
Introduction of SlagVis - Slag Viscosity Calculation Software -

RCCM, Research Center of
Computational Mechanics, Inc.

Status of theoretical models

- Features of best theoretical models so far: (More than 10 available)
 - Seetharaman Physical meaning: clear
 Gibbs Energy: Necessary
 Multi Composition: Difficult
 - Zhang Physical meaning: clear
 Gibbs Energy: Necessary
 Multi Composition: Difficult
 - Iida Experimental data is necessary to fix Al_2O_3 parameter
 Multi Composition: Easy
- Slags have wide variety in range of compositions, so there are right now no general theoretical models which can be utilized

Development Background of *SlagVis*

The Iron and Steel Institute of Japan: Autumn Conference in 2005

“Evaluation of viscosity of molten slag by using neural network computation”

Osaka University: Prof. Tanaka, Dr. Nakamoto

Sumitomo Metal Industries Ltd.: Dr. Kawamoto, Dr. Hanao

Considerably high accuracy of Slag Viscosity Calculation has been introduced for the first time.

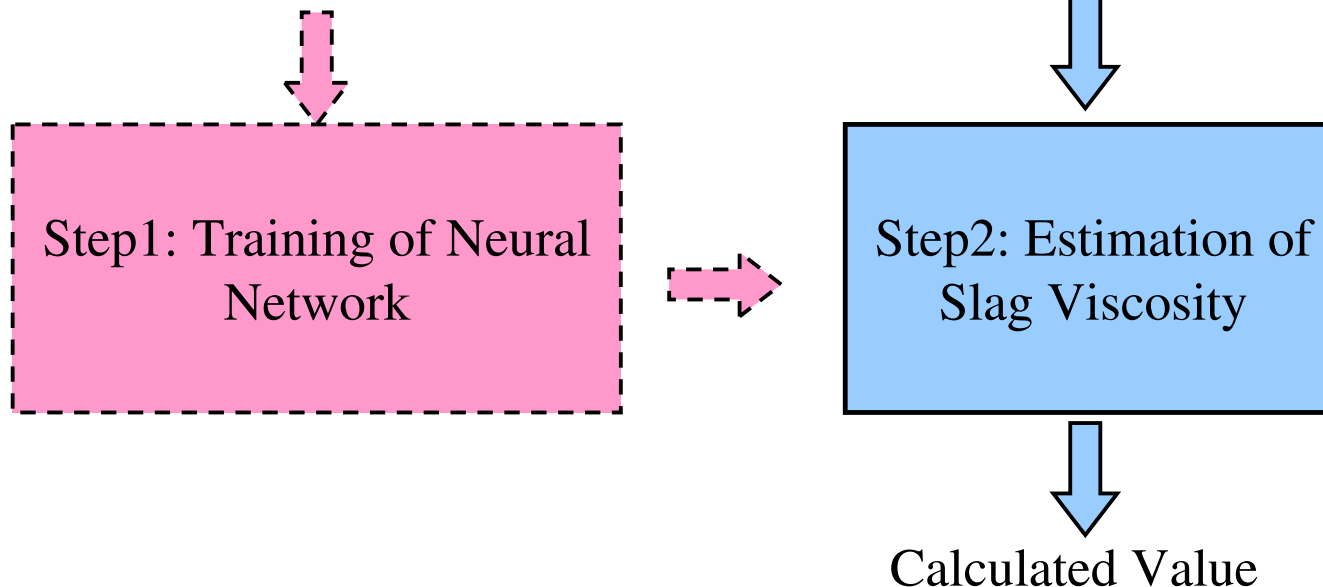
*In cooperation with Osaka University and Sumitomo Metal Industries ,
RCCM has developed software the interactive software SlagVis*



Calculation Process of *SlagVis*

Measured values: Composition,
Temperature, Viscosity)

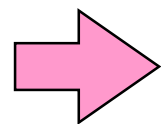
Composition and Temperature of Slag



In *SlagVis*, the Neural Network has already been trained by use of the ‘Round Robin’ data. In case that the composition and temperature of the slag to be calculated is close to the ‘Round Robin’ data, Step1 can be skipped. In case it is far from these, a “*new*” Step1 should be necessary.

