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Research on Structure and Properties of the Fused Cast AZCS Refractory

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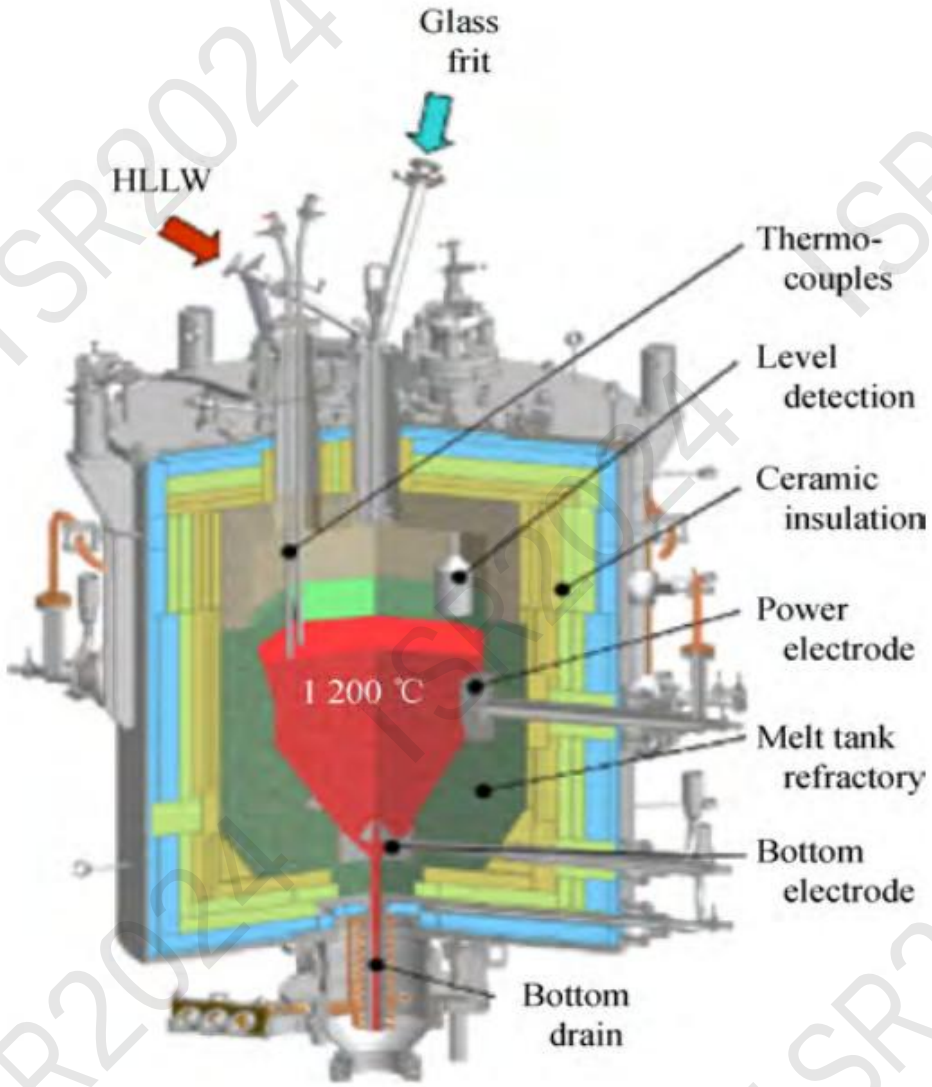
1. Introduction

- At present, high level liquid waste (HLW) vitrification is the only mature technology that achieves engineering applications in the treatment of high-level radioactive waste.

- The key equipment of vitrification is the Joule heated ceramic melter/furnace.

- This work investigates the structure and properties of fused cast aluminum-zirconium-chromium-silicon (AZCS) refractory for the Joule heated ceramic furnace.

Schematic of the Joule heated ceramic furnace



2. Experimental Procedures

- The chemical analyses of the samples were performed by X-ray fluorescence spectrometer in accordance with the requirements of GB/T 21114-2019.
- The apparent porosity and bulk densities of samples were measured by kerosene absorption as indicated in GB/T 2997-2015.
- Determinations of exudation of glass phase of samples were conducted according to appendix B of JC/T 493-2015.
- According to the JC/T 805-2013 and JC/T 639-2013 testing standards, the initial exudation temperature of glass phase and the bubble rate of samples are measured respectively;
- According to the GB/T 5072-2023 and GB/T 7320-2018 standards, the cold crushing strength and linear expansion rate of the test sample are measured separately.
- According to JC/T 806-2013, the static corrosion resistance tests were performed at 1500 ℃ for 36 h, using test specimens with a size of 10 mm×10 mm×70 mm.

