	0.291	0.073	91	-0.037	0
11	1.587	0.396	38	3.157	0.786	65	0.311	0.078	92	--	0.048
12	1.974	0.4925	39	5.521	1.375	66	0.473	0.118	93	--	0
13	0.524	0.131	40	7.197	1.790	67	0.834	0.208	94	--	0
14	0.525	0.131	41	5.269	1.315	68	2.559	0.637	95	--	0
15	0.838	0.209	42	--	0.289	69	2.151	0.535	96	--	0.052
16	0.820	0.204	43	--	0.170	70	2.419	0.603	97	--	0.049
17	--	0.097	44	--	0.110	71	4.593	1.144	98	--	0.554
18	--	0.443	45	--	0.065	72	6.30	1.57	99	--	0.048
19	--	0.096	46	21.60	5.39	73	2.203	0.549	100	--	0.566
20	--	0.428	47	3.566	0.889	74	1.388	0.346	101	--	0.334
21	2.606	0.650	48	6.976	1.739	75	2.209	0.550	102	--	0.309
22	2.385	0.595	49	0.289	0.072	76	2.741	0.684	103	--	0.097
23	2.305	0.575	50	0.509	0.127	77	3.452	0.860	104	1.002	0.2495
24	0.618	0.154	51	0.858	0.2139	78	2.299	0.572	105	0.906	0.226
25	7.80	1.95	52	1.016	0.253	79	15.60	3.89	106	--	0.062
26	3.242	0.808	53	2.057	0.512	80	3.874	0.965	107	--	0.046
27	6.942	1.732	54	1.389	0.346	81	6.748	1.68			

TABLE 2 (continued)

 $\phi = -45^\circ$ $\alpha = -45^\circ$

Run 40

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	0.767	0.1705	28	11.253	2.49	55	3.668	0.785	82	3.352	0.745
2	1.404	0.312	29	5.844	1.292	56	3.450	0.765	83	4.755	1.057
3	5.565	1.237	30	3.036	0.6725	57	2.085	0.462	84	2.949	0.655
4	4.048	0.896	31	5.453	1.209	58	1.722	0.382	85	13.00	2.89
5	0.312	0.0693	32	4.902	1.087	59	4.100	0.908	86	22.9	5.08
6	--	0.046	33	5.787	1.28	60	0.187	0.041	87	2.949	0.653
7	0.164	0.0364	34	4.605	1.021	61	0.177	0.039	88	-0.080	-0.0177
8	0.426	0.0945	35	1.906	0.423	62	0.324	0.072	89	-0.038	-0.0084
9	2.664	0.591	36	1.803	0.400	63	1.251	0.277	90	2.210	0.490
10	4.165	0.925	37	1.997	0.443	64	0.820	0.182	91	-0.068	-0.0151
11	2.295	0.509	38	5.447	1.209	65	0.720	0.160	92	--	0
12	2.936	0.650	39	4.872	1.08	66	1.227	0.272	93	--	0
13	0.493	0.109	40	4.976	1.102	67	2.309	0.512	94	--	0
14	0.635	0.141	41	4.343	0.963	68	3.861	0.855	95	--	0
15	0.843	0.187	42	--	0.286	69	3.177	0.704	96	--	0.046
16	1.110	0.246	43	--	0.129	70	3.652	0.810	97	--	0.044
17	--	0.143	44	--	0.129	71	6.44	1.43	98	--	0.045
18	--	0.473	45	--	0.086	72	6.00	1.33	99	--	0.043
19	--	0.113	46	30.00	6.65	73	2.873	0.637	100	--	0.046
20	--	0.461	47	5.109	1.131	74	1.802	0.400	101	--	0
21	2.825	0.626	48	8.136	1.80	75	3.236	0.716	102	--	0.183
22	2.609	0.578	49	0.468	0.1039	76	3.592	0.795	103	--	0.043
23	2.193	0.486	50	1.056	0.234	77	3.960	0.876	104	0.168	0.0372
24	0.488	0.108	51	1.820	0.395	78	2.541	0.564	105	0.905	0.201
25	8.10	1.80	52	1.845	0.400	79	22.9	5.08	106	--	0.028
26	2.841	0.630	53	2.865	0.621	80	5.973	1.325	107	--	0.040
27	12.839	2.84	54	2.696	0.585	81	8.834	1.957			

TABLE 2 (continued)

 $\phi = -45^\circ$ $\alpha = -15^\circ$

Run 5

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	1.752	0.439	28	12.99	3.24	55	4.531	1.132	82	6.136	1.531
2	3.695	0.924	29	9.766	2.44	56	4.778	1.195	83	10.137	2.54
3	5.319	1.33	30	3.322	0.831	57	3.858	0.965	84	6.084	1.52
4	4.711	1.18	31	3.389	0.847	58	4.486	1.12	85	11.138	2.781
5	0.760	0.190	32	1.688	0.422	59	8.962	2.22	86	23.153	5.78
6	--	0.155	33	3.880	0.970	60	1.266	0.317	87	5.627	1.405
7	0.410	1.025	34	2.621	0.655	61	0.734	0.184	88	0.099	0.0248
8	0.716	0.179	35	2.410	0.601	62	1.159	0.290	89	-0.057	-0.01425
9	4.102	1.026	36	1.954	0.488	63	3.267	0.817	90	0.048	0.012
10	6.174	1.544	37	1.371	0.343	64	2.222	0.556	91	-0.052	-0.013
11	5.231	1.309	38	10.789	2.695	65	2.093	0.523	92	--	0
12	5.859	1.465	39	13.094	3.27	66	3.742	0.936	93	--	0
13	3.376	0.844	40	9.782	2.441	67	6.708	1.677	94	--	0
14	1.322	0.331	41	8.132	2.03	68	3.553	0.889	95	--	0
15	0.692	0.173	42	--	0.515	69	2.814	0.704	96	--	0.052
16	1.994	0.499	43	--	0.266	70	3.623	0.905	97	--	0.049
17	--	0.418	44	--	0.364	71	9.001	2.25	98	--	0.101
18	--	0.345	45	--	0.486	72	4.179	1.045	99	--	0.048
19	--	0.349	46	3.050	0.763	73	4.280	1.070	100	--	0.052
20	--	0.306	47	5.296	1.322	74	2.513	0.628	101	--	0
21	4.233	1.058	48	6.675	1.67	75	2.676	0.669	102	--	0.155
22	2.076	0.519	49	0.650	0.1625	76	2.318	0.579	103	--	0.194
23	1.707	0.427	50	1.552	0.388	77	2.376	0.594	104	0.316	0.079
24	0.364	0.091	51	2.931	0.734	78	1.558	0.389	105	0.115	0.0288
25	5.448	1.360	52	4.594	1.15	79	19.575	4.89	106	--	0.047
26	2.893	0.723	53	5.049	1.26	80	5.918	1.48	107	--	0.227
27	14.801	3.70	54	3.827	0.956	81	16.333	4.085			

TABLE 2 (continued)

 $\phi = -45^\circ$ $\alpha = 30^\circ$

Run 15

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	4.422	0.925	28	5.939	1.240	55	3.127	0.654	82	5.828	1.22
2	7.566	1.581	29	6.085	1.270	56	5.118	1.070	83	11.188	2.34
3	7.493	1.565	30	2.114	0.442	57	3.124	0.654	84	8.434	1.760
4	8.463	1.770	31	1.630	0.341	58	3.083	0.645	85	18.334	3.84
5	4.544	0.950	32	0.999	0.209	59	5.040	1.051	86	24.672	5.160
6	2.447	0.512	33	1.701	0.356	60	--	0.344	87	8.620	1.80
7	1.216	0.253	34	1.233	0.2581	61	--	0.165	88	5.993	1.251
8	1.480	0.3084	35	1.383	0.290	62	--	0.241	89	2.753	0.575
9	3.921	0.818	36	1.631	0.342	63	--	0.336	90	0.695	0.145
10	-0.018	0.00376	37	1.019	0.2101	64	--	0.556	91	0.256	0.535
11	0.001	0.000208	38	4.577	0.966	65	--	0.283	92	5.275	1.104
12	11.407	2.383	39	6.616	1.290	66	--	0.201	93	3.467	0.725
13	--	0.390	40	7.227	1.51	67	--	0.055	94	0.888	0.186
14	--	0.266	41	10.477	2.19	68	5.945	1.241	95	0.215	0.045
15	--	0.172	42	2.909	0.609	69	3.596	0.752	96	0.537	0.112
16	--	0.351	43	1.637	0.342	70	3.218	0.673	97	0.229	0.048
17	--	0.690	44	2.882	0.603	71	4.253	0.88	98	0.086	0.018
18	--	0.431	45	--	0.814	72	5.237	1.096	99	-0.019	-0.004
19	--	0.527	46	0.985	0.2059	73	3.995	0.836	100	--	0.259
20	--	1.859	47	5.732	1.195	74	6.858	1.435	101	--	0.040
21	2.941	0.615	48	8.041	1.680	75	3.045	0.636	102	--	0.087
22	1.534	0.321	49	0.642	0.134	76	2.552	0.534	103	--	0.081
23	1.574	0.329	50	1.726	0.360	77	3.013	0.630	104	0.322	0.0673
24	0.327	0.068	51	3.445	0.720	78	4.060	0.850	105	0.410	0.0856
25	6.327	1.32	52	2.572	0.538	79	11.563	0.242	106	--	0.143
26	1.548	0.324	53	4.561	0.955	80	7.077	1.478	107	--	0.076
27	8.993	1.879	54	2.906	0.6075	81	18.081	3.94			

