

가스화 공정에서의 슬래그 거동

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오명숙

2001년 1/4 분기 IGCC 기술연구회

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Ash Content and Composition in Gasification Feedstocks



Feedstock	Ash Content (%)	Major Components
Coal	3 ~ 17	Si, Al, Ca, Fe, Mg
Vacuum Resid	1 ~ 4	V, Ni
Petroleum Coke	1 ~ 4	V, Ni
Tires	4 ~ 5	Zn, Si
Orimulsion	0.04 ~ 0.25	V, Mg, Ni

Ash causes more process problems than the organics in the feed



- Slagging

- -
- 가
-

- Deposits

- Burner Deposits – 가

- 가
-
- 가

Deposits

Deposit (: As at 100 °C)

NiS Deposit

- Toxic Trace Elements

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Importance of Slag Viscosity in IGCC

- 슬래그 점도는 온도와 성분의 함수이며 슬래그안의 결정체 형성은 점도를 큰 폭으로 변화 시킨다.

- η , ρ 가

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- Refractory Corrosion

- Refractory

- Deposit Formation

-

-

가 deposit model

Slag Viscosity and the gasification temperature



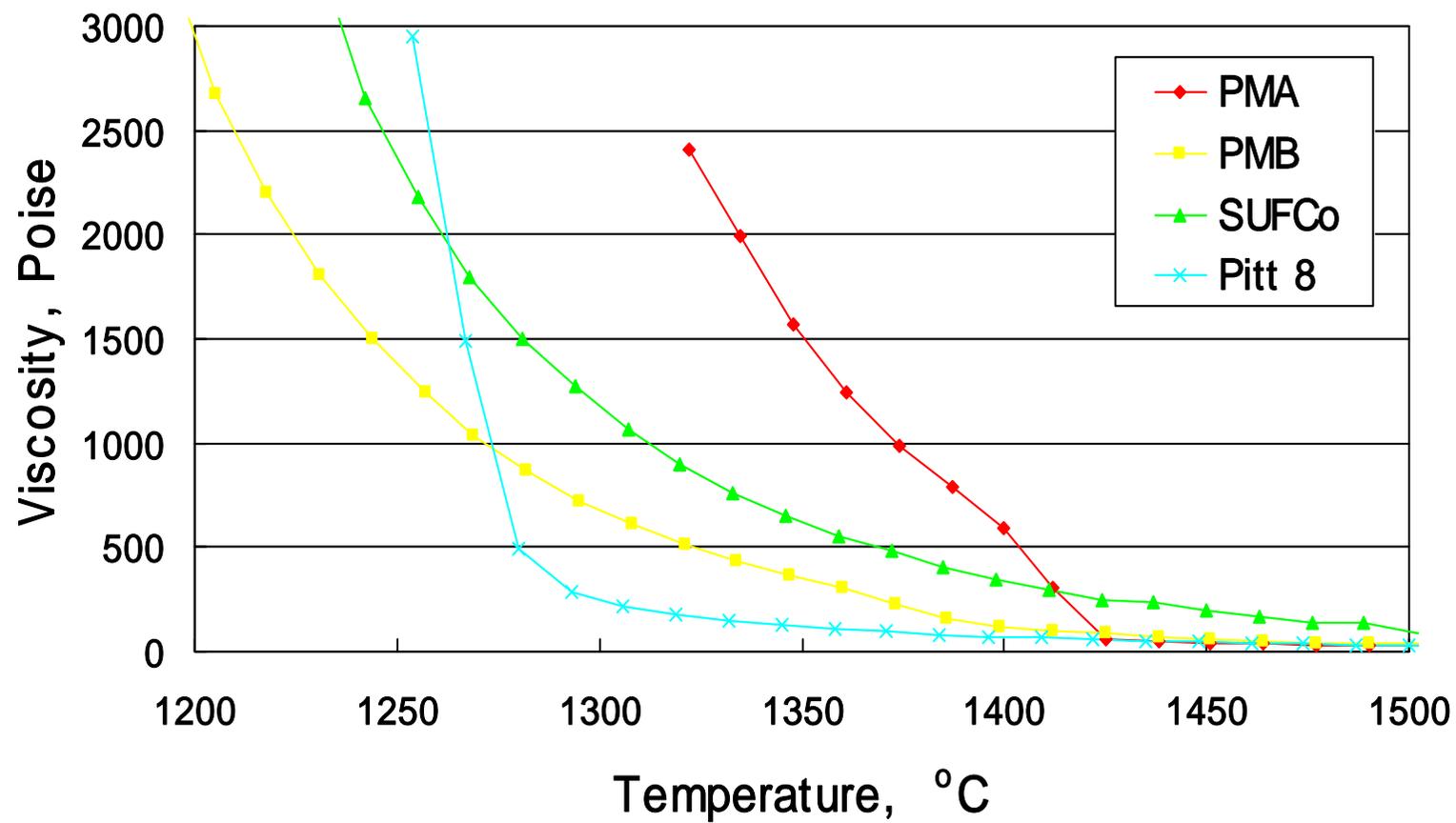
- For slag tapping, Corey (1964) recommended
 - Optimum viscosity – 150 poise
 - Maximum viscosity – 250 poise
- (홍익대) Minimum gasification temperature
 - Glassy slags: $T(1000 \text{ poise}) + 50 \text{ }^\circ\text{C}$
 - Crystalline slags: $T_{cv} + 50 \text{ }^\circ\text{C}$
- 온도 vs. 점도의 전체 경향이 중요함