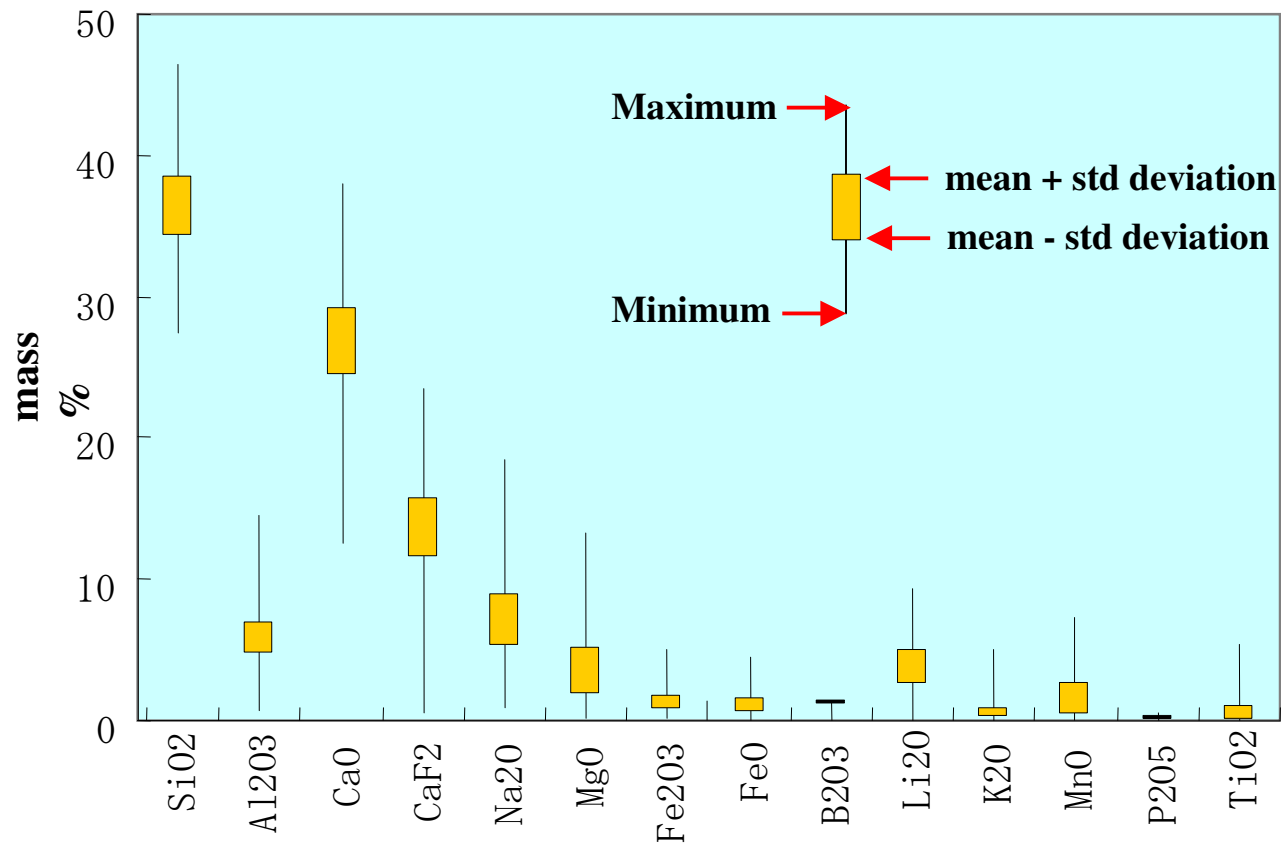
'Round Robin' Project (1997-2000)

