Compare Onset and Permanent dry Out Heat Flux For 2×8 Grid with Different Parameters

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***Abstract*— A comparison of onset and permanent dry out heat flux for a 2x8 grid with different parameters and different conditions .The different parameters are film Reynolds number , Reynolds number of air , Reynolds number of water and the conditions are used with only flow of water and the simultaneous flow of water and air. The cooled water made to spray over the hot water tubes in the form of droplets, column and sheet form. So the patches are appears on the surface of hot tubes.**

***Index Terms*— Dry Patches, onset heat flux, permanent heat flux, film Reynold's number**

I. Introduction

The onset patches and permanent patches produced due to the mass flow rate of hot water and the appearance of onset patches are temporary while the Appearance of permanent patches is permanent. The appearance of large dry patches in liquid films flowing over surfaces heated or unheated have been recently observed and reported by several researchers. The appearance and the behavior of these vapor patches in two-phase systems with heat addition are important for several reasons. The appearance of patches and the attendant break-up of the liquid film may mark a change in the flow regime from annular to drop flow. The appearance and the persistence of dry patches on the surface result in an abrupt decrease of the heat transfer coefficient and attendant overheating of the surface which may cause the "burnout" of the heated duct.

The various possible mechanisms which may generate large vapor patches on a heated surface are discussed elsewhere [7]. The problem which we consider here is as follows: assume that a large vapor patch has been formed (by any of the various possible mechanisms) in a flowing, heated liquid film which is thereby broken up; we wish to determine under what conditions such a liquid rupture will persist, i.e. under what conditions will the dry patch remain attached to the surface? We consider therefore the stability of a dry patch and we seek the value of the minimum flow in the liquid which is necessary to remove (sweep) the dry patch from the heating surface. Here the onset and permanent patches are formed by the falling water. The cold water falls from the top of the tube to the hot grid. It is like a falling film evaporator. The Main advantages and possible operational problems concerning falling film evaporators were presented in comprehensive literature reviews carried out by Thome [1] and more recently by Ribatski and Jacobi [2]. There are two types of patches temporary patches which is called onset patches and the heat flux related to this is called onset dry out heat flux and the patches which not rewetted again and again is called permanent patches and the heat flux related to it is called permanent dry out heat flux. Ganic´ and Roppo [8] performed dry out experiments for an evaporating falling film on horizontal tubes for sub cooled water. They found that the heat flux for dry patch appearance increases with Reynolds number. At a fixed film flow rate, they found firstly an increase in the heat flux for dry patch formation when increasing tube pitch from 12.7 to 25.4 mm; a further increase from 25.4 to 50.8 mm causes a decrease in the heat flux for dry patch formation.

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II. Mechanism of Formation of Dry Patches

Consider a film of liquid flowing uniformly over the surface of a flat plate, for example the flow due to gravity down an inclined plane. If the flow rate is reduced sufficiently the stream will break away from the edges of the plate or else disrupt over the central area giving rise to one or more dry patches.

The cold water made to flow over a tube for about 50 hours until the tube was fouled so as to match the actual condition so first find the minimum wetting rate (at no heat load). The initial value of flow rate was fixed more than minimum wetting rate now the hot water flow through the tube at 60±1°Cto provide the heat load and the heat flux increased by increasing flow rate of hot water step by step up to the steady condition not achieved the heat load was increased up to the till the dry patches not appeared for the first time on the outer surface of the tube. This condition of formation of dry patches is refers to the flux. Most of the dry patches were rewetted by the cooling water but some of the dry patches remained dry. These dry patches were rewetted manually by putting more drops of cooling water manually by dropper over the surface of tube. After getting disappearance of the dry patches from the outer surface of the tube, the heat load was again increased by increasing the flow rate of hot water in small steps and the steady flow condition was achieved. This process was continued till the state came that the dry patches were not disappearing even after increasing the flow rate of the cooling water or by placing more droplets manually over the surface of tube. This condition of formation of dry patch is referred to

T_{pi} (0^oC)	W_w (kg/s)	T_{wi}	$Re_{,w}$
65±1	0.020 to 0.190	34.8 to 36	14.99 to 141.73
60±1	0.020 to 0.190	34.8 to 37	14.24 to 137.30
55±1	0.020 to 0.190	34 to 36.2	13.60 to 129.77

the condition of permanent dry patch formation and corresponding heat load is termed as the permanent dry out heat flux.