Slag Viscosity Measurements

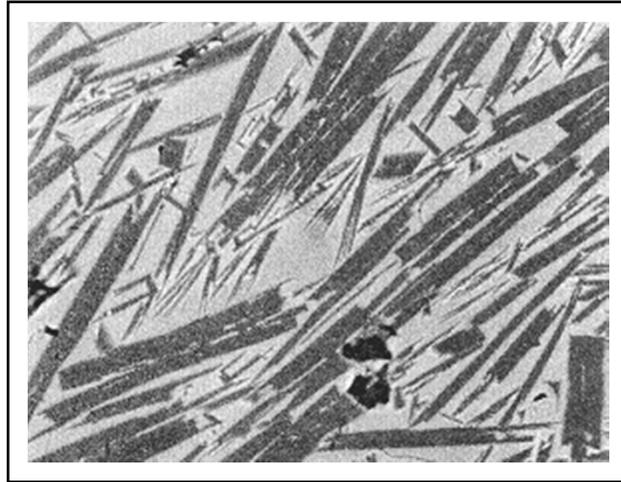


- Viscometer
 - Searl type concentric cylinder viscometer
 - Cell placed in a high temperature ($T_{\max}: 1600\text{ }^{\circ}\text{C}$) furnace
 - Calibration using a standard glass at high temperatures or polymer liquids at $25\text{ }^{\circ}\text{C}$
 - The rotors of various shapes are being used to minimize the end effects and the inertial effects.
- -
 - Constant T or a constant cooling rate was employed
- : , , ,

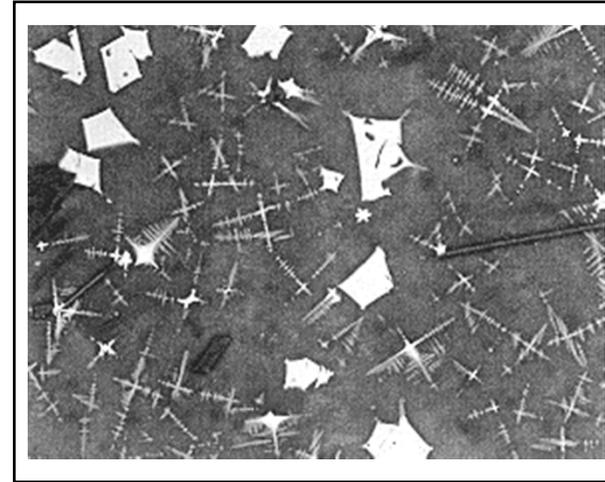
Slag Viscosity as a Function of Temperature



