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QUENCHING EXPERIMENT ON VERTICAL TUBE USING CARBON NANO TUBE (CNT) NANOFLUIDS

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Abstract

Quenching experiment on vertical tube using Carbon Nanotube (CNT) nanofluids were conducted to see the effect of using CNT nanofluids on the quenching speed. Homogeneous and stable CNT nanofluids have been produced by suspending well dispersible CNT nano-particle into water base fluid. CNT nanofluids (0.0001 vol.% and 0.01 vol.%) were prepared for experiments. From zeta potential results our CNT nano-fluids has a good stability. The test section was an annular channel with a concentric inner rod made of stainless steel SS316 and an outer tube made of quartz glass. The experimental data obtained show that quenching speed using CNT nanofluids enhanced compare to water.

Keywords: film boiling; Nanofluids; CNT nanofluids , quenching

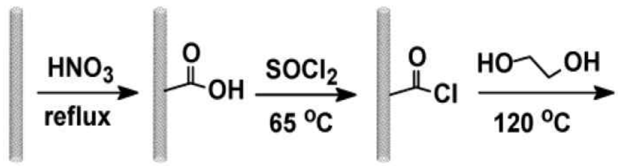
I. INTRODUCTION

Core cooling process using water on nuclear power plant accident is an accident management which must be done to terminate a transient accident in light water reactor. This situation will be worst by resulting on core melt down caused an anomaly on boiling heat transfer during lost of cooling accident (LOCA). Thus, study on boiling heat transfer due to bottom flooding, especially in PWR type become more attractive in research field on nuclear engineering. In nuclear reactor context, wet at cladding wall during ECCS injection have been studying since two decade, using experimental model or analytical model. The ECCS systems which inject cold water in the reactor core, is immediately actuated to reduce the fuel temperature. The use of nanofluids potentially could afford a significant increase of the quench speed and thus improvement of safety performance of the reactor.

II. EXPERIMENT

II.A. Nanofluids Preparations

The CNTs type is multi-walled CNT. It was purchased from Sigma Aldrich Korea. Here are the procedures of CNT with acid treatment: A 250 mL flask charged with 5.0 g of crude CNTs and 100 mL of 60% HNO3 aqueous solution was sonicated in a bath (40 kHz) for 30 min. The mixture was then stirred for 24 h under reflux. After cooling to room temperature, it was diluted with 200 mL of deionized water and then vacuum filtered through a 0.22 μm polycarbonate membrane. The solid was washed with deionized water until the pH of the filtrate reached 7. The filtered solid was then dried under vacuum for 12 h at 60 °C to give 3.05 g (60%) of carboxylic acid-functionalized CNT (CNT-COOH). Figure 1 is shown the scheme of acid treatment procedure.



CNT CNT-COOH CNT-COCl

Figure.1. the scheme of CNT treatment procedure

II.B. Experiment Apparatus and Procedure

II.B.1. Experiment Apparatus

The diagram of the experimental apparatus is shown in Fig. 2. The test section was an annular channel with a concentric inner rod and an outer tube. The length of the test section was 1000 mm. The inner rod was made of a stainless steel SS316 tube with 0.7mm wall thickness and 9.8mm outer diameter.

The test section was heated using a couple of semicylindrical ceramic fiber heaters, which raised the rod temperature up to 800ºC by radiation heating.

At locations (TC_1-TC_8) of the outer surface of the inner rod, K-type Chromel-Alumel thermocouples were spotwelded at their end and were guided through the hole inside the inner tube.

Cooling nanofluids was introduced at a predetermined flow rate and temperature via the bottom of the test section. The quenching process was observed using a high speed camera. The temperature signals were amplified and recorded on a personal computer. To ensure the stability of nanofluids we use transparent tank.

