Preliminary PbLi Melting Experiment for Developing the PbLi Loop in KAERI

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1. Introduction

In the construction of the ITER, a Test Blanket Module (TBM) will be installed for the verification of the tritium breeding using lithium by neutrons from the plasma. There have been some forms of lithium like solid or liquid one to be considered as a breeding material.

In KAERI, liquid lithium material has been considered for the breeding material. Pb-15.7Li, where Li is 15.7 at %, hereafter called PbLi, has been procured and experimented for its basic characteristics [1-4]. The result will be applied to the operation of a test loop called ELLI (Experimental Liquid Lithium, which is now constructed at KAERI as shown in Figure 1) where effect of magneto-hydro dynamics and materials compatibility will be assessed.

Figure 1. PbLi circulation loop under construction in KAERI(ELLI).

2. PbLi melting experiments

Of the liquid type breeder material, PbLi is much safer than Li itself, as liquid metal can be ignited when it meets with water or air. There is still concern on using PbLi, it is not fully proven whether it will react with water or air when it is in a molten state, as it contains lithium. This work is thus the result on the reactivity of PbLi and ascertaining whether it will show consistent value of melting and solidifying temperatures for the many cycles of heating and cooling at various conditions of loop operation. In which, we can also investigate the contamination of PbLi according to the cyclic use.

For the operation of ELLI loop, prior knowledge of PbLi behavior with variations of temperature, atmosphere, and contact of water are very important. Thus a dedicated reactor was made and utilized for doing experiments on the effect of atmosphere and presence of water during the heating of PbLi. This reactor has the function of controlled heating, measuring temperatures and data sending to a computer, water addition hole at the lid, argon passage route, and the seeing window (Figure 2). Different phases of heating experiments have been planned:

(1) Ascertaining consistent temperature of melting and cooling of a PbLi sample at separated times
(2) Ascertaining consistent temperature of melting and cooling with different samples of PbLi
(3) Effect of water addition on molten PbLi

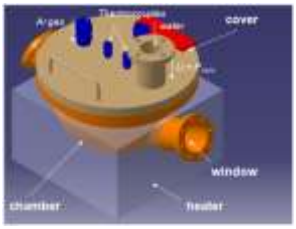

Figure 2. Picture of reactor for the PbLi melting characterization

Of these, until now items (1) and (3) has been accomplished with satisfactory results which will be exploited for the operation of ELLI. For the phase (1), a sample of PbLi was measured of its melting and solidifying behavior in the reactor, as shown in Figure 3. A typical result of the experimental phase (1), i.e. melting point and solidifying temperature measurement of a PbLi sample at some different period of date, is shown in Table 1.

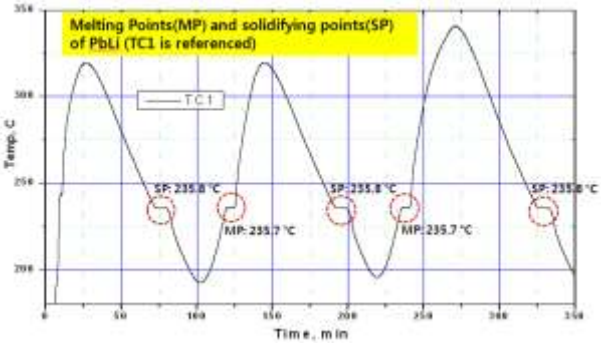

Figure 3. Melting and solidifying behavior of a PbLi sample in argon atmosphere.(Sample: 373.62gm, Argon atmosphere)

Table 1. Measurement result of meting point and solidifying temperature of one PbLi sample (Sample #2, Work done: Mar 3~8, 2010)

Date	MP	SP	Heating Cycles	Probe
Mar03	235.7, 235.7	235.8, 235.8, 235.8	3	TC1
Mar04	235.1, 234.9	234.7, 234.6	2	TC3
Mar08	235.1	234.6	1	TC3

Ideally, melting point(MP) and solidifying temperature(SP) of PbLi should show an identical value for each of the measured result. However, when PbLi melts or solidifies, temperature measuring probe representing the MP or SP can be different each time PbLi changes its phases. This is why the probes in Table1 is different. Even with this different probes, overall difference between the highest value and lowest one of MP(or SP) is 1.2 ^{o}C. We consider this value of discrepancy as satisfactory data for the future operation of ELLI with reliable PbLi behavior of MP and SP. That is, PbLi eutectic that is filled in the ELLI loop can be melted and solidified many times without worrying about its deterioration with the many cycles of operation.

