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 then 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 Al2O3 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"

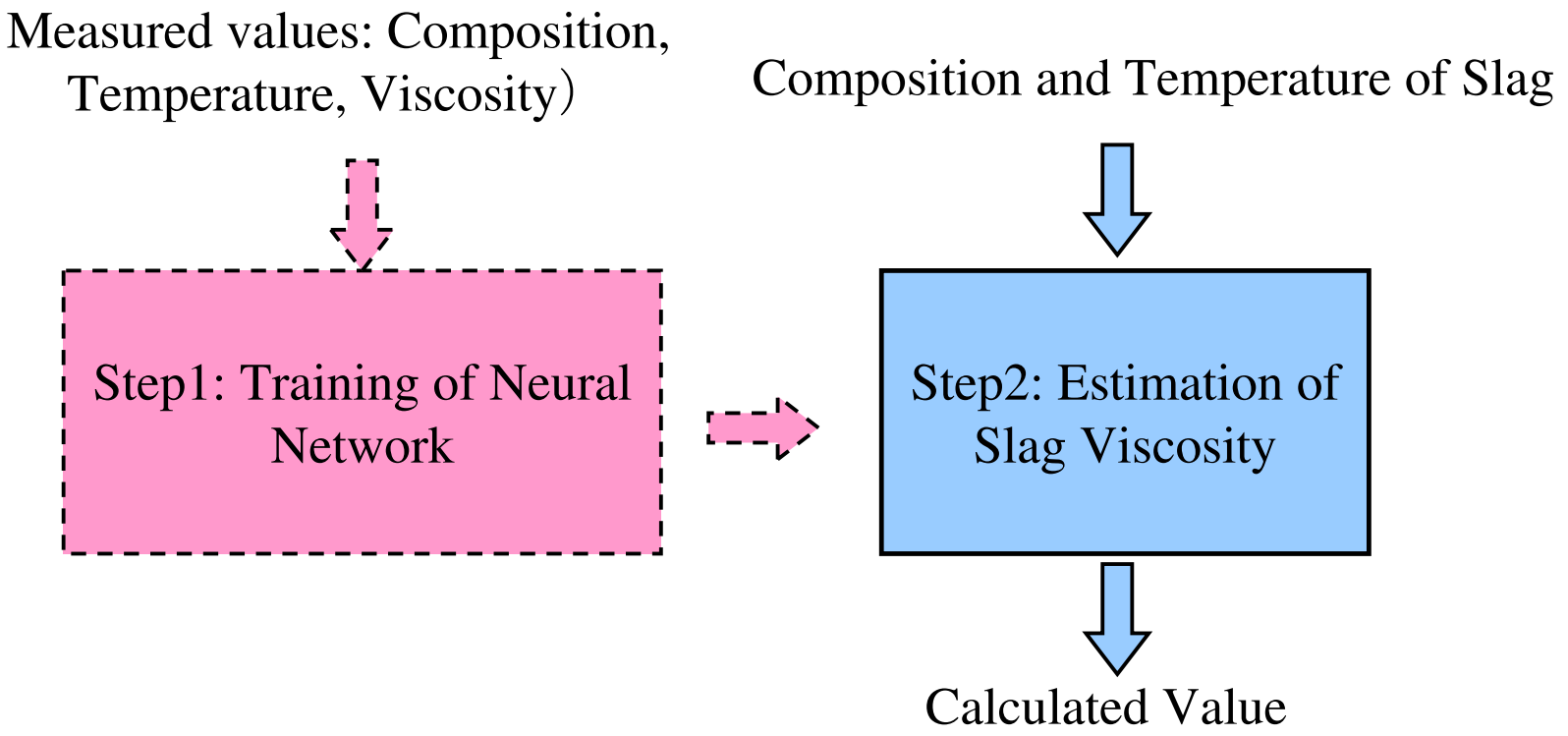
Osaka University: Prof. Tanaka, Dr. Nakamoto

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 havs developed software the interactive software *SlagVis*

Calculation Process of ***SlagVis***



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.

