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Enhancement of heat transfer rate in pool boiling on Nichrome wire by addition of surfactants in pure water

#1S.L. Suryavanshi, #2Prof.S.G. Dambhare

#1sangamsuryavanshi24@gmail.com

#1PVPIT, Bavadhan, India.

ABSTRACT

Heat transfer enhancement is a major focus of the many researchers. The heat transfer in boiling can be enhanced through many ways like adding small amount of additive in fluid, increasing roughness of the surface etc. It is observed in many research studies that the addition of small amount of additive in the fluid changes the physical behavior of the boiling phenomenon. Surfactant changes thermo-physical properties of the fluid. The objective behind this study is to find the effects of concentration of different surfactants on the heat transfer rate of pure water without any abnormalities and optimize the concentration of surfactants. In this study the kinetics of boiling (bubble nucleation, growth and departure) was recorded by video camera and the boiling curves (q Vs (Tw-Tsat)) for different concentrations of surfactants in pure water were obtained. Also from the current data, the heat transfer coefficient for pure water with and without surfactants were calculated and compared. The results of this study showed that the addition of surfactant can enhance the water boiling heat transfer, and the enhancement is more obvious for SDS and Triton X-100 solution. Also the bubble behaviour and the heat transfer mechanism for the surfactant solution are quite different from those of pure water. In order to study the effect of wettability, it is essential to measure the contact angle .If the contact angle becomes lower which will be increase the wettability and this result in enhancement of heat transfer phenomenon.

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I. INTRODUCTION

The pool boiling techniques are using in various industries like processing, thermal, refrigeration and air conditioning, production etc. The interest in enhanced heat transfer is closely tied to energy prices. Energy is the basic necessity for life. But for energy no form of life would have ever emerged. We all know energy for providing us light and comfort. In the 1980s and 1990s, energy prices were low due to oil and natural gas "bubbles". Recently, however, increased demand and inadequate supply or distributions have resulted in large increases in the price of energy. There is now an incentive to save energy, and enhanced heat transfer can be exploited to do so. Whereas in the previous two decades, enhancement was employed to reduce the size of equipment, thereby saving space, it is now applied to save energy costs.

An energy crisis is any great bottleneck (or price rise) in the supply of energy resources to an economy. A global energy crisis is defined as any great shortfall in the supply of energy to an economy. Energy is oil, electricity, or other natural resources like coal and natural gas. When the energy supply to an economy becomes endangered or scarce, prices raise to record highs.

There has been an enormous increase in the global demand for energy in recent years as a result of industrial development and population growth. Since the early 2000s the demand for energy, especially from liquid fuels, and limits on the rate of fuel production has created such a bottleneck leading to the current energy crisis. Due to the energy crisis problem, the aim is to reduce the energy required for phase change during the pool boiling. For increasing heat transfer rate the boiling curve must shift towards left.

A. Boiling Heat Transfer:-

Boiling is the convective heat transfer process that involves a phase change from liquid to vapour state. Boiling is also defined as evaporation at solid-liquid surface. This is possible only when the temperature of surface exceeds the saturation temperature corresponding to the liquid pressure heat is transferred from solid surface to the liquid according to the law,

$$Q= h\times (T_s-T_{sat}) = h\times\Delta T_e$$

Where, $\Delta T_e= (T_s-T_{sat})$ is known as excess temperature.

II. LITRATURE SURVEY

Many researchers are conducted research in this field, Kandlikar (2001) developed theoretical model to describe the hydrodynamic behavior of the vapor liquid interface of a bubble at the heater surface leading to the initiation of critical heat flux (CHF) condition. The momentum flux resulting from evaporation at the bubble base is identified to be an important parameter. Mukherjee and Kandlikar (2007) conducted research on nucleate boiling as Nucleate pool boiling is typically characterized by cyclic growth and departure of vapor bubbles from a heated wall. In their numerical study, a static contact angle model and dynamic contact angle models based on the contact line velocity and the sign of the contact line velocity have been used at the base of a vapor bubble growing on a heated wall. As aresult of their research, Navier–Stokes equations are solved and the liquid–vapor interface is captured using the level-set technique. The effect of dynamic contact angle on bubble dynamics and vapor volume growth rate is compared with results obtained with the static contact angle model.