TABLE 2 (continued)

 $\phi = -45^\circ$ $\alpha = 45^\circ$

Run 29

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	4.425	0.925	28	6.076	1.27	55	2.112	0.441	82	7.593	1.582
2	5.967	1.245	29	6.264	1.310	56	5.886	1.23	83	10.614	2.22
3	8.554	1.785	30	4.360	0.912	57	2.622	0.549	84	10.833	2.26
4	6.547	1.365	31	--	0.349	58	2.132	0.445	85	7.736	1.621
5	11.321	2.36	32	--	0.671	59	3.494	0.730	86	11.954	2.490
6	--	0.906	33	1.493	0.312	60	--	0.577	87	5.036	1.05
7	3.432	0.716	34	1.902	0.398	61	--	0.227	88	7.421	1.55
8	3.033	0.634	35	2.072	0.433	62	--	0.311	89	5.313	1.110
9	2.711	0.566	36	1.984	0.415	63	--	0.166	90	1.001	0.209
10	3.924	0.820	37	1.478	0.3081	64	--	0.487	91	0.445	0.0930
11	4.494	0.938	38	3.290	0.686	65	--	0.266	92	7.427	1.551
12	11.921	2.490	39	4.299	0.895	66	--	0.165	93	8.670	1.810
13	1.212	0.253	40	4.490	0.938	67	--	0.080	94	2.568	0.563
14	--	0.221	41	4.327	0.905	68	7.488	1.565	95	0.600	0.125
15	--	0.302	42	2.411	0.503	69	3.237	0.675	96	--	0.473
16	1.519	0.317	43	0.995	0.208	70	2.569	0.536	97	--	0.291
17	0.542	0.113	44	0.654	0.137	71	3.385	0.707	98	--	0.211
18	0.632	0.132	45	0.820	0.171	72	3.858	0.805	99	--	0.161
19	0.895	0.187	46	0.616	0.1285	73	3.009	0.628	100	--	0.129
20	0.777	0.162	47	4.338	0.905	74	7.231	1.510	101	--	0.080
21	1.844	0.385	48	5.192	1.081	75	3.640	0.760	102	--	0.086
22	1.070	0.223	49	0.569	0.119	76	2.733	0.570	103	--	0.081
23	1.098	0.229	50	1.064	0.222	77	2.039	0.425	104	0.362	0.0755
24	0.298	0.062	51	2.427	0.507	78	1.644	0.343	105	0.851	0.1775
25	5.296	1.105	52	2.412	0.504	79	12.627	2.64	106	--	0.258
26	1.616	0.337	53	2.981	0.624	80	7.083	1.48	107	--	0.114
27	6.262	1.31	54	1.894	0.396	81	17.832	3.72			

TABLE 2 (continued)

$\phi = -45^\circ$

$\alpha = 60^\circ$

Run 28

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	4.005	0.956	28	2.520	0.602	55	2.055	0.479	82	8.079	1.930
2	4.856	1.160	29	2.832	0.675	56	4.406	1.054	83	6.158	1.475
3	6.904	1.650	30	1.695	0.405	57	1.570	0.375	84	6.612	1.581
4	6.077	1.451	31	--	0.150	58	2.695	0.645	85	8.942	2.14
5	2.692	0.643	32	--	0.288	59	5.936	1.420	86	9.069	2.17
6	--	0.345	33	0.874	0.209	60	--	0.221	87	4.483	1.072
7	2.920	0.698	34	0.745	0.178	61	--	0.143	88	6.088	1.458
8	4.187	1.00	35	0.977	0.234	62	--	0.322	89	3.801	0.910
9	1.962	0.479	36	0.999	0.2384	63	--	0.731	90	5.234	1.25
10	2.694	0.644	37	0.847	0.203	64	--	0.248	91	2.225	0.532
11	2.681	0.642	38	1.130	0.2702	65	--	0.194	92	6.344	1.518
12	4.657	1.112	39	1.482	0.355	66	--	0.189	93	4.292	1.027
13	0.587	0.140	40	2.009	0.479	67	--	0.487	94	5.754	1.377
14	--	0.152	41	2.481	0.595	68	5.497	1.315	95	4.047	0.968
15	--	0.197	42	0.134	0.032	69	1.136	0.272	96	--	0.148
16	1.396	0.334	43	0.192	0.046	70	0.730	0.175	97	--	0.429
17	0.216	0.052	44	0.677	0.162	71	1.643	0.393	98	--	0.290
18	0.176	0.042	45	0.827	0.198	72	1.704	0.408	99	--	0.369
19	0.483	0.116	46	0.126	0.0301	73	4.155	0.994	100	--	0.148
20	0.746	0.178	47	3.636	0.867	74	11.786	2.820	101	--	0.046
21	0.983	0.235	48	4.161	0.995	75	1.535	0.357	102	--	0.099
22	0.503	0.120	49	0.394	0.094	76	1.273	0.305	103	--	0.093
23	0.303	0.072	50	1.014	0.242	77	1.032	0.247	104	0.119	0.0284
24	0.029	0.007	51	3.115	0.745	78	0.837	0.200	105	0.985	0.239
25	5.429	1.295	52	5.643	1.35	79	16.253	3.89	106	--	0.237
26	1.084	0.259	53	2.193	0.524	80	5.613	1.34	107	--	0.130
27	2.546	0.608	54	2.272	0.544	81	11.204	2.68			

TABLE 2 (continued)

$\phi = -45^\circ$

$\alpha = 75^\circ$

Run 37

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	5.125	1.150	28	1.588	0.355	55	0.717	0.161	82	3.143	0.705
2	16.60	3.72	29	1.086	0.243	56	1.898	0.425	83	3.96	0.886
3	2.980	0.668	30	0.705	0.158	57	1.084	0.243	84	6.277	1.409
4	3.951	0.885	31	--	0.047	58	1.678	0.376	85	12.00	2.69
5	2.149	0.482	32	--	0.045	59	4.050	0.908	86	5.272	1.180
6	1.865	0.418	33	0.494	0.111	60	--	0.177	87	3.549	0.795
7	2.241	0.502	34	0.191	0.0427	61	--	0.067	88	13.569	3.04
8	2.319	0.520	35	0.390	0.0875	62	--	0.100	89	10.094	2.45
9	1.222	0.274	36	0.536	0.120	63	--	0.386	90	6.759	1.515
10	1.584	0.355	37	0.421	0.0943	64	--	0.116	91	4.283	0.960
11	1.491	0.334	38	0.620	0.139	65	--	0.104	92	16.497	3.699
12	1.535	0.342	39	0.943	0.211	66	--	0.177	93	16.934	3.797
13	0.398	0.089	40	1.575	0.353	67	--	0.285	94	8.725	1.956
14	0.461	0.103	41	3.196	0.715	68	2.476	0.555	95	6.142	1.377
15	0.689	0.154	42	0.130	0.029	69	0.713	0.160	96	--	0.741
16	0.809	0.181	43	0.129	0.029	70	0.574	0.1289	97	--	1.206
17	0.110	0.025	44	0.228	0.051	71	1.285	0.2882	98	--	0.227
18	0.130	0.029	45	1.003	0.225	72	0.529	0.119	99	--	0.431
19	0.117	0.026	46	0.222	0.475	73	1.277	0.286	100	--	0.509
20	0.189	0.042	47	2.732	0.612	74	6.189	1.388	101	--	0.646
21	0.482	0.108	48	4.425	0.991	75	0.864	0.1937	102	--	1.296
22	--	0.083	49	0.434	0.0974	76	0.577	0.1295	103	--	0.087
23	--	0.085	50	0.498	0.112	77	0.280	0.0627	104	0.370	0.083
24	--	0.083	51	1.137	0.255	78	0.326	0.073	105	0.829	0.186
25	3.26	0.731	52	2.586	0.580	79	12.814	2.877	106	--	0.305
26	0.336	0.075	53	3.415	0.765	80	3.179	0.712	107	--	0.162
27	2.185	0.490	54	1.344	0.302	81	7.799	1.75			

TABLE 2 (continued)