- Determination of the accuracy and reliability of various models used to estimate the viscosities of industrial slags
- Establishment of a database for viscosity - temperature - composition data
 - (1) mold fluxes (14 components)
 - (2) blast furnace slags ($\text{SiO}_2, \text{Al}_2\text{O}_3, \text{CaO}, \text{MgO}$)
 - (3) coal slags ($\text{SiO}_2, \text{Al}_2\text{O}_3, \text{CaO}, \text{FeO}$)



Training data for Neural Network
in *SlagVis*

Composition of mold fluxes



14 components, 138 samples

Training data for Neural Network

- Round Robin Project
 - (1) mold fluxes (14 components)
 - (2) blast furnace slags (mainly SiO_2 , Al_2O_3 , CaO , MgO)
 - (3) coal slags (mainly SiO_2 , Al_2O_3 , CaO , FeO)
- Private Database
 - (4) Your measurement data
- “Mixture” of Source Data permitted
 - (1)+(4), (2)+(4), (2)+(3), ...

Training of Neural Network

Training Data file path →

Parameters for training →

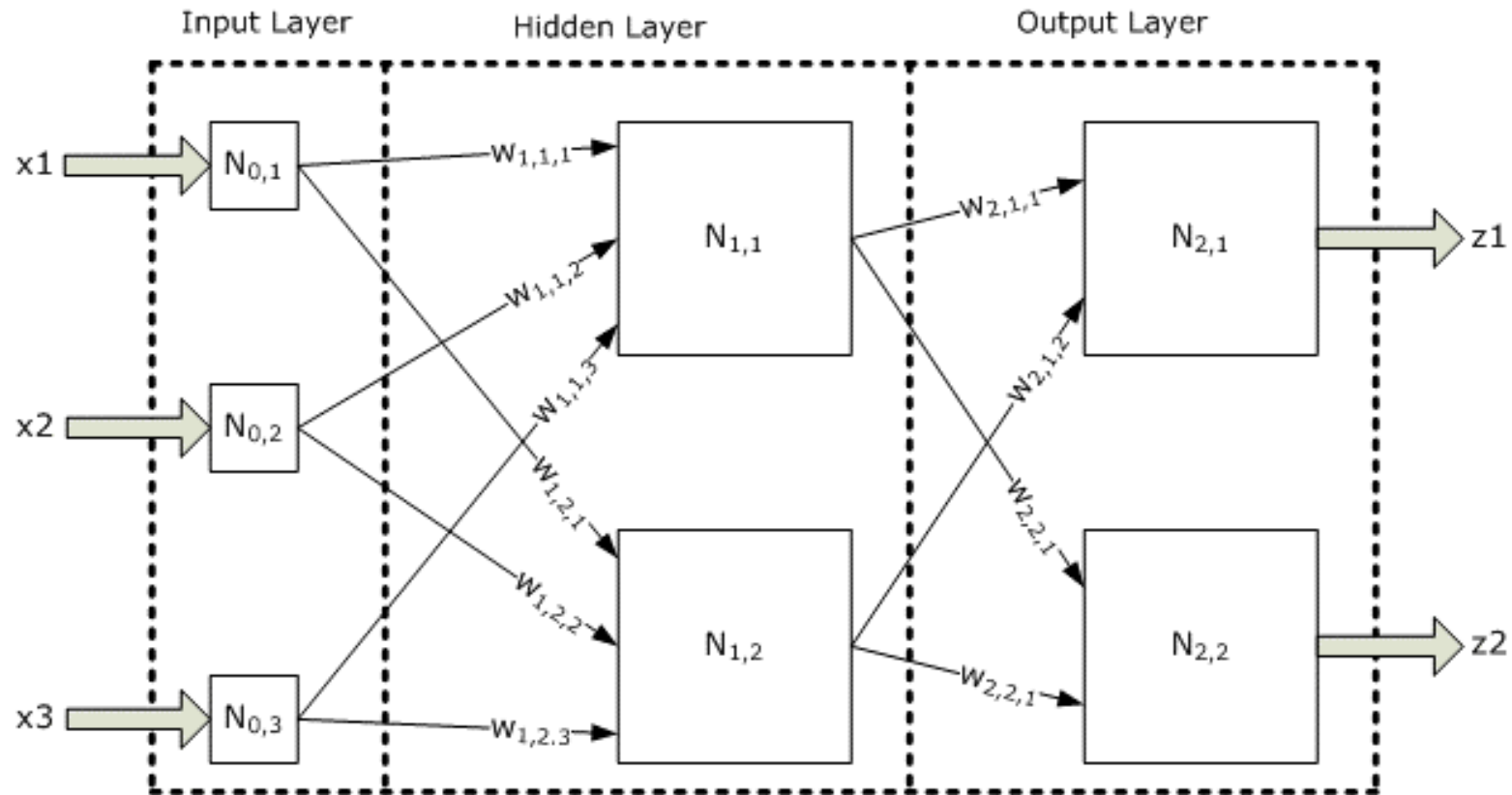
Reproducibility →

Unit of Temperature →

180	40.700000	4.4000e-001	4.8849e-001	11.021
181	44.400000	7.0000e-001	6.7159e-001	4.059
182	46.500000	1.0500e+000	1.0986e+000	4.625
183	40.900000	5.4000e-001	4.8534e-001	10.122
184	34.000000	7.5000e-002	8.1220e-002	8.293
185	36.500000	1.0200e-001	1.2708e-001	24.592
186	38.200000	4.6400e-001	4.9937e-001	7.622
187	38.500000	1.1400e-001	1.0852e-001	4.809