III. Methodology

A. Procedure

The cold water was made to shower over the test tube for 10 hours until the tube was completely fouled. For the first set of readings, the air velocity at the top of the test section was fixed at 0.8 m/s and the relative humidity at the inlet of test unit varied from 50% to 90% with a step increase of 10%. The flow rate of cooling water initially at 2.00x10^-2 kg/s to 9.30x10^-2 kg/s with step increase of 0.65x10^-2 kg/s, the initial value of flow rate was fixed more than the minimum wetting rate, which is defined as the rate of cooling water at which the unit length of the copper tube becomes completely wet at no heat load and the hot water then made to flow through the tube at 60±1°C to provide the heat load and the heat flux was increased by increasing the flow rate of hot water in small steps and the steady state was achieved. The heat load was increased till the dry patches appeared for the first time on the outer surface of the tube and the temperature of hot water at the inlet and at the outlet of tube was noted, also the temperature of cooling water at the inlet of spray pipe, average temperature of the tube surface, dry bulb and wet bulb temperature of air at the inlet of test section was noted.

B. Governing Equations

The heat dissipation rate from a tube can be written as:

$Q_{wa} = Wp.\ Cp.\ (t_{h1}\text{-}t_{h2})$ ……………………………. (1)

Reynolds number of air and cooling water are determined as:

$Re_a = \rho.\ V_t\ D_o /\ \mu_a$ ……………………………...... (2)
$Re_w = 4\Gamma /\ \mu_w$ ……………………………........ (3)

Mass flow rate of cooling water, Γ is found as:

$\Gamma = W_w / 2.\ l$ ……………………………………….……..(4)

where, l is the active length of tube and its value used here is 0.6 m.
Dry out heat flux which causes the onset and permanent dry patch is determined by using the following relation:

Q_{on} or $q_p = Q_w / A_o$ ……………………………….. (5)

Where, outside surface area of the test tube (A_o) is calculated as 0.376 m^2.

C. Limits of Operating variables

Table.1 data for Water Flow only

Table.2 For simultaneously flow of water and air

T_{pi} (°C)	W_w (kg/s)	T_{wi} (°C)	$Re_{,w}$
65±1	0.02 to 0.19	32.5 to 36	14.44 to 138.96
60±1	0.02 to 0.19	34.8 to 36.6	14.77 to 139.9
55±1	0.02 to 0.19	34 to 36.8	14.98 to 140

IV. Results and Discussion

A. Effects of Reynolds number of water and inlet temperature of process fluid on dry out heat flux

Results are represented in graphical form in fig.1 & 2 is shows that the effect of Reynolds number of water (Re_w) on the onset (q_{on}) and permanent dry out heat fluxes (q_p),for a few inlet temperature levels of process fluid. The fig.1 & 2 shows that due to increase the value Reynolds number of water & inlet temperature of process fluid (t_{pi}) the dry out heat flux on q_{on} & q_p are increased. dry out heat flux on onset (q_{on}) increased by 25.54 to %1205.28 and dry out heat flux on permanent (q_p) by 47.07to 1220.64%, when flow rate of cooling water and temperature of process fluid were varied in the range as given table. 1.

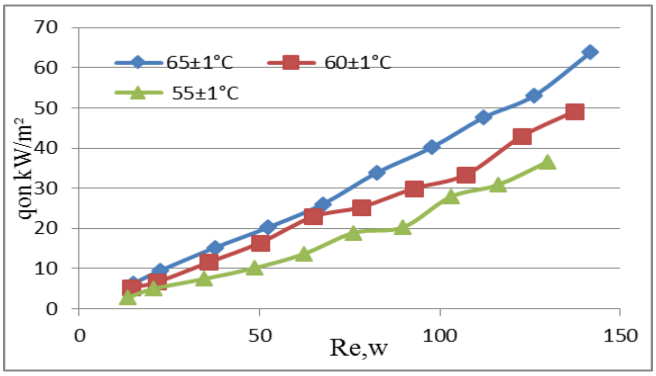


Figure.1 Effect of film Reynolds number on the onset dry out heat flux of 2x8 grid with only water

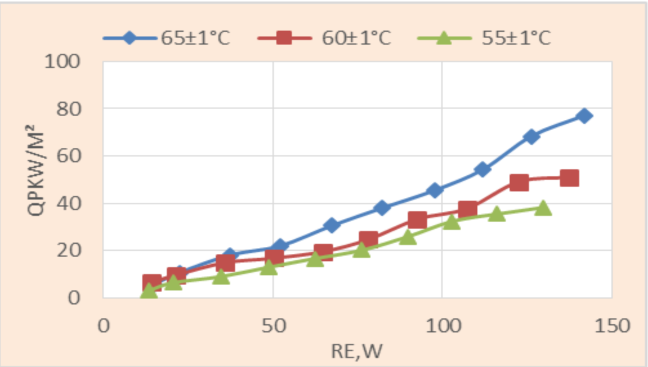


Figure.2 Effect of film Reynolds number on the permanent dry out heat flux of 2x8 grid with only water

B. Effects of Reynolds number of cooling water on dry out heat flux

The effect of Reynolds number of cooling water (Re_w) on the onset dry out heat flux (q_{on}) and permanent dry out heat flux (q_p) are shown in figure 3, 4 and for some selected values of Reynolds number of air (Re_a) . It is found from figure 3 that q_{on} increases with Reynolds number of water. It is because of the fact that higher is the flow rate of cooling water being sprayed over the tube, greater becomes the heat flux required to evaporate water at faster rate from the tube surface to give the appearance of dry patches. The q_{on} with Reynolds number of water (Re_w) increases 11.75% to 623.77 % and if Reynolds number of air is varied in the range of 1556 to 6192 and the q_p with Reynolds number of water (Re_w) increases 33% to 601%.