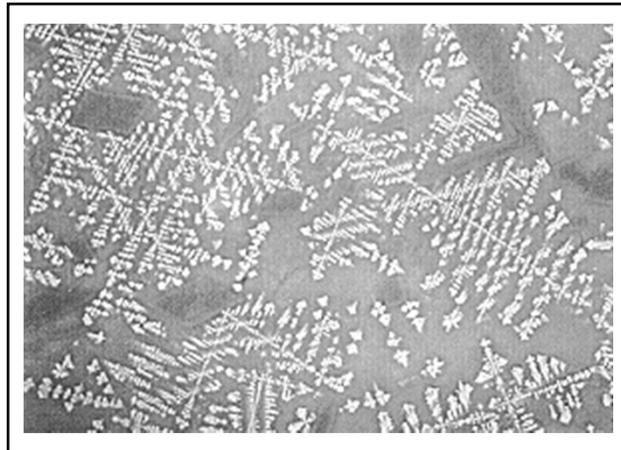
SEM Micrographs of Crystalline Phases



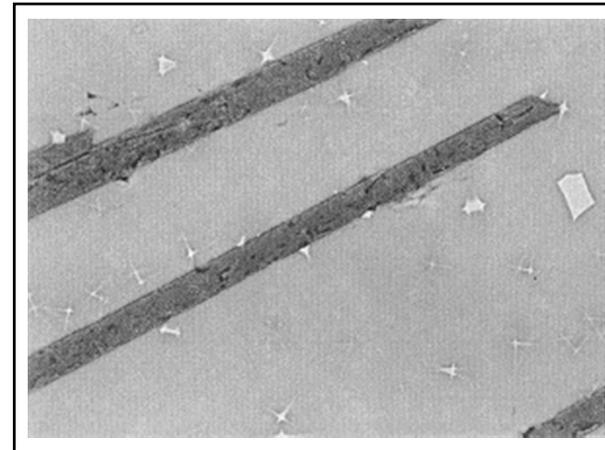
SUFCo



Pittsburgh #8



Powell Mountain A



Powell Mountain B

Slag Viscosity Models



- - Si -Ratio Model, Urbain Model, Modified Urbain Model, Watt - Fereday Model
 - Glassy Slag 가 .
 - 어떤 한 모델도 모든 슬래그의 점도를 예측하지 않는다.
- **Crystalline Slag : Annen Model**
 - ()
 -
- - Emperical models (Seggiani, 1999; Hurst et al., 1999)
 - (Nowak, 1994; Seetharaman and Sichen, 1997; Ji et al., 1999)

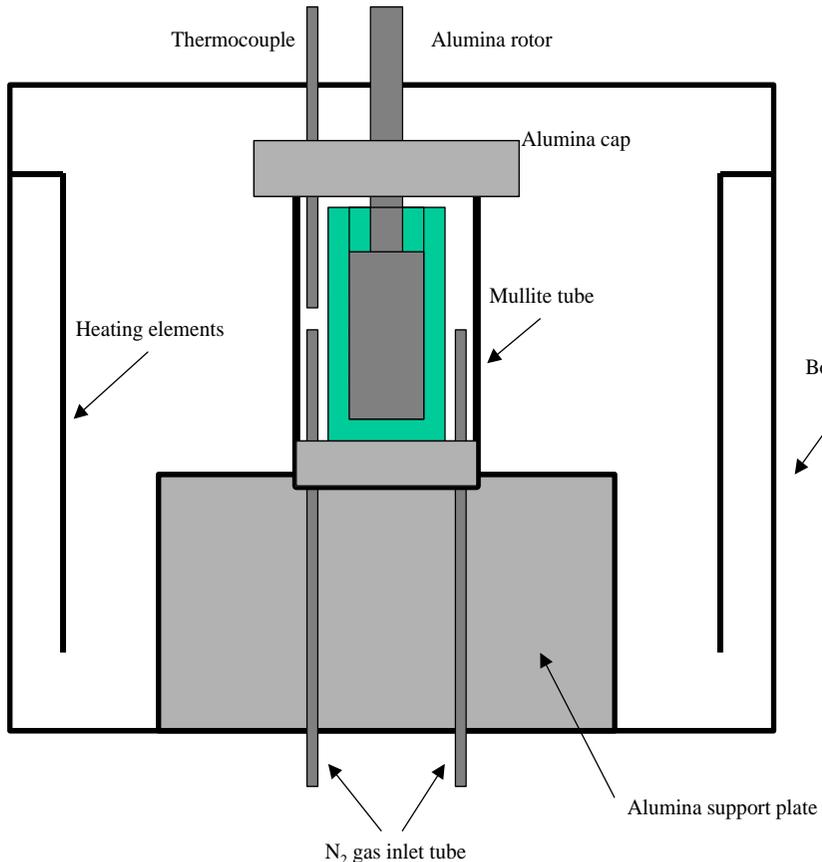
국내 석탄 슬래그 점도 연구



- , 가 (2 -9)
가
-
-
- 3- , 4- Tcv
- 가
- homepage



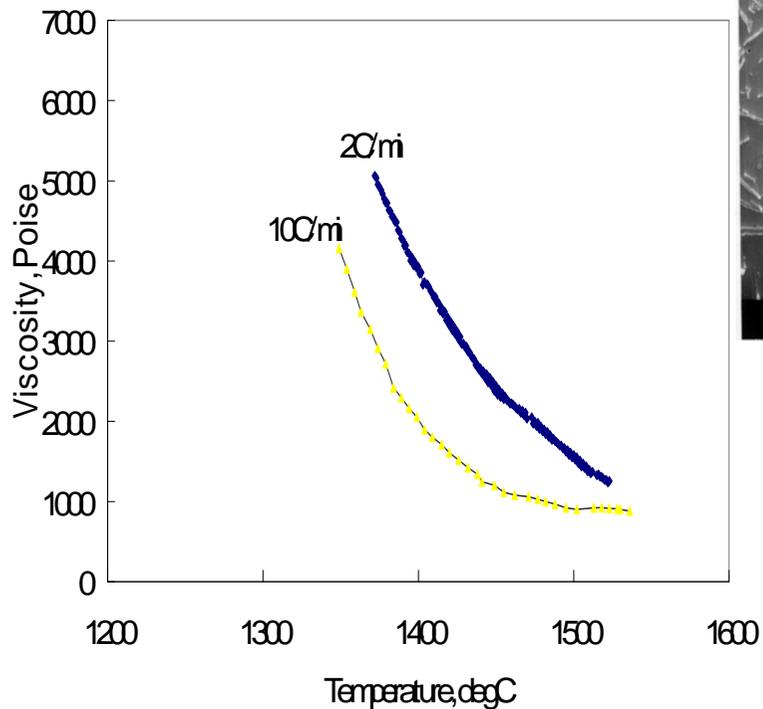
High Temperature Slag Viscometer (홍익대)