188	37.800000	1.7700e-001	1.7956e-001	1.449
189	32.500000	1.3000e-001	1.4754e-001	13.495
190	32.500000	1.8000e-001	2.0661e-001	14.785
191	42.500000	2.3000e-001	2.3793e-001	3.446
192	32.000000	2.0000e-001	2.0524e-001	2.618
193	37.500000	5.0000e-001	4.9558e-001	0.885
194	37.500000	2.5000e-001	2.1298e-001	14.809
195	32.500000	1.6000e-001	1.4380e-001	10.125
196	33.500000	1.2000e-001	9.4550e-002	21.208
197	34.500000	1.6000e-001	1.5870e-001	0.816

Optimize Save Network

Structure of Neural Network



Adjustable parameters: Weights (by training),
number of neurons in hidden layer (by setting)

Estimation of Slag Viscosity

Estimated Value

Composition

Composition

Summary of Training Data

Network File Path

The screenshot shows the SlagVis software window. At the top, there is a menu bar with 'User', 'RoundRobin', 'NeuOpt', 'Help', and 'Exit'. Below the menu bar, there is an 'Estimate' button and a text field containing '0.315'. To the right of this, there is a label 'Unit of Temperature: [C]'. Below these, there are two tables for composition. The left table lists various oxides and their values, and the right table lists other components and their values. At the bottom, there is a text field for the network file path and a 'Summary' button.

Component	Value
SiO2	39.6
Al2O3	6.4
CaO	27.91
CaF2	13.36
Na2O	9.7
MgO	0.56
Fe2O3	0.8
FeO	0
B2O3	0
Li2O	0