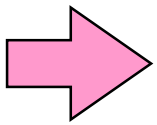
'Round Robin' Project (1997-2000)

- 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)

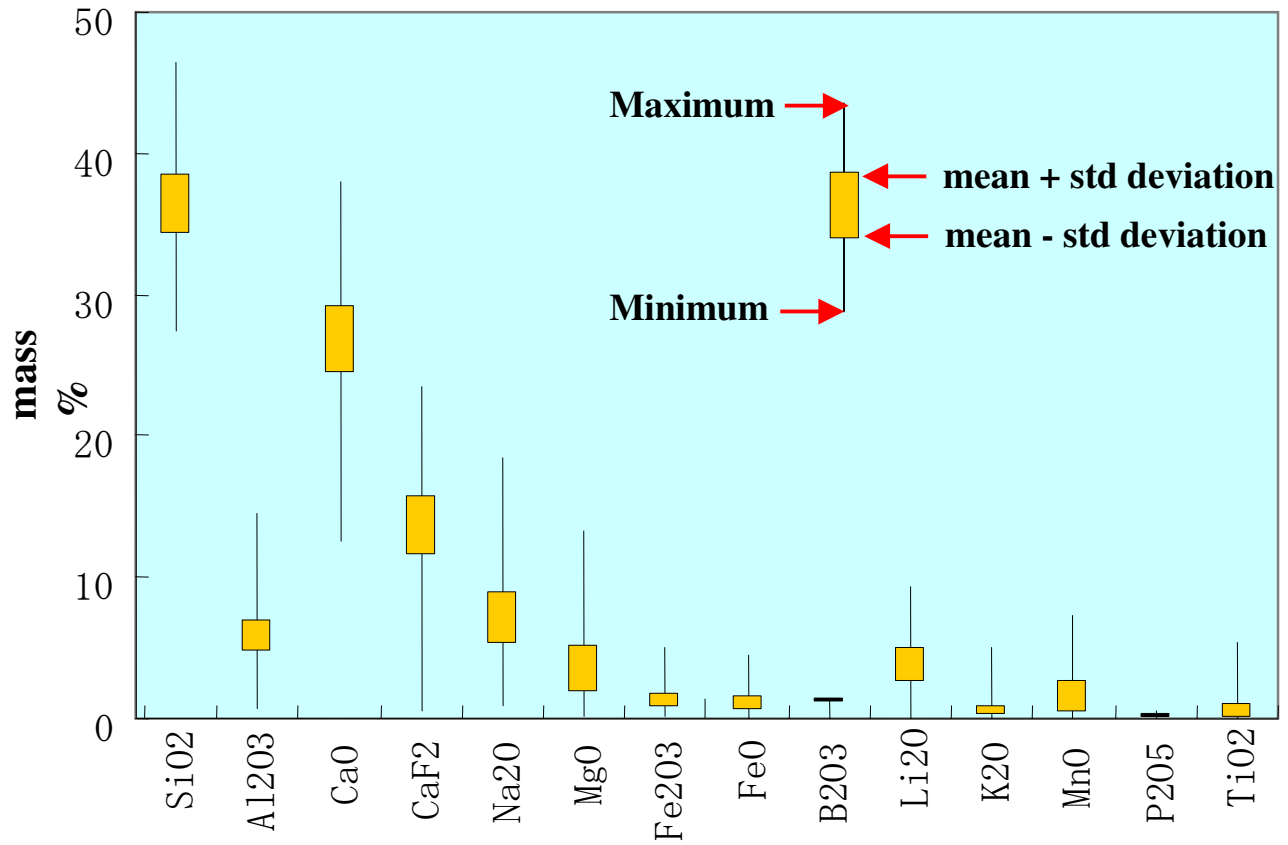
  (2) blast furnace slags (SiO_2,Al_2O_3,CaO,MgO)

  (3) coal slags (SiO_2,Al_2O_3,CaO,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