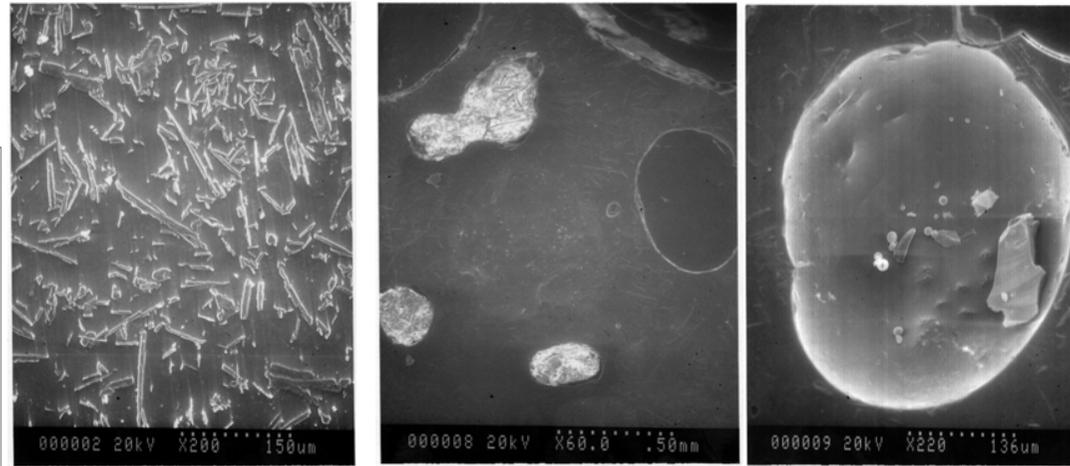
- Cell
- ,
- CO/CO₂ 가
- Mullite 가 ,

High Temperature Viscometer

Denisovsky Slag



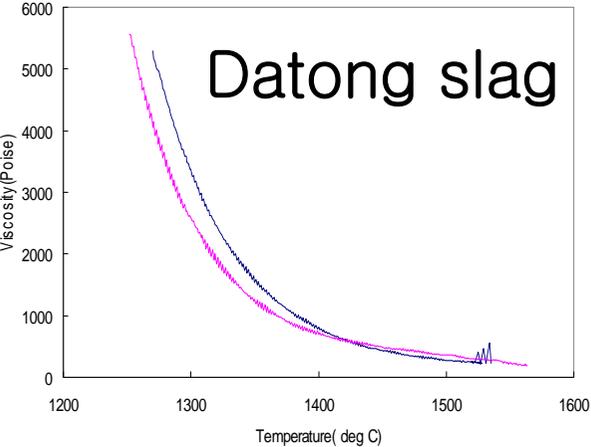
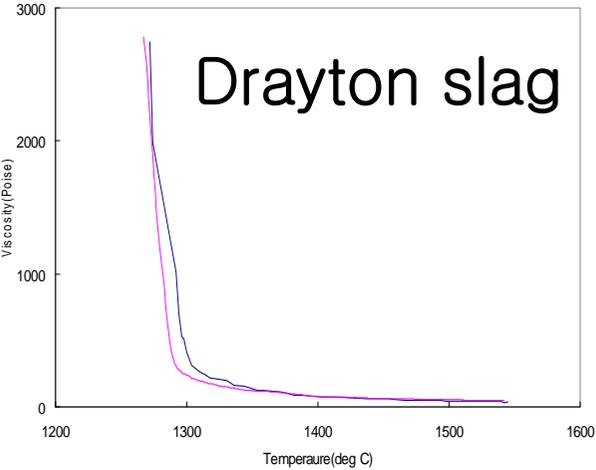
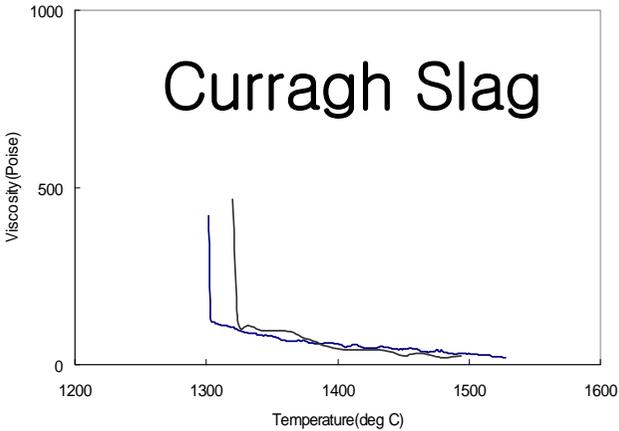
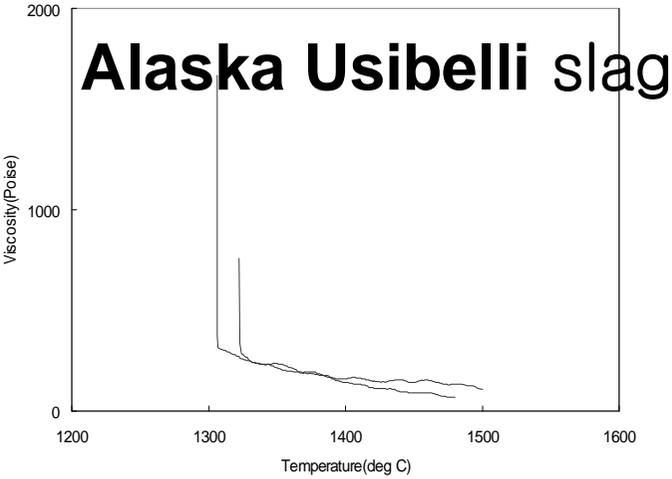
Viscosity of Denisovsky slag at two cooling rates



