## LIST OF FIGURES

Figure 1.1	Different regimes of flow	4
Figure 1.2	Thin shock layer	6
Figure 1.3	Entropy layer	7
Figure 1.4	Temperature profile.	8
Figure 1.5	High temperature shock layer on a blunt body	9
Figure 1.6	Characteristics of hypersonic flow	11
Figure 1.7	Schematic of the hypersonic flow over flat plate	12
Figure 1.8	Heating of body and air around the body	15
Figure 1.9	Comparison of blunt and slender body	16
Figure 1.10	Sketches of Models with Different Bluntness Ratio	17
Figure 1.11	Effect of nose radius on drag coefficient	18
Figure 1.12	Combined mechanism of counter flowing jet and forward-facing	20
	cavity	
Figure 1.13	Schematic representation of the combination of counter flowing jet	20
	and energy deposition	
Figure 1.14	Schematic representation of the flow field properties around the aero	21
	disked blunt cone with counter flowing jets	
Figure 1.15	Flow field around Aerospike and Aerodisk	23
Figure 4.1	Fluid dynamics - Three dimensions	51
Figure 4.2	Relation between ( <i>u</i> , $\overline{u}$ and <i>u'</i> )	63
Figure 4.3	Base Geometry	77
Figure 4.4	Hemispherical Aerodisk	78
Figure 4.5	Flat Aerodisk	79
Figure 4.6	Flat Triangular Aerodisk	80

Figure 4.7	Cell centers and grid Points	81
Figure 4.8	Types of Grids	82
Figure 4.9	Initial meshes around hemispherical aerodisks	83
Figure 4.10	Adapted meshes around hemispherical aerodisks	84
Figure 4.11	Discretization of a transport equation over a finite control volume	86
Figure 4.12	Evaluation of gradient at cell centroid	96
Figure 4.13	Numerical boundaries around a spiked configuration	98
Figure 4.14	Surface pressure distribution for various grid refinements	100
Figure 4.15	Heat flux distributions for spiked hemisphere cylinder	101
Figure 5.1	Peak reattachment pressure for single disk aerospike	103
Figure 5.2	Drag coefficient for single disk aerospike	104
Figure 5.3	Contours of axial velocity for single disk aerospike with $r = 4 mm$	106
Figure 5.4	Pressure coefficient for flat aerodisk $l/D=1.5$ , $r=8 mm$	106
Figure 5.5	Temperature contours of single disk aerospikes	107
Figure 5.6	Integral Heat transfer rates	108
Figure 5.7	Temperature contours for flat triangular aerodisk with $r_1=6 mm$	109
Figure 5.8	Axial Velocity contours for hemispherical double disk aerospike of	110
	$l/D = 2, r_1 = 6 mm r_2 = 4 mm, l_1/l = 0.5$	
Figure 5.9	Axial Velocity contours for hemispherical double disk aerospike of	111
	$l/D = 2, r_1 = 6 mm r_2 = 4 mm, l_1/l = 0.75$	
Figure 5.10	Axial Velocity contours for flat double disk aerospike of	112
	$l/D = 2, r_1 = 6 mm r_2 = 4 mm, l_1/l = 0.50$	
Figure 5.11	Surface Pressure distribution for double disk aerospikes	113
Figure 5.12	Normalized drags for spiked blunt body with two hemispherical	114
	aerodisks	
Figure 5.13	Surface pressure distribution for hemispherical aerodisk	116
Figure 5.14	Surface pressure distribution for flat aerodisk	117
Figure 5.15	Surface pressure distribution for flat triangular aerodisk	118
Figure 5.16	Normalized drags for spiked blunt body with double flat aerodisks	119

Figure 5.17	Normalized drags for spiked blunt body with double flat triangular aerodisks	120
Figure 5.18	Surface heat flux distributions for hemispherical double disk	122
Figure 5.19	Total heat transfer rates on main body for hemispherical double disk aerospike for various disk radii	124
Figure 5.20	Temperature contours for hemispherical aerodisk with disk radii $r_1=6 mm$ , $r_2=4 mm$	126
Figure 5.21	Temperature contours for hemispherical aerodisk with disk radii $r_1=8 mm$ , $r_2=6 mm$	128
Figure 5.22	Surface heat flux distributions for double flat disk	129
Figure 5.23	Temperature contours for double flat disk aerospike with disk radii $r_1=6 mm$ and $r_2=4 mm$	132
Figure 5.24	Temperature contours for double flat disk aerospike with disk radii $r_1=8 mm$ and $r_2=6 mm$	133
Figure 5.25	Total heat transfer rates for double flat disk for various disk radii	134
Figure 5.26	Temperature contours for double disk aerospike with disk radii $r_1=6 mm$ and $r_2=4 mm$	136
Figure 5.27	Surface heat flux distributions for double flat disk	137
Figure 5.28	Total heat transfer rates for double flat triangular disk for various disk radii	138
Figure 5.29	Contours of velocity for configurations with triple hemispherical aerodisks	139
Figure 5.30	Comparisons of the contours of axial velocity	141
Figure 5.31	Contours of axial velocity for configurations with triple flat aerodisks	142
Figure 5.32	Comparisons of contours of axial velocity for triple disk configurations with $r_1$ =8 mm, $r_2$ =6 mm and $r_3$ =4 mm	144
Figure 5.33	Normalized drag for configurations with three hemispherical aerodisks	146

Figure 5.34	Surface pressure distribution for hemispherical aerodisk with $r_1=6$	149
	<i>mm</i> , $r_2=4$ <i>mm</i> and $r_3=2$ <i>mm</i>	
Figure 5.35	Surface pressure distribution for hemispherical aerodisk with $r_1=8$	150
	<i>mm</i> , $r_2=6$ mm and $r_3=4$ mm	
Figure 5.36	Normalized drag for configurations with three flat aerodisks	152
Figure 5.37	Surface pressure distribution for flat aerodisk with $r_1=8$ mm, $r_2=6$	153
	and $r_3=4 mm$	
Figure 5.38	Normalized drag for configurations with three flat triangular	155
	aerodisks	
Figure 5.39	Surface heat flux distribution for flat aerodisk with $r_1=6$ mm, $r_2=4$	157
	$mm$ and $r_3=2 mm$	
Figure 5.40	Surface heat flux distribution for hemispherical aerodisk with	158
	$r_1=8 mm$ , $r_2=6 mm$ and $r_3=4 mm$	
Figure 5.41	Contours of temperatures for hemispherical three disk aerospikes	159
Figure 5.42	Surface heat flux distribution for flat aerodisk with	161
	$r_1 = 6 mm$ , $r_2 = 4 mm$ and $r_3 = 2 mm$	
Figure 5.43	Surface heat flux distribution for flat aerodisk with $r_1=8$ mm, $r_2=6$	163
	<i>mm</i> and $r_3=4$ <i>mm</i>	
Figure 5.44	Total heat transfer rates for various hemispherical triple aerodisk	165
	configurations	
Figure 5.45	Total heat transfer rates for various hemispherical triple aerodisk	167
	configurations	
Figure 5.46	Comparison of drag for selected single and multiple disk spiked	169
	configurations	
Figure 5.47	Comparison of surface pressure distribution for selected single and	171
	multiple disk spiked configurations with front disk size of 4 mm	
Figure 5.48	Comparison of surface heat flux distribution for selected single and	173
	multiple disk spiked configurations with front disk size of 4 mm	
Figure 5.49	Comparison of total heat transfer rates for selected single and	174
	multiple disk spiked configurations with front disk size of 4 mm	