Hetsroni et al (2004) experimentally investigated Saturated and sub cooled pool boiling of environmentally acceptable surfactant solutions, on a horizontal tube. The evolution of vapor bubbles in a boiling liquid, in particular the growth of bubbles is one of the parameters Determining the intensity of the heat transfer from a heated surface. The growth of the bubble in the liquid containing surfactants is affected by a number of specific factors. Kandlikar 2002 presents a brief historical review of the available literature on the photographic studies in pool and flow boiling, The results of the photographic studies conducted in the authors' laboratory on liquid droplets impinging on a heated surface. Liquid–vapor interface and contact line movements are observed through a high speed camera at high resolution. The effect of surface roughness and surface temperature on dynamic advancing and receding contact angles has been studied.

III. EXPERIMENTAL SETUP

Fig 4.1 shows the experimental setup used for this work,

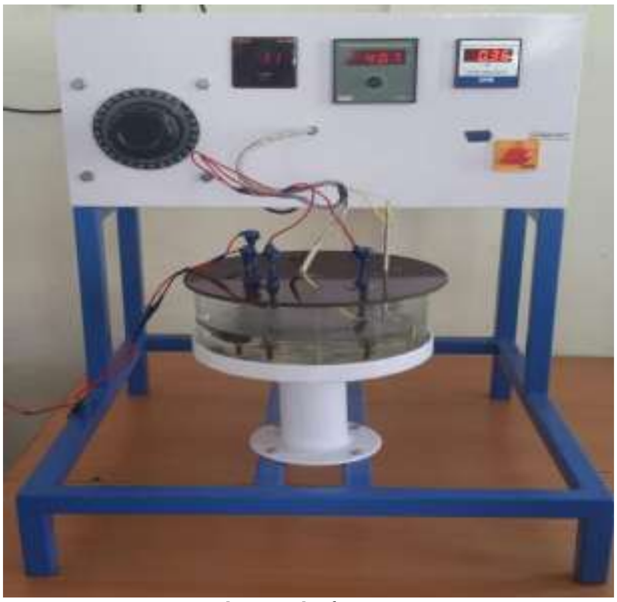


Figure 4.1 Photograph of set up

For this work a Nichrome wire is used which consist of 80% Nickel and 20% Chromium This Nicrome wire has high resistance to heat generate the desired temperature, sufficient stiffness, high melting point, In this work SODIUM DODECYL SULPHATE LR is also used. SDS has the chemical formula C12H25NaO4S or CH3-(CH2)11-OSO3-Na+ and its structure is presented in Figure 4.2. SDS is a high production volume chemical (i.e., annual production and/or importation volumes

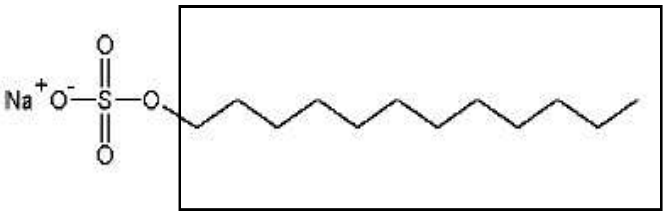


Figure 4.2 Chemical Structure of Sodium Dodecyl Sulfate

IV. EXPERIMENTAL INVESTIGATION

Procedure for Part A:-

1. He glass container was filled with 2.5 liters of pure water and it kept on a stand, which is fixed on a metal platform.

2 .Initial heating is provided by main heater up to saturation temperature. Then main heater is switch off & test heater (nichrome wire heater) is started.

3.Varying heat flux after each equal interval of time (2 min) we observed readings.

4. He kinetics of boiling (bubble nucleation, growth and departure) i.e. bubble behavior with and without surfactants in water was recorded by CAMERA having following specification

ODEL – CANON EOS 6D features

- 0.2 MP

- spect ratio 3:2

- mage resolution

  5472X 3648 (20.2 mp 3:2)

- 0 fps

5. Experiments were carried with and without surfactant (SDS) in pure water by varying heat flux

Above 1 million pounds in the United States). In solution, the sodium cation (Na+) dissociates from the Anionic part of the compound (lauryl or dodecyl sulphate), and this anionic compound is the active chemical.

6. Concentration of SDS was varied from 300-2000 ppm in pure water. Respective SDS solution was prepared according to table no 4.13

7. each experiment was repeated.

V. Results And Discussion

The extensive experimentation of pool boiling was carried for pure water with and without surfactant of varying concentrations of SDS and heat flux. From the obtained experimental data, results are plotted in terms of boiling curve as a heat flux vs. heater excess temperature. Also the some images of kinetics of boiling (bubble nucleation, growth and departure) i.e. bubble behaviour for water and water with surfactants by varying heat flux were recorded by high megapixel camera.

