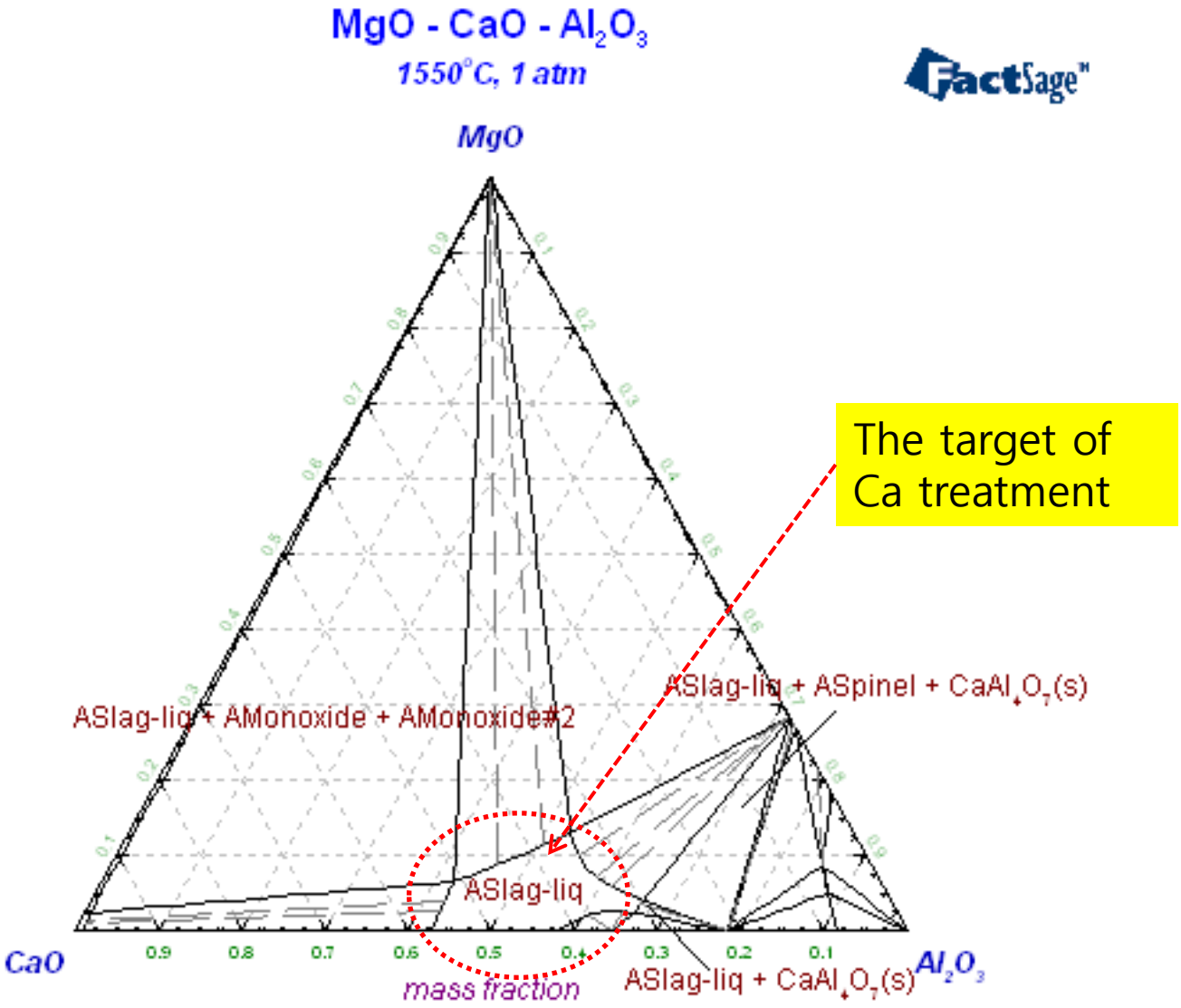
Application 5: **Re-oxidation and inclusion modification in the tundish – Ca treatment**

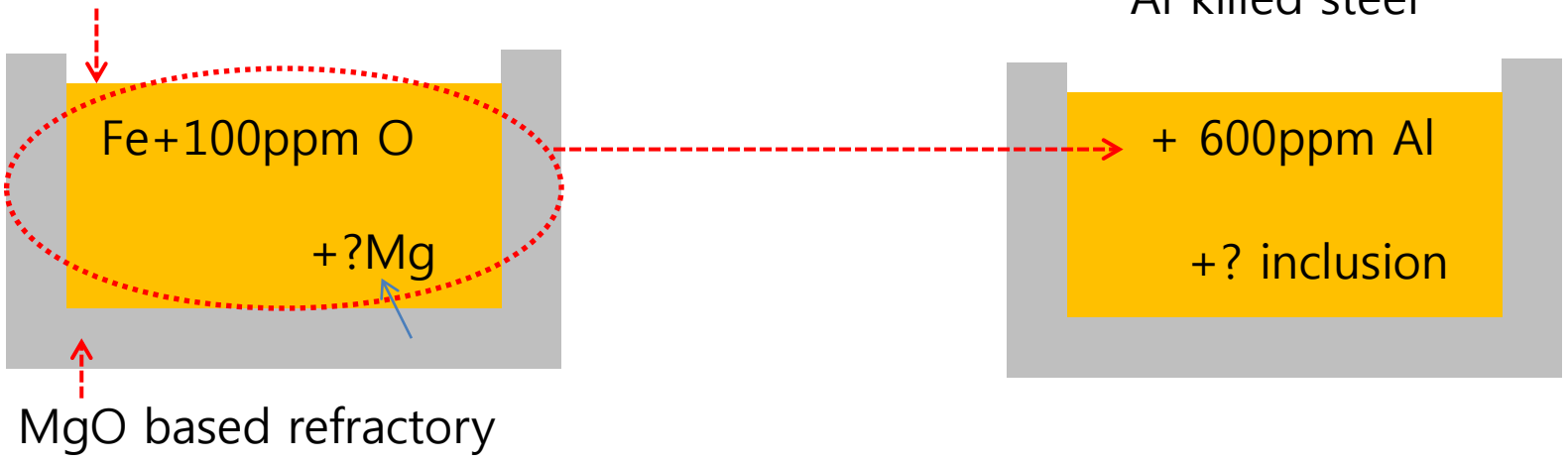
Junghwan Kim
Email: junghwan.kim@mail.mcgill.ca

