FLEX
(Flame Extinguishment Experiment)

1
00:00:06,630 --> 00:00:05,269
strange flames on the international

2
00:00:09,990 --> 00:00:06,640
space station

3
00:00:12,230 --> 00:00:10,000
presented by science at nasa

4
00:00:14,629 --> 00:00:12,240
fire it is often said is mankind's

5
00:00:16,310 --> 00:00:14,639
oldest chemistry experiment

6
00:00:18,790 --> 00:00:16,320
for thousands of years people have been

7
00:00:20,950 --> 00:00:18,800
mixing the oxygen-rich air of earth with

8
00:00:23,189 --> 00:00:20,960
an almost endless variety of fuels to

9
00:00:24,550 --> 00:00:23,199
produce hot luminous flame

10
00:00:25,990 --> 00:00:24,560
there's an arc of learning about

11
00:00:28,310 --> 00:00:26,000
combustion that stretches from the

12
00:00:30,470 --> 00:00:28,320
earliest campfires of primitive humans

13
00:00:32,229 --> 00:00:30,480

to the most advanced automobiles racing

14
00:00:33,830 --> 00:00:32,239
down the super highways of the 21st

15
00:00:35,510 --> 00:00:33,840
century

16
00:00:37,830 --> 00:00:35,520
engineers study burning to produce

17
00:00:39,670 --> 00:00:37,840
better internal combustion engines

18
00:00:41,510 --> 00:00:39,680
chemists peer into flames looking for

19
00:00:43,430 --> 00:00:41,520
exotic reactions

20
00:00:44,950 --> 00:00:43,440
chefs experiment with fire to cook

21
00:00:46,630 --> 00:00:44,960
better food

22
00:00:47,750 --> 00:00:46,640
you would think there's not much more to

23
00:00:49,750 --> 00:00:47,760
learn

24
00:00:51,590 --> 00:00:49,760
dr foreman a williams a professor of

25
00:00:54,150 --> 00:00:51,600
physics at the university of california

26
00:00:56,470 --> 00:00:54,160
san diego would disagree

27
00:00:58,470 --> 00:00:56,480
when it comes to fire he says we're just

28
00:01:00,470 --> 00:00:58,480
getting started

29
00:01:02,229 --> 00:01:00,480
flames are hard to understand because

30
00:01:04,630 --> 00:01:02,239
they're complicated

31
00:01:07,030 --> 00:01:04,640
in an ordinary candle flame thousands of

32
00:01:09,030 --> 00:01:07,040
chemical reactions take place

33
00:01:11,670 --> 00:01:09,040
hydrocarbon molecules from the wick are

34
00:01:13,590 --> 00:01:11,680
vaporized and cracked apart by heat

35
00:01:17,670 --> 00:01:13,600
they combine with oxygen to produce

36
00:01:19,830 --> 00:01:17,680
light heat carbon dioxide and water

37
00:01:22,149 --> 00:01:19,840
some of the hydrocarbon fragments form

38
00:01:25,030 --> 00:01:22,159

ring-shaped molecules called polysilic

39
00:01:26,550 --> 00:01:25,040
aromatic hydrocarbons and eventually

40
00:01:31,109 --> 00:01:26,560
soot

41
00:01:33,429 --> 00:01:31,119
simply drift away as smoke

42
00:01:35,749 --> 00:01:33,439
the familiar teardrop shape of the flame

43
00:01:38,230 --> 00:01:35,759
is an effect caused by gravity

44
00:01:39,429 --> 00:01:38,240
hot air rises and draws fresh cool air

45
00:01:41,429 --> 00:01:39,439
behind it

46
00:01:44,469 --> 00:01:41,439
this is called buoyancy and is what

47
00:01:46,230 --> 00:01:44,479
makes the flame shoot up and flicker

48
00:01:49,350 --> 00:01:46,240
but what happens when you light a candle

49
00:01:52,069 --> 00:01:49,360
say on the international space station

50
00:01:55,270 --> 00:01:52,079
in microgravity flames burn differently

51
00:01:57,190 --> 00:01:55,280
they form little spheres says williams

52
00:01:58,950 --> 00:01:57,200
space station flame balls turn out to be

53
00:02:00,230 --> 00:01:58,960
wonderful mini labs for combustion

54
00:02:02,310 --> 00:02:00,240
research

55
00:02:04,310 --> 00:02:02,320
unlike flames on earth which expand

56
00:02:07,510 --> 00:02:04,320
greedily when they need more fuel

57
00:02:09,990 --> 00:02:07,520
flame balls let the oxygen come to them

58
00:02:11,830 --> 00:02:10,000
oxygen and fuel combine in a narrow zone

59
00:02:14,229 --> 00:02:11,840
at the surface of the sphere

60