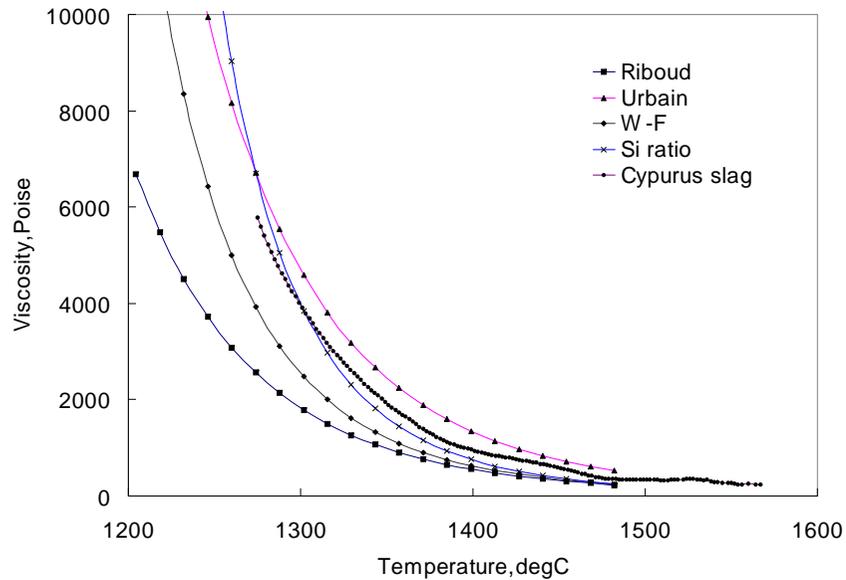
(a) Top (b) Bottom $\times 60$ (c) Pore

- 점도 실험 후 냉각시 과다 기포 생성
- 낮은 점도에서 **FeO**가 **Fe** 로 환원되면서 **metallic Fe** 생성
- **Tcv : 1490**

Slag Viscosities



Comparison with Model Predictions

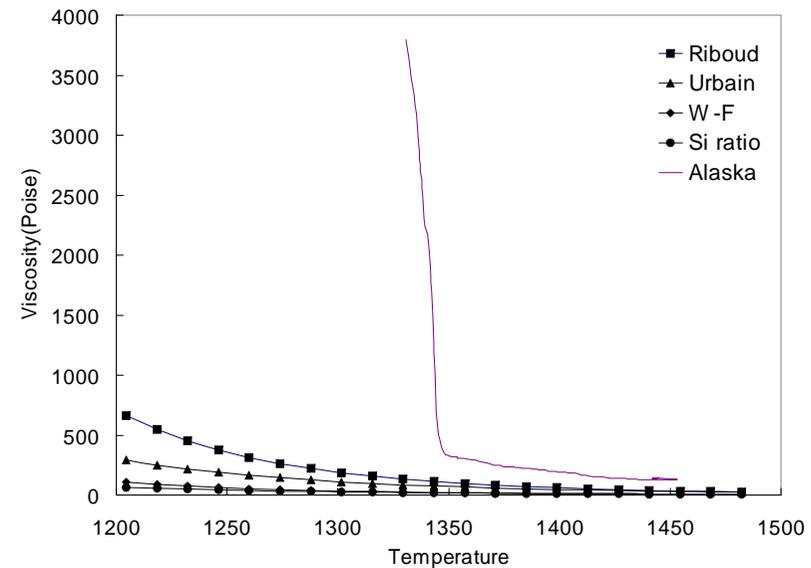


Glassy Slag :

결정상이 생성되지 않음

완만한 점도의 증가

점도 모델식으로 예측 가능



Crystalline Slag :