Ex4-1. Reoxidation and inclusion modification in the tundish

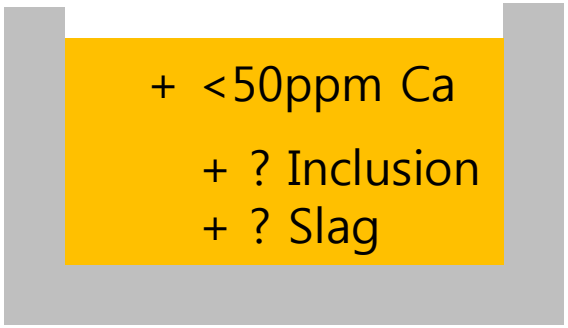


Ex4-1. Reoxidation and inclusion modification in the tundish

At 1550°C

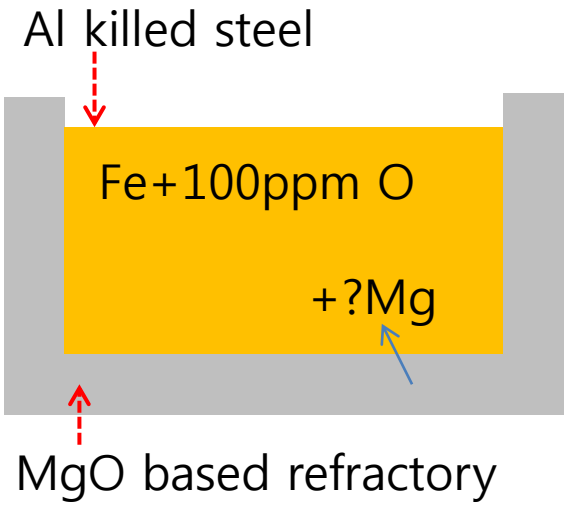


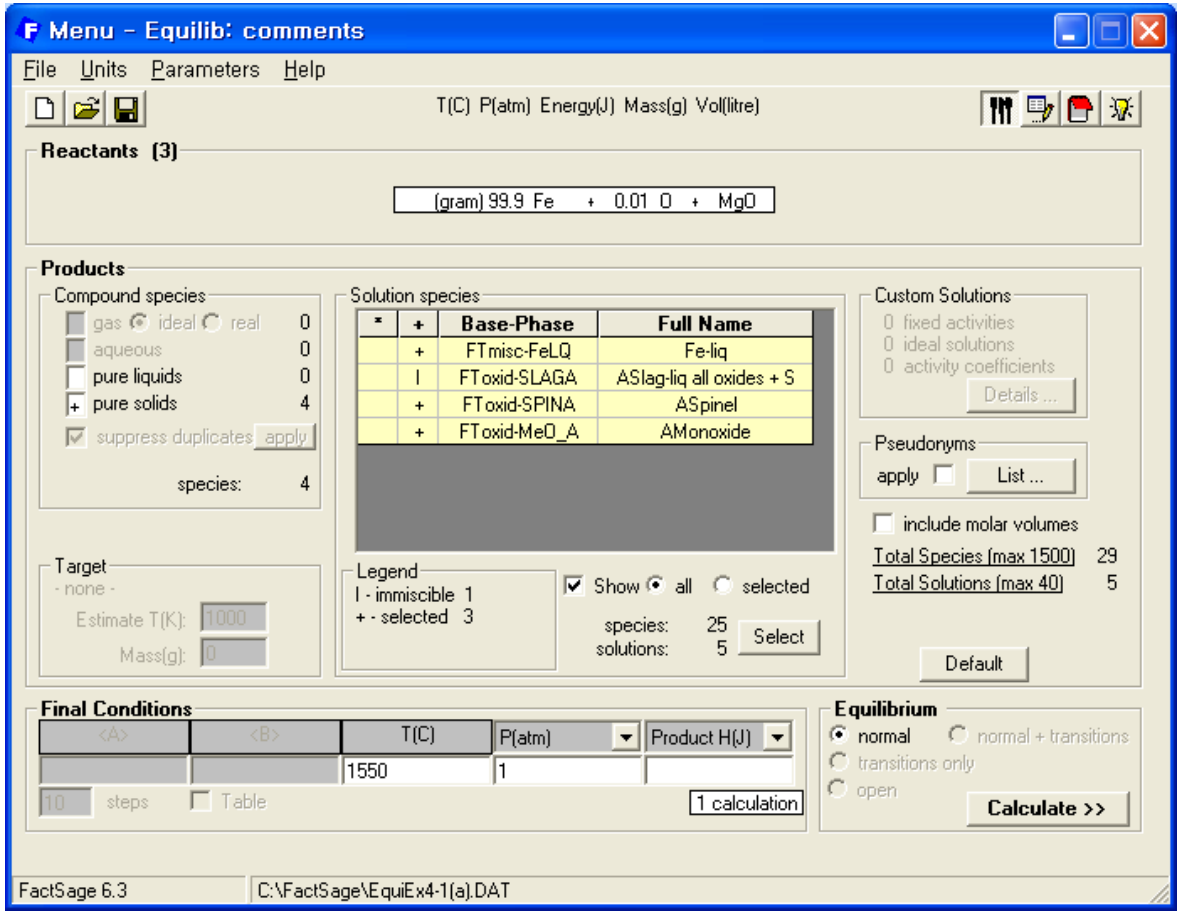
Ca treatment: liquid slag



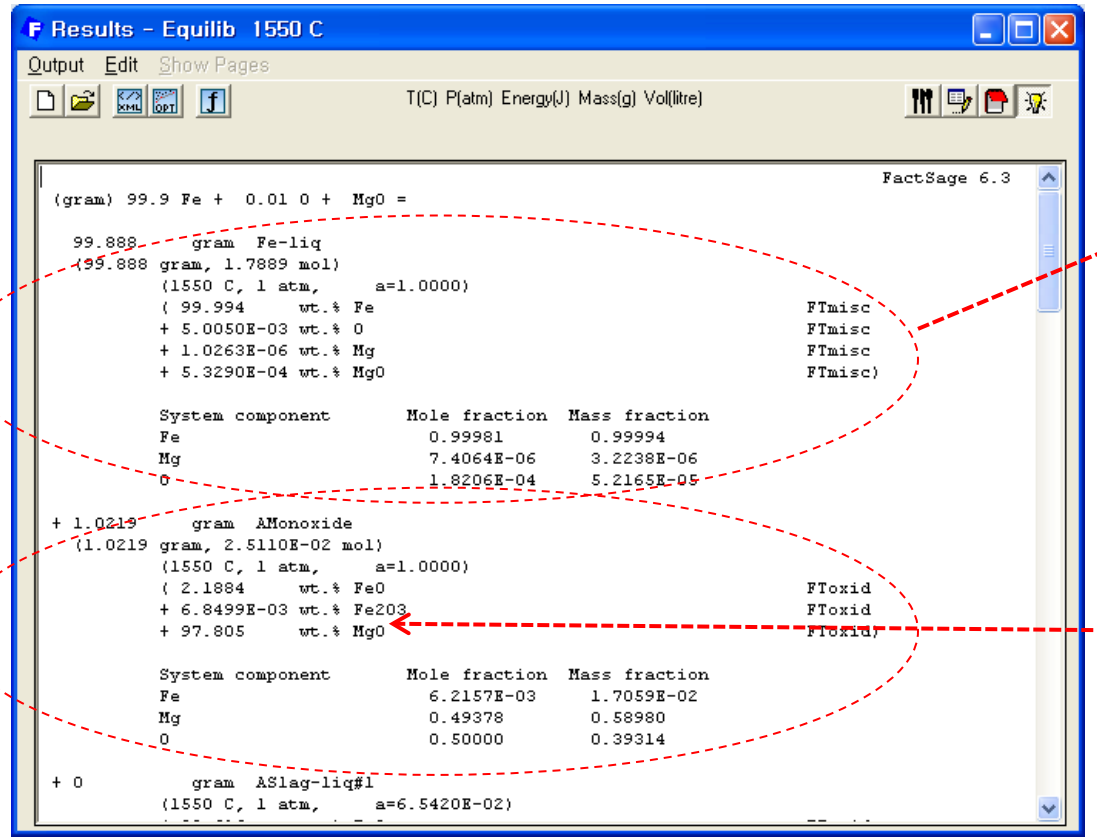
Reoxidation: assuming mainly due to SiO2 based slag