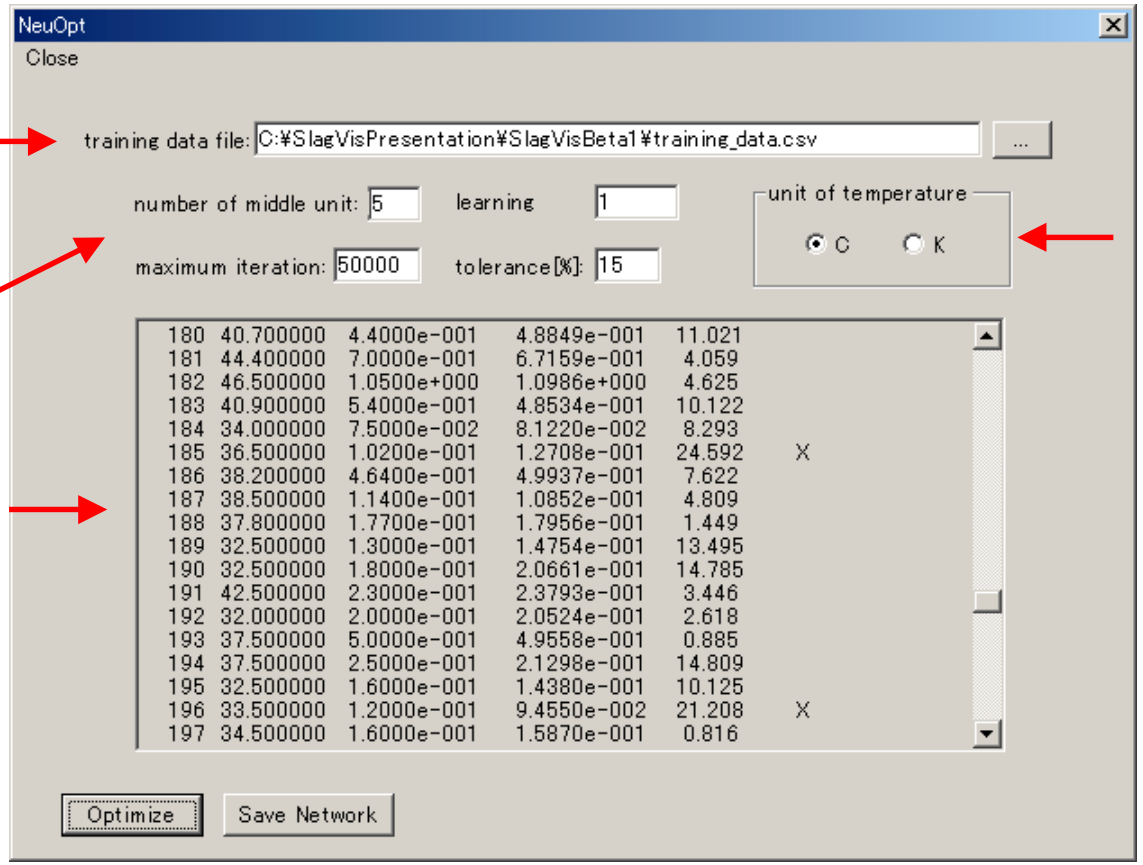
  (1)+(4), (2)+(4), (2)+(3), …

Training of Neural Network

Training Data file path

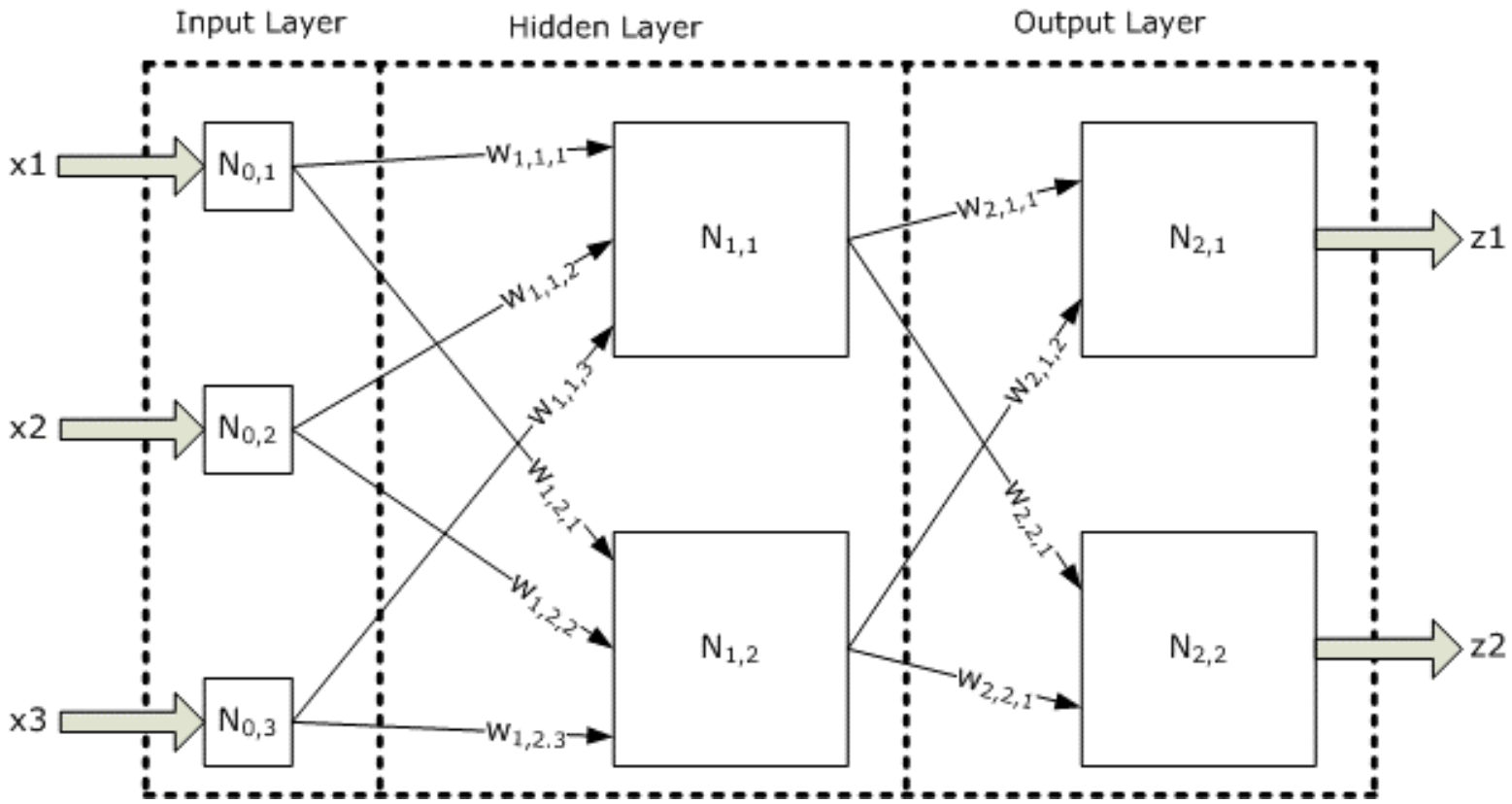
Parameters for training

Reproducibility



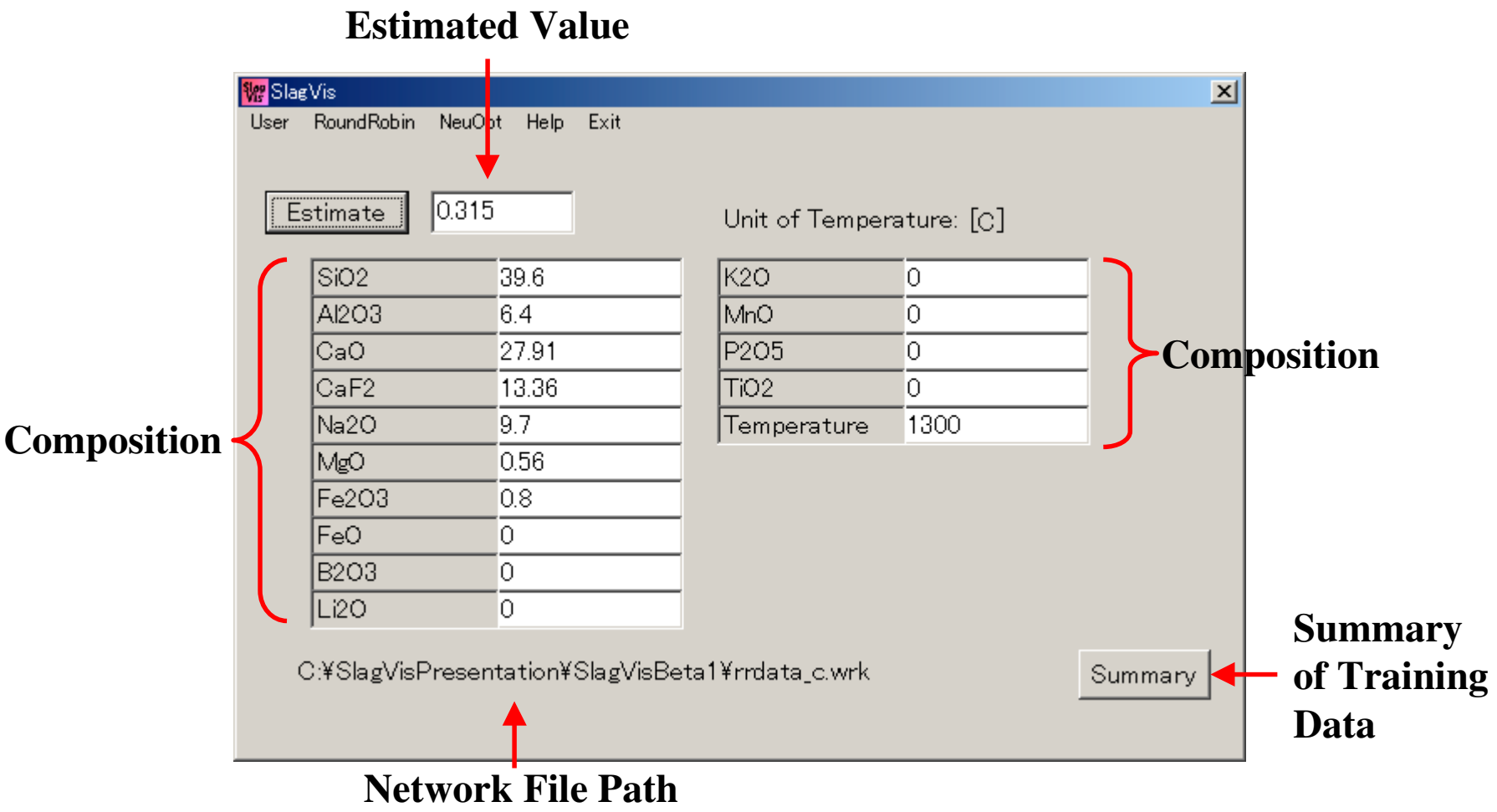