결정상이 생성

T_{cv} 에서 급격한 점도증가

점도 모델식으로 예측 불가능

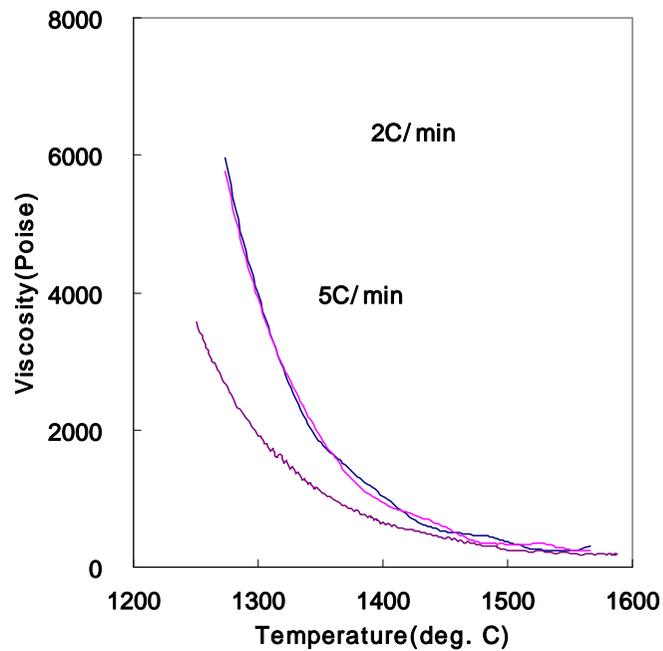
Minimum Gasifier Temperatures



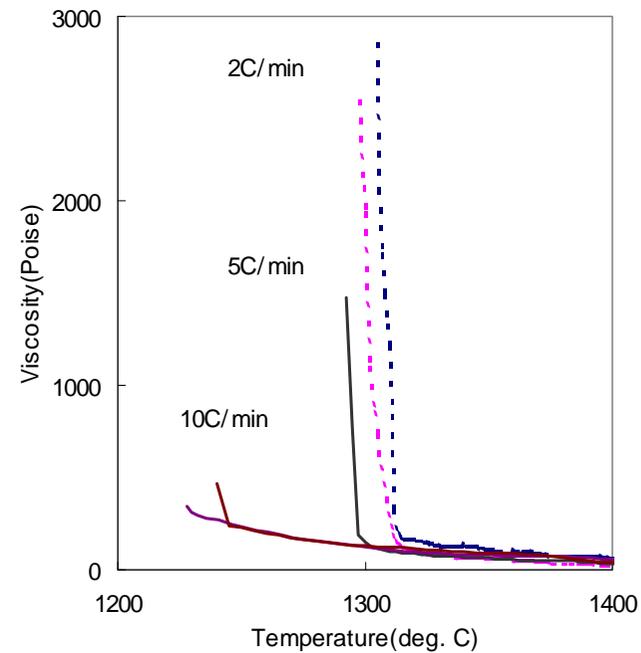
Slag	Type	T _{min} (°C)	Best Model
Alaska Usibelli	C	1364	Riboud
Curragh*	C	1360	Watt-Fereday
Drayton*	C	1336	Si-ratio or Urbain
Kideco	C	1399	-
Datong*	G	1482	-
Cypurus	G	1425	Si-ratio
Adaro	C	1407	Si-ratio
Denisovsky	G	1422	-
Baiduri	C	1373	-

