
ND TUNNEL MODEL
CO

1
00:01:10,390 --> 00:00:42,830
so

2
00:01:14,149 --> 00:01:12,870
the nasa lewis research center is in a

3
00:01:16,710 --> 00:01:14,159
unique position

4
00:01:17,749 --> 00:01:16,720
to take advantage of computational fluid

5
00:01:20,070 --> 00:01:17,759
dynamics

6
00:01:21,030 --> 00:01:20,080
structural mechanics and material

7
00:01:22,950 --> 00:01:21,040
science

8
00:01:24,230 --> 00:01:22,960
to develop new techniques for

9
00:01:27,670 --> 00:01:24,240
multi-component

10
00:01:30,630 --> 00:01:27,680
multi-discipline analysis design

11
00:01:32,310 --> 00:01:30,640
and optimization of advanced engine

12
00:01:34,069 --> 00:01:32,320
systems

13
00:01:36,950 --> 00:01:34,079

to that end many of the lewis

14
00:01:39,030 --> 00:01:36,960
organizations have formed research teams

15
00:01:41,109 --> 00:01:39,040
whose activities are directed towards a

16
00:01:44,469 --> 00:01:41,119
common long-range vision

17
00:01:45,109 --> 00:01:44,479
of a numerical test cell for studies on

18
00:01:48,710 --> 00:01:45,119
advanced

19
00:01:49,590 --> 00:01:48,720
engine systems this unique computational

20
00:01:52,830 --> 00:01:49,600
capability

21
00:01:55,109 --> 00:01:52,840
in turn sets the stage for new levels of

22
00:01:56,950 --> 00:01:55,119
understanding once the scientist or

23
00:01:58,709 --> 00:01:56,960
engineer is satisfied

24
00:02:01,190 --> 00:01:58,719
that the critical physics are being

25
00:02:03,830 --> 00:02:01,200
modeled in the analysis

26
00:02:04,709 --> 00:02:03,840
however confidence in computational

27
00:02:07,429 --> 00:02:04,719
science

28
00:02:08,550 --> 00:02:07,439
can only be achieved by detailed

29
00:02:11,670 --> 00:02:08,560
comparison

30
00:02:12,470 --> 00:02:11,680
with experimental data obtained in test

31
00:02:16,550 --> 00:02:12,480
cells

32
00:02:19,190 --> 00:02:16,560
or wind tunnels one such validation

33
00:02:19,589 --> 00:02:19,200
experiment was performed in the 10 by 10

34
00:02:22,630 --> 00:02:19,599
foot

35
00:02:23,589 --> 00:02:22,640
supersonic wind tunnel at the nasa lewis

36
00:02:27,350 --> 00:02:23,599
research center

37
00:02:29,430 --> 00:02:27,360
in cleveland ohio in this experiment

38
00:02:31,030 --> 00:02:29,440

instrumentation was installed in a

39
00:02:34,710 --> 00:02:31,040
supersonic inlet

40
00:02:35,190 --> 00:02:34,720
designed for mach 5 to provide detailed

41
00:02:38,710 --> 00:02:35,200
data

42
00:02:40,949 --> 00:02:38,720
for code validation a 3d

43
00:02:41,830 --> 00:02:40,959
viscous computer simulation of this

44
00:02:44,630 --> 00:02:41,840
inlet

45
00:02:46,229 --> 00:02:44,640
revealed previously unknown strong

46
00:02:48,830 --> 00:02:46,239
secondary flows

47
00:02:50,070 --> 00:02:48,840
as can be seen from these particle

48
00:02:52,949 --> 00:02:50,080
traces

49
00:02:53,990 --> 00:02:52,959
these secondary flows are formed because

50
00:02:56,390 --> 00:02:54,000
of shock wave

51
00:02:58,149 --> 00:02:56,400
interactions with the turbulent side

52
00:03:01,670 --> 00:02:58,159
wall boundary layers

53
00:03:04,149 --> 00:03:01,680
and they create additional inlet losses

54
00:03:05,910 --> 00:03:04,159
the close coupling between analysis and

55
00:03:08,470 --> 00:03:05,920
the validation experiment

56
00:03:09,509 --> 00:03:08,480
was designed to confirm both the cause

57
00:03:12,309 --> 00:03:09,519
and effect

58
00:03:14,550 --> 00:03:12,319
of these previously unknown secondary

59
00:03:17,190 --> 00:03:14,560
flows

60
00:03:19,670 --> 00:03:17,200
a second important application of

61
00:03:23,350 --> 00:03:19,680
computational fluid dynamics

62
00:03:25,830 --> 00:03:23,360
is to analyze new concepts in propulsion

63
00:03:27,670 --> 00:03:25,840

such as this supersonic fan blade

64
00:03:31,190 --> 00:03:27,680
designed using a 2d

65
00:03:32,149 --> 00:03:31,200
analysis a 3d viscous computer

66
00:03:35,030 --> 00:03:32,159
simulation

67
00:03:36,949 --> 00:03:35,040
predicted blade pressures shown here in

