POOL BOILING HEAT TRANSFER UNIT

MODEL: HE 154

THIS Pool Boiling Heat Transfer Unit (Model: HE 154) has been designed for students demonstrations on convective, nucleate and film boiling. The unit mainly consists of a thick walled glass cylinder fitted internally with a heating element and a coil type condenser. Instrumentations are provided for the measurement of temperature, pressure, flowrate and power. The unit helps students to understand better the heat transfer processes from a hot region to a colder one in countless industrial applications, e.g. thermal and nuclear power generation in steam plants, refrigeration, heat transmission, etc.

DESCRIPTION

Boiling

During the production of vapour bubbles, due to surface tension, the vapour inside a bubble must be at a higher pressure than the surrounding liquid. The pressure difference increases as the diameter of the bubble decreases and is insignificant when the bubble is large. However, when the bubble is minute, an appreciable pressure difference exists.

The pressure inside a bubble is the vapour pressure corresponding with the temperature of the surrounding liquid. Thus, when no bubbles exist, or when they are very small, it is possible for the liquid temperature in the region of the heat transfer surface to be well above the temperature of the bulk of the liquid.

Convective Boiling

When the heating surface temperature is slightly hotter than the saturation temperature of the liquid, the excess vapour pressure is unlikely to produce bubbles. The locally warmed liquid expands and convection currents carry it to the liquid-vapour interface where evaporation takes place and thermal equilibrium is restored. Thus, in this mode, evaporation takes place at small temperature differences and with no bubble formation.

Nucleate Boiling

As the surface becomes hotter, the excess of vapour pressure over local liquid pressure increases and eventually bubbles are formed. These occur at nucleating points on the hot surface where minute gas pockets, existing in surface defects form the nucleus for the formation of a bubble. As soon as a bubble is formed, it expands rapidly as the warmed liquid evaporates into it.

The buoyancy detaches the bubble from the surface and another starts to form. Nucleate boiling is characterised by vigorous bubble formatic and turbulence. Exceptionally high heat transfer rates and heat transfer coefficients with moderate temperature differences occur in nucleate boiling, and in practical applications boiling is nearly always in this mode.

Film Boiling

As the heating surface temperature rises the rate of production of vapour bubbles becomes so high that eventually the surface becomes enveloped in a blanket or film of vapour which prevents the liquid from wetting the surface. When this happens, the insulating effect of the film greatly reduces the rate of heat transfer. Unless the heat input is correspondingly reduced, the heating surface temperature will rise until by a combination of radiation and convection the temperature difference is sufficient to drive the heat through the resistance offered by the vapour film. Frequently a metallurgical or other failure will occur before the new equilibrium condition is reached and for this reason the condition where film boiling is just established is often called “Burn Out”.

EXPERIMENTAL CAPABILITIES

- Visual demonstrations of convective, nucleate and film boiling.
- Direct and quick measurements of:
  a) rate of heat transfer
  b) surface temperature
  c) liquid temperature

  at pressures up to 2 Bar above atmospheric pressures.
- Calculation of heat flux and surface heat transfer coefficient in the three modes of boiling. This enables the production of graphs of:
  a) Heat Flux against Temperature Difference
  b) Heat Transfer Coefficient against Temperature Difference
  c) Critical Heat Flux against Saturation Pressure
- Demonstration of the phenomenon of “Burn Out” from which students readily appreciate the dangers and problems associated with boiling heat transfer at high heat fluxes.
- Demonstration of film condensation and provides data for the determination of overall heat transfer coefficient in a simple water cooled coil and shell condenser.
- Demonstration of the effect of air presence on the rate of heat transfer in a condenser.
- May be used as a Marcet Boiler to provide the saturation pressure / temperature relationship for a pure substance (R123) over limited pressure range.
- Demonstrates Dalton’s Law of Partial Pressures.

SPECIFICATIONS

Panel:

High quality epoxy coated frame laminated with formica, on which the chamber and instrumentations are mounted.

Chamber:

Thick walled glass cylinder with stainless steel end plates. The chamber houses the heating element and the condenser.
Size: 75 mm (dia.) x 300 mm (L)

Heating Element:

300 W “high watt density” cartridge heater swaged into a thick walled copper sleeve to give a uniform surface temperature. Effective heating surface area approximately 13cm^2.

Condenser:

9 coils of stainless steel tube. Mean surface area approximately 0.032 m^2

Variable Transformer:
To give infinitely variable heat input to the heating element.

Charging and Drain Valve:
Fitted to lower end plate to charge or discharge the R123.

INSTRUMENTATIONS

Voltage & Current Meter:
To measure electrical input to the heating element.

Temperature Sensors and Indicators:
To measure the surface temperature of the heating element.
To measure the water inlet and outlet temperatures
To measure the R123 liquid temperature
To measure the R123 vapour temperature

Pressure Gauge:
To measure the pressure in chamber
Range: -1 to 4 kg/cm^2

Water Flow Meter:
Range: 0 to 5 lpm

SAFETY

High Temperature Cut-out:
Incorporated in temperature indicator to interrupt electrical input to the heater element if its surface temperature exceeds 170 ^{o}C. The cut-out is "fail safe" in the event of the thermocouple becoming disconnected.

High Pressure Cut-out:
To interrupt electrical input if chamber pressure exceeds 2.2 kg/cm^2

Relief Valve:
To discharge vapour from the chamber when pressure exceeds 2.5 kg/cm^2

Electrical Circuit Breaker:
Fused circuit and mains switch fitted with indicating lamp.

OPTIONAL ITEMS

- EI
DIGITAL INSTRUMENTATIONS
i) 2 units of digital indicator
ii) 4 units of RTD sensor c/w transmitters
iii) 1 unit of power transducer
iv) 1 unit of electronic flowmeter
v) 1 unit of pressure transmitter

-DAS
SOLDAS DATA ACQUISITION SYSTEM
i) A PC with latest Pentium Processor
ii) An electronic signal conditioning system
iii) Stand alone data acquisition modules
iv) Windows based software
- Data Logging
- Signal Analysis
- Process Control
- Real-Time Display
- Tabulated Results
- Graph of Experimental Results

- CAL
SOLCAL COMPUTER AIDED LEARNING SOFTWARE
i) Interactive multimedia features
ii) Graphical simulation
iii) Experiment results samples
iv) Full experiment manuals

REQUIREMENTS

Electrical : 240VAC, 1-phase, 50Hz
Water : Laboratory mains supply

OVERALL DIMENSIONS

Height : 0.710 m
Width : 0.710 m
Depth : 0.240 m

MANUAL

The unit is supplied with Operating and Experimental Manuals in English.

SOFTWARE & E - LEARNING

Our range of teaching equipment can be complemented with our SOLDAS and SOLCAL software.

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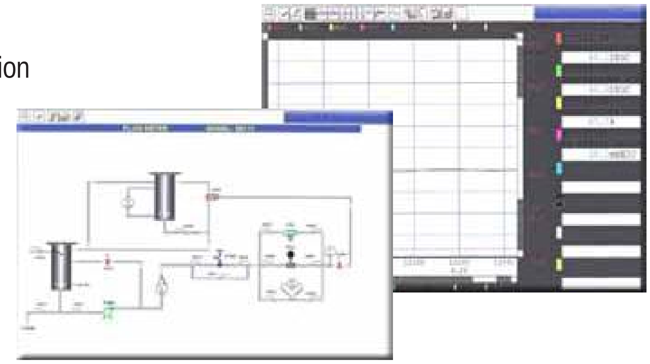

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