

# Pool Boiling Heat Transfer Studies of $\text{Al}_2\text{O}_3$ –Water Nanofluid with Sand Blasted Surface

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**Abstract** — A study on pool boiling was carried out using Sand Blasted Surface (SBS) for maximizing the Critical Heat Flux (CHF). The results showed that the SBS surface has more enhancements in CHF with DI water as well as 1 g/l, 4 g/l and 8 g/l of  $\text{Al}_2\text{O}_3$ -water nanofluid when compared with smooth surface. It was identified that more in nucleation sites was the plausible reason for enhancing the CHF. However, the heat transfer coefficient decreased with the increase in nanoparticle concentrations due to particle deposition on the heater surface thereby plugging the nucleation sites.

**Keywords** — pool boiling, critical heat flux, sand blasted surface, alumina nanofluid.

## I. INTRODUCTION

The concept of pool boiling heat transfer and its limitation by CHF was first described by Nukiyama [1]. The CHF is the point in which the vapour bubbles are formed rapidly and covers the entire heating surface as a dense layer thereby increasing the temperature rapidly, resulting burnout of the material. Hence it is an urgent need to enhance the boiling performance of engineering devices such as nuclear reactors, spray cooling, refrigeration etc. It is accepted by the heat transfer community that the CHF of pool boiling heat transfer was enhanced by the addition of nanoparticles (1-100 nm) to the base fluid like water, ethylene glycol, oil etc. The experimental result of Vassallo et al. [2] showed an enhancement in CHF for about 60% and many other researchers also confirmed the CHF enhancement with increase in nanoparticle concentrations. However, it has been understood that the effect of heater surface modification by the deposition of nanoparticle was the plausible mechanism of CHF enhancement in many of the cases [3, 4]. In addition, the deposition of nanoparticles on smooth heater contributed to the increased surface roughness, leading to the increase in nucleate boiling heat transfer whereas there was no obvious change for rough heater [5]. Hence the present study aimed to use various concentrations of  $\text{Al}_2\text{O}_3$ -water nanofluid such as 1 g/l, 4 g/l and 8 g/l in addition to the modification of the heater surface by sand blasting.

## II. PREPARATION OF NANOFLUIDS AND COPPER SPECIMEN

The top down method through size reduction, called two step method is used to prepare most of the nanofluids like  $\text{Al}_2\text{O}_3$ ,  $\text{TiO}_2$ , CNT, and Ag. Since this method works well with metal oxide particles, the preparation of 1g/l, 4 g/l and 8

g/l  $\text{Al}_2\text{O}_3$ -water nanofluid was done by this method. The dispersion of nanoparticles in the base fluid was obtained by Ultra Sonicator in order to improve the dispersion stability and to avoid particle cluster. It was observed that stabilized alumina nanofluids thus obtained is more stable without any tendency of agglomeration.

A copper test specimen of size 10 mm×10 mm×15 mm was used for this study. There are two different specimens viz. smooth and sand blasted surface were prepared in order to compare the enhancement in CHF. The smooth surface was obtained by using emery sheets of average grain size 60 grade whereas sand blasting machine was used for sand blasted surface.

## III. EXPERIMENTAL SETUP

The pool boiling experimental facility consists of reflux condenser (1), borosilicate glass vessel (2), cartridge heater block (3), Data Acquisition system (4), Multimeter (5) and a variac (6) as shown in Fig.1. A reflux condenser was used to condense the vapour and retains the mass of liquid in the borosilicate glass. Since borosilicate glass is a good insulator, it is used in the present study. The required quantity of 600 ml fluid was poured into the borosilicate vessel.



Fig. 1. Pool boiling setup.

A cartridge heater of 600 watts was used in this study. This heater was kept in a cartridge heater block of size 3 cm × 170 cm and necessary provisions were made on the top to hold the copper specimen and to measure the surface temperatures. T-type thermocouples with 3 mm diameter were used to measure both the surface temperature and the

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