Ex4-1. Reoxidation and inclusion modification in the tundish





Ex4-1. Reoxidation and inclusion modification in the tundish



Only save liquid Fe
as stream file for next step

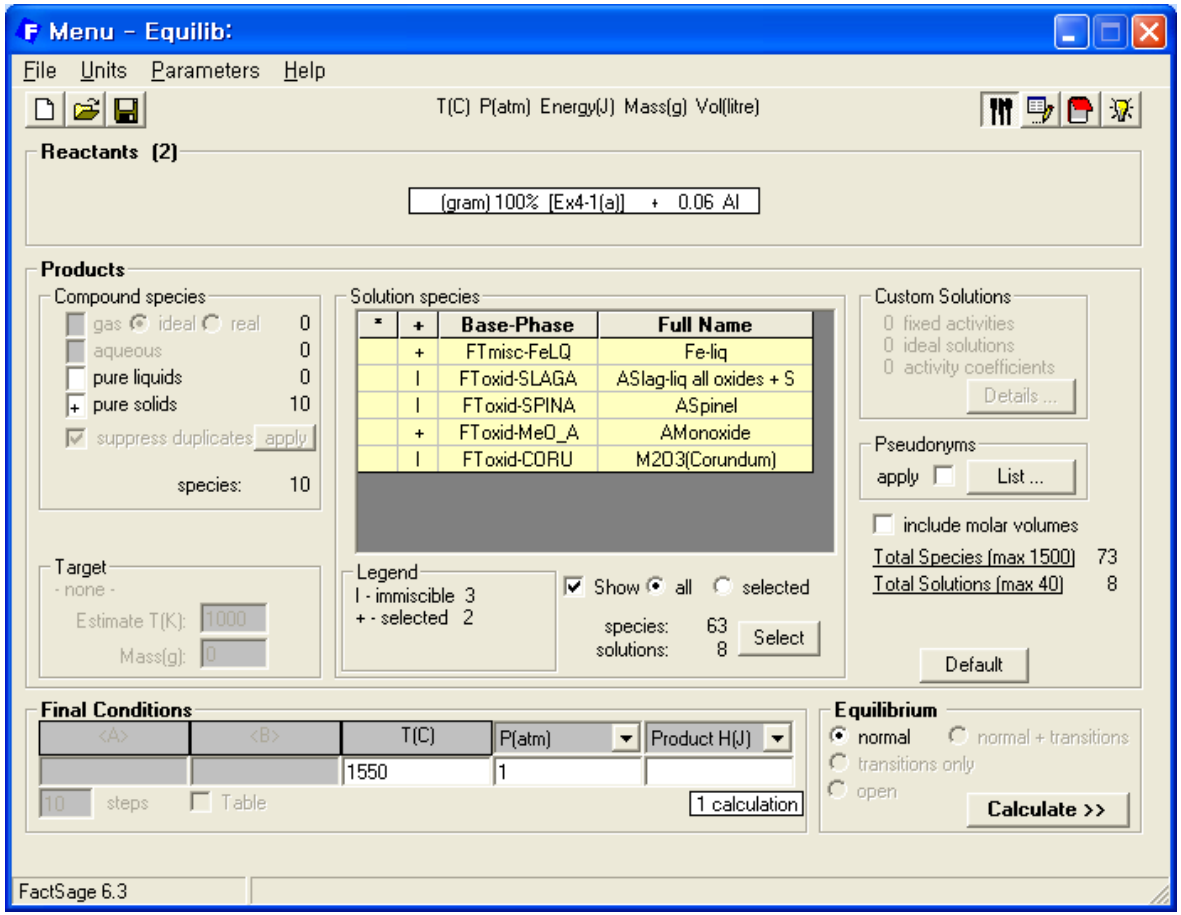
MgO based
refractory

Ex4-1. Reoxidation and inclusion modification in the tundish

Al killed steel

+ 600ppm Al

+? inclusion



Ex4-1. Reoxidation and inclusion modification in the tundish

Results - Equilib 1550 C

Output Edit Show Pages

T(C) P(atm) Energy(J) Mass(g) Vol(litre)

```
(gram) 100% [Ex4-1(a)] +  0.06 Al =

  99.938      gram  Fe-liq
  (99.938 gram, 1.7906 mol)
          (1550 C, 1 atm,      a=1.0000)
          ( 99.945      wt.% Fe
          + 5.4402E-02 wt.% Al
          + 9.5917E-05 wt.% O
          + 2.6226E-06 wt.% Mg
          + 2.5691E-05 wt.% MgO
          + 3.7605E-04 wt.% AlO
          + 7.6232E-05 wt.% Al2O

          System component       Mole fraction  Mass fraction
          Fe                       0.99886        0.99945
          Al                       1.1314E-03     5.4697E-04
          Mg                       4.1599E-07     1.8115E-07
          O                        9.1930E-06     2.6353E-06

+ 7.8284E-03 gram  M2O3(Corundum)#1
  (7.8284E-03 gram, 7.6778E-05 mol)
          (1550 C, 1 atm,      a=1.0000)
          ( 100.00      wt.% Al2O3
          + 7.8267E-06 wt.% Fe2O3

          System component       Mole fraction  Mass fraction
          Fe                       1.9989E-08     5.4742E-08
          Al                       0.40000        0.52925
          O                        0.60000        0.47075
```

Alumina inclusion cause nozzle clogging

Results - Equilib 1550 C

Output Edit Show Pages

T(C) P(atm) E

```
+ 2.7607E-03 gram  ASpinel#1
  (2.7607E-03 gram, 1.9721E-05 mol)
          (1550 C, 1 atm,      a=1.0000)
          ( 9.2977E-09 wt.% Fe3O4
          + 1.1533E-09 wt.% Fe3O4[1-]
          + 1.1207E-12 wt.% Fe3O4[1+]
          + 9.5681E-06 wt.% Fe3O4[2-]
          + 3.9227E-07 wt.% Fe1O4[5-]
          + 3.2543E-03 wt.% Fe1O4[6-]
          + 6.4220E-02 wt.% FeAl2O4
          + 50.356     wt.% Al3O4[1+]
          + 7.8750E-03 wt.% Al1Fe2O4[1-]
          + 2.3230     wt.% Al1O4[5-]
          + 7.7410E-06 wt.% FeAl2O4[1+]
          + 7.6524E-06 wt.% Al1Fe2O4[1+]
          + 34.676     wt.% MgAl2O4
          + 6.5010     wt.% Al1Mg2O4[1-]
          + 4.4735     wt.% Mg3O4[2-]
          + 1.5818     wt.% Mg1O4[6-]
          + 5.2979E-06 wt.% MgFe2O4
          + 1.0057E-06 wt.% Fe1Mg2O4[1-]
          + 8.3436E-03 wt.% Fe1Mg2O4[2-]
          + 5.4520E-03 wt.% MgFe2O4[2-]
```