00:02:16,630 --> 00:02:14,239
not hither and yawn throughout the flame

61
00:02:18,470 --> 00:02:16,640
it's a much simpler system

62
00:02:20,309 --> 00:02:18,480
recently williams and colleagues were

63
00:02:22,390 --> 00:02:20,319

doing a space station experiment called

64
00:02:24,229 --> 00:02:22,400
flex to learn how to put out fires in

65
00:02:25,990 --> 00:02:24,239
microgravity when they came across

66
00:02:27,990 --> 00:02:26,000
something odd

67
00:02:30,630 --> 00:02:28,000
small droplets of heptane were burning

68
00:02:32,949 --> 00:02:30,640
inside the flex combustion chamber

69
00:02:34,949 --> 00:02:32,959
as planned the flames went out

70
00:02:36,630 --> 00:02:34,959
but unexpectedly the droplets of fuel

71
00:02:39,030 --> 00:02:36,640
continued burning

72
00:02:41,110 --> 00:02:39,040
that's right burning without flames says

73
00:02:42,550 --> 00:02:41,120
williams at first we didn't believe it

74
00:02:44,710 --> 00:02:42,560
ourselves

75
00:02:47,030 --> 00:02:44,720
in fact williams believes the flames are

76
00:02:50,070 --> 00:02:47,040
there just too faint to see

77
00:02:52,229 --> 00:02:50,080
these are cool flames he explains

78
00:02:54,869 --> 00:02:52,239
ordinary visible fire burns at a high

79
00:02:56,630 --> 00:02:54,879
temperature between 2200 and 3100

80
00:02:58,630 --> 00:02:56,640
degrees fahrenheit

81
00:03:01,430 --> 00:02:58,640
heptane flame balls on the space station

82
00:03:03,270 --> 00:03:01,440
started out in this hot fire regime

83
00:03:05,110 --> 00:03:03,280
but as the flame balls cooled and began

84
00:03:06,869 --> 00:03:05,120
to go out a different kind of burning

85
00:03:08,869 --> 00:03:06,879
took over

86
00:03:11,110 --> 00:03:08,879
cool flames burn at the relatively low

87
00:03:12,949 --> 00:03:11,120
temperature of 400 to 1000 degrees

88
00:03:14,710 --> 00:03:12,959

fahrenheit says williams

89
00:03:15,990 --> 00:03:14,720
and their chemistry is completely

90
00:03:17,910 --> 00:03:16,000
different

91
00:03:19,910 --> 00:03:17,920
normal flames produce soot carbon

92
00:03:21,990 --> 00:03:19,920
dioxide and water

93
00:03:23,750 --> 00:03:22,000
cool flames produce carbon monoxide and

94
00:03:25,509 --> 00:03:23,760
formaldehyde

95
00:03:27,430 --> 00:03:25,519
similar cool flames have been produced

96
00:03:28,710 --> 00:03:27,440
on earth but they flicker out almost

97
00:03:30,869 --> 00:03:28,720
immediately

98
00:03:33,030 --> 00:03:30,879
on the space station however cool flames

99
00:03:34,550 --> 00:03:33,040
can burn for nearly a minute

100
00:03:36,550 --> 00:03:34,560
there are practical implications of

101
00:03:38,550 --> 00:03:36,560
these results notes williams

102
00:03:40,390 --> 00:03:38,560
for instance they could lead to cleaner

103
00:03:41,910 --> 00:03:40,400
auto ignitions

104
00:03:45,030 --> 00:03:41,920
one of the ideas that auto companies

105
00:03:47,030 --> 00:03:45,040
have worked on for years is hcci

106
00:03:48,470 --> 00:03:47,040
short for homogeneous charge compression

107
00:03:50,390 --> 00:03:48,480
ignition

108
00:03:52,309 --> 00:03:50,400
in the automobile cylinder instead of a

109
00:03:53,910 --> 00:03:52,319
spark there would be a gentler less

110
00:03:55,350 --> 00:03:53,920
polluting combustion process throughout

111
00:03:57,670 --> 00:03:55,360
the chamber

112
00:04:00,470 --> 00:03:57,680
the chemistry of hcci involves cool

113
00:04:02,309 --> 00:04:00,480

flame chemistry says williams the extra

114
00:04:03,990 --> 00:04:02,319
control we get from steady-state burning

115
00:04:05,910 --> 00:04:04,000
on the space station will give us more

116
00:04:07,350 --> 00:04:05,920
accurate chemistry values for this type

117
00:04:09,750 --> 00:04:07,360
of research

118
00:04:11,350 --> 00:04:09,760
just getting started indeed

119
00:04:13,350 --> 00:04:11,360
for more information about strange