Unit of Temperature

Structure of Neural Network



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

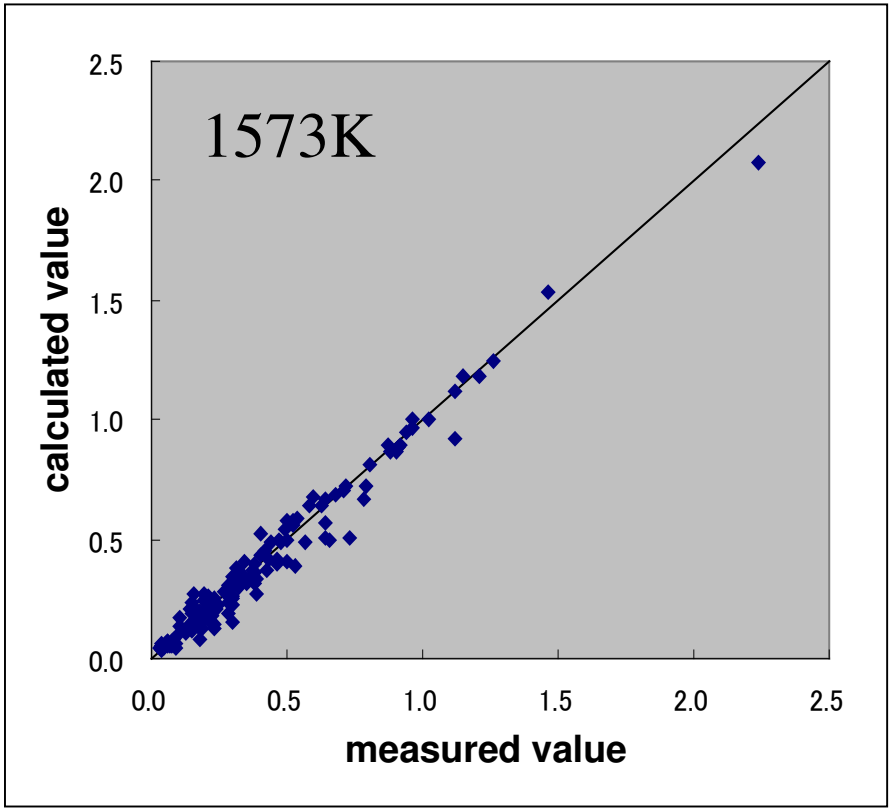
Estimation of Slag Viscosity

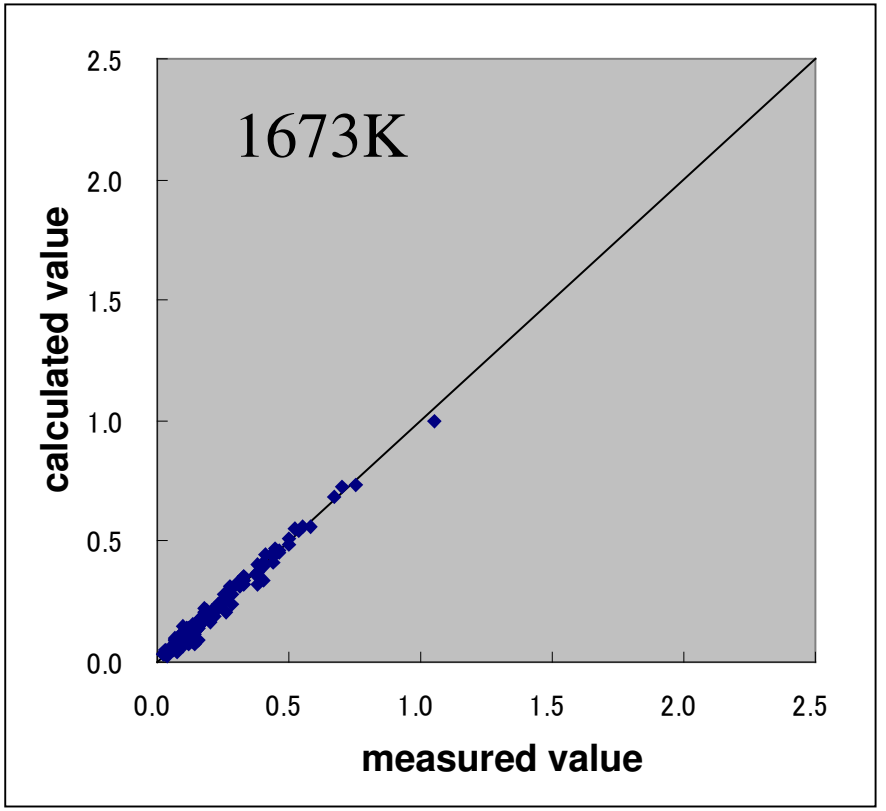


Summary of Training Data

Component	Min	Max	Average	Sdev	Ndata
wt%					
SiO2	27.5	46.5	36.41	4.2	275
Al2O3	0.66	14.55	5.86	2.26	275
CaO	12.51	38.01	26.83	5.03	275
CaF2	0	23.39	13.53	4.29	273
Na2O	0	18.5	7.08	3.65	271
MgO	0	13.31	3.47	3.46	239
Fe2O3	0	5	1.22	1.05	135
FeO	0	4.56	1.06	1.09	94
B2O3	0	1.25	1.25	0	4
Li2O	0	9.4	3.56	2.49	53
K2O	0	4.96	0.55	0.75	162
MnO	0	8.4	1.45	2.3	110
P2O5	0	0.46	0.17	0.14	36
TiO2	0	5.4	0.53	1.06	106
Temp.(K)	1573.15	1673.15	1622.97	50	275