 $\phi = -45^\circ$ $\alpha = 90^\circ$

Run 36

T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$	T/C	$\dot{q}_w$	$\frac{\dot{q}_{wall}}{\dot{q}_{ref}}$
1	3.784	0.808	28	0.330	0.0703	55	0.218	0.0466	82	0.973	0.208
2	12.20	2.61	29	0.409	0.0872	56	1.116	0.238	83	1.052	0.225
3	1.409	0.301	30	0.392	0.0878	57	0.329	0.0704	84	1.543	0.330
4	1.580	0.337	31	--	0.090	58	0.349	0.0745	85	1.736	0.371
5	2.740	0.585	32	--	0	59	0.481	0.1029	86	1.469	0.314
6	2.207	0.472	33	0.228	0.051	60	--	0.113	87	0.684	0.146
7	2.570	0.549	34	0.467	0.1047	61	--	0.021	88	5.412	1.159
8	2.202	0.471	35	0.693	0.153	62	--	0.043	89	6.579	1.405
9	0.805	0.172	36	0.572	0.128	63	--	0.056	90	6.845	1.46
10	0.938	0.201	37	0.514	0.1099	64	--	0.056	91	10.036	2.21
11	0.571	0.122	38	0.383	0.0815	65	--	0.050	92	6.255	1.337
12	1.011	0.216	39	0.841	0.1795	66	--	0.056	93	6.962	1.488
13	0.191	0.041	40	1.095	0.234	67	--	0.081	94	6.391	1.366
14	0.232	0.050	41	1.023	0.219	68	1.674	0.358	95	22.040	4.710
15	0.345	0.074	42	0.023	0.005	69	0.342	0.073	96	--	0.309
16	0.320	0.068	43	0.005	0.001	70	0.423	0.090	97	--	0.596
17	6.763	1.445	44	-0.020	-0.004	71	1.036	0.221	98	--	0.605
18	1.944	0.415	45	0.156	0.033	72	0.304	0.065	99	--	0.370
19	0.578	0.124	46	0.282	0.0602	73	0.650	0.139	100	--	0.221
20	0.504	0.108	47	1.687	0.360	74	4.550	0.972	101	--	0.287
21	0.175	0.037	48	1.996	0.426	75	0.842	0.1795	102	--	0.573
22	--	0.079	49	1.402	0.300	76	0.794	0.1692	103	--	0.083
23	--	0.081	50	0.380	0.0811	77	0.604	0.129	104	0.736	0.157
24	--	0.079	51	0.049	0.0149	78	0.670	0.143	105	1.470	0.314
25	1.016	0.2165	52	0.399	0.0852	79	7.466	1.595	106	--	0.132
26	0.471	0.101	53	1.614	0.345	80	2.607	0.556	107	--	0.155
27	0.308	0.0655	54	0.768	0.164	81	4.236	0.902			

TABLE 3

Heat Transfer Rate to One-Foot Radius Sphere Using Wind Tunnel Conditions

$$\dot{q}_{\text{ref}} = 865 \left(\frac{V}{10^4} \right)^{3.15} \sqrt{\frac{\rho/\rho_{\text{SL}}}{r}}$$

Run No.	P ₀ (psia)	T ₀ (°R)	$\dot{q}_{\text{ref}}$ (Btu/ft ² -sec)	Run No.	P ₀ (psia)	T ₀ (°R)	$\dot{q}_{\text{ref}}$ (Btu/ft ² -sec)	Run No.	P ₀ (psia)	T ₀ (°R)	$\dot{q}_{\text{ref}}$ (Btu/ft ² -sec)
2	375	1911	4.35	20	397	1910	4.42	38	415	1989	4.69
3	392	1964	4.54	21	398	1972	4.64	39	394	1950	4.65
4	396	2042	4.71	22	399	1931	4.49	40	387	1961	4.51
5	398	1771	4.00	23	396	2049	4.76	41	411	1919	4.01
6	392	1999	4.61	24	402	2027	4.74	42	378	2009	4.57
7	429	1991	4.78	25	404	2008	4.75	43	388	1941	4.49
8	382	1965	4.47	26	399	1907	4.43	44	388	1944	4.49
9	394	2021	4.66	27	390	2032	4.70	45	387	1957	4.52
10	391	1951	4.53	28	394	1833	4.18	46	388	2025	4.68
11	383	1986	4.52	29	418	1997	4.79	47	413	1958	4.65
12	387	1969	4.53	30	386	1975	4.51	48	400	1949	4.60
13	384	2002	4.60	31	389	2045	4.73	49	393	1973	4.56
14	386	1986	4.54	32	404	1901	4.42	50	379	1880	4.30
15	412	2019	4.78	33	413	2052	4.92	51	391	1970	4.56
16	393	1964	4.57	34	393	1908	4.40	52	390	1984	4.57
17	413	1918	4.60	35	382	2015	4.61	53	396	1964	4.60
18	405	2015	4.73	36	406	1985	4.68	54	416	1934	4.41
19	397	1968	4.60	37	378	1960	4.46	55	417	2041	4.80

TABLE 4
Thermocouple Switching Schedule

Numbered T/Cs on Beckman

Blank spaces indicate T/C recorded on oscillograph

TC No.	6	13	14	15	16	17	18	19	20	21	22	23	24	26	31	32	42	43	44	45	60	61	62	63	64	65	66	67	72	73	74	92	93	94	95	96	97	98	99	100	101	102	103	106	107				
Actual Run No.																																																	
1		13	14	15	16						21	22	23	24	26	31	32													72	73	74	92	93						100	101	102	103	106	107				
2		13	14	15	16						21	22	23	24	26	31	32													72	73	74	92	93						100	101	102	103	106	107				
3		13	14	15	16						21	22	23	24	26	31	32				60	61	62	63	64	65	66	67	72	73	74																		
4		13	14	15	16						21	22	23	24	26	31	32				60	61	62	63	64	65	66	67	72	73	74																		
5		13	14	15	16						21	22	23	24	26	31	32				60	61	62	63	64	65	66	67	72	73	74																		
6	6	13	14	15	16											31	32	42															92	93	94	95	96	97	98	99	100	101	102	103	106	107			
7	6					17	18	19	20						26	31	32	42	43	44	45									72	73	74	92	93	94	95													
8	6					17	18	19	20						26	31	32	42	43	44	45									72	73	74	92	93	94	95													
9		13				17	18	19	20	21	22	23	24	26	31	32	42	43	44	45										72	73	74	92																
10	6	13	14	15	16	17	18	19	20	21	22	23	24	26	31	32														72	73	74	92																
11	6	13									21	22	23	24	26															72	73	74	92	93	94	95	96	97	98	99	100	101							
12	6	13				16	17	18	19	20	21	22	23	24	26	31	32													72	73	74	92	93	94	95													
13	6					17	18	19	20							31	32	42	43	44										72	73	74	92	93	94	95	96	97	98	99									
14	6					17	18	19	20	21	22	23	24	26	31	32														64	65	66	67	72	73	74	92	93	94										
15	6										21	22	23	24	26	31	32	42	43	44										72	73	74	92	93	94	95	96	97	98	99									
16		13	14	15	16						21	22	23	24	26	31	32				60	61	62	63	64	65	66	67	72	73	74																		
17		13	14	15	16						21	22	23	24	26	31	32				60	61	62	63	64	65	66	67	72	73	74																		
18		13	14	15	16						21	22	23	24	26	31	32				60	61	62	63	64	65	66	67	72	73	74																		
19		13	14	15	16						21	22	23	24	26	31	32				60	61	62	63	64	65	66	67	72	73	74																		
20	6	13	14	15	16											31	32	42															92	93	94	95	96	97	98	99	100	101	102	103	106	107			
21	6															26		42	43	44	45									72	73	74	92	93	94	95	96	97	98	99	100	101	102	103	106				
22	6															26		42	43	44	45									72	73	74	92	93	94	95	96	97	98	99	100	101	102	103	106				
23	6															26		42	43	44	45									72	73	74	92	93	94	95	96	97	98	99	100	101	102	103	106				
24	6					17	18	19	20	21	22	23	24	26	31	32	42	43	44	45										72	73	74	92	93	94														
25	6					17	18	19	20	21	22	23	24	26	31	32	42	43	44	45										72	73	74	92	93	94														
26	6					17	18	19	20	21	22	23	24	26	31	32														64	65	66	67	72	73	74	92	93	94										
27	6					17	18	19	20	21	22	23	24	26	31	32														64	65	66	67	72	73	74	92	93	94										
28		13				16	17	18	19	20	21	22	23	24	26			42	43	44	45									72	73	74	92	93	94	95													
29		13				16	17	18	19	20	21	22	23	24	26			42	43	44	45									72	73	74	92	93	94	95													
30	6															26		42	43	44	45									72	73	74	92	93	94	95	96	97	98	99	100	101	102	103	106				
31	6															26		42	43	44	45									72	73	74	92	93	94	95	96	97	98	99	100	101	102	103	106				
32	6					17	18	19	20	21	22	23	24	26	31	32	42	43	44	45										72	73	74	92	93	94														
33	6					17	18	19	20	21	22	23	24	26	31	32	42	43	44	45										72	73	74	92	93	94														
34	6					17	18	19	20	21	22	23	24	26	31	32	42	43	44	45										72	73	74	92	93	94														
35	6					17	18	19	20	21	22	23	24	26	31	32	42	43	44	45										72	73	74	92	93	94														
36	6	13	14	15	16	17	18	19	20	21					26		42	43	44	45										72	73	74	92	93	94	95													
37	6	13	14	15	16	17	18	19	20	21					26		42	43	44	45										72	73	74	92	93	94	95													
38		13	14	15	16						21	22	23	24	26	31	32				60	61	62	63	64	65	66	67	72	73	74																		
39		13	14	15	16						21	22	23	24	26	31	32				60	61	62	63	64	65	66	67	72	73	74																		
40		13	14	15	16						21	22	23	24	26	31	32				60	61	62	63	64	65	66	67	72	73	74																		
41		13	1																																														

priority thermocouples, i. e., those expected to experience higher heating rates during each run, were routed through the Beckman and the rest were routed through the oscillograph. This means that some of the thermocouples were switched back and forth between the Beckman and the oscillograph. Table 4 shows the actual thermocouple switching which was performed before each run in the test. The thermocouples which were routed through the Beckman system appear in the table. The thermocouples which were read by the oscillograph are left blank in the table. Forty-five of the thermocouples were subject to switching and the rest were permanently read out through the Beckman. Of the 45 thermocouples, 22 were read by the Beckman and 23 by the oscillograph.

