Development of Vapor Explosion Promotor for Rapid Cooling and Atomizing of High Melting Point Metal

Background

Amorphous materials have functional characteristics such as electro-magnetic property and corrosion resistance. The material compositions to be amorphized are, however, limited due to low cooling rate of conventional liquid atomizing methods. Therefore, we have proposed the ultra rapid cooling and atomization technique using sustainable small-scale vapor explosion, namely CANOPUS＊1. Cooling rate of the CANOPUS method is more than 280 times as high as that of the conventional liquid atomizing methods. Vapor explosion can occur below a certain molten material temperature. The upper-limit temperature of the molten material, in which vapor explosion can occur, differs from one coolant to another. In order to amorphize high melting-point materials, it is necessary to develop a vapor explosion promotor that induces vapor explosion in high-temperature molten materials.

Objectives

To develop a vapor explosion promotor that induces vapor explosion in high-temperature molten materials and to clarify the promotion mechanism of vapor explosion,

Principal Results

1. Development of vapor explosion promotor

A molten tin droplet was released from a nozzle into a coolant pool to investigate the temperature range of molten tin where vapor explosion occurred. When a salt is dissolved into water, the upper-limit temperature shifts to the higher temperature (Fig.1). The highest temperature shift was achieved for a lithium chloride aqueous solution among other solutions, as the vapor explosions were observed over 1000°C in the lithium chloride aqueous solution. The lithium chloride aqueous solution is, therefore the most efficient vapor explosion promoter within the test solutions.

2. Evaluation of vapor film collapse process

In order to investigate the effect of salt additives on the shifts of upper-limit temperature, a high-temperature stainless-steel sphere was immersed into a coolant pool. The acquired temperature at the vapor film collapse in salt water is higher than that in water (Fig.2). In addition, measured time traces of the temperature signals indicate that film boiling heat transfer is increased for the salt additives into water, which may cause a shift of upper-limit temperature of the vapor explosion (Fig.3).

3. Clarification of mechanism which promotes vapor explosion

The temperature of vapor film collapse roughly agrees with the upper-limit temperature of vapor explosion region into the same solution (Fig.4). Therefore, salt additives into water induce the collapse of vapor film at high temperature, which results in the triggering of vapor explosions.

Future Developments

The developed vapor explosion promotors will be applied on the basis of the CANOPUS method for producing new functional amorphous powders.

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Reference

T. Arai, et.al., 2006, “Development of Vapor Explosion Promotor for Rapid Cooling and Atomizing of High Melting Point Metal“, CRIEPI Report, L05013 (in Japanese)

＊1：CANOPUS is an abbreviation of Cooling and Atomizing based on NOble Process Utilizing Steam explosion.

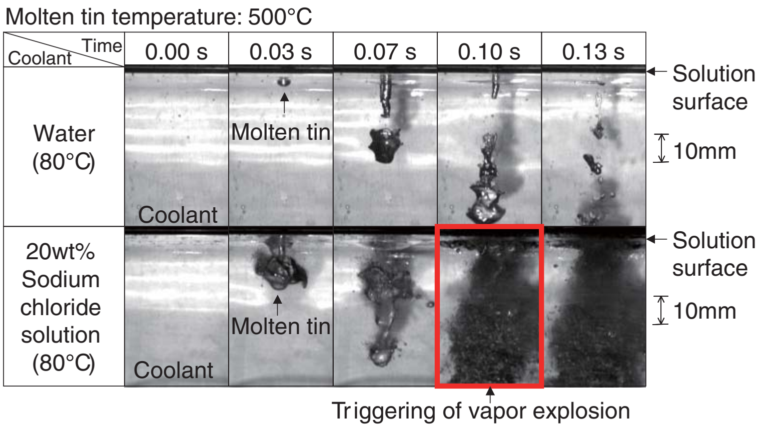

Fig.1 Effect of salt additives on vapor explosion

Table 1 Upper-limit temperature of vapor explosion

Coolant (80 °C) (20wt% solution)	Upper-limit temperature of vapor explosion (°C)
Water	No explosion
$MgSO_4$ solution	425
NaCl solution	550
$MgCl_2$ solution	650
$CaCl_2$ solution	730
LiCl solution	1190