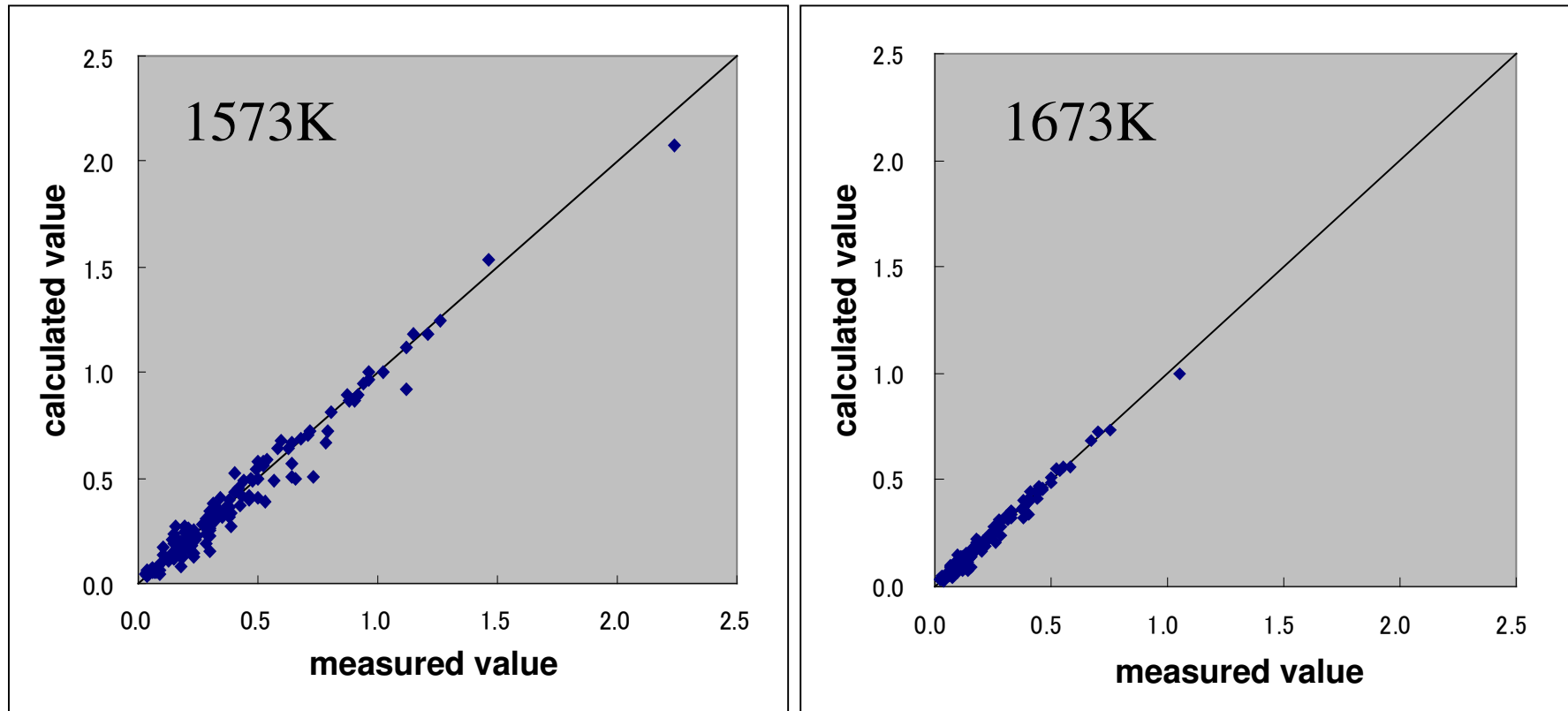
Component	Value
K2O	0
MnO	0
P2O5	0
TiO2	0
Temperature	1300