At the conclusion of the test, a calibration was performed by immersing the model in ice water and then in hot water (up to 202° F) while it was still in the test section. The thermocouple outputs were recorded on oscillograph tape.

For Runs 8, 18 and 50, a phase change coating was spray painted on the model with the model attitude the same as in Runs 7, 17 and 49, respectively. The painted model was photographed by a motion picture camera at 64 frames per second.

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V. ACCURACY OF DATA

The accuracy of the temperature reading for a chromel-alumel thermocouple, in standard wire size, is given in Table 4.1 of Ref. 5 as:

<u>Temperature (°F)</u>	<u>Error</u>
0 to 530	$\pm 4^{\circ} \text{ F}$
530 to 2300	$\pm 3/4\%$

The accuracy of the slope of the time-temperature curve is about $\pm 1/2$ degree according to the testing facility. The error is caused by the noise level in the instrumentation. A typical slope is about 30 degrees. This would cause an error of $\pm 1-2/3\%$. The temperature error is not likely to affect the slope since it is almost certain to be biased in the same direction along the time-temperature curve.

Figures 308 to 315 show the repeatability of the data. Figures 304 to 307 are also indications of repeatability. The runs being compared in the latter figures were made without any intermediate changes in model attitude; there were model attitude changes between the runs compared in Figs. 308 to 315. This means that the repeatability errors were caused by errors in resetting model attitude rather than in errors in the thermocouple readings. Therefore, there are errors due to thermocouple readings as well as errors due to the accuracy of the model attitude setting. The average difference at 1.5 seconds between the data in Figs. 304 to 307 where model attitude was not reset was 2.29%, and for Figs. 308 to 315 where model attitude was reset it was 3.37%.

Another source of data error is the measurement of the skin thicknesses of the model. The error in this measurement can be expected to be as large as $\pm 5\%$.

Accumulating these errors, the accuracy of the final tabulated data is on the order of $\pm 10\%$. It should be noted that before one second (see Fig. 13), temperature transients are present and the data are not valid.

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VI. DATA PRESENTATION

A. DATA PROCESSING

Data read into the Beckman system were recorded on magnetic tape. A separate tape reel was used for each run to reduce the risk of inadvertently destroying the information. A card was made for each run to record the constants which changed as a result of thermocouple switching between the Beckman and the oscillograph. The magnetic tapes were processed in a digital computer. The primary results are in the form of tabulated data which appear in Table 2. They were also machine plotted to show temperature versus time (slopes) and heat input in Btu/ft²-sec versus time for each of the 84 thermocouples read by the Beckman system for each run. Figures 13 and 14 are tracings and photographs of the machine plots.

Selected thermocouples read by the oscillograph were processed by hand by measuring the slopes and calculating the heat inputs from these slopes.

For processing the data by computer at the testing facility, a curve of specific heat versus temperature, shown in Fig. 15, was supplied to the project engineer at the wind tunnel. Skin thicknesses for each thermocouple location were supplied to the facility.

For the calculation of the heat transfer rate, the following equation was used:

$$\dot{q}_{\text{wall}} = \rho \tau C_p \frac{dT}{dt}$$

where:

$\dot{q}_{\text{wall}}$ = heat transfer rate to the sensing surface (Btu/ft²-sec)

ρ = density of Inconel 600 (lb/ft³)

τ = thickness of skin (ft)

C_p = specific heat of Inconel 600 (Btu/lb-°F)

$\frac{dT}{dt}$ = change in temperature (°F/sec)

The data which were received from the testing facility were further reduced by reading the values of heat transfer rate at a particular time--one to two seconds after the quick insertion mechanism was activated. At this time, transient errors in the outputs, due to insertion

conditions, were gone and conduction had not yet affected the readings seriously. These values were then divided by a reference heat transfer rate which was the heat transfer rate to a one-foot radius sphere according to the following equation:

$$\dot{q}_{\text{ref}} = 865 \left(\frac{V_{\infty}}{10^4} \right)^{3.15} \sqrt{\frac{\rho/\rho_{\text{SL}}}{r}}$$

where:

V_{∞} = free stream velocity (fps)

ρ = free stream density of the air (slugs/ft³)

ρ_{SL} = sea level density of the air (slugs/ft³)

r = sphere radius (ft).

The reference heat transfer rate was calculated for each run and appears in Table 3. The actual heat transfer rate ratios are tabulated for each thermocouple at all of the model attitudes tested in Table 2 and constitute the final reduced data used for analysis and discussion. The plotted data for each thermocouple versus angle of attack appear in Figs. 31 to 103. Figures 104 to 110 show plotted data on the heating rates to the inside wall of the separator. Figures 111 to 161 give the heating rates on the generator body and fins. Figures 162 to 302 are profiles of the heating rates around the sections, shown in Fig. 12, of the sensory ring and generator. These figures are a pictorial presentation where the heating rate at each thermocouple is represented by the length of the bar. The relationships between heating rate and model shape, and model attitude and the location of local hot spots can be observed by inspection of these figures. Figures 16 to 30 show the distribution of the averaged heating rates of each section over the angle-of-attack range tested and for each angle of roll.

VII. DISCUSSION OF RESULTS

A. SENSORY RING

The heat distributions for each thermocouple at each angle of roll and over the angle-of-attack range tested are plotted in Figs. 31 to 103. Figure 12 shows cross section diagrams of the sensory ring and generator and the thermocouples which lie in or near the planes of these sections. The sections are identified. Where the thermocouples do not lie in these planes, the radial plane in which they do lie is indicated. Figures 162 to 302 show the heat distribution profiles around each of the sections at the angles of attack and roll at which the model was tested. The lengths of the lines extending outward perpendicularly from the model surface are proportional to the heating rate. A scale for measuring these values appears on each figure. The heating rates were averaged around each section and the resulting values were plotted against angle of attack for each angle of roll and are presented in Figs. 16 to 30.

1. Heating Distributions by Nimbus Sensory Ring Section

Table 4 shows the averages of the $(\dot{q}_{\text{wall}}/\dot{q}_{\text{ref}})_{\text{ave}}$ over the angle of attack range tested for each angle of roll. It can be seen from this table that most of the heating rates averaged more than the reference heating rate. Sections B-1 and B-2 of the Nimbus sensory ring (see Table 5) show lower average heating rates when Thermocouples 85 and 81, respectively, are not included. These two thermocouples are located in the structural members of the A frame (see Fig. 12). The overall heating was greatest for sections A-3 and D-3. The hottest portions of these sections form a tee in the bottom view of the sensory ring shown in Fig. 303. The conclusion is that the regions including the A frame, the IDCS-TV camera and the cover over the HDRSS electronics experienced the most aerodynamic heating. The regions which had stagnation point heating did not get the hottest. Such regions are the dome of the SIRS and the surfaces facing the flow of the components on the bottom of the sensory ring such as the S-band antennas, MRIR, HRIR, the IR interferometer spectrometer and the sides of the sensory ring at certain attitudes. Figures 180, 181 and 182 show that flow-through regions between the A frame, SIRS and the inner wall of the sensory ring received high heating rates at angles of attack near zero.

2. Heating Rates of Individual Thermocouples

Figures 31 to 103 and Figs. 180 to 182 show that most thermocouples experienced the greatest heating rates at angles of attack near zero degrees. The only exceptions are thermocouples which are in stagnation point flow or appear to be in areas of shock wave impingement at

TABLE 5

Average Aerodynamic Heating to Sensory Ring by Section Through 180-Degree Angle of Attack from -90° to +90°

	$\left(\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}} \right)_{\text{average}}$														
	Section				Section					Section					Generator Section
	A-1	A-2	A-3	A-4*	B-1	B-2	C-3	C-4	C-5	D-1	D-2	D-3	D-4	D-5	
$\phi = 0^\circ$ Without T/C 81, 85	1.30	0.86	2.42	0.78	1.37 • 1.14	1.19 • 0.89	1.12	1.76	0.83	0.61	1.23	2.38	1.45	0.40	0.47
$\phi = 45^\circ$ Without T/C 81, 85	1.04	0.67	2.30	0.90	1.20 • 0.93	1.21 • 0.63	1.13	1.85	0.92	0.74	1.32	2.39	1.26	0.55	0.46
$\phi = 90^\circ$ Without T/C 81, 85	0.99	0.65	2.45	0.82	1.40 • 1.18	1.13 • 0.91	1.19	2.20	0.83	0.72	1.53	2.16	1.30	0.91	0.20
$\phi = -45^\circ$ Without T/C 81, 85	1.02	0.67	2.03	0.56	1.16 • 0.93	0.97 • 0.62	0.88	1.57	0.68	0.70	1.29	2.08	1.27	0.55	0.50

*Not including the generator

other angles of attack as illustrated by the generator section in Figs. 162, 195 and 273. With the exception of the generator, the hottest thermocouples have peak heating at angles of attack near zero; T/C 59, Fig. 66, is an example of this. Thermocouples which showed high average heating rates were 59, 79, 81, 85 and 86. All are on or very near structural members of the A frame. The A frame is illustrated in Fig. 11 and appears in most of the photographs of the model.

