CHAPTER ONE

INTRODUCTION

1.1. General

Boiling is a phase change process involves formation of vapor bubbles either in a superheated liquid or in vapor cavities on a heated surface. The nucleation process in the former case is referred to as "homogeneous", whereas the latter is called "heterogeneous" nucleation. Large number of system variables such as heater geometry and orientation, surface finish, wettability, contamination, liquid subcooling, flow velocity, gravity, system pressure, thermal properties of solid, among other, influences the characteristics of the boiling process. Based on the liquid flow velocity, boiling is classified as either "pool" (zero bulk fluid velocity) or "flow" (finite bulk fluid velocity) boiling. Boiling at the surface of body immersed in an extensive pool of motionless liquid is referred to as "pool boiling". The nature of the pool boiling process varies considerably depending on the condition at which it occurs. The heat flux level, the thermophysical properties of the boiling fluid, the heated surface material and its finish, and the geometry of the heated surface may all have a significant effect on the boiling process.

Conventional and enhanced boiling of liquids have a wide range of industrial applications that include power generation, chemical and petrochemical production, air conditioning, refrigeration, cryogenics, metallurgical quenching process, electronics cooling, desalination of seawater, in nuclear power plants and either of heating or electricity generation, among other.

A typical pool boiling curve for the case of uniform heat flux at the heater surface is shown in Figure 1.1. For the different pool boiling regimes presented in Figure 1.1, their respective schematic representations for boiling on a horizontal surface are shown in Figure 1.2. At very low wall heat fluxes, heat is transferred from the heater surface to the liquid pool only by natural convection (part a-c). At sufficiently higher wall heat fluxes, onset of nucleate boiling (point c), some cavities on the surface activate to form vapor bubbles. Depending on the liquid pool temperature (saturated or subcooled), these bubbles either grow on the surface or condense. The onset of nucleate boiling (ONB) is characterized by an appreciable decrease in wall superheat, and the corresponding magnitude of temperature drop is a strong function of wetting characteristics of the liquid on a given heater surface.

Any further increase in the wall heat flux leads to a corresponding increase in the wall superheat and activation of more number of nucleation sites. This portion of the curve corresponds to the nucleate boiling regime and is given by (part d-f) in Figure 1.2. Initially the active sites are few and widely separated (part d-e), which is referred to as isolated bubble regime or partially developed nucleate boiling regime. With increasing wall heat flux, more and more sites become active, and the bubble frequency at each site increases. Eventually, the active sites are spaced so closely that bubbles from the adjacent sites merge together during the final growth and release. Vapor is produced so rapidly when bubbles merging together from columns of vapor slug that rise upward in the liquid pool toward its free surface. This portion of the boiling curve, corresponding to segment (e-f), is referred to as a fully developed nucleate boiling regime or regime of slugs and columns. Increasing the wall heat flux and wall superheat within the regime of slugs and columns produces an increase in the flow rate of vapor away from the surface.