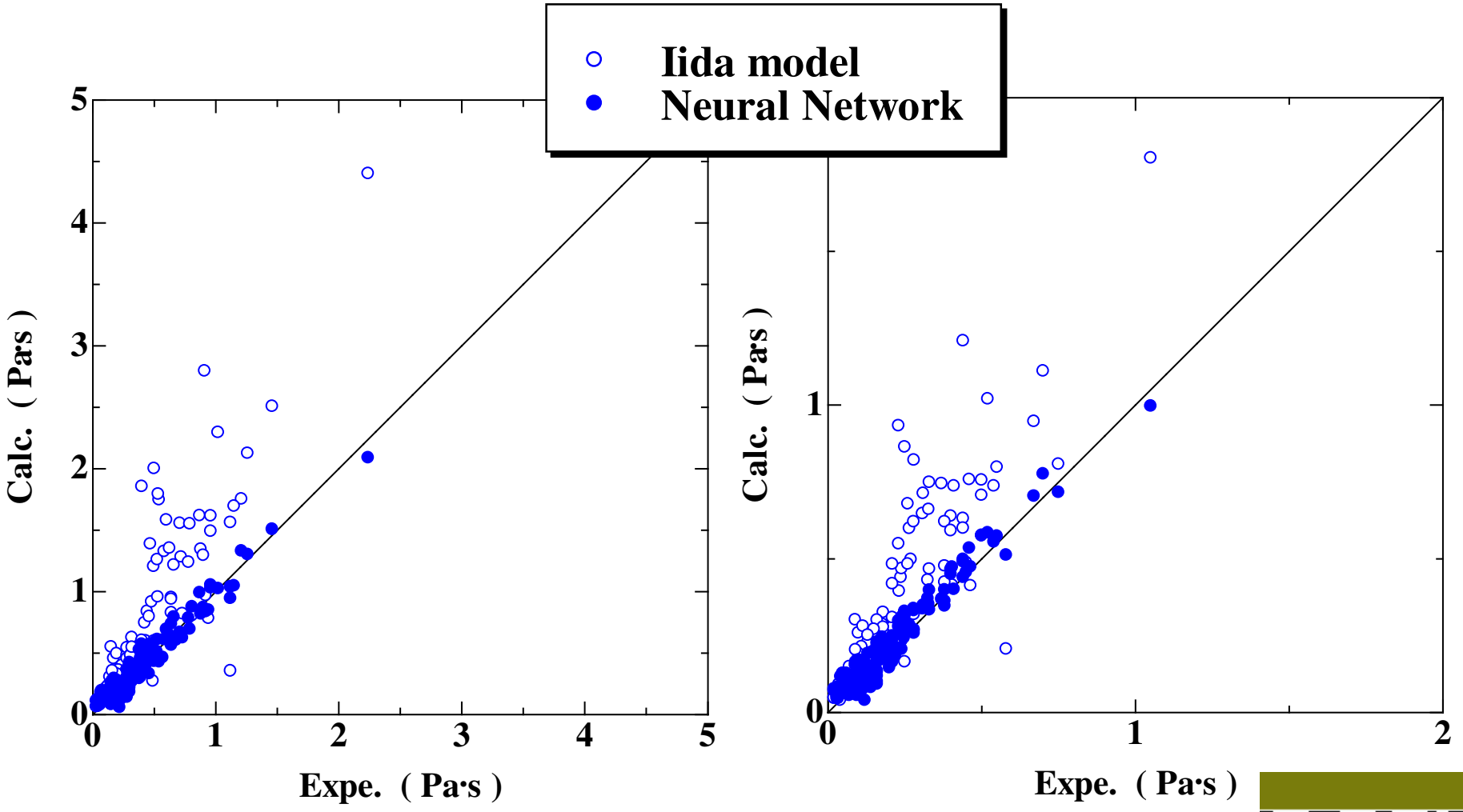
Measured versus calculated values





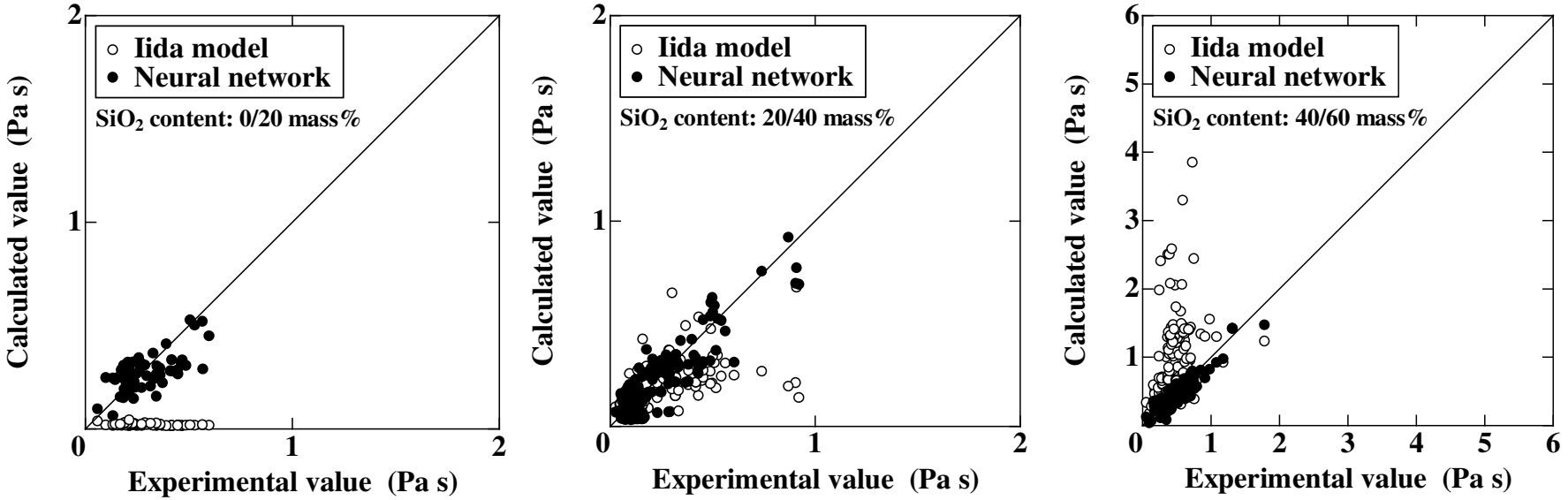
Measured viscosity: Mold fluxes collected by Round Robin Project