3. Effect of Angle of Attack

It can be seen in Figs. 16 to 30 and 162 to 302 that, generally, the sections received more heat at angles of attack near zero degrees. This was caused by very high heating rates to the bottom surfaces and on the inside walls where flow-through caused turbulent flow and boundary layer re-attachment occurred. At angles of attack near ± 90 degrees, stagnation heating occurred over smaller areas and there was less boundary layer re-attachment and turbulent flow.

4. Effect of Angle of Roll

Figures 16 to 30 show that angles of roll made local differences in the heating rates but did not make large differences in the averaged values shown in Table 5. The effect of angle of roll is far less than the effect of angle of attack. Some examples of the local differences are noted here. In Figs. 16 to 19, 21, 22, 25 and 27, there was peak heating of these sections at -30 degrees angle of attack with the model at zero degrees angle of roll and at -60 degrees angle of attack when the model was at a 45 -degree angle of roll. This pattern repeated itself in all of these sections in a similar manner. From a comparison of Figs. 174 and 177 and of Figs. 207 and 210, for example, the increase in the heating rates on the inner walls indicated an increase in flow-through at these model attitudes. This was accompanied by an increase in the overall heating rate to the sections involved.

B. THE SEPARATOR-NIMBUS SENSORY RING

A scale simulation of a Nimbus sensory ring separator was built into the model and was located in the sensory ring halfway between the two S-band antennas. Scale flow-through holes, two on the top and bottom and an elongated one on the side of the sensory ring, were incorporated. The inside wall was instrumented with four thermocouples (Nos. 34, 35, 36 and 37). Figures 8 and 9 show the separator, and Figs. 104 to 110 have sketches showing the location of the four internal thermocouples in the separator. Section A-1 shown in Fig. 12 is the outside of the separator.

1. External Heating of the Separator

Sections A-4, B-1, B-2, C-3 and C-5 are geometrically similar to Section A-1 even though they are not necessarily at separator locations and do not have any flow-through holes. However, Table 5 shows that these sections all had average heating rates, over the angle-of-attack range, about equal to the reference heating rate.

2. Internal Heating of the Separator

Figures 104 to 110 and Table 6 show that the heating rates to the inside wall of the separator were greater at 0 to -90 degrees angle of attack than at 0 to +90 degrees. The greatest heating rate to the inside wall was usually near the elongated opening on the side of the sensory ring. The heating rate to the inside wall was about three times as large as the average heating rate when the model was at zero degrees angle of roll. The inside of the separator got the most heat when one or more of the openings were in stagnation flow were the most flow-through occurred (see Table 6). At zero degrees angle of attack, the heating rate averaged about 1-1/2 times the reference heating rate as shown in Table 6. When the model was tilted so that the elongated hole was at about 60 degrees angle of attack and the roll angle placed it near stagnation flow, the heating of the inside wall of the separator was maximum and averaged somewhat more than 1-1/2 times the reference heating rate (see Table 6). However, the overall average heating rate of the inside wall throughout the angle-of-attack and roll range was about half the average heating rate to the exterior of the separator section as shown in the tabulation.

$$\text{Heating Rate } \frac{1}{N} \sum \left(\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}} \right)_{\text{ave}}$$

	$\phi = 0^\circ$	$\phi = 45^\circ$	$\phi = 90^\circ$	$\phi = -45^\circ$
Section A-1	1.30	1.04	0.99	1.02
Inside wall of separator	0.694	0.475	0.328	0.485

C. THE GENERATOR

Thermocouples 88 to 106 are located on the generator body and fins. Thermocouple 107 is located on the generator standoff support. Figures 89 to 103 are plots of the heating rates at these thermocouple locations versus angle of attack. Figures 111 to 161 are plots of the heating rates around the body and on the fins for each angle of attack and roll.

TABLE 6

Average Aerodynamic Heating to Inside Wall of Separator

α (deg)	ϕ (deg)	$\left(\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}}\right)_{\text{ave}}$	ϕ (deg)	$\left(\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}}\right)_{\text{ave}}$	ϕ (deg)	$\left(\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}}\right)_{\text{ave}}$	ϕ (deg)	$\left(\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}}\right)_{\text{ave}}$
-90	0	0.952	45	0.584	90	0.065	-45	0.400
-75	0	1.019	45	0.448	90	0.092	-45	0.533
-60	0	1.584	45	1.616	90	0.440	-45	0.681
-45	0	0.457	45	0.378	90	0.393	-45	0.572
-30	0	1.217	45	0.157	90	0.123	-45	
-15	0	0.423	45	0.212	90	0.218	-45	0.521
0	0	1.542	45	1.542	90	1.542	-45	1.542
15	0	0.374	45	0.437	90	0.465	-45	
30	0	0.348	45	0.465	90	0.158	-45	0.275
45	0	0.407	45	0.283	90	0.702	-45	0.389
60	0	0.600	45	0.027	90	0.032	-45	0.213
75	0	0.101	45	0.007	90	0.008	-45	0.086
90	0	0.002	45	0.013	90	0.023	-45	0.124
$\sum \left(\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}}\right)_{\text{ave}}$		9.026		6.169		4.261		5.336
$\frac{1}{N} \sum \left(\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}}\right)_{\text{ave}}$		0.694		0.475		0.328		0.485

Note: $\left(\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}}\right)_{\text{ave}}$ was obtained by averaging the values of T/C 34, 35, 36 and 37 which lie along the inside wall of the separator.

Thermocouples on Generator with $\dot{q}_{\text{wall}}/\dot{q}_{\text{ref}}$ Greater than 3.5

<u>T/C</u>	<u>$\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}}$</u>	<u>α (deg)</u>	<u>ϕ (deg)</u>	<u>T/C Locations</u>	
101	3.85	-90	0	Wind →
102	4.19	-90	0		
90	3.56	75	0	Wind →
97	7.87	-90	45	Wind →
98	3.67	-90	45		
101	6.45	-90	45		
102	9.53	-90	45		
104	4.80	-90	45		
88	3.65	45	45	Wind →
88	4.12	75	45		
89	4.22	75	45		
91	3.60	90	45		
94	6.30	-90	90	Wind →
98	7.18	-90	90		
92	3.53	-75	90		
96	3.74	-75	90		
92	3.70	75	-45	Wind →
93	3.80	75	-45		
95	4.71	90	-45		

1. Effect of the Sensory Ring on Generator Heating

It is clear from the plotted data in Figs. 89 to 103 and 111 to 161 and from examining the generator section in Figs. 162 to 300, that the sensory ring did protect the generator from aerodynamic heating at most of the attitudes in the test. The heating rate usually dropped off very fast as soon as the angle of attack moved toward zero degrees. Table 5 shows that the averaged heating rates to the generator were lower than for any other section.

At angles of attack near ± 90 degrees, the windward side of the generator received more heat. The following table of the hottest thermocouple readings shows this clearly.

Figures 162 and 273 show the heating distribution on part of the generator body when it was toward the trailing edge of the sensory ring at -90 degrees angle of attack. There was considerable local heating probably caused by boundary layer re-attachment.

Figures 195, 198, 231, 234, 297 and 300 show what happened to some of the thermocouples facing the flow when the generator was toward the leading edge of the sensory ring at $+75$ and $+90$ degrees angle of attack. The heating was less local than when the generator was trailing because the conditions were more like stagnation flow.

D. EFFECT OF PHASE CHANGE COATING

Figures 304 to 307 show that the phase change coating had no effect on the thermocouple readings. The differences in the time temperature slopes, which were the basis for not painting the model for every run, were apparently caused by the difference in tunnel conditions. After the non-dimensionalized heating rates were computed for the runs with and without the coating, the difference disappeared.

The lighting was not adequate to obtain good motion picture coverage of the coating changing phase. Therefore, none of the films could be used for analysis.

During the runs, where phase change coating was used, most of the coating ablated and was blown away from the surface. All that was left was some of the coating in protected areas which was unchanged. It was easily cleaned off with solvent.

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VIII. CONCLUSIONS AND RECOMMENDATIONS

From the results of the wind tunnel test of the 10% scale heat transfer model of the Nimbus B sensory ring and generator at $M = 10$, the following conclusions and recommendations are made.

