

Flihy Summary: Calorimetry Results

Brent Freeze

APEX 2nd electronic meeting

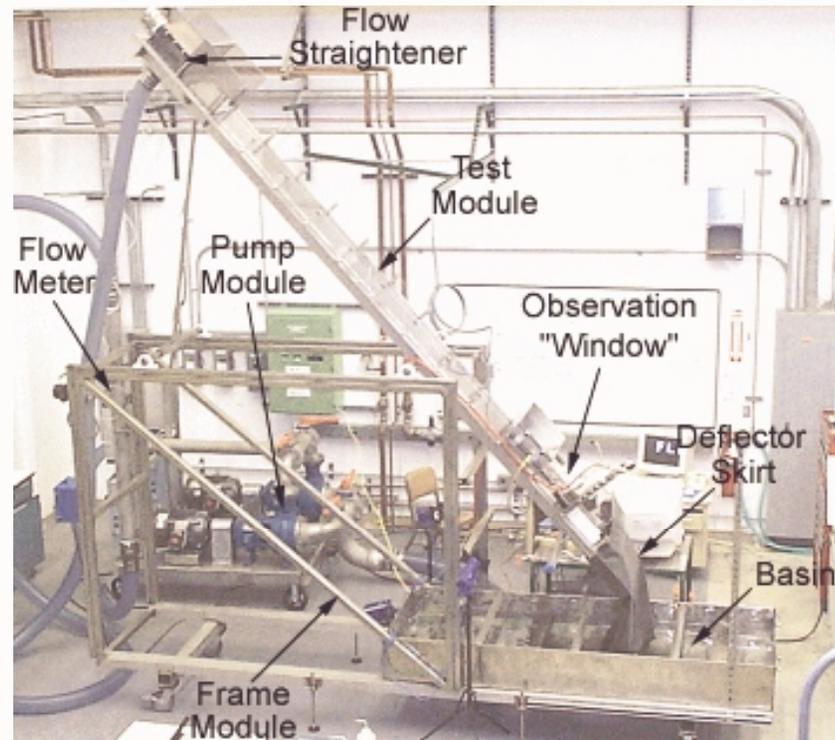
August 13, 2002

Overview

- Background of FliHy Facility
- Problem Statement
- Calorimetry Experiment
- Energy Balance Analysis
- Summary of Results

FliHy Facility Background

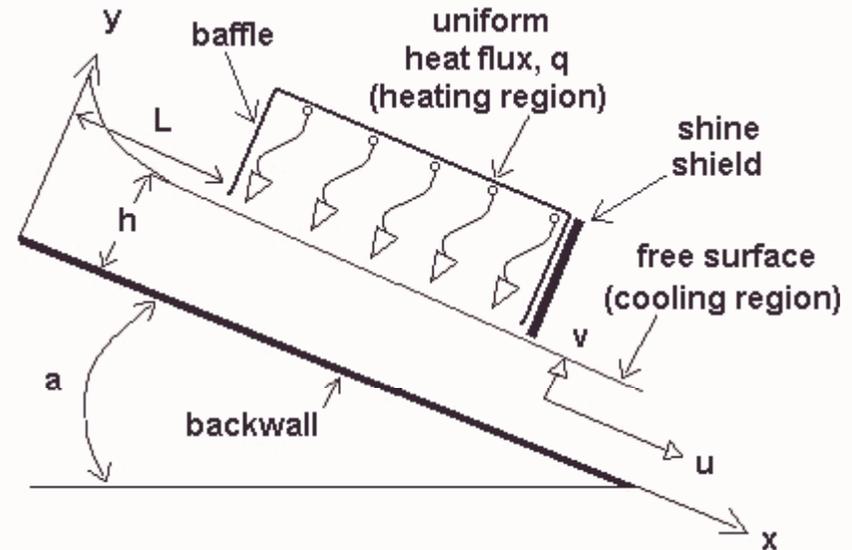
- Studies inclined ($\alpha > 1$), wavy ($Fr > 1$), and turbulent ($Re > 10^4$) fully developed flow
- Thermograph diagnostic makes use of IR heater and camera to find free surface temp. field
- Quantifying heat flux is important for modeling