Formation of spinel phase

Save all phases as stream file for next step

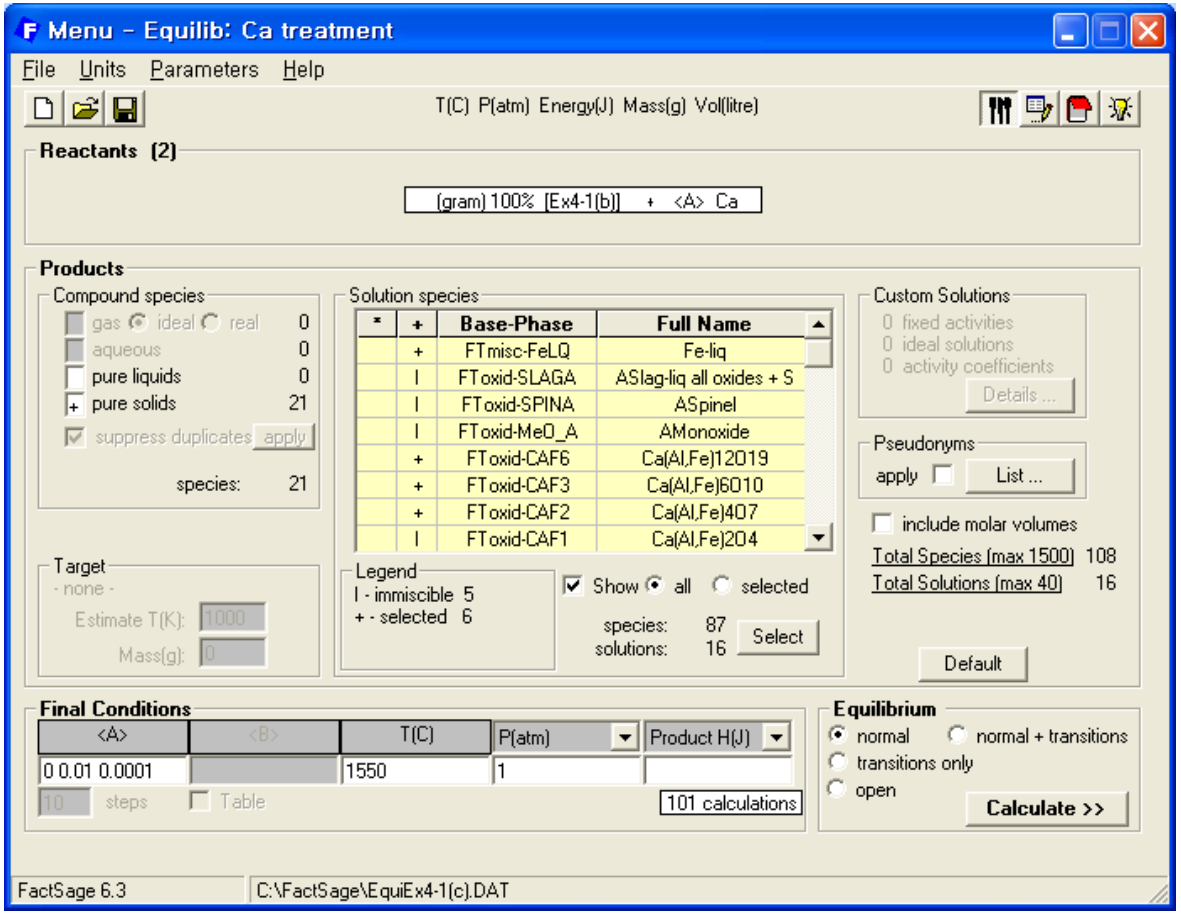
Ex4-1. Reoxidation and inclusion modification in the tundish