Table 1 Chemical analysis of the test glass

Composition	SiO_2	B_2O_3	Na_2O	Li_2O	K_2O	Al_2O_3	CaO	MgO	BaO
ordinary soda lime glass	72.2	/	14.3	/	0.3	1.5	7.8	3.9	/
borosilicate glass	44.89	12.26	11.06	2.18	/	5.11	6.72	4.37	3.51

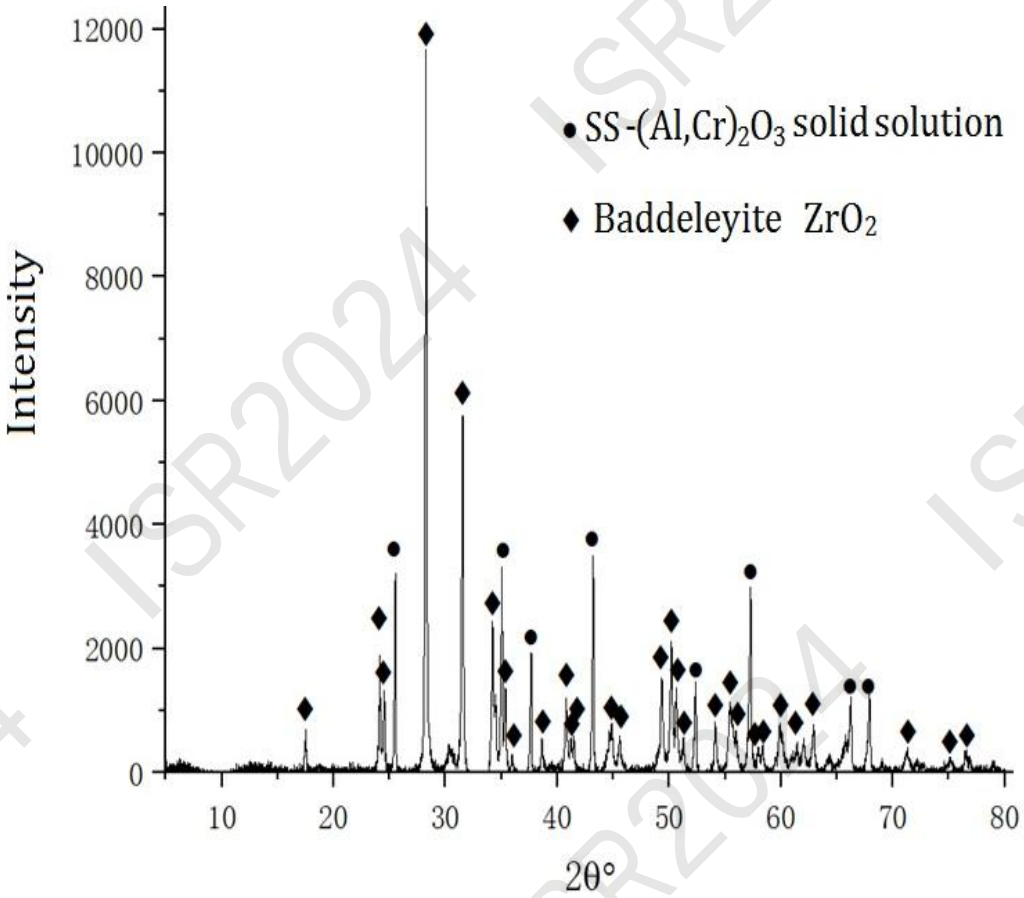
The static corrosion resistance test

3. Results and Discussion

Table 2 Physical and chemical properties of the AZCS samples

	Material properties	index
Chemical-composition /w %	SiO_2	12.31
	Al_2O_3	29.70
	ZrO_2	25.32
	Cr_2O_3	31.22
	Na_2O	0.80
	MgO	0.26
	others	0.39
Physical-property	Bulk density /($g \cdot cm^{-3}$)	3.80～4.01
	Apparent porosity /%	3.0～5.0
	Cold crushing strength /MPa	398
	Rate of static corrosion resistance to ordinary soda-lime glass /$mm \cdot d^{-1}$ (1500 ℃×36 h)	0.31
	Rate of static corrosion resistance to borosilicate glass /$mm \cdot d^{-1}$ (1500 ℃×36 h)	0.35
	Exudation of Glass Phase /% (1500 ℃×4 h)	1.46
	Initial exudation temperature of glass phase /℃	1460
	Bubble rate /% (ordinary soda-lime glass, 1300 ℃×10 h)	0.80
	Linear expansion rate /% (400～1300 ℃)	0.71