Flibe Hydrodynamics Facility (FliHy) at UCLA

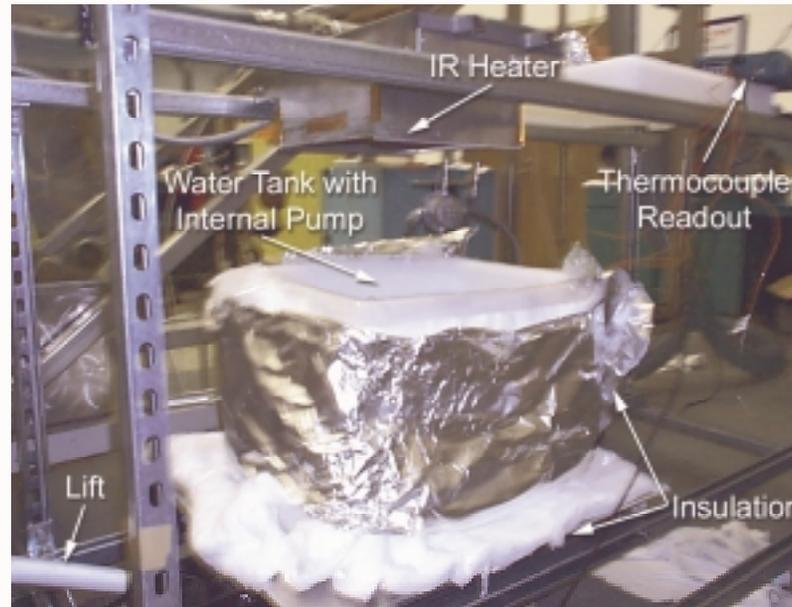
Energy Balance Problem

- IR heater electrical energy input readout did not equal thermal input into water bulk
- Initially attributed to structural and other loss mechanisms
- Special calorimetry experiment performed to ascertain energy balance



Cross-sectional diagram of IR heater and flow beneath it.

Calorimetry Experiment



The reduced scale testing facilities provide conditions the same as those in the FliHy experiment:

- the same heater;
- the same location of the heater unit above the water
 - the same heating regime;
- water circulation with the same velocity;
- waviness similar to that in FliHy.

This gives credence to the application of the reduced scale facility (calorimetry) results to FliHy's energy balance.

Energy Balance Analysis

$$Q = \frac{W_{\text{elec}} P - L_{\text{heatsink}} - L_{\text{evap}} - L_{\text{free}} - L_{\text{forced}} - L_{\text{rad}}}{\text{Area}}$$

	Measured Heater Power (Averaged over Test Interval)		Calculated Losses (Averaged over Test Interval)						Net Power Absorbed			Power absorbed by Experimental Apparatus (averaged over test Interval)			
	Heater Hardware	Oscilloscope	Heater Structure Heat Capacity	Heater Shield Radiation	Surface Evaporation	Reflected Power	Chimney Effect	Convected by air stream	Predicted	Percentage Difference	Measured	Pump Power	Heating Tank	Heating Pump	Heating Water
Less Wavy	3093	2252	416	176	303	0	7	0	1350	1.7%	1373	-315	7	28	1653
More Wavy	3139	2292	352	112	516	0	5	0	1307	0.5%	1301	-315	49	27	1540

Losses discovered to be 50% of original readout value, due to:

- 1) Power supply readout error
- 2) Thermal Capacitance
- 3) Evaporation
- 4) Radiation
- 5) Free & Forced Convection

Summary of Calorimetry Results

- The reduced scale facilities were constructed to provide the same heat transfer conditions as those in FliHy, to perform calorimetry measurements. Different flow regimes (with and without waves) were tested to reproduce different flow regimes in the FliHy facility.
- The calorimetry measurements show that the amount of heat accumulated by water is within 45-50% of the original indicator readings (less convective and radiative losses), depending on the flow regime.
- The measurements were accompanied by analytical estimations to see the possible routes for heat loss. It has been found that the major losses are due to accumulating of heat by the heater unit itself and due to evaporation. The measurements and the estimations are in a good agreement.
- These calorimetry data will be used to analyze the heat transfer data obtained in the FliHy experiment. The sensitivity of the final data evaluated from the experimental results to changes in the heat flux has also been analyzed.