C:\SlagVisPresentation\SlagVisBeta1\rrdata_c.wrk

Summary of Training Data

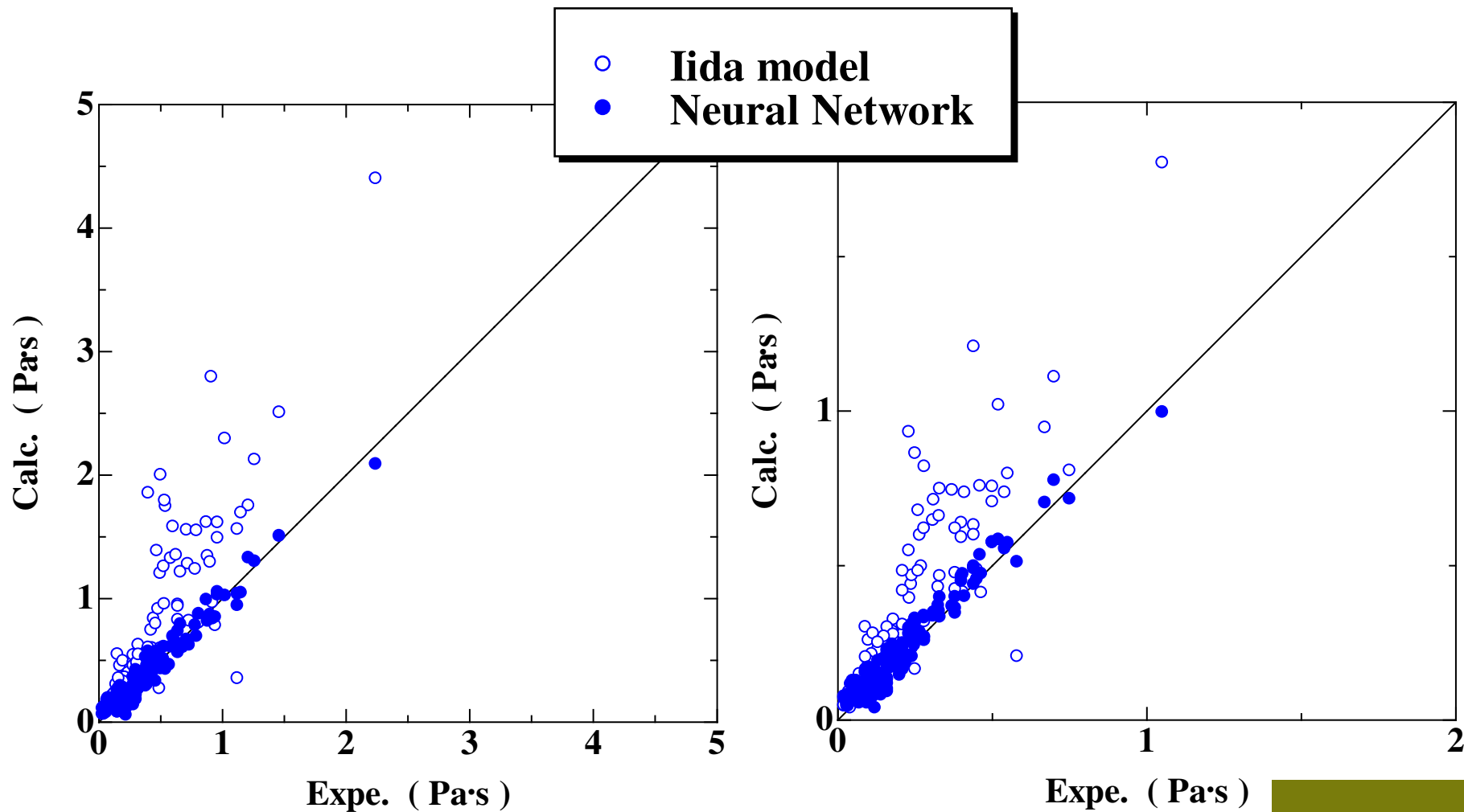
<i>Component</i>	<i>Min</i>	<i>Max</i>	<i>Average</i>	<i>Sdev</i>	<i>Ndata</i>
wt%					
SiO ₂	27.5	46.5	36.41	4.2	275
Al ₂ O ₃	0.66	14.55	5.86	2.26	275
CaO	12.51	38.01	26.83	5.03	275
CaF ₂	0	23.39	13.53	4.29	273
Na ₂ O	0	18.5	7.08	3.65	271
MgO	0	13.31	3.47	3.46	239
Fe ₂ O ₃	0	5	1.22	1.05	135
FeO	0	4.56	1.06	1.09	94
B ₂ O ₃	0	1.25	1.25	0	4
Li ₂ O	0	9.4	3.56	2.49	53
K ₂ O	0	4.96	0.55	0.75	162
MnO	0	8.4	1.45	2.3	110
P ₂ O ₅	0	0.46	0.17	0.14	36
TiO ₂	0	5.4	0.53	1.06	106
Temp.(K)	1573.15	1673.15	1622.97	50	275

