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PROGRESS REPORT ON GRANT NO. DE-FG02-84CH10205

ESTABLISHING FEASIBILITY FOR PROVIDING PASSIVE COOLING
WITH SOLAR UPDRAFT AND EVAPORATIVE DOWNDRAFT CHIMNEYS

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PROJECT STATUS AND OVERVIEW

At the present time all experimental towers (chimneys) are completed and operating. This consists of both a solar updraft and a naturalⁱ-evaporative downdraft tower retrofitted to an existing residence structure and a greenhouse. The residential, experimental, natural-draft cooling system was completed in May, 1985, and we have acquired five months of summer data on a Hewlet Packard 85 data acquisition computer with a digital voltmeter. The cooling tower and solar chimney on the experimental greenhouse became operational in September of 1985, (See the September 1985 report for a more detailed account of the cooling tower and solar chimney designs). A conceptual drawing of both the greenhouse and the residence natural-draft towers is included in the appendix along with the September 85 progress report.

In general, the results of this work have been very favorable. The residential structure performed very well during the record breaking hot summer of 1985. Temperatures inside the house never rose above 78F, while outside temperatures rose to 109 in June. Again during the August monsoon season, when conditions are at their worst for evaporative cooling, inside temperatures stayed below 78, although the ambient wet bulb reached 75F. Computer-generated graphical data for the hottest days of June, July, and August are also included in the appendix.

This passive cooling strategy has attracted much interest from the public, and has been highly publicized by the press. Judging from the responses we have received to date, this technology is likely to have a significant impact on the HVAC industry. The University of Arizona has applied for a patent on this invention, and a patent search is now in progress.

CURRENT EFFORT

We are currently working on correlating the data to determine the flow resistances for the house, attic, pads, etc. A flow problem in with the greenhouse tower has been encountered, and this is being pursued. Due to the nature of this passive cooling project, the majority of the experiments need to be done during the summer. As the weather warms up in the spring, the pace of the experiments will increase on both the residence and the greenhouse natural-draft cooling towers.

If this project is continued for the third year, more work will be done, improving the efficiency of the downdraft cooling towers. Barometric (gravity) dampers are of primary interest to improve the tower performance. The third year of this project will also be employed reducing this technology to practice, in order that engineers and architects will have design tools that can be easily used.

FOG/MIST CONSIDERATIONS

Initially we had thought that a fog/mist type of system would be an improvement over a wetted pad, but we can now see where this type of system would have a significant control problem. Ideally there is only one airflow rate and humidity that will work with one fog/mist control valve setting. For optimum performance one would need to continually adjust the water flow rate to match the varying conditions of the incoming air, or waste the excess water. For example, if the weather were windy, hot and dry, the water flow should be higher than in a less windy period at the same temperature and humidity. During a strong gust of wind the airflow would exceed the fixed rate of humidification of the fog system, and warm dry air would enter the structure. Also, pumping and equipment costs are much higher for the high-pressure fog than for the low-pressure wetted pad system.

SOLAR CHIMNEY CONSIDERATIONS

At the beginning of this project, we thought that a solar chimney would be necessary for this design to work at its optimum. Now, after further analysis and experience, we feel that the solar chimney is not necessary. In order for the solar chimney to contribute to the performance of the system, the air in it must be hotter than the ambient. A solar chimney that will do this must be quite large to heat the large airflow. (Our residence structure natural-draft

cooling system usually moves 3000 to 4000 cubic feet of air per minute, which is required for evaporative cooling.) The residence structure uses the entire roof as a solar collector to drive the solar chimney. This creates temperatures inside the solar chimney of 10 to 20F above ambient from 10 AM until 3 PM, and all other times of the day and night, the solar chimney works against the flow because the air inside is colder than the ambient.

Windows on the leeward side of the structure may also be used effectively to exhaust air from the building. To avoid opening and closing windows as the wind changes direction, a special exhaust structure may be used. The exhaust structure should be designed to take advantage of the wind from any direction. This can be accomplished by having openings on all sides allowing the wind to blow through and create a low pressure inside the structure. During the summer of 86 we will experiment using only the downdraft cooling tower, exhausting through the windows.

GEEENHOUSE COOLING TOWER PERFORMANCE

Airflow velocities of over 300 feet per minute have been measured in the experimental greenhouse. With the current design, it appears that wind is the dominating driving force for the airflow. Calm days produce air velocities of less than 50 feet per minute, which is lower than would be expected from the density differences. This low velocity is

believed to be caused by a small airflow that we have discovered flowing up the downdraft chimney, and we are currently investigating methods to prevent it. This reverse flow is along the top of the greenhouse and up the inside of the tower. To stop the reverse flow a polyethylene curtain was hung between the cooling tower and the greenhouse, leaving two to three feet open at the bottom. After this curtain was installed, the back flow was reduced, although it was still present in the corners of the cooling tower. We have never seen this occur in the smaller residential cooling tower, and believe it could be related to rectangular geometry of the greenhouse towers. We may have to divide the rectangular tower into square cells for the system to operate at its optimum capacity, or perhaps a more efficient barometric damper will be necessary. This is something that we need to investigate further and will work on this Spring and during the third year.

Temperatures in the center of the greenhouse have been three to four degrees Fahrenheit cooler than the ambient, and about three degrees warmer than ambient at the exhaust end on the structure. Without cooling towers, the inside temperatures could easily stagnate at 50F hotter than the ambient. Ideally we would like to have the temperatures about 10 degrees lower than the ambient. The higher temperatures are due to the low airflow rates which are caused by the reverse flow discussed above.

APPENDIX

5' LONGITUDINAL SECTION

COOLING CYCLE AIRFLOW GREENHOUSE

W SECTION
LOOKING SOUTH

ISOMETRIC
E.H. GREENHOUSE

E SECTION
LOOKING NORTH

ISOMETRIC
E.H. SOLAR VILLAGE STRUCTURE H1'S

COOLING CYCLE AIRFLOW RESIDENCE

4' SECTION

<p>SOLAR S</p>	<p>grant # DEFG02 94CH10205</p>	<p>PASSIVE COOLING CONCEPT SOLAR UPGRADE & EVAPORATIVE DOWNDRAFT CHIMNEY'S</p>	<p>University of Arizona Environmental Research Laboratory</p>
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