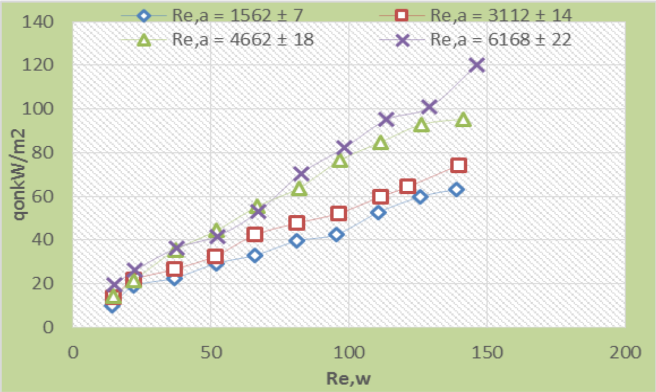
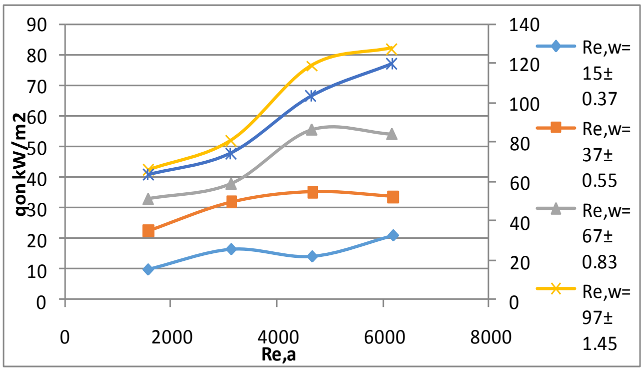


Figure. 3 Effect of film Reynolds number on the onset dry out heat flux of 2x8 grid with simultaneous flows of water and air

C. Effects of Reynolds number of air on the dry out heat flux

The effect of Re_a on q_{on}, qi can be studied from fig 5 & 6. It conclude that when velocity of air did not exceed 4m/s because the shear force at air velocity above this limit caused the interfacial film region to move upwardly from fig. 5 & 6 the q_{on} and q_p was increased with Re_a if Re_w is fixed within the range of 29.8 to 891. As the flow rate of air increases, both convective effect and heat flux required to break the water film increases and finally dry out heat flux. Percentage



increases in q_{on} & q_p by 16.8% to 173.97%, 6.96%to 81.9% respectively if Re_w is varied from 29.8 to 891. Here the range of Reynolds number of air is 1546 to 6163.

Figure.5 Effects of air Reynolds number on the onset dry out heat flux of a 2x8 grid with simultaneous flows of water and air

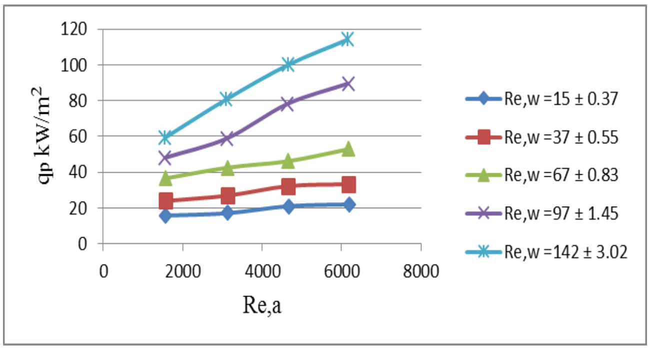


Figure.6 Effects of air Reynolds number on permanent dry out heat flux of 2x8 grids with simultaneous flows of water and air

V. CONCLUSIONS

In this investigation, experiment has been conducted with simultaneous flows of water and air. The copper coils (2×8 grids) subject to cooling water from shower at the top and process fluid (hot water) flows inside the test tubes. Experiment have been operated under various operating conditions to determine dry out heat fluxes pertaining to onset and permanent dry patch formations on a horizontal tube.

Following major conclusions are drawn from the dry out heat transfer studies being carried out on the horizontal tubes (2×8 grid) of the heat dissipator which was subject only to water flow in the form of sprays from the top

(i) The cooling water rate increases, the heat load required causing onset or permanent dry patch formation increases.

(ii) As the inlet temperature of process fluid increases but temperature and flow rate of cooling water are kept constant, heat flux required to cause a temporary or permanent dry patch formation increases.

(iii) The quantitative effects of Reynolds number of water on the onset and permanent dry out heat fluxes as given for a given set of operating conditions.

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