Measured versus calculated values



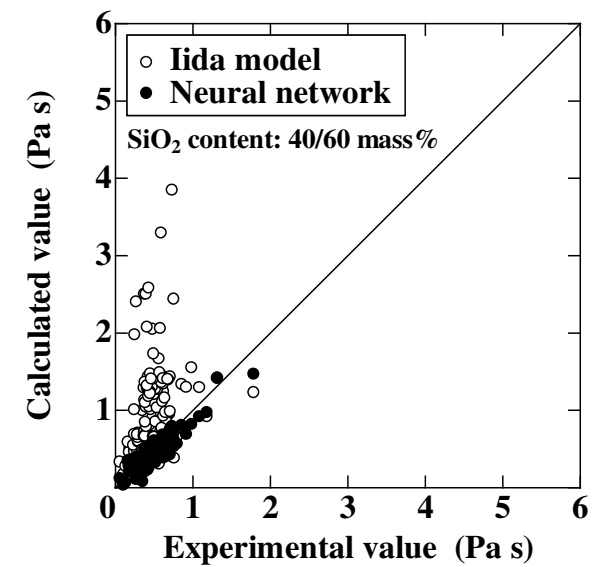
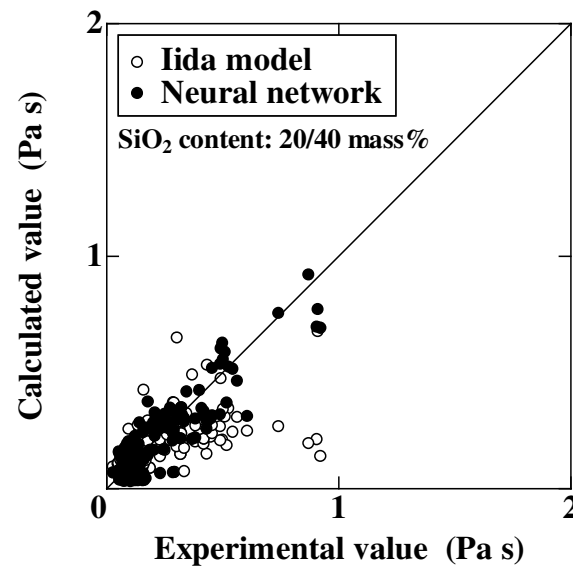
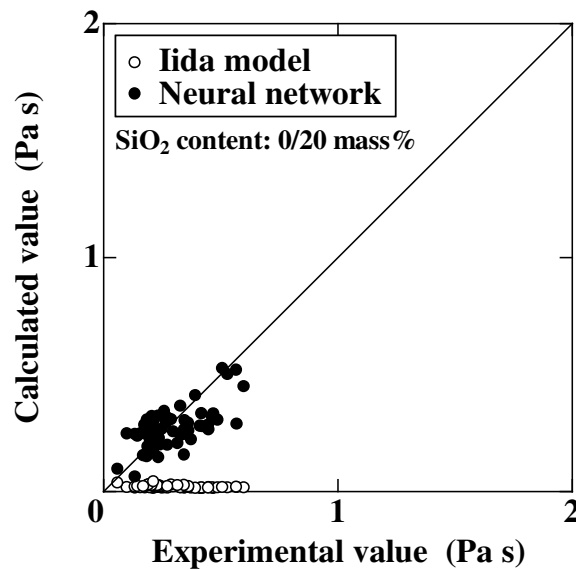
Measured viscosity: Mold fluxes collected by Round Robin Project