Ca treatment: liquid slag

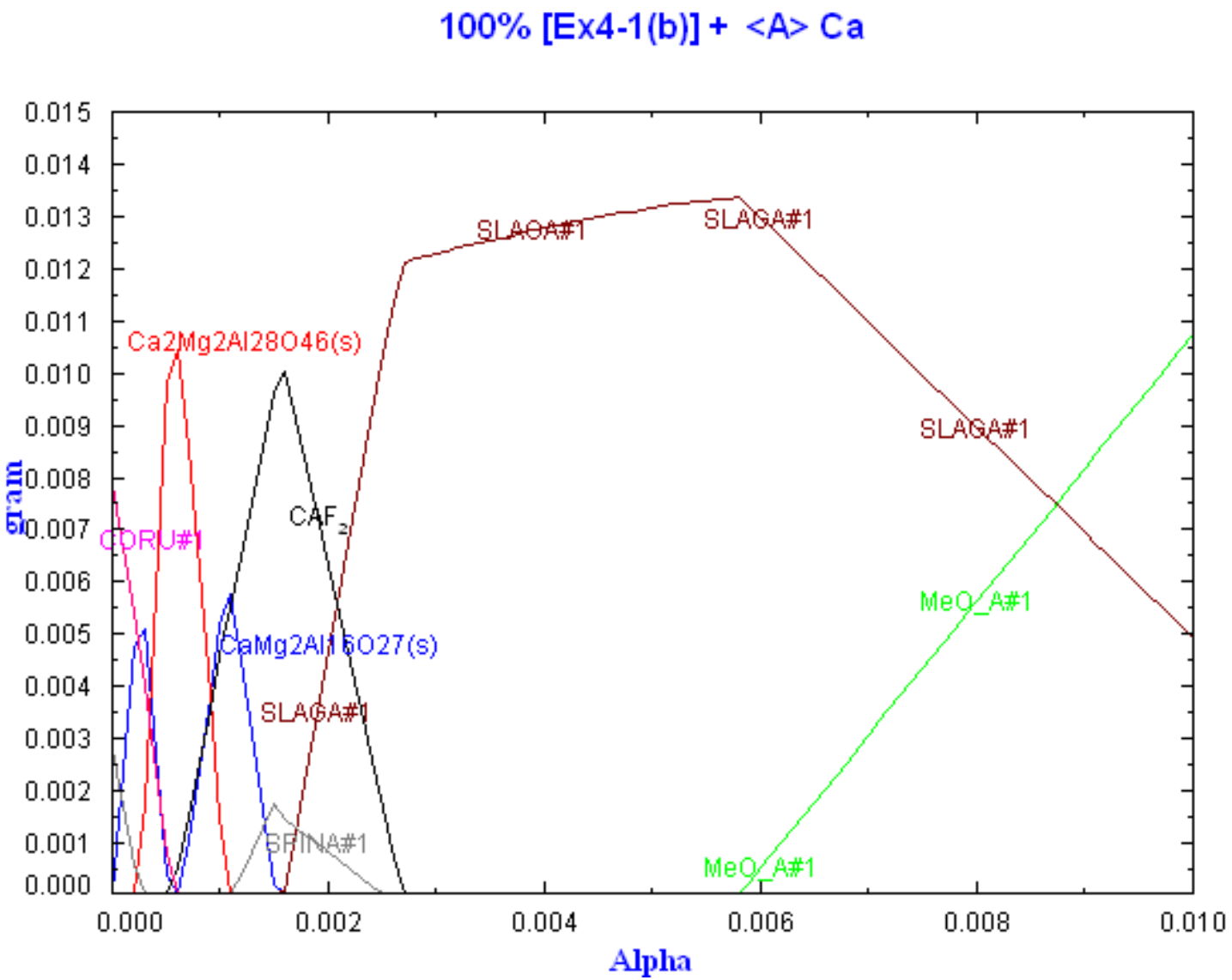
+ <100ppm Ca

+ ? Inclusion

+ ? Slag



Ex4-1. Reoxidation and inclusion modification in the tundish



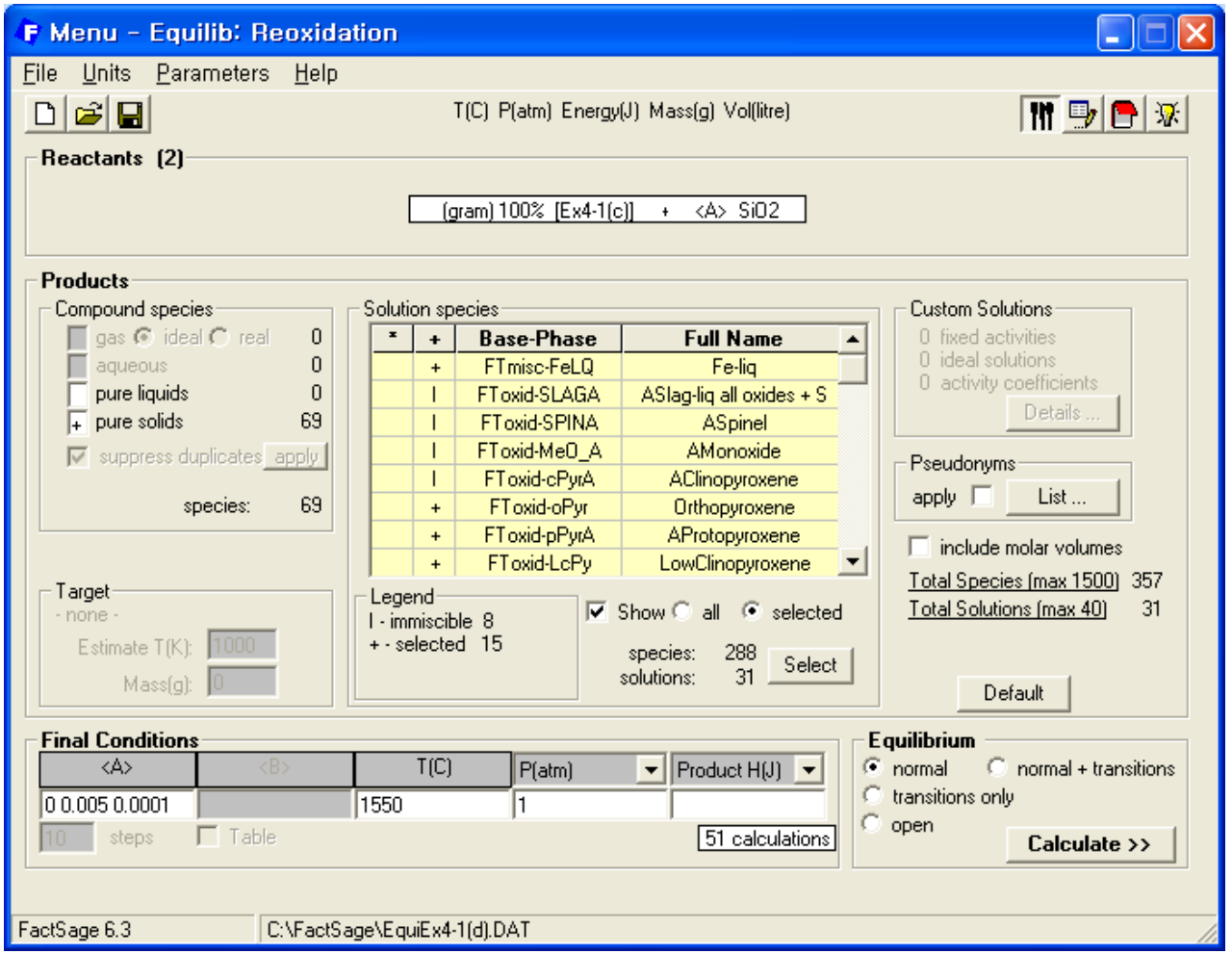
Ex4-1. Reoxidation and inclusion modification in the tundish