* : flux 포함, C : Crystalline slag , G : Glassy slag , - : 불가능

Effect of Measurement Conditions - Cooling Rate

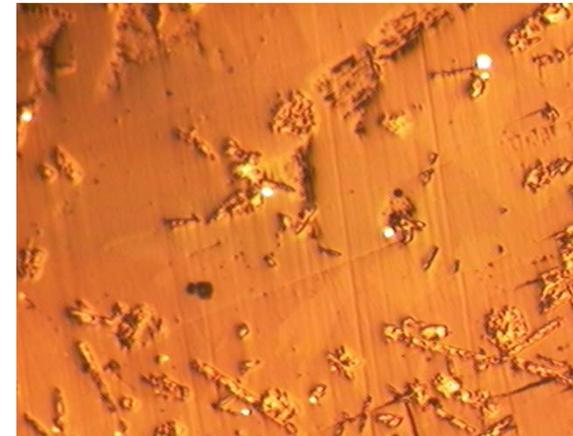
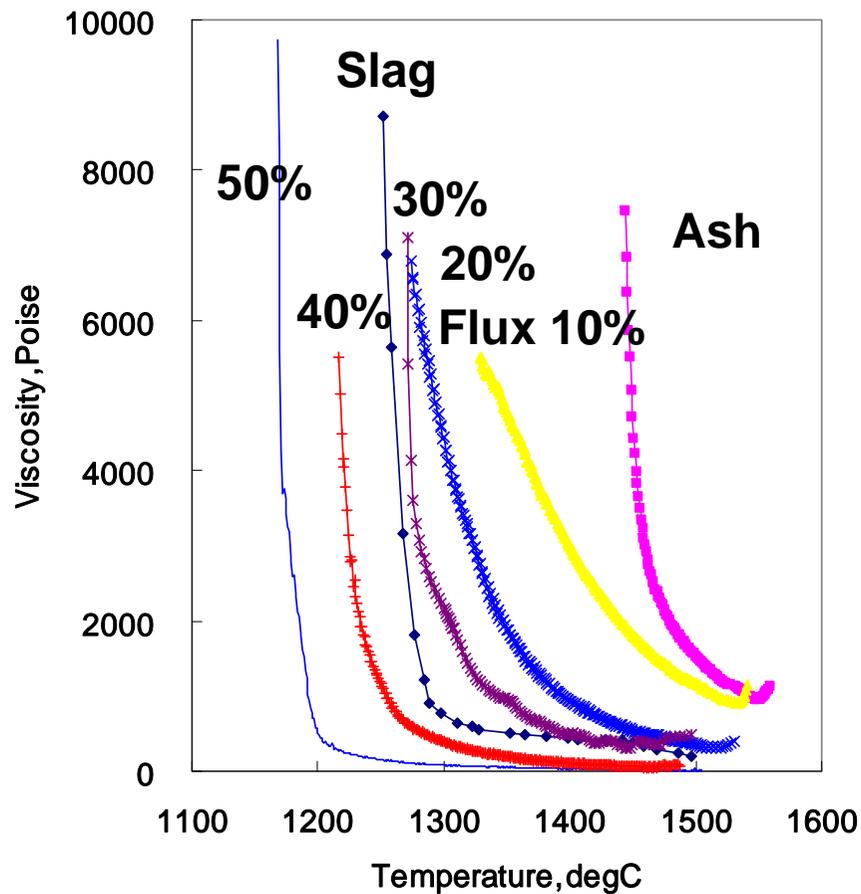


Cypurus Slag

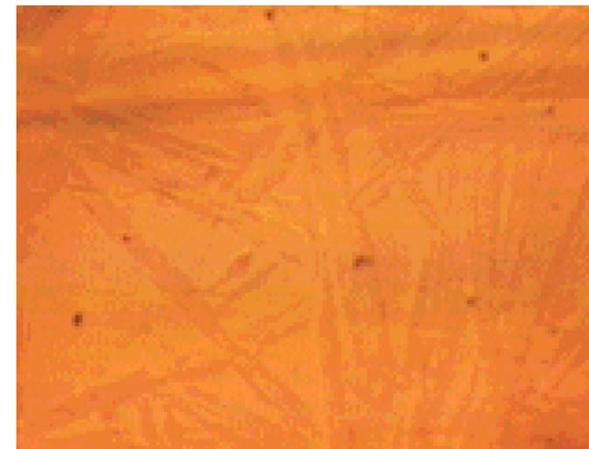


Adaro Slag

Optimum Flux Concentration Determination

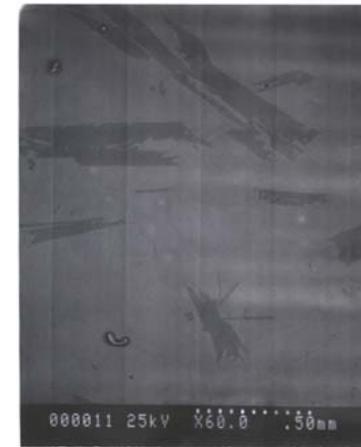
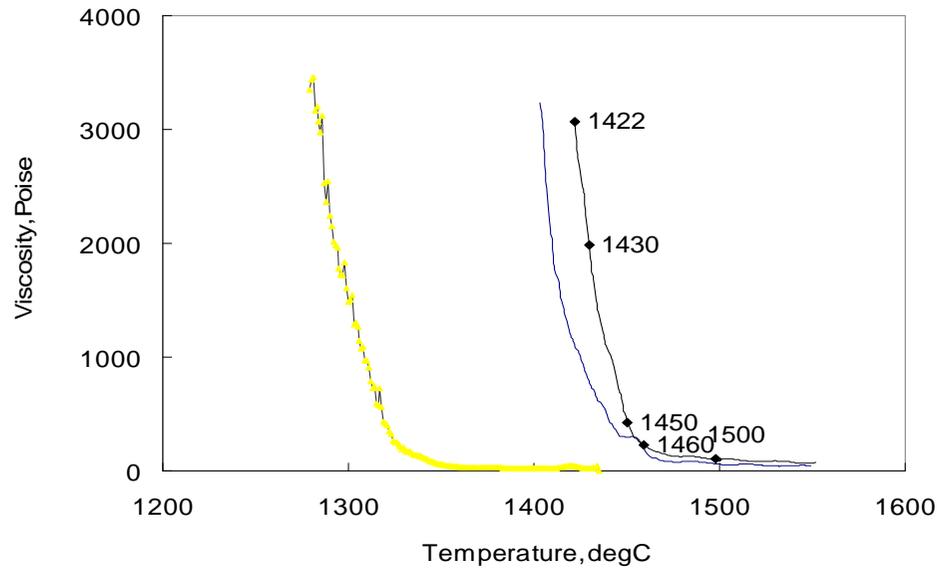