SlagVis versus lida model, part I

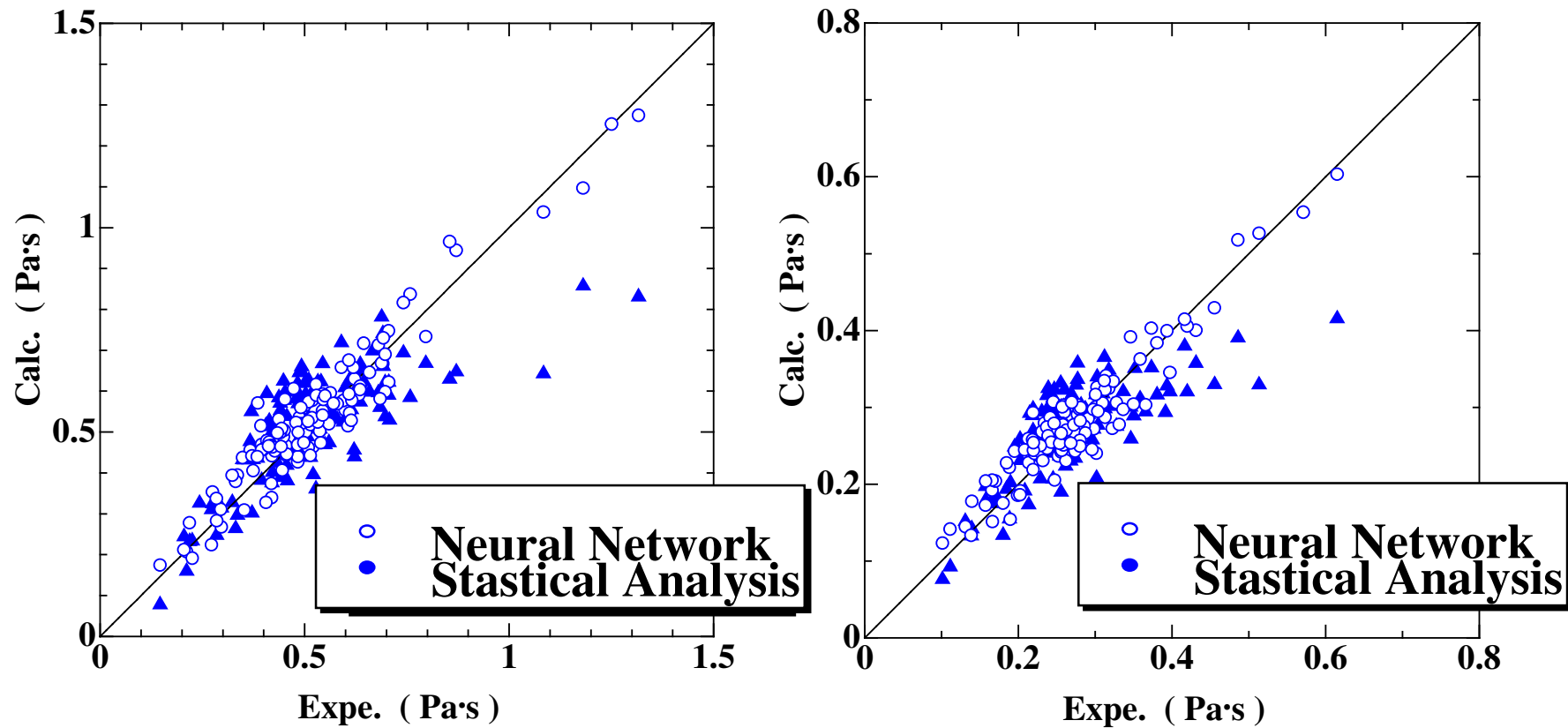


SlagVis versus Iida model, part II

$\text{SiO}_2\text{-CaO-Al}_2\text{O}_3\text{-MgO-Na}_2\text{O-F-ZrO}_2\text{-Li}_2\text{O-TiO}_2\text{-B}_2\text{O}_3\text{-BaO-MnO-FeO}$
13comp. System with 344 data points



SlagVis versus Statistical Analysis



Summary of Features of *SlagVis*

- **High Accuracy**

SlagVis : 15% versus Iida et al. : 24.4-29.6% or Riboud et al. : 30.9-35.4%

Neural Network

- Possible to determine the relation between components and viscosity
- Possible to obtain new neural network data by training of new measured values
- Possible to comply with various slag types because of independence of theoretical models

- **Easy to use**

Input of slag composition and temperature for estimation after the neural network is trained.

The neural network trained by the data of 'Round Robin' project comes with

SlagVis.