A. CONCLUSIONS

1. The sensory ring reduced the aerodynamic heating of the generator to levels as low as $1/10$ to $1/20$ of rate at angles of attack near ± 90 degrees when the generator was in the wake of the ring and the ring was at angles of attack between -75 and $+75$ degrees (passing through zero degrees). This was generally true at all angles of roll.
2. Turbulent flow, shock wave impingement, and/or boundary layer re-attachment caused a greater heat transfer rate than stagnation heating. This was evident from the location of the thermocouples which received the most heat during each run. As a result of this, the portion of the sensory ring which received the most heating throughout the angle of attack range was the A frame members and the area bounded by the A frame members which held the TV camera and HDRSS electronics and multiplexer boxes.
3. The sensory ring received the most heating at angles of attack near zero degrees. This was because of the flow through the open spaces around the A frame members and between these members and inner walls of the sensory ring, which resulted in turbulent flow, boundary layer re-attachment and shock wave impingement from the many stagnation points jutting out from the bottom of the sensory ring.
4. The separator location which was selected appears to have received about the same amount of heating as it would have received at the other separator locations. When the separator holes were located in the flow so that the flow-through was maximum, the internal aerodynamic heating became large but was still much less than the external aerodynamic heating. The heating rate to the inside of the separator was about half the heating rate to the outside of it.

B. RECOMMENDATIONS

It is recommended that a similar heat transfer test be made covering angle-of-attack range which was not tested where the generator is always in stagnation flow. This recommendation is made because force tests indicate that the spacecraft would probably tumble through 360 degrees angle of attack at hypersonic speeds.

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Fig. 1. Model Showing Layout of Ames 3.5-Foot Hypersonic Wind Tunnel

Fig. 2. Model of Ames 3.5-Foot Hypersonic Wind Tunnel Showing Heater, Nozzles and Test Section

Fig. 3. Heater, Nozzle and Test Section of Ames 3.5-Foot Hypersonic Wind Tunnel

Fig. 4. Model Installation in the Wind Tunnel (sting mounted in SIRS)

Run 42
-60 deg angle of attack; 0 deg angle of roll

Run 43
-45 deg angle of attack; 0 deg angle of roll

Run 44
-75 deg angle of attack; 0 deg angle of roll

Run 45
-90 deg angle of attack; 0 deg angle of roll

Fig. 5. Model Installation in the Wind Tunnel (sting mounted in the side of the sensory ring)

Fig. 6. Test Section of Ames 3.5-Foot Hypersonic Wind Tunnel

Fig. 7. Ten Percent Scale Model of Nimbus B Sensory Ring and Generator

Fig. 8. Post-test Photograph of Model, Sting and Components

Fig. 9. Three-Quarter Top View of Model Showing Two Movable Bundles of Wire Routed Through Side of Sensory Ring at 45-Degree Angle of Roll Location (post-test photograph)

Fig. 10. Top View of Model Showing Routing of Thermocouple Wires and Sting Mount into SIRS (post-test photograph)

Fig. 11. Selected Model Parts Before Assembly

Fig. 12. Sections of 10% Model of Nimbus B Sensory Ring and Generator Showing Thermocouple Locations

Fig. 13. Traces of Machine Plotted Data Received from Ames 3.5-foot Hypersonic Wind Tunnel

Fig 14a Example of Machine Plots Received from Ames 3 5-foot Hypersonic Wind Tunnel (reduced from 30 x 30 inches)

Fig. 14b. Example of Machine Plots Received from Ames 3.5-foot Hypersonic Wind Tunnel (reduced from 30 x 30 inches)

Fig. 15. Specific Heat of Inconel 600

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Section A ①

Fig. 16. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

Section A ②

Fig. 17. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

$$\left(\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}} \right)_{\text{Ave.}}$$

Fig. 18. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

Fig. 19. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 20. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Section B 1

Fig. 21. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

Section B 2

Fig. 22. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Section C ③

Fig. 23. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Section C 4

Fig. 24. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

Section C 5

Fig. 25. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Section D ①

Fig. 26. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

Section D ②

Fig. 27. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Section D 3

Fig. 28. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 29. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Section D 5

Fig. 30. Averaged Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees of Sections of Nimbus B Sensory Ring and Generator

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 31. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 32. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

	0°	45°	90°	-45°
ϕ	○	△	□	▽

Fig. 33. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 34. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 35. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 36. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 37. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 38. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 39. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 40. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 41. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 42. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Figs. 43 and 44. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Figs. 45 and 46. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 47. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 48. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 49. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

	0°	45°	90°	-45°
ϕ	○	△	□	▽

Fig. 50. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 51. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 52. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 53. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 54. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 55. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 56. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 57. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Figs. 58 and 59. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 60. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 61. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 62. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 63. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Angle of Attack

Figs. 64 and 65. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 66. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 67. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 68. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 69. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Figs. 70 and 71. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 72. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Figs. 73 and 74. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 75. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Angle of Attack

Figs. 76 and 77. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 78. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 79. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

13.09

Fig. 80. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 81. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 82. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 83. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 84. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 85. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 86. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 87. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Figs. 88 and 89. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 90. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 91. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Figs. 92 and 93. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 94. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 95. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 96. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 97. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 98. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Fig. 99. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Figs. 100 and 101. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

LEGEND

ϕ	0°	45°	90°	-45°
	○	△	□	▽

Figs. 102 and 103. Heat Distribution over 180 Degrees of Angle of Attack and at Angles of Roll of 0, 45, 90 and -45 Degrees for each Thermocouple in Nimbus B Sensory Ring and Generator Model

Fig. 104. Heat Distribution Along Inside Surface of Separator Portion of Model

Fig. 105. Heat Distribution Along Inside Surface of Separator Portion of Model

Fig. 106. Heat Distribution Along Inside Surface of Separator Portion of Model

Fig. 107. Heat Distribution Along Inside Surface of Separator Portion of Model

Fig. 108. Heat Distribution Along Inside Surface of Separator Portion of Model

Fig. 109. Heat Distribution Along Inside Surface of Separator Portion of Model

Fig. 110. Heat Distribution Along Inside Surface of Separator Portion of Model

Fig. 111. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 45 ϕ 0° α -90°

Fig. 112. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 44, $\phi = 0^\circ$, $\alpha = -75^\circ$

Fig. 113. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 42, $\phi = 0^\circ$, $\alpha = -60^\circ$

Fig. 114. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 43, $\phi = 0^\circ$, $\alpha = -45^\circ$

Fig. 115. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 16, $\phi = 0^\circ$, $\alpha = -30^\circ$

Fig. 116. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 3, $\phi = 0^\circ$, $\alpha = -15^\circ$

Fig. 117. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 2 $\phi = 0^\circ$ $\alpha = 0^\circ$

Fig. 118. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 7, $\phi = 0^\circ$, $\alpha = 15^\circ$

Fin thermocouples

Body thermocouples

Fig. 119. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 12 $\phi = 0^\circ$ $\alpha = 30^\circ$

Fig. 120. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 22, $\phi = 0^\circ$, $\alpha = 45^\circ$

Fig. 121. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 23, $\phi = 0^\circ$, $\alpha = 60^\circ$

Fig. 122. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 30, $\phi = 0^\circ$, $\alpha = 75^\circ$

Fig. 123. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 31, $\phi = 0^\circ$, $\alpha = 90^\circ$

Fig. 124. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 46, $\phi = 45^\circ$, $\alpha = -90^\circ$

Fig. 125. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 46, $\phi = 45^\circ$, $\alpha = -90^\circ$

Fig. 126. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 53, $\phi = 45^\circ$ $\alpha = 75^\circ$

Figs. 127 and 128. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 55, $\phi = 45^\circ$, $\alpha = -60^\circ$

Fig. 129. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 54, $\phi = 45^\circ$, $\alpha = -45^\circ$

Fig. 130. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 17, $\phi = 45^\circ$, $\alpha = -30^\circ$

Fig. 131. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 4, $\phi = 45^\circ$, $\alpha = -15^\circ$

Fig. 132. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 10, $\phi = 45^\circ$, $\alpha = 15^\circ$

Fig. 133. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 13, $\phi = 45^\circ$, $\alpha = 30^\circ$

Fig. 134. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 24, $\phi = 45^\circ$, $\alpha = 45^\circ$

Fig. 135. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 25, $\phi = 45^\circ$, $\alpha = 60^\circ$

Fig. 136. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 33, $\phi = 45^\circ$, $\alpha = 75^\circ$

Fig. 137. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 32, $\phi = 45^\circ$, $\alpha = 90^\circ$

Figs. 138 and 139. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 48, $\phi = 90^\circ$, $\alpha = -90^\circ$

Fig. 140. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 49, $\phi = 90^\circ$, $\alpha = -75^\circ$

Fig. 141. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 52, $\phi = 90^\circ$, $\alpha = -60^\circ$

Fig. 142. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 51, $\phi = 90^\circ$, $\alpha = -45^\circ$

Fig. 143. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 20, $\phi = 90^\circ$, $\alpha = -30^\circ$

Fig. 144. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 6, $\phi = 90^\circ$, $\alpha = -15^\circ$