These are discussed in Comparative studies of results of surfactant were broadly discussed into two categorize as boiling behaviour and boiling curves.

BOILING BEHAVIOUR:-

The kinetics of vapour bubble in pool boiling phenomena for pure water with and without surfactants was observed in terms of bubble nucleation, growth and departure the evolution of vapour bubble. The growth of bubble is one of the parameters determining the intensity of the heat transfer from a heated surface. The pool boiling experiments were carried out under atmospheric pressure. The phenomenon of foaming, often observed during boiling in the presence of surfactant in water. The bubble behaviour was recorded at high megapixel video camera and recording was done for varying the concentration of the surfactants and heat flux.

6.2 BOILING CURVES

The saturated pool boiling curves are plotted with varying concentrations of surfactant in pure water as a function of the heat flux q (kW/m^2) vs. the heater temperature (Tw-Tsat) ^{0}C. 1.SDS solution 2.Triton x-100 2

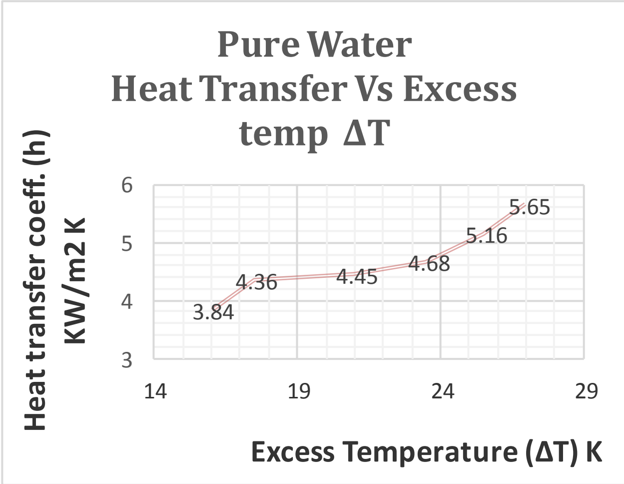
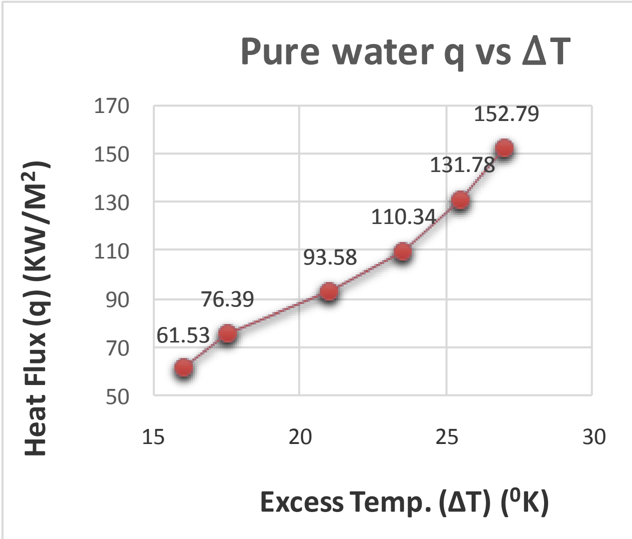


Figure No 6.1



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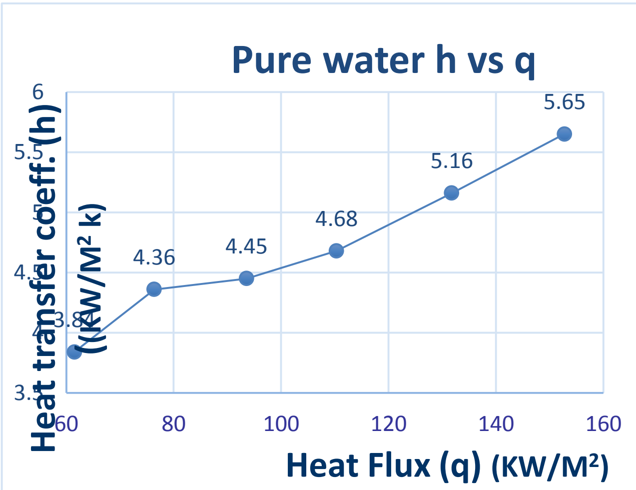