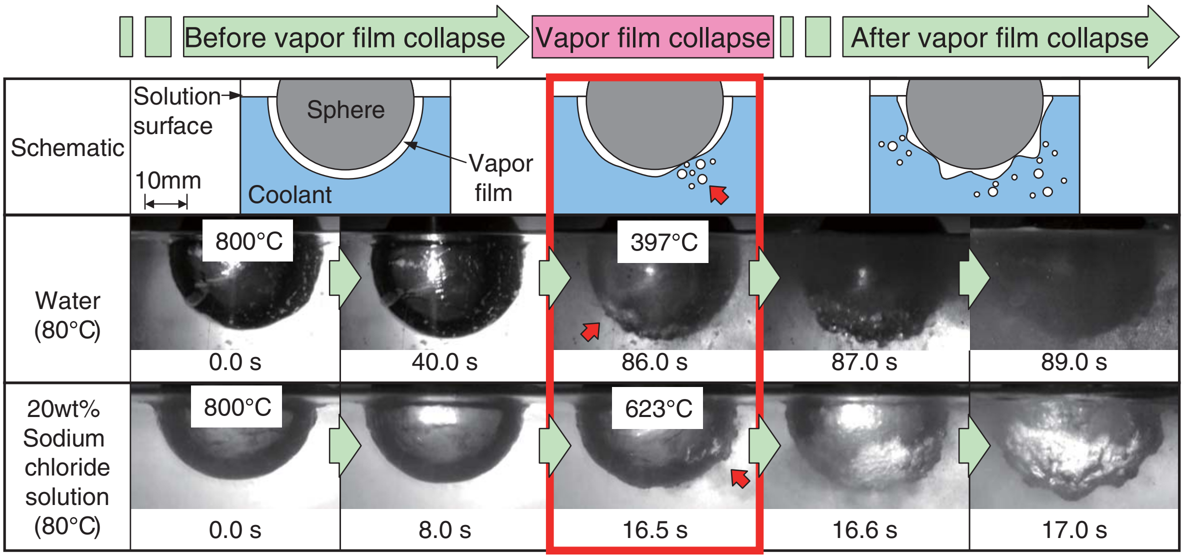

Fig.2 Effect of salt additives on vapor film collapse

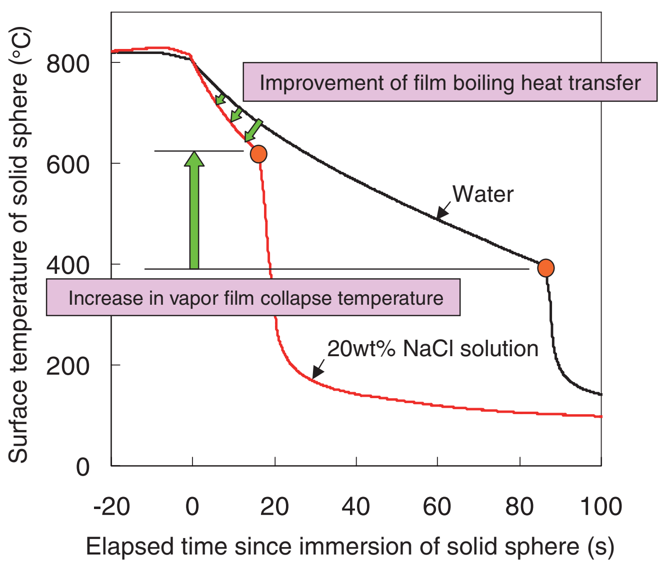

Fig.3 Effect of salt additives on quenching curve

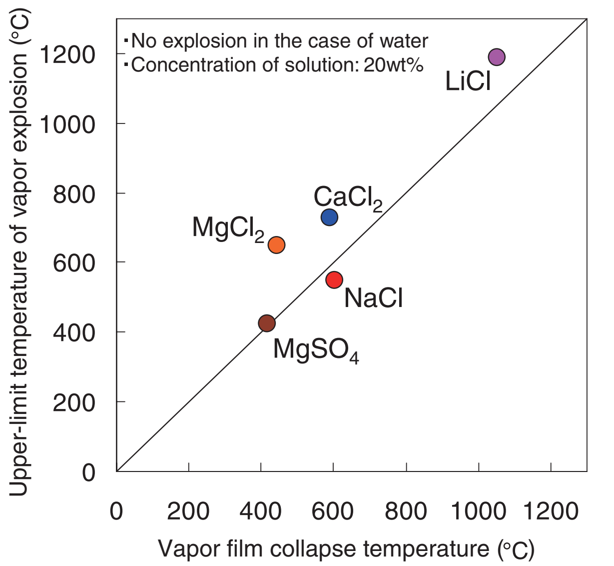

Fig.4 Relationship of upper-limit temperature of vapor explosion to vapor film collapse temperature