SlagVis versus Iida model, part I

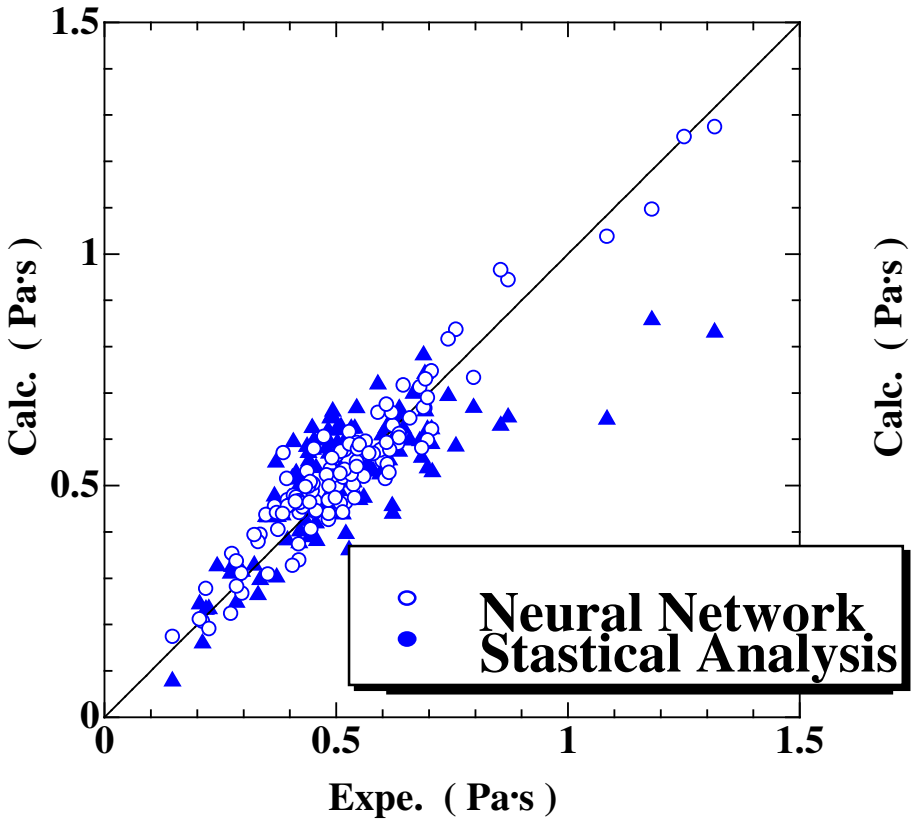


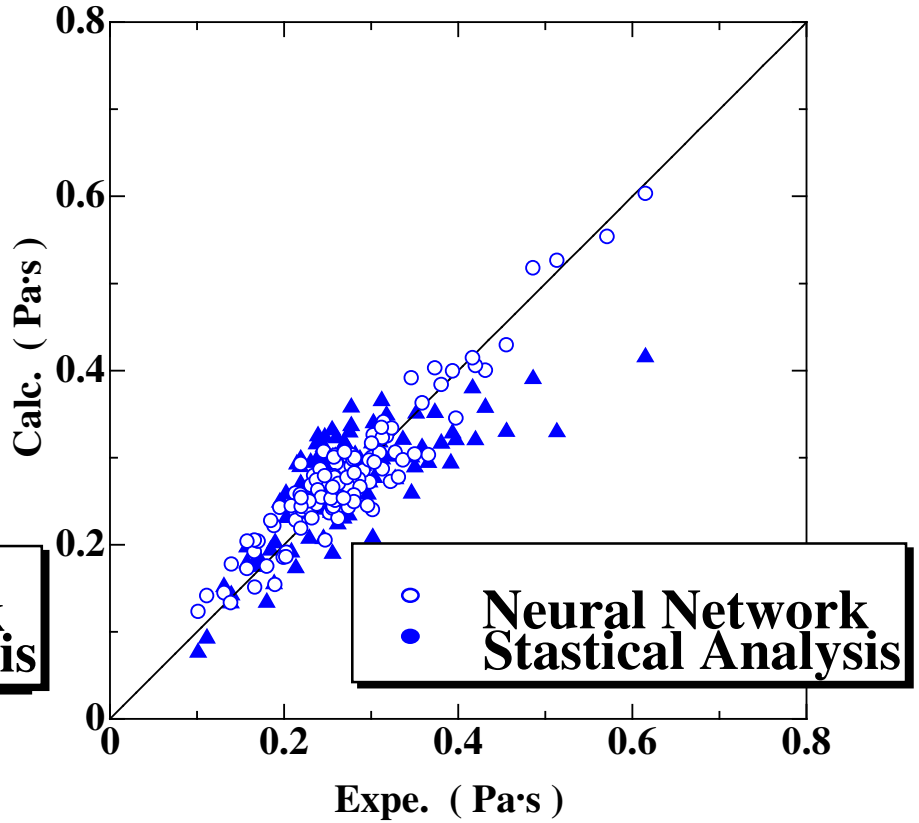
SlagVis versus Iida model, part II

SiO_2-CaO-Al_2O_3-MgO-Na_2O-F-ZrO_2-Li_2O-TiO_2-B_2O_3-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***.