Fig. 145. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 9, $\phi = 90^\circ$, $\alpha = 15^\circ$

Fig. 146. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 14, $\phi = 90^\circ$, $\alpha = 30^\circ$

Fig. 147. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 26, $\phi = 90^\circ$, $\alpha = 45^\circ$

Fig. 148. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 27, $\phi = 90^\circ$, $\alpha = 60^\circ$

Fig. 149. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 34, $\phi = 90^\circ$, $\alpha = 75^\circ$

Fig. 150. Heat Distribution Along Body and on Fins of Generator Portion of Model -- Run 35, $\phi = 90^\circ$, $\alpha = 90^\circ$

Fig. 151. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 39, $\phi = -45^\circ$, $\alpha = -90^\circ$

Fig. 152. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 38, $\phi = 40^\circ$, $\alpha = 75^\circ$

Fig. 153. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 41, $\phi = -45^\circ$, $\alpha = -60^\circ$

Fig. 154. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 40, $\phi = -45^\circ$, $\alpha = -45^\circ$

Fig. 155. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 5, $\phi = -45^\circ$, $\alpha = -15^\circ$

Fig. 156. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 15, $\phi = -45^\circ$, $\alpha = 30^\circ$

Fig. 157. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 29, $\phi = -45^\circ$, $\alpha = 45^\circ$

Fig. 158. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 28, $\phi = -45^\circ$, $\alpha = 60^\circ$

Fig. 159. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 37, $\phi = -45^\circ$, $\alpha = 75^\circ$

Fig. 160 and 161. Heat Distribution Along Body and on Fins of Generator Portion of Model--Run 36, $\phi = -45^\circ$, $\alpha = 90^\circ$

Fig. 162. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 45, $\phi = 0^\circ$, $\alpha = -90^\circ$

Fig. 163. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 45, $\phi = 0^\circ$, $\alpha = -90^\circ$

Fig. 164. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 45, $\phi = 0^\circ$, $\alpha = -90^\circ$

Fig. 165. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 44, $\phi = 0^\circ$, $\alpha = -75^\circ$

Fig. 166. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 44, $\phi = 0^\circ$, $\alpha = -75^\circ$

Fig. 167. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 44, $\phi = 0$, $\alpha = -75^\circ$

Fig. 168. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 42, $\phi = 0^\circ$, $\alpha = -60^\circ$

Fig. 169. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 42, $\phi = 0^\circ$, $\alpha = 60^\circ$

Fig. 170. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 42, $\phi = 0^\circ$, $\alpha = -60^\circ$

Fig. 171. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 43, $\phi = 0^\circ$, $\alpha = -45^\circ$

18 T/C at 45, 65, 211 and 225 degrees

16 T/C at 139, 310, 315 and 332-1/2 degrees

C-C

Fig. 172. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 43, $\phi = 0^\circ$, $\alpha = -45^\circ$

Fig. 173. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 43, $\phi = 0^\circ$, $\alpha = -45^\circ$

Fig. 175. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 16, $\phi = 0^\circ$, $\alpha = -30^\circ$

Fig. 176. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 16, $\phi = 0^\circ$, $\alpha = -30^\circ$

Fig. 177. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 3, $\phi = 0^\circ$, $\alpha = -15^\circ$

Fig. 178. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 3, $\phi = 0^\circ$, $\alpha = -15^\circ$

Fig. 179. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 3, $\phi = 0^\circ$, $\alpha = -15^\circ$

Fig. 181. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 2, $\phi = 0^\circ$, $\alpha = 0^\circ$

Fig. 182. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 2, $\phi = 0^\circ$, $\alpha = 0^\circ$

$q_{\text{wall}}/q_{\text{ref}}$

0 1 2 3 4 5 6 7 8 9 10

SC ALF

Fig. 183. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 7, $\phi = 0^\circ$, $\alpha = 15^\circ$

Fig. 184. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 7, $\phi = 0^\circ$, $\alpha = 15^\circ$

Fig. 185. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 7, $\phi = 0^\circ$, $\alpha = 15^\circ$

Fig. 186. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 12, $\phi = 0^\circ$, $\alpha = 30^\circ$

Fig. 187. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 12, $\phi = 0^\circ$, $\alpha = 30^\circ$

Fig. 188. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 12, $\phi = 0^\circ$, $\alpha = 30^\circ$

$\dot{q}_{\text{wall}}/\dot{q}_{\text{ref}}$
0 1 2 3 4 5 6 7 8 9 10
SCALE

Fig. 189. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 22, $\phi = 0^\circ$, $\alpha = 45^\circ$

Fig. 190. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 22, $\phi = 0^\circ$, $\alpha = 45^\circ$

Fig. 191. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 22, $\phi = 0^\circ$, $\alpha = 45^\circ$

$\dot{q}_{\text{wall}}/\dot{q}_{\text{ref}}$

0 1 2 3 4 5 6 7 8 9 10

SCALE

Fig. 192. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 23, $\phi = 0^\circ$, $\alpha = 60^\circ$

Fig. 193. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 23, $\phi = 0^\circ$, $\alpha = 60^\circ$

Fig. 194. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 23, $\phi = 0^\circ$, $\alpha = 60^\circ$

Fig. 195. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 30, $\phi = 0^\circ$, $\alpha = 75^\circ$

Fig. 196. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 30, $\phi = 0^\circ$, $\alpha = 75^\circ$

Fig. 197. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 30, $\phi = 0^\circ$, $\alpha = 75^\circ$

Fig. 198. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 31, $\phi = 0^\circ$, $\alpha = 90^\circ$

Fig. 199. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 31, $\phi = 0^\circ$, $\alpha = 90^\circ$

Fig. 200. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 31, $\phi = 0^\circ$, $\alpha = 90^\circ$

MND-3607-95

Fig. 201. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 46, $\phi = 45^\circ$, $\alpha = -90^\circ$

Fig. 202. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 46, $\phi = 45^\circ$, $\alpha = -90^\circ$

MND-3607-95

Fig. 203. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 46, $\phi = 45^\circ$, $\alpha = -90^\circ$

Fig. 204. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 53, $\phi = 45^\circ$, $\alpha = -75^\circ$

Fig. 205. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 53, $\phi = 45^\circ$, $\alpha = -75^\circ$

Fig. 206. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 53, $\phi = 45^\circ$, $\alpha = -75^\circ$

Fig. 207. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 55, $\phi = 45^\circ$, $\alpha = -60^\circ$

Fig. 208. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 55, $\phi = 45^\circ$, $\alpha = -60^\circ$

D-D

18 T/C at 90, 98-1/2, 100, 112, 260 and 270 degrees

Fig. 209. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 55, $\phi = 45^\circ$, $\alpha = -60^\circ$

Fig. 210. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 54, $\phi = 45^\circ$, $\alpha = -45^\circ$

Fig. 211. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 54, $\phi = 45^\circ$, $\alpha = -45^\circ$

Fig. 212. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 54, $\phi = 45^\circ$, $\alpha = -45^\circ$

Fig. 213. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 17, $\phi = 45^\circ$, $\alpha = -30^\circ$

Fig. 214. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 17, $\phi = 45^\circ$, $\alpha = -30^\circ$

Fig. 215. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 17, $\phi = 45^\circ$, $\alpha = -30^\circ$

Fig. 216. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 4, $\phi = 45^\circ$, $\alpha = -15^\circ$

Fig. 217. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 4, $\phi = 45^\circ$, $\alpha = -15^\circ$

Fig. 218. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 4, $\phi = 45^\circ$, $\alpha = -15^\circ$

Fig. 219. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 10, $\phi = 45^\circ$, $\alpha = 15^\circ$

18 T/C at 45 65 211 and 225 degrees

16 T/C at 139, 310, 315 and 332-1/2 degrees

Fig. 220. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 10, $\phi = 45^\circ$, $\alpha = 15^\circ$

Fig. 221. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 10, $\phi = 45^\circ$, $\alpha = 15^\circ$

Fig. 222. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 13, $\phi = 45^\circ$, $\alpha = 30^\circ$

Fig. 223. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 13, $\phi = 45^\circ$, $\alpha = 30^\circ$

D-D

18 T/C at 90, 98-1/2, 100, 112, 260 and 270 degrees

Fig. 224. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 13, $\phi = 45^\circ$, $\alpha = 30^\circ$

Fig. 225. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 24, $\phi = 45^\circ$, $\alpha = 45^\circ$

Fig. 226. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 24, $\phi = 45^\circ$, $\alpha = 45^\circ$

Fig. 227. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 24, $\phi = 45^\circ$, $\alpha = 45^\circ$

Fig. 228. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 25, $\phi = 45^\circ$, $\alpha = 60^\circ$

$\dot{q}_{\text{wall}} / \dot{q}_{\text{ref}}$
0 1 2 3 4 5 6 7 8 9 10
SCALE

Fig. 229. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 25, $\phi = 45^\circ$, $\alpha = 60^\circ$

Fig. 230. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 25, $\phi = 45^\circ$, $\alpha = 60^\circ$

Fig. 231. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 33, $\phi = 45^\circ$, $\alpha = 75^\circ$