From the MP or SP, composition of the PbLi can be determined from the relationship between the MP (or SP) and the composition[5].

$$T = 328.79 - 4.85\left({X_{Li}}/{at\%}\right) - 0.0543\left(\frac{X_{Li}}{at}\%\right)^2$$

A typical result of obtaining the PbLi composition is shown in Figure 4. By this way, we can obtain the composition of the PbLi from the MP (or SP) data.

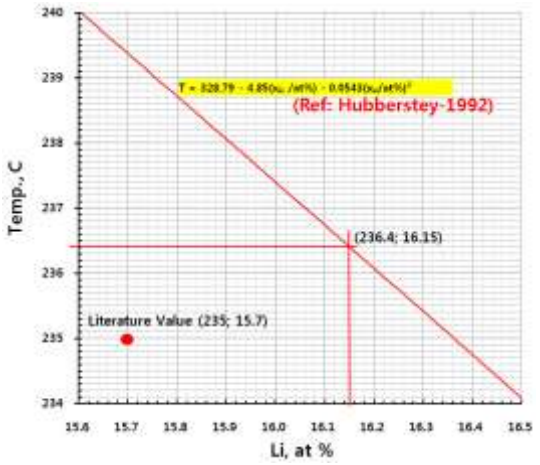

Figure 4. A typical result of obtaining composition from the MP(or SP) data of PbLi.

Effect of water addition to the molten PbLi is experimented, and a typical result is shown in Figure 5. One conclusion is that the molten PbLi, when met with water, will not react with water. Rather, molten PbLi will cool down when it meets water. This is good news for the operation of ELLI, as we can be free of concern on PbLi reactivity with water, which is contrary with the result of molten lithium which reacts violently with evolution of large heat. Besides, experiments of melting and cooling in some cases of air-contact resulted insignificant changes in the characteristics of PbLi. However, for the minimum change of PbLi characteristics, it is advisable to do PbLi experiments in argon atmosphere.

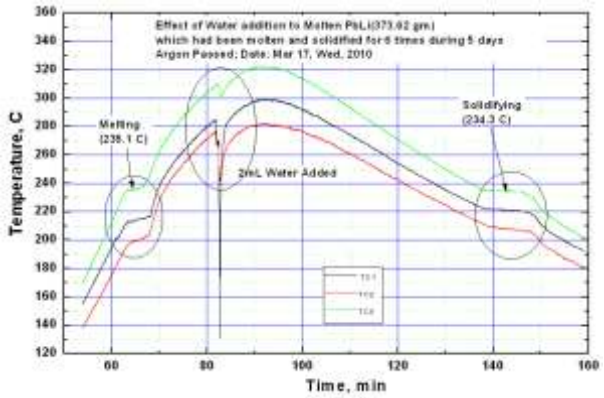

Figure 5. Effect of water addition to the molten PbLi in argon atmosphere

3. Conclusion

Results confirmed many cycles of safe melting and solidifying of PbLi is expected for the ELLI operation without significant change of PbLi composition. Specifically, water addition did not result any temperature rise. Contrary to the lithium metal which evolves much heat when in contact with water, molten PbLi cooled when water was added. This is very good for the sate operation of ELLI. Progresses are now achieved in the TBM development by using PbLi as a breeding material. Completion of the test loop for the PbLi circulation and the ensuing experiments with this will further furnish necessary knowledge for the TBM completion.

References

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