DOE/CE/26559--T7

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DISTRICT COOLING

PROJECT TITLE: Phase II - Direct Freeze Ice Slurry System Testing

OBJECTIVES: The objectives of this research are to:

1. Extend the range of pressure drop data for ice-water slurry flows.
2. Design and build a prototypical ice slurry distribution system which demonstrates ice slurry handling at an end user's heat exchanger, without sending ice slurry directly through the heat exchanger.

Previous research (Phase I) conducted by CBI under DOE contract DE-FG01-86CE26564 has shown a friction reducing effect of ice crystals in water flow. The results of this work demonstrated a 40% reduction in pump power required to move an ice-water slurry versus the same mass flow of water only. In addition to lower pressure drop, pumping ice slurries is advantageous because of the large latent and sensible heat cooling capacity stored in the ice compared to only sensible heat in chilled water. For example, an ice-water slurry with a 20% ice fraction (by mass) has a mass flow rate that is 70% less than the mass flow rate required for a chilled water system cooling and equivalent load. The greatly reduced mass flow combined with the friction reducing effects of ice-water slurries results in a total savings of 83% in pumping power. Therefore, a substantial savings potential exists for capital costs and system operating costs in ice-water slurry district cooling systems.

One potential disadvantage of an ice-slurry district cooling system is the introduction of ice into equipment not so designed, such as air handlers at end user locations. A prototypic ice slurry distribution loop will demonstrate a cooling network which will provide ice slurry to an end user but sends ice free water into the actual heat transfer.

To clearly determine and document the economic benefits of ice-water slurries in district cooling systems, more research is necessary to extend the range of data for pressure drop in ice-water slurries and to demonstrate an efficient method for handling ice slurries throughout the system.

RESEARCH PLAN:

Task 1: The existing Ice Slurry District Cooling Pilot Plant from Phase I will undergo modifications. First, the 10 ton lubricated reciprocating compressor will be replaced with a oil-free type, and the system will be cleaned to remove all residual oil. An oil-free compressor will eliminate traces of oil present in the ice slurry pressure drop test sections and thus allow a confirmation that the pressure drop results of Phase I were not affected by the presence of oil in the system. The existing variable speed pump will be replaced with a new one designed to deliver the higher flowrates required to extend the pressure drop data. Instrumentation will also be modified as necessary.

Task 2: All instrumentation will be calibrated and the ice generation system will be charged and started up. The pressure drop tests will be performed up to the maximum ice fraction for each of the test sections for several fluid velocities.

Task 3: An interim report will be prepared for the pressure drop results.

Task 4: The ice slurry distribution loop will be designed and built consisting of:

- a slurry vessel capable of supplying an ice slurry to the loop using ice-free water returning from the loop,
- two end user locations with variable cooling loads,
- an ice slurry mixing section which accepts slurry from the main distribution loop and mixes it with a portion of the warm water leaving the heat exchanger to produce an ice-free flow to the heat exchanger,
- the necessary instrumentation to monitor and control these tests, and
- a central ice storage tank to facilitate thermal energy storage.

Task 5: All instrumentation will be calibrated and slurry vessel performance will be verified. The characteristics of the ice extraction section will be determined and the system operation will be automated.

Task 6: An interim report will be prepared for the ice slurry distribution results.

Task 7: A final report will be prepared.

MILESTONES:

	Original Estimated Completion	Actual Completion
Task 1:	5/89	6/89
Task 2:	8/89	7/90
Task 3:	8/89	8/90
Task 4:	9/89	8/90
Task 5:	12/89	12/90
Task 6:	12/89	
Task 7:	1/90	

CURRENT STATUS:

During the first quarter of 1989, all items included in Task 1 as described in the Research Plan were completed except for the installation of some instrumentation.

During the second quarter of 1989, Task 1 was completed. Some calibration has been completed in Task 2. Other items in Task 2 are ongoing.

During the third quarter of 1989, work consisted of calibration work under Task 2. The preliminary distribution loop design under Task 4 has also been completed.

During the fourth quarter of 1989, Task 2 calibration work was completed and efforts were shifted toward gaining operating experience with the modified system.

In the first quarter of 1990, significant progress was made toward the successful operation of the system for Task 2. Most of the detailed design work in Task 4 has been completed and most major equipment has been procured.

During the second quarter of 1990, the accuracy of the existing slurry velocity instrumentation was analyzed. A new flowmeter was purchased and installed at the Contractor's expense and work resumed on the completion of Task 2 data collection. Task 4 system design and procurement are complete and most of the construction work is finished.

In the third quarter of 1990, the Task 2 pressure drop tests were successfully completed. The Task 3 interim report for this work was also completed and submitted to DOE. The Task 4 slurry distribution loop construction has been completed and progress is being made on the Task 5 performance evaluation.

In the fourth quarter of 1990, the Task 5 system characterization testing was completed and the Task 6 interim report was begun. In addition, a document was prepared to describe in more detail the results obtained in the Task 2 hydraulic testing and reported in the Task 3 interim report. This document was requested by DOE.

FUTURE ACTIVITIES: During the next quarter, the Task 6 interim report and the Task 7 final report will be drafted and submitted to DOE.

COMMUNICATIONS: Chicago Bridge & Iron Technical Services Company is responsible for all phases of this research program.

Conferences: IDHCA, Virginia Beach, VA, June 1989

District Cooling Feasibility Assessment Contractors Meeting, New Orleans, LA, August 1989

ASHRAE, Atlanta, GA, February 1990

IDHCA, Toronto, CA, June 1990

ASHRAE, St. Louis, MO, June 1990

IDHCA, Pittsburgh, PA, October 1990

PUBLICATIONS: Knodel, B.D. "Phase II - Direct Freeze Ice Slurry District Cooling", presented at the 80th Annual Conference of the International District Heating and Cooling Association, Virginia Beach, VA, June 1989.

RESEARCH PRODUCTS: An Ice Slurry District Cooling Pilot Plant

Capabilities:

Ice Slurry Generation System:
- 5 ton refrigeration capacity
- Continuous ice generation by direct contact heat exchange between a refrigerant and fresh water
- Oil-free compressor technology

Ice Slurry Pressure Drop Test Section:
- Three 25 foot test sections 2", 4" and 6" in diameter
- Variable speed pump capable of delivering a slurry flow up to 1,300 gpm

Ice Slurry Distribution Loop:
- 5 ton cooling capacity
- Two user locations capable of simulating variable cooling loads
- One ice storage tank for simulating thermal energy storage

PROJECT
INFORMATION:

Contractor: Chicago Bridge & Iron Technical Services Co.

Principal Investigator: Philip J. Winters

Other Researchers: Arif Y. Kiziltug, Richard J. Kooy

Starting Date of Contract: 12/88

Completion Date of Contract: 12/90

Total Funding to Date:

Federal Funding: $143,000
Private Sector Participation: $48,000

Total FY 1989 Funding:

Federal Funding: $143,000 (Grant)
Private Sector Participation: $48,000

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