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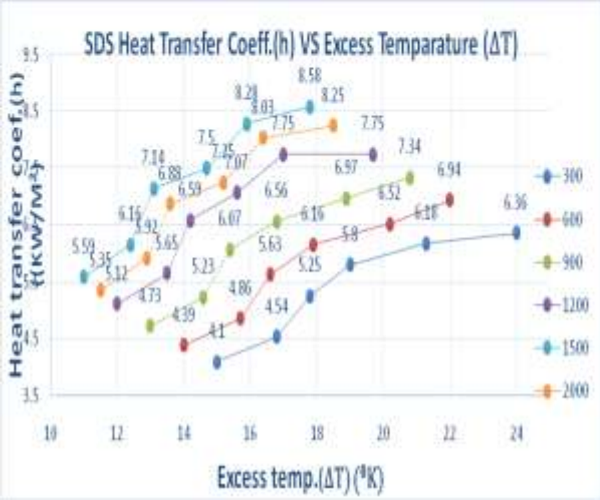

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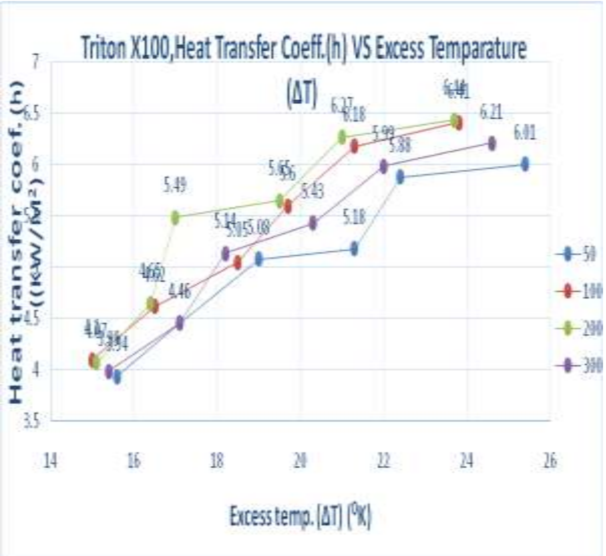

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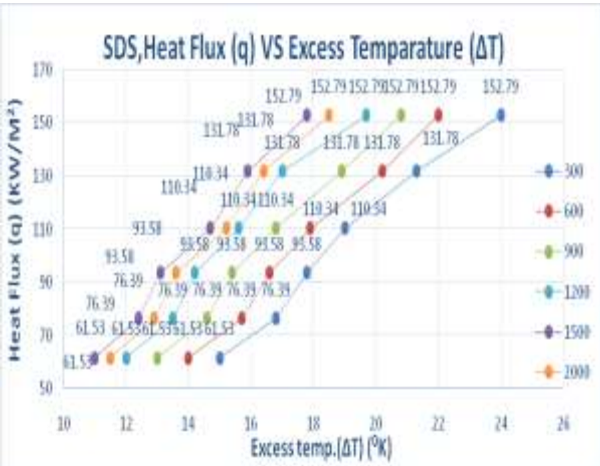

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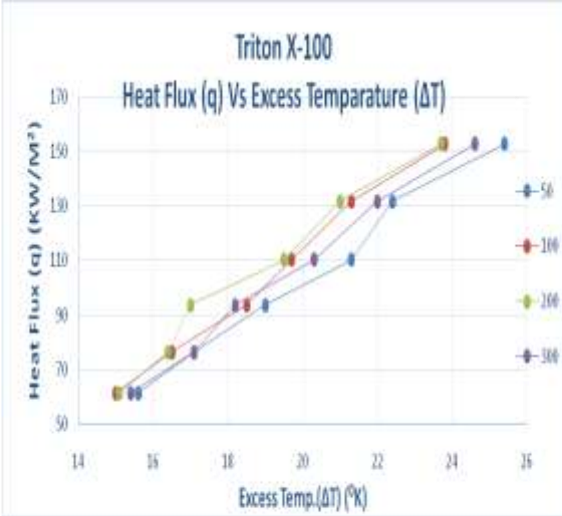

Figure No 6.7

Graph 6.1 to graph 6.7 shows the behavior of heat transfer characteristics of system with SDS and triton X100.

VI. Conclusion

From the experimental results of this study the following major conclusions are drawn.

1) The addition of small amount of surfactant Sodium Dodecyl Sulphate(SDS) in water makes the boiling behaviour quite different from that of pure water. It might be that reduction in surface tension results in a decrease of energy required to create a bubble.

2) The boiling excess temperature ΔT excess becomes smaller and the vapour bubbles are formed more easily. It might be due to presence of surfactant in water promotes activation of nucleation sites in a clustered mode.

Presence of the surfactant reduces the boiling excess temperature ΔT. It is observed as the boiling curves shifted to the left side and Promotes activation of nucleation sites in a clustered mode.

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