Fig. 232. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 33, $\phi = 45^\circ$, $\alpha = 75^\circ$

Fig. 233. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 33, $\phi = 45^\circ$, $\alpha = 75^\circ$

Fig. 234. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 32, $\phi = 45^\circ$, $\alpha = 90^\circ$

Fig. 235. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 32, $\phi = 45^\circ$, $\alpha = 90^\circ$

Fig. 236. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 32, $\phi = 45^\circ$, $\alpha = 90^\circ$

Fig. 237. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 48, $\phi = 90^\circ$, $\alpha = -90^\circ$

B-B

18 T/C at 45, 65, 211 and 225 degrees

16 T/C at 139, 310, 315 and 332-1/2 degrees

C-C

Fig. 238. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 48, $\phi = 90^\circ$, $\alpha = -90^\circ$

Fig. 239. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 48, $\phi = 90^\circ$, $\alpha = -90^\circ$

Fig. 240. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 49, $\phi = 90^\circ$, $\alpha = -75^\circ$

Fig. 241. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 49, $\phi = 90^\circ$, $\alpha = -75^\circ$

Fig. 242. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 49, $\phi = 90^\circ$, $\alpha = -75^\circ$

$\hat{q}_{wall}/q_{ref}$
 0 1 2 3 4 5 6 7 8 9 10
 SCALE

Fig. 243. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 52, $\phi = 90^\circ$, $\theta = -60^\circ$

B-B

18 T/C at 45, 65, 211 and 225 degrees

16 T/C at 139, 310, 315 and 332-1/2 degrees

C-C

Fig. 244. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 52, $\phi = 90^\circ$, $\theta = -60^\circ$

Fig. 245. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 52, $\phi = 90^\circ$, $\alpha = -60^\circ$

Fig. 246. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 51, $\phi = 90^\circ$, $\alpha = -45^\circ$

Fig. 247. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 51, $\phi = 90^\circ$, $\alpha = -45^\circ$

Fig. 248. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 51, $\phi = 90^\circ$, $\alpha = -45^\circ$

Fig. 249. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 20, $\phi = 90^\circ$, $\alpha = -30^\circ$

Fig. 250. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 20, $\phi = 90^\circ$, $\alpha = -30^\circ$

D-D

18 T/C at 90, 98-1/2, 100, 112, 260 and 270 degrees

Fig. 251. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 20, $\phi = 90^\circ$, $\alpha = -30^\circ$

40 T/C at 0, 180 and 355 degrees

Fig. 252. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 6, $\phi = 90^\circ$, $\alpha = -15^\circ$

Fig. 253. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 6, $\phi = 90^\circ$, $\alpha = -15^\circ$

Fig. 254. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 6, $\phi = 90^\circ$, $\alpha = -15^\circ$

Fig. 255. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 9, $\phi = 90^\circ$, $\alpha = 15^\circ$

Fig. 256. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 9, $\phi = 90^\circ$, $\alpha = 15^\circ$

Fig. 257. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 9, $\phi = 90^\circ$, $\alpha = 15^\circ$

Fig. 258. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 14, $\phi = 90^\circ$, $\alpha = 30^\circ$

Fig. 259. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 14, $\phi = 90^\circ$, $\alpha = 30^\circ$

Fig. 260. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 14, $\phi = 90^\circ$, $\alpha = 30^\circ$

Fig. 261. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 26, $\phi = 90^\circ$, $\alpha = 45^\circ$

18 T/C at 45, 65, 211 and 225 degrees

16 T/C at 139, 310, 315 and 332-1/2 degrees

*No correlation to
circuit failure

Fig. 262. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 26, $\phi = 90^\circ$, $\alpha = 45^\circ$

Fig. 263. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 26, $\phi = 90^\circ$, $\alpha = 45^\circ$

Fig. 264. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 27, $\phi = 90^\circ$, $\alpha = 60^\circ$

Fig. 265. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 27, $\phi = 90^\circ$, $\alpha = 60^\circ$

Fig. 266. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 27, $\phi = 90^\circ$, $\alpha = 60^\circ$

Fig. 267. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 34, $\phi = 90^\circ$, $\alpha = 75^\circ$

Fig. 268. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 34, $\phi = 90^\circ$, $\alpha = 75^\circ$

Fig. 269. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 34, $\phi = 90^\circ$, $\alpha = 75^\circ$

Fig. 270. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 35, $\phi = 90^\circ$, $\alpha = 90^\circ$

Fig. 271. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 35, $\phi = 90^\circ$, $\alpha = 90^\circ$

Fig. 272. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 35, $\phi = 90^\circ$, $\alpha = 90^\circ$

Fig. 273. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model.--Run 39, $\phi = -45^\circ$, $\alpha = -90^\circ$

Fig. 274. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 39, $\phi = -45^\circ$, $\alpha = -90^\circ$

Fig. 275. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 39, $\phi = -45^\circ$, $\alpha = -90^\circ$

Fig. 276. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 38, $\phi = -45^\circ$, $\alpha = -75^\circ$

Fig. 277. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 38, $\phi = -45^\circ$, $\alpha = -75^\circ$

Fig. 278. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 38, $\phi = -45^\circ$, $\alpha = -75^\circ$

40 T/C at 0, 180 and 355 degrees

Fig. 279. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 41, $\phi = -45^\circ$, $\alpha = -60^\circ$

B-B

18 T/C at 45 65 211 and 225 degrees

C-C

Fig. 280. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 41, $\phi = -45^\circ$, $\alpha = -60^\circ$

Fig. 281. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 41, $\phi = -45^\circ$, $\alpha = -60^\circ$

Fig. 282. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 40, $\phi = -45^\circ$, $\alpha = -45^\circ$

Fig. 283. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 40, $\phi = -45^\circ$, $\alpha = -45^\circ$

Fig. 284. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 40, $\phi = -45^\circ$, $\alpha = -45^\circ$

$\frac{\dot{q}_{\text{wall}}}{\dot{q}_{\text{ref}}}$
 0 1 2 3 4 5 6 7 8 9 10
 SCALE

Fig. 285. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 5, $\phi = -45^\circ$, $\alpha = -15^\circ$

B-B

18 T/C at 45, 65, 211 and 225 degrees

C-C

Fig. 286. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 5, $\phi = -45^\circ$, $\alpha = -15^\circ$

Fig. 287. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 5, $\phi = -45^\circ$, $\alpha = -15^\circ$

Fig. 288. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 15, $\phi = -45^\circ$, $\alpha = 30^\circ$

Fig. 289. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 15, $\phi = -45^\circ$, $\alpha = 30^\circ$

Fig. 290. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 15, $\phi = -45^\circ$, $\alpha = 30^\circ$

Fig. 291. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 29, $\phi = -45^\circ$, $\alpha = 45^\circ$

Fig. 292. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 29, $\phi = -45^\circ$, $\alpha = 45^\circ$

D-D

18 T/C at 90, 98-1/2, 100, 112, 260 and 270 degrees

Fig. 293. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 29, $\phi = -45^\circ$, $\alpha = 45^\circ$

Fig. 294. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 28, $\phi = -45^\circ$, $\alpha = 60^\circ$

Fig. 295. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 28, $\phi = -45^\circ$, $\alpha = 60^\circ$

$\dot{q}_{wall}/\dot{q}_{ref}$

0 1 2 3 4 5 6 7 8 9 10

SCALE

Fig. 296. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 28, $\phi = -45^\circ$, $\alpha = 60^\circ$

Fig. 297. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 37, $\phi = -45^\circ$, $\alpha = 75^\circ$

Fig. 298. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model -- Run 37, $\phi = -45^\circ$, $\alpha = 75^\circ$

Fig. 299. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 37, $\phi = -45^\circ$, $\alpha = 75^\circ$

Fig. 300. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 36, $\phi = -45^\circ$, $\alpha = 90^\circ$

Fig. 301. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model--Run 36, $\phi = -45^\circ$, $\alpha = 90^\circ$

Fig. 302. Heat Distribution Profiles Around Sections of Nimbus B Sensory Ring and Generator Model --Run 36, $\phi = -45^\circ$, $\alpha = 90^\circ$

Fig. 303. Region of Greatest Heating on Sensory Ring Surface for Angles of Attack from -90 to +90 Degrees

Fig. 304. Effect of Phase Change Coating on Thermocouple Readings

Fig. 305. Effect of Phase Change Coating on Thermocouple Readings

Fig. 306. Effect of Phase Change Coating on Thermocouple Readings

Fig. 307. Effect of Phase Change Coating on Thermocouple Readings

Fig. 308. Repeatability of Data

Fig 309. Repeatability of Data

Fig. 310. Repeatability of Data

Fig. 311. Repeatability of Data

Fig. 312. Repeatability of Data

Fig. 313. Repeatability of Data

Fig. 314. Repeatability of Data

Fig. 315. Repeatability of Data

NOTE:

Model shown at 0° angle of roll and pitch.

In setting model attitudes of combined pitch and roll, model is first set at desired angle of attack and then rolled about body axis to desired angle of roll.

Fig. 316. Definition of Model Attitude