68
00:03:39,270 --> 00:03:36,959
varying colors

69
00:03:41,910 --> 00:03:39,280
the simulation also allowed designers

70
00:03:43,190 --> 00:03:41,920
and engineers to visualize secondary

71
00:03:45,350 --> 00:03:43,200
flow

72
00:03:46,229 --> 00:03:45,360
here particle traces show the passage

73
00:03:48,710 --> 00:03:46,239
vortex

74
00:03:50,070 --> 00:03:48,720
which can be traced to its origin as a

75
00:03:53,910 --> 00:03:50,080
horseshoe vortex

76
00:03:56,390 --> 00:03:53,920
ahead of the blade a third application

77
00:03:58,149 --> 00:03:56,400
of computational fluid dynamics at nasa

78
00:04:00,309 --> 00:03:58,159
lewis research center

79
00:04:01,990 --> 00:04:00,319
lies in the study of interactions which

80
00:04:05,350 --> 00:04:02,000
are difficult to measure

81
00:04:07,990 --> 00:04:05,360
such as this supersonic combustor

82
00:04:10,229 --> 00:04:08,000
the combustion process shown was modeled

83
00:04:12,869 --> 00:04:10,239
as two hydrogen jets

84
00:04:16,310 --> 00:04:12,879
operating at a pressure ratio of eight

85
00:04:18,949 --> 00:04:16,320
and injecting into a rectangular duct

86
00:04:19,509 --> 00:04:18,959
compression waves are generated upstream

87
00:04:21,670 --> 00:04:19,519
of each

88
00:04:23,350 --> 00:04:21,680

jet as can be seen from these color

89
00:04:25,990 --> 00:04:23,360
contours

90
00:04:28,550 --> 00:04:26,000
on the top wall the two jets create an

91
00:04:30,390 --> 00:04:28,560
adverse pressure gradient which causes

92
00:04:31,909 --> 00:04:30,400
the free stream particles to move

93
00:04:35,510 --> 00:04:31,919
outward laterally

94
00:04:38,790 --> 00:04:35,520
as well as downward the jets are bent

95
00:04:40,310 --> 00:04:38,800
by the free stream the second jet

96
00:04:42,390 --> 00:04:40,320
penetrates more deeply

97
00:04:43,990 --> 00:04:42,400
into the free stream flow than the first

98
00:04:47,909 --> 00:04:44,000
jet

99
00:04:51,749 --> 00:04:47,919
mixing of hydrogen

100
00:04:56,150 --> 00:04:51,759
and air and consequently more complete

101
00:04:57,990 --> 00:04:56,160
combustion computational fluid dynamics

102
00:05:00,469 --> 00:04:58,000
is also being used

103
00:05:01,430 --> 00:05:00,479
to study the interaction of the external

104
00:05:04,870 --> 00:05:01,440
environment

105
00:05:08,469 --> 00:05:04,880
with a propulsion system in this example

106
00:05:11,830 --> 00:05:08,479
an under expanded 3d asymmetric nozzle

107
00:05:15,430 --> 00:05:11,840
at a pressure ratio of 10 exhaust

108
00:05:18,710 --> 00:05:15,440
supersonically into quiescent air

109
00:05:21,909 --> 00:05:18,720
nozzle flow expands laterally downstream

110
00:05:22,469 --> 00:05:21,919
of the lower lip compression waves

111
00:05:25,189 --> 00:05:22,479
reflect

112
00:05:26,070 --> 00:05:25,199
off the upper and lower shear layers and

113
00:05:30,550 --> 00:05:26,080

a very thin

114
00:05:35,189 --> 00:05:32,469
the high temperature high stress

115
00:05:37,270 --> 00:05:35,199
requirements of modern aircraft engines

116
00:05:38,390 --> 00:05:37,280
necessitate the development of novel

117
00:05:40,550 --> 00:05:38,400
materials

118
00:05:43,670 --> 00:05:40,560
the study of which can greatly benefit

119
00:05:47,430 --> 00:05:43,680
from computational material science

120
00:05:48,310 --> 00:05:47,440
metals ceramics polymers and composites

121
00:05:51,110 --> 00:05:48,320
of these

122
00:05:52,070 --> 00:05:51,120
are all employed to satisfy the high

123
00:05:55,350 --> 00:05:52,080
temperature

124
00:05:57,430 --> 00:05:55,360
strength and durability requirements

125
00:05:59,909 --> 00:05:57,440
material science is concerned with

126
00:06:01,029 --> 00:05:59,919
phenomena that range from rapid material

127
00:06:03,029 --> 00:06:01,039
processes

128
00:06:04,150 --> 00:06:03,039
with solidification rates measured in

129
00:06:07,270 --> 00:06:04,160
meters per second

130
00:06:08,629 --> 00:06:07,280
in melt spinning to deposition rates of

131
