The Effect of Ni Nano Particles on the Chemical Activity of Liquid Sodium

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1. Introduction

Liquid sodium is considered as a substitutable coolant for SFR(Sodium cooled Fast Reactor), because of its much higher thermal conductivity than water. However it has a critical problem that it explosively reacts when it contacts to water due to its strong chemical activity. Liquid sodium is designed to exchange heat to water indirectly in a stream generator and an enormous explosion will occur if any leak appears in a steam generator part.

A recent research about sodium [1] clarifies the atomic interaction between nano particles and sodium, in order to control the chemical activity of sodium with suspended nano particles. They suggest that when the nano particles enter into liquid sodium, the nano particle forms a cluster that nano particles surrounded by sodium atoms with strong atomic bond. Transient metal has much stronger atomic interaction than other elements due to stronger atomic bond between transient metal and sodium atoms than sodium atoms itself and large electronegativity difference. This strong atomic bond between sodium atoms and nano particle is expected to reduce the chemical activity of sodium.

Nickel is also one of transient metal that has large electronegativity, however nickel has not been used in previous research [1]. It should have any effect on the chemical activity of liquid sodium. In this study, we investigate an effect of nickel nano particles on the chemical activity of liquid sodium.

2. Experiment

We disperse nickel nano particles into liquid sodium and it is called as sodium nano fluid. We investigate how nickel nano particles affect to the chemical activity of sodium through comparing the two reactions that one is sodium-water reaction and other one is sodium nano fluid-water reaction.

2.1 Experimental Apparatus

The present reactor is design to conduct the sodium-water reaction experiment. A brass vessel is shape of the half circle that can naturally contain liquid sodium in the center of the vessel. The brass vessel is heated up by a copper heater block that two cartridge heaters are inserted in it. A cylindrical Pyrex glass is installed between the vessel and the main body to observe the sodium water reaction. The main body is made of stainless steel that does not only guarantee the safety, but also it is stable steel at the contact with liquid sodium. Several gas lines for retaining argon condition inside of the reactor are installed on the top of the reactor. Absolute pressure gauge and k-type thermocouples are selected to measure the change of pressure and temperature inside. Water injection line is closely installed above the vessel for complete contact between liquid sodium and water.

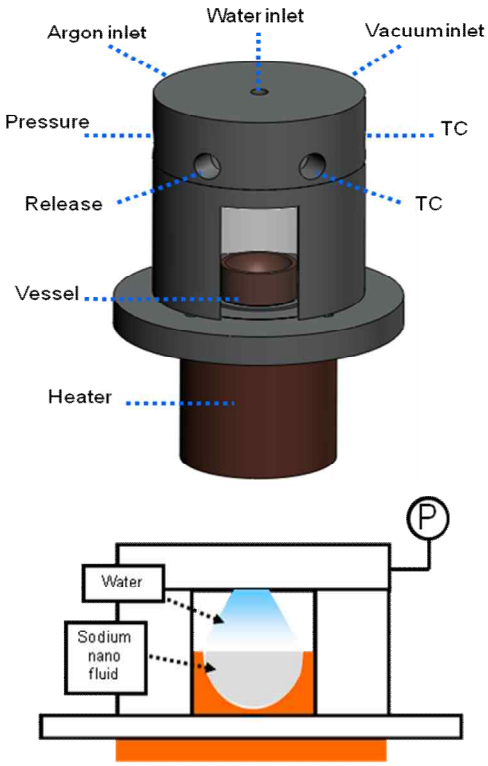

Fig. 1. Schematics of the reactor

2.2 Experiment Procedure

An inside of the reactor becomes argon condition to prevent oxidation of sodium by argon circulation during heating up the brass vessel. The temperature of the reactor inside and the vessel maintains above 120° c since the melting point of sodium is slightly below 100° c at atmosphere. Nickel spherical nano particle that size of 40nm is chosen because early research [1]

suggests transient metal will make a strong atomic bond with sodium atom to reduce the chemical activity. 10% volume fraction of Ni nano particle is dispersed in liquid sodium. 0.3ml of sodium nano fluid is inserted into the reactor and 1ml of pure water is directly injected to sodium nano fluid. When sodium reacts with water, hydrogen is rapidly generated as Eq. (1) and this hydrogen generation increases the absolute pressure in the reactor. Therefore we measure the change of pressure as a function of time and it represents how strongly sodium water reaction occurs.

$$Na + H_2O \rightarrow NaOH + 1/2H_2 \qquad (1)$$

3. Result

The chemical activity of liquid sodium is represented by the rate of hydrogen generation due to the chemical reaction between sodium and water. When sodium reacts with water, hydrogen is rapidly generated and this increases the absolute pressure in the reactor. Therefore we measure the change of pressure and it represents how strongly sodium water reaction occurs. Fig.2 shows the rate of pressure change inside of the reactor. The both of sodium-water and sodium nano fluid-water begin with atmosphere pressure and it rapidly increases with injection water to sodium. Two remarkable phenomena have shown in this result. Sodium nano fluid-water reaction shows the lower first pressure increase that is called as the shock pressure, than sodium-water reaction. Moreover the pressure rises gradually after the shock pressure. Theses mean hydrogen generation from sodium nano fluid – water reaction is much slower than sodium-water reaction.

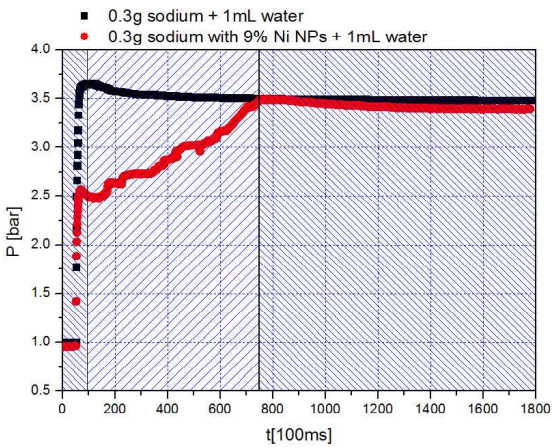

Fig. 2. The pressure change as a function of reaction time

4. Conclusions

Nickel nano particle is dispersed in liquid sodium making sodium nano fluid. The reaction between sodium nano fluid and water has been conducted and the result shows that the shock pressure of sodium nano fluid –water reaction is approximately 30% reduced and reaction time is also delayed for about 60 seconds comparing with sodium-water reaction. This result provides evidence that nickel nano particles affect to a mechanism of reaction between sodium and water in some way or other.

ACKNOWLEDGEMENT

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MEST) (No. 2011-0006359)

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