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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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Time Period: March 1985 - September 1985

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Overview

At the present time all experimental towers (chimneys) are completed, and operating. This consists of both a solar updraft and a natural evaporative downdraft tower built onto an existing residence structure and a greenhouse.

Project Status -Residence Design and Performance

The test structure chosen for this work is called Structure 3, which is a well insulated frame building with 1000 square feet of floor space, and is part of ERL'S Passive Solar Village. Structure 3 was retrofitted with an evaporative cooling tower that measures 6 ft X 6 ft in cross section and is 25 ft tall. The downdraft tower uses frame construction with plywood siding and one inch of Styrofoam insulation on the inside. At the top, a 4 inch thick, vertical, wetted cellulose pad was used to cool the air. A plywood "X" baffle in the top prevents air from blowing straight through the tower and acts to catch wind and funnel it downward. A 1/15 HP pump recirculates the water over the pads from a sump at the base of the pads, and in the near future this will be replaced with a more efficient 1/25 HP pump. Make-up water is added and regulated with a typical cooler type float valve. Vertical pads were chosen over horizontal pads primarily because of the reduction in pumping requirements. A Horizontal pad arrangement would require a larger pump with a sump at the base of the tower. Earlier consideration was given to a fog/mist type of system for humidification and cooling, but the idea was rejected due to the high pumping energy and control problems.

The solar chimney is also built of wood frame and plywood but without insulation and measures 11 ft X 4 ft X 25 ft tall. The entire roof and attic space is used as a solar collector to drive the solar chimney. This is achieved by exhausting all of the return air thru the ceiling into the attic. The exhaust air makes two passes thru the attic due to a baffle down the center of the ridge. This cools the attic and heats the air in the solar chimney. The design airflow rate for this cooling experiment is 3000 cubic feet per minute, which is an air change every 2.67 minutes.

Construction of the experimental natural draft chimneys on Structure 3 was completed during the first week of May 1985, and data has been taken on a Hewlett Packard computerized data acquisition system since May 14, 1985.

Performance of the residential cooling system has been very promising throughout the summer of 1985. Performance data for the hottest days of June, July, and August are included at the end of this report.

Data graphs show ambient outside air temperature, inside air temperature, and the wet bulb temperature. Notice that the inside air temperature NEVER exceeded 78°F all summer.

Project Status - Greenhouse Design

An existing 2300 square foot greenhouse has been retrofitted with a 25 foot tall down draft cooling tower at the south end, and a 15 foot tall solar chimney on the north. The greenhouse is 24 feet by 96 feet long and oriented with its long axis running north and south. Both chimneys are constructed with steel bar joists set into concrete, and glazed with polyethylene. Since the cooling tower is on the south, it is glazed with clear poly to avoid casting a shadow on the greenhouse floor. This tower uses the same type of 4 inch thick cellulose cooling pad and sump return trough as the residential tower. A 1/3 HP submersible pump circulates water over the 2.5 feet tall cooling pads. This tower also has a baffle to catch the wind and funnel it downward into the greenhouse. The baffle is made of polyethylene and also acts as a barometric damper that closes off the leeward side of the tower when the wind blows.

The solar chimney height was reduced to 15 feet from the planned 25 foot height. This change was made because the analysis showed that the taller tower would reduce the airflow, due to the inside temperatures being lower than the ambient. It is glazed with clear fiberglass on its south side to take maximum advantage of the solar gain, and black polyethylene on the north side to absorb it. The exhaust structure has a plywood roof, but is completely open three feet below the roof to take advantage of the wind. Any wind blowing through the top of this tower will create a low pressure inside the tower, and pull air out of the greenhouse. Although wind will enhance the airflow of either tower it is not necessary for this cooling system to operate properly; it will work well when there is no wind at all.

Instrumentation for computerized data acquisition is currently being installed. Data will be taken with hand held instruments until the automated system is running.

RUN PERIOD: 85/06/05 00:00 THRU 85/06/09 23:00-Julian hours: 3720 to 3839

COOL TOWER PERFORMANCE DATA

RUN PERIOD: 85/07/07 00:00 THRU 85/07/12 23:00-Julian hours: 4488 to 4631
RUN PERIOD: 85/07/07 00:00 THRU 85/07/12 23:00-Julian hours: 4488 to 4631

COOL TOWER PERFORMANCE DATA

RUN PERIOD: 85/08/19 00:00 THRU 85/08/23 23:00-Julian hours: 5520 to 5639

COOL TOWER PERFORMANCE DATA

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