00:06:11,990 --> 00:06:08,639
microns per hour

132
00:06:15,990 --> 00:06:12,000
in chemical vapor deposition

133
00:06:18,710 --> 00:06:16,000
temperature coatings

134
00:06:19,990 --> 00:06:18,720
fibers and semiconductors such as

135
00:06:23,510 --> 00:06:20,000
silicon carbide are

136
00:06:24,790 --> 00:06:23,520
made this process involves injecting a

137
00:06:27,590 --> 00:06:24,800
nutrient gas

138
00:06:28,710 --> 00:06:27,600

into a reactor in which the gas then

139
00:06:31,670 --> 00:06:28,720
undergoes several

140
00:06:32,870 --> 00:06:31,680
gas phase chemical reactions as it

141
00:06:36,550 --> 00:06:32,880
passes across

142
00:06:39,510 --> 00:06:36,560
a heated susceptor subsequent surface

143
00:06:43,590 --> 00:06:39,520
reactions deposit the needed materials

144
00:06:46,390 --> 00:06:43,600
in this case silicon on the susceptor

145
00:06:49,830 --> 00:06:46,400
the computer simulation shown includes

146
00:06:52,309 --> 00:06:49,840
the 3d aspects of the reactor

147
00:06:54,710 --> 00:06:52,319
strong natural buoyancy causes

148
00:06:55,670 --> 00:06:54,720
substantial distortions of convecting

149
00:06:58,390 --> 00:06:55,680
fields

150
00:07:00,710 --> 00:06:58,400
shown here as path lines of neutrally

151
00:07:02,469 --> 00:07:00,720
buoyant particles

152
00:07:05,270 --> 00:07:02,479
subsequent distortions in both the

153
00:07:07,950 --> 00:07:05,280
temperature and reacting species fields

154
00:07:09,270 --> 00:07:07,960
are evident resulting in severe

155
00:07:13,110 --> 00:07:09,280
non-uniformities

156
00:07:15,830 --> 00:07:13,120
in coating thickness and structure

157
00:07:17,909 --> 00:07:15,840
additional analyses show an excellent

158
00:07:19,990 --> 00:07:17,919
agreement between the experimental and

159
00:07:21,990 --> 00:07:20,000
numerical deposition rates on the

160
00:07:24,150 --> 00:07:22,000
susceptor

161
00:07:25,670 --> 00:07:24,160
this study shows that computational

162
00:07:28,469 --> 00:07:25,680
material science

163
00:07:29,430 --> 00:07:28,479

can provide information important for

164
00:07:32,550 --> 00:07:29,440
the understanding

165
00:07:34,710 --> 00:07:32,560
and design of new materials

166
00:07:37,670 --> 00:07:34,720
the nasa lewis research center couples

167
00:07:39,990 --> 00:07:37,680
computational and experimental programs

168
00:07:43,589 --> 00:07:40,000
for efficiently meeting the requirements

169
00:07:45,350 --> 00:07:43,599
of modern aircraft engines

170
00:07:47,350 --> 00:07:45,360
the development and practical

171
00:07:48,950 --> 00:07:47,360
application of advanced numerical

172
00:07:51,670 --> 00:07:48,960
simulation codes

173
00:07:52,550 --> 00:07:51,680
for propulsion systems will require

174
00:07:55,749 --> 00:07:52,560
increases

175
00:07:58,469 --> 00:07:55,759
in computing power that is speed

176
00:08:00,070 --> 00:07:58,479
and memory these advances will have to

177
00:08:01,990 --> 00:08:00,080
be matched by improvements in

178
00:08:04,230 --> 00:08:02,000
computational support

179
00:08:05,749 --> 00:08:04,240
program development and computer

180
00:08:09,670 --> 00:08:05,759
graphics

181
00:08:12,790 --> 00:08:09,680
important because of the massive amounts

182
00:08:15,670 --> 00:08:12,800
of data that need to be understood

183
00:08:17,990 --> 00:08:15,680
the lewis goal in scientific computing

184
00:08:19,350 --> 00:08:18,000
is to provide high performance graphics

185
00:08:22,230 --> 00:08:19,360
workstations

186
00:08:23,189 --> 00:08:22,240
having access to parallel processors

187
00:08:27,270 --> 00:08:23,199
mainframe

188
00:08:30,070 --> 00:08:27,280

and supercomputers nasa lewis research

189
00:08:31,589 --> 00:08:30,080
center is moving as rapidly as possible

190
00:08:34,230 --> 00:08:31,599
towards the establishment of a

191
00:08:36,550 --> 00:08:34,240
high-performance computing environment

192
00:08:37,670 --> 00:08:36,560
that will satisfy the long-term

193
00:08:40,469 --> 00:08:37,680
experimental