**Flux
20%**



**Flux
40%**

Synthetic Slag Study– 4-Components (SiO_2 , CaO , Al_2O_3 , FeO)



1450C



1430C



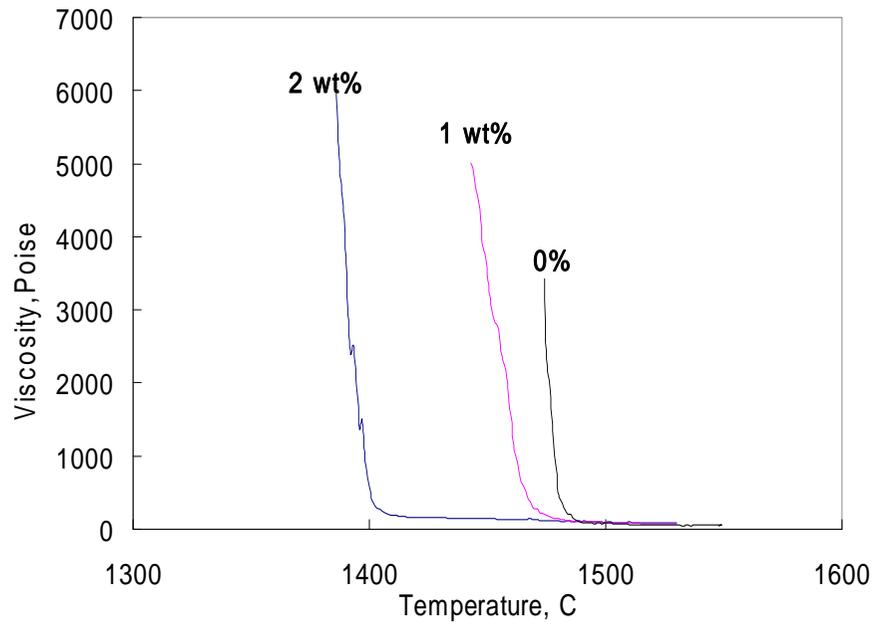
1422C

- 결정상들이 자라면서 점도가 증가함 확인
- 4-성분계 점도- 실제 Model 슬래그와 차이가 많이 남.

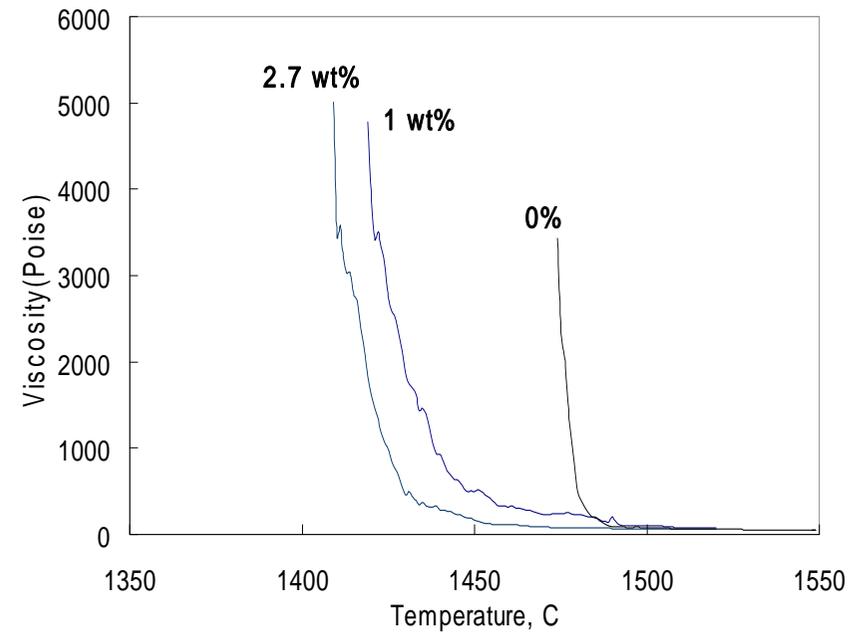
Synthetic Slag Study– Effects of minor components on Viscosity



Na₂O **MgO** – 낮은 농도에서도 점도에 많은 영향을 미침.



Effect of Na₂O



Effect of MgO



Future Research Needs

- Refractory Corrosion
 - 2 9 4-5
 - 99.9% Alumina Refractory Cr-Al Refractory Tests
- -
 - 가
- Deposit 가
-
- Slag Chemistry