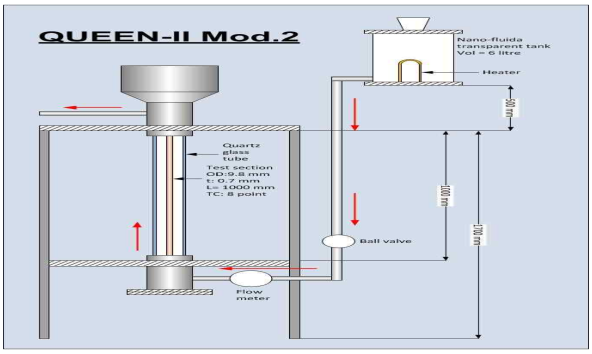


Figure.2. schematic of experiment apparatus

II.B.2. Experiment procedure

The experimental procedures were as follows.The test section was preheated step by step carefully to prevent the breach of the quartz glass outer tube. When the desired temperature (800ºC) was reached, the heater was switched off and removed from the test section. Then, the cooling water was supplied to the test section from the bottom. The transient temperatures of the outer surface of the inner tube were measured using the thermocouples and the data were recorded on the computer.

The experimental conditions are shown in Table 1. The inlet temperature of the cooling nanofluids was kept at 75ºC. It is known that the reflooding process is strongly affected by the flow rate and temperature of the coolant. From the study of Kaminaga and Uchita,[1] it was demonstrated that at low coolant temperature, the quenching process is stable, but the violent boiling makes it difficult to observe the phenomenon, while at high coolant temperature, the quenching process becomes unstable under the low flow rate condition.

Therefore, in the present study, based on the observations in preliminary tests, the inlet water temperature was set at 75ºC and flow rate 0.65L/m to obtain a stable quenching and clear observation.

TABLE I. Experimental conditions

Experimental Conditions	
Pressure (atm)	1
Initial Temperature (ºC)	800
Flow rate (L/m)	0.65
Working Fluids	
DI Water	
CNT nanoparticle-DI Water	0.01 volume% and 0.001volume%

III. RESULTS AND DISCUSSION

III.A. Zeta Potential Measurement

In this study, zeta potential of CNTs nanofluids with varying time and concentration were measured by Zetasizer Nano Zas. The zeta potential of CNTs and Fullerene nanofluids were in the range of 30-40 mV. The zeta potential of nanofluids was constant for more than one month.

III.B. Quenching Experiment

Figure 3 show the heated rod wall temperature histories during cooling process for initial temperature. It is shows that quenching time of CNT nanofluids to be slightly faster than water.

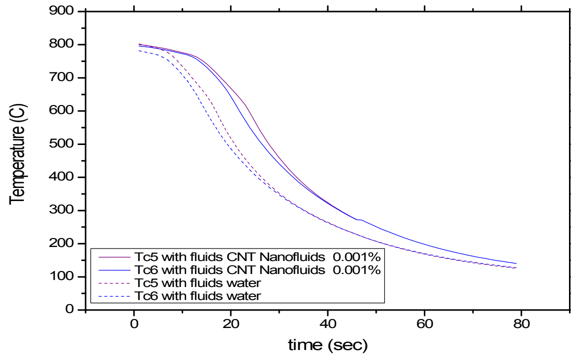


Figure.3. Transient temperature of quenching rod

During this submission of paper the experiment were still been conducted.

IV. CONCLUSIONS

The zeta potential of CNTs nanofluids were in the range of 30-40 mV. The zeta potential of nanofluids was constant for more than one month. It concludes that the treatment has been succeeded produces water dispersible CNTs nanofluids with good stability. From the quenching experiment It's shows that quenching time of CNT nanofluids to be slightly faster than water.

ACKNOWLEDGMENTS

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REFERENCES

1. F. Kaminaga, H. Uchita, ''Reflooding phenomena in a single heated rod (1 Experimental-study),'' Trans. Japan Soc. Mech. Eng., 44[387], 3875–3883 (1978).
2. Mulya Juarsa, et.al, "Study on Boiling heat transfer during reflooding process in Queen Test Section." Proceeding of ICAPP 05 Seoul Korea, Mat 15-19 2005.