Fig. 1 XRD pattern of the fused-cast AZCS material

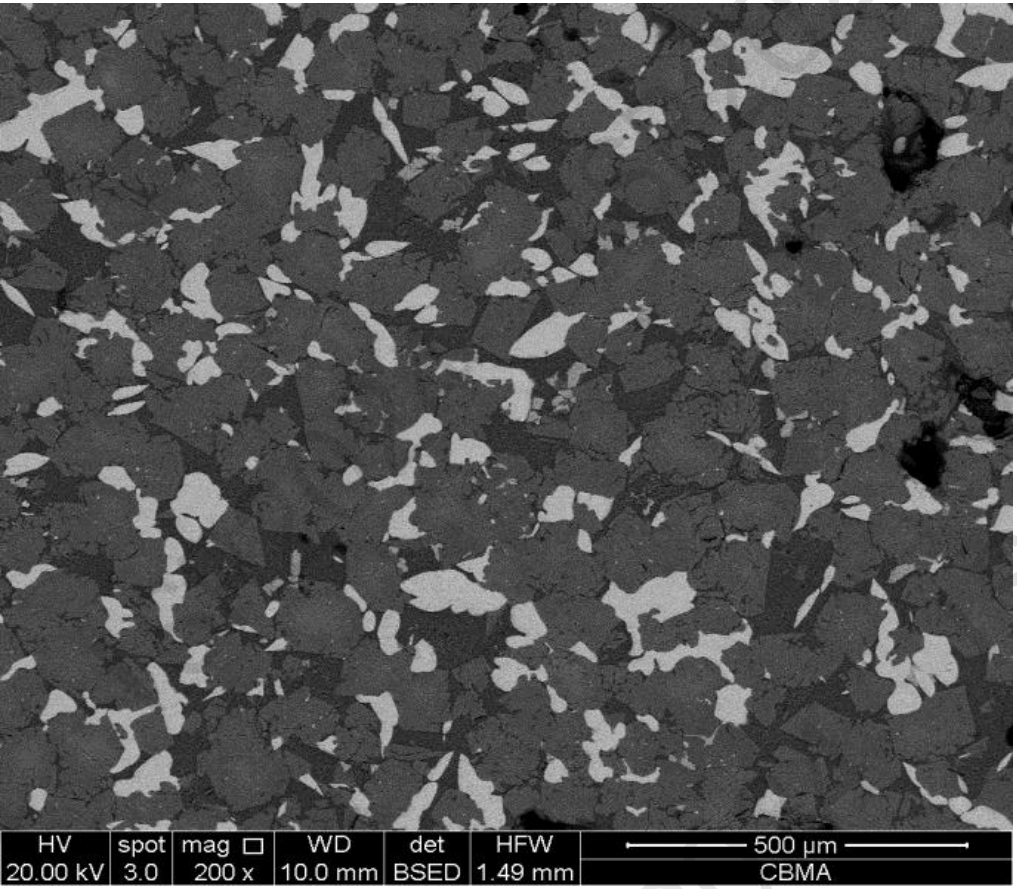


Typical phase composition of AZCS

- Al_2O_3-Cr_2O_3 solid solution 50-53%,
- Monoclinic ZrO_2 26-29%
- glass phase 16-18%.

there is no corundum or Al_2O_3-ZrO_2 eutectoid, nor is there any free Cr_2O_3

Fig. 2 Micro-morphology of the fused cast AZCS



- Due to its rich (Al, Cr) $_2O_3$ with good chemical stability and the secondary crystal phase is ZrO_2 baddeleyite
- AZCS have high erosion resistance to glass.

Table 3 Comparison of main performance of fused cast refractory

Refractory		Fused-cast AZCS	Fused-cast AZS 33	Fused-cast AZS 41
Main chemical composition / w %	ZrO_2	24～28	32～35	40～44
	Al_2O_3	27～33	47～51	45～46
	SiO_2	11～15	≤16	≤13
	Cr_2O_3	24～28	/	/
Rate of static corrosion resistance to ordinary soda-lime glass /mm·d^{-1}		0.31	1.60*	1.30*
Initial exudation temperature of glass phase /℃		1460	1400*	1400*
Bubble rate /% (ordinary soda-lime glass, 1300 ℃×10 h)		0.80	2.0*	1.0*
Exudation of Glass Phase /% (1500 ℃×4 h)		1.46	2.0*	3.0*

* Quoted from JC/T 493-2015

- The corrosion resistance of fused-cast AZCS material is at least 4-5 times higher than that of fused-cast AZS material.
- According to Vogel Fulcher Tammann (VFT) law, the Al^{3+} and Cr^{3+} ions in the glass phase of AZCS have both positive influence on the high-temperature viscosity (log η).
- Therefore, compared with fused-cast AZS materials, the AZCS materials have higher initial exudation temperature of glass phase, lower exudation of glass phase and bubble rate.

4. Summary

- AZCS material has a unique microstructure and properties including the excellent erosion resistance, making it has broad application prospects in glass fiber furnaces, colored glass melting furnaces, etc.
- It can be used in areas where severe corrosion occurs in glass furnaces, such as doghouse corners, bubbler zone, weirs, and throats. It can also be used as a patch tile for glass tank to extend the service life of sidewall.

Thanks!

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