

3-31-2005

## Developing A Sensing System for the Measurement of Oxygen Concentration in Liquid Pb-Bi Eutectic: Quarterly Progress Report (Jan. 01 – March. 31, 2005)

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### Repository Citation

Jiang, Y., Fu, B. (2005). Developing A Sensing System for the Measurement of Oxygen Concentration in Liquid Pb-Bi Eutectic: Quarterly Progress Report (Jan. 01 – March. 31, 2005). 1-3.

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**Quarterly Progress Report**  
**(Jan. 01 – March. 31, 2005)**

**Task 13:**  
**Developing A Sensing System for the Measurement of Oxygen**  
**Concentration in Liquid Pb-Bi Eutectic**

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# **Developing A Sensing System for the Measurement of Oxygen Concentration in Liquid Pb-Bi Eutectic**

## **Introduction**

We performed data analysis on the data collected from LANL test loop. One student was hired to perform the data analysis. A new proposal is submitted to TRP program. We have one paper accepted for publication in International Journal of Heat and Mass Transfer, and another paper accepted for oral presentation by IEEE International Symposium of Circuits and Systems for the track Chemical Sensors. A manuscript regarding to the RGA analysis for the calibration of oxygen sensor is on the way.

## **Personnel**

Principal Investigators:

Dr. Yingtao Jiang (Electrical and Computer Engineering)  
Dr. Bingmei Fu (Mechanical Engineering)

Professional

Dr. Jian Ma, Professional, (Mechanical Engineering)

Student:

Ms. Yi Lu (Electrical and Computer Engineering)

## **Management Progress**

Expenditures incurred during this quarter are within the target amount allocated.

## **Management Problems**

Experimental work in LANL was not running at the full capacity due to various safety issues that were surfaced in the past a few months.

## **Technical Progress**

- A journal article on the oxygen sensor is right on the way.
- A manuscript entitled “Enhancement of Oxygen Transfer in Liquid Lead and Lead-Bismuth Eutectic by Natural Convection” has been accepted for publication by International Journal of Heat and Mass Transfer.
- A paper has been accepted by IEEE International Symposium of Circuits and Systems for the track Chemical Sensors. This work will be presented in the conference in this coming May.
- Preparation of a paper regarding to the RGA analysis for the calibration of oxygen sensor is on the way.
- Delta loop experimental data analysis to find the temperature response of the YSZ oxygen sensor under the hydrogen injection condition.

## Technical Difficulties and Plan for Next Quarter

- The sensors based on the YSZ (solid electrolyte) /BiBi<sub>2</sub>O<sub>3</sub> (reference electrode) system have been studied by UNLV/LANL. However, the development of this type of sensor was hindered by the following problems.
  - The leakage of the liquid metal can contaminate the sensor chamber.
  - YSZ oxygen sensor will stop functioning, once the signal wire is extremely oxidized after a certain amount of running time. This negates our effort in the process of oxygen sensor calibration, and it can be a serious problem for this type sensor to be used in long-term monitoring of the dissolved oxygen concentration in large loops.
  - The thermal shock of solid electrolyte can pose a serious reliability problem.
- There are a few problems in the apparatus developed by TRP Task 13 team members and also the experiment.
  - Current heating method can only heat the liquid LBE up to 480 °C. Such temperature is lower than expected operating temperature range (> 750 °C). Even though some preliminary oxygen sensor calibration curves have been achieved and some significant improvement have been designed and taken into the practice, the comprehensive calibration curves showing the sensor characteristics and sensor response are still waiting to be addressed in the future study.
  - Currently, we are able to produce a sound (pressure and vacuum) tight seal between the sensor tip and the metal body. Temperature over the melting point (780 °C) of the braze material will cause the leakage of liquid metal into the sensor chamber.
  - From time to time, oxygen sensors need to be replaced. As shown in Fig. 1, a thick lead oxide layer may form at the surface of the LBE liquid. The surface of the oxygen sensor will be immediately blocked by the lead oxide when the oxygen sensor is inserted into the liquid LBE again. This may cause the oxygen sensor stop functioning.



Figure 1. Thick Lead Oxide Layer on the Surface of LBE after Open to Air.