Reoxidation: assuming mainly due to SiO2 based slag

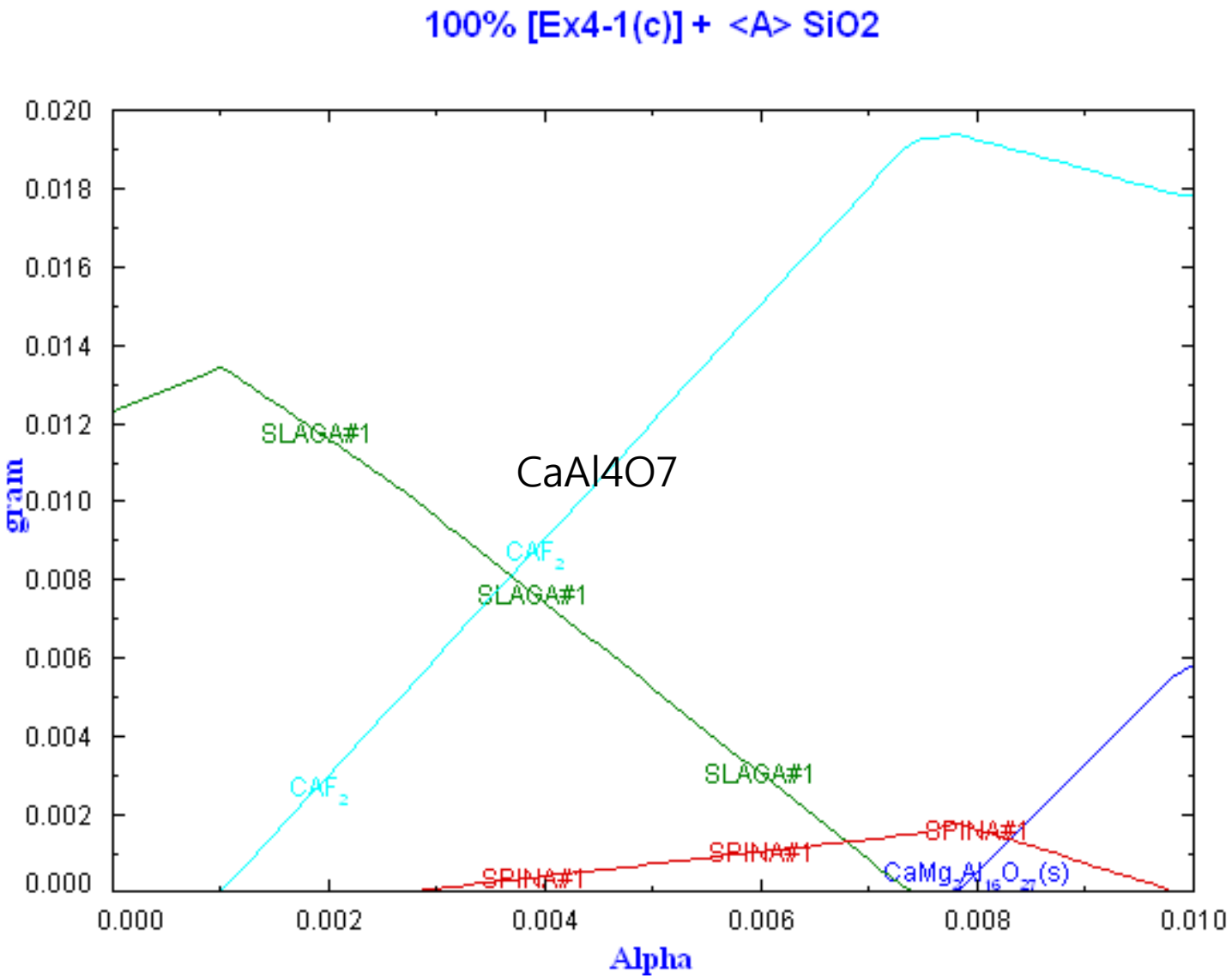
+ <100ppm SiO2

+ ? Inclusion

+ ? Slag



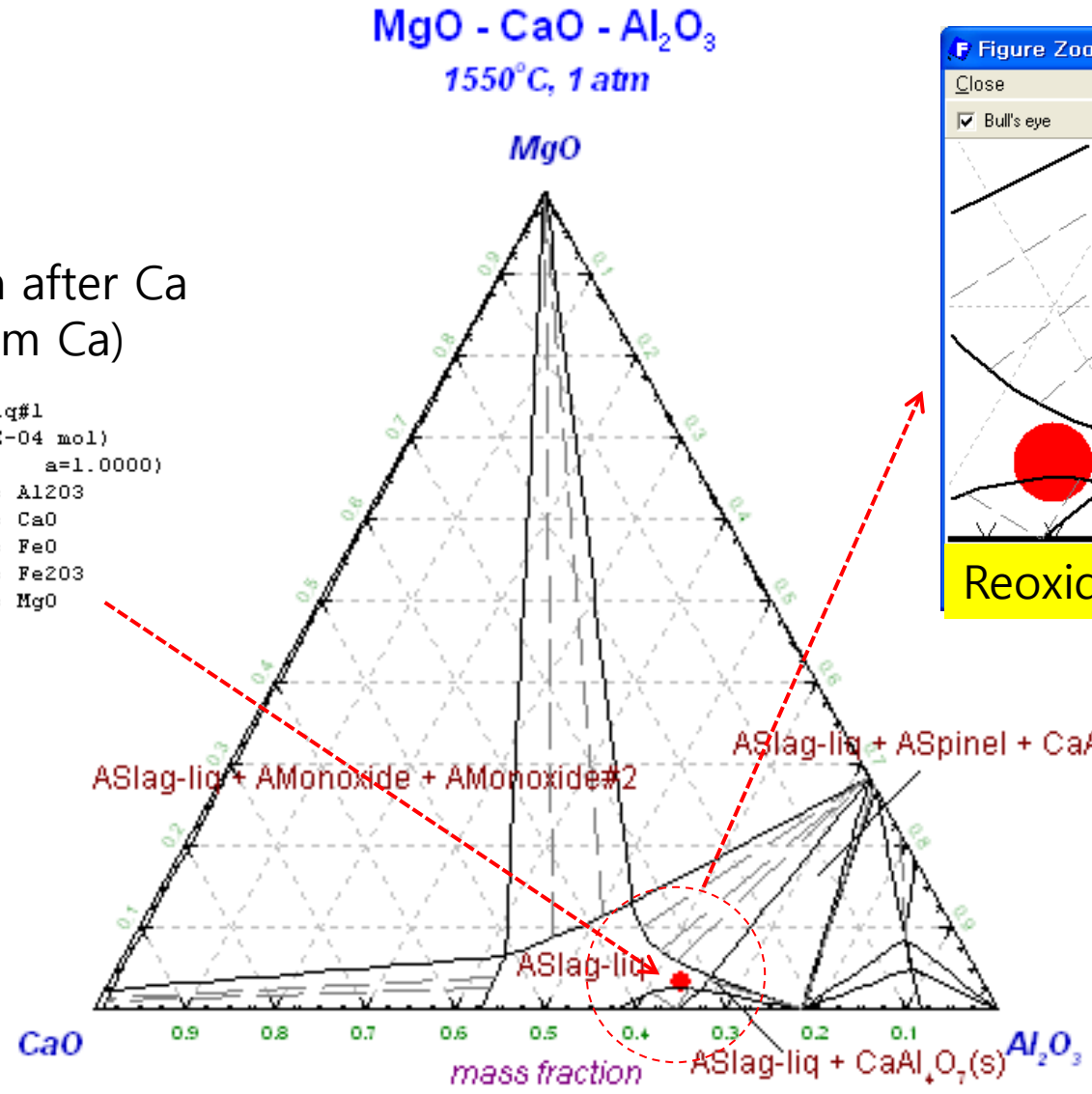
Ex4-1. Reoxidation and inclusion modification in the tundish

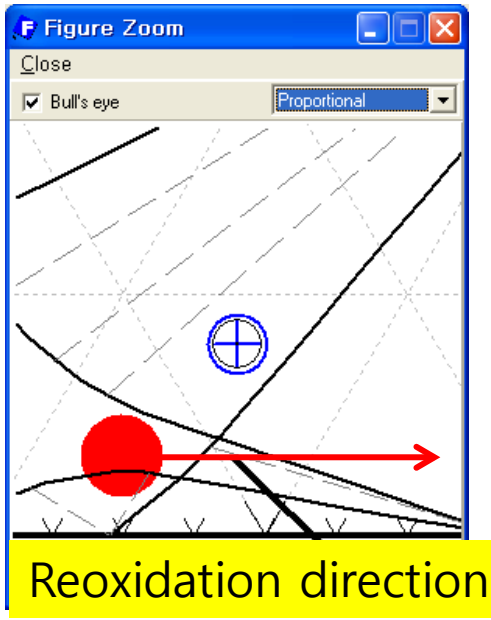


Ex4-1. Reoxidation and inclusion modification in the tundish

Slag composition after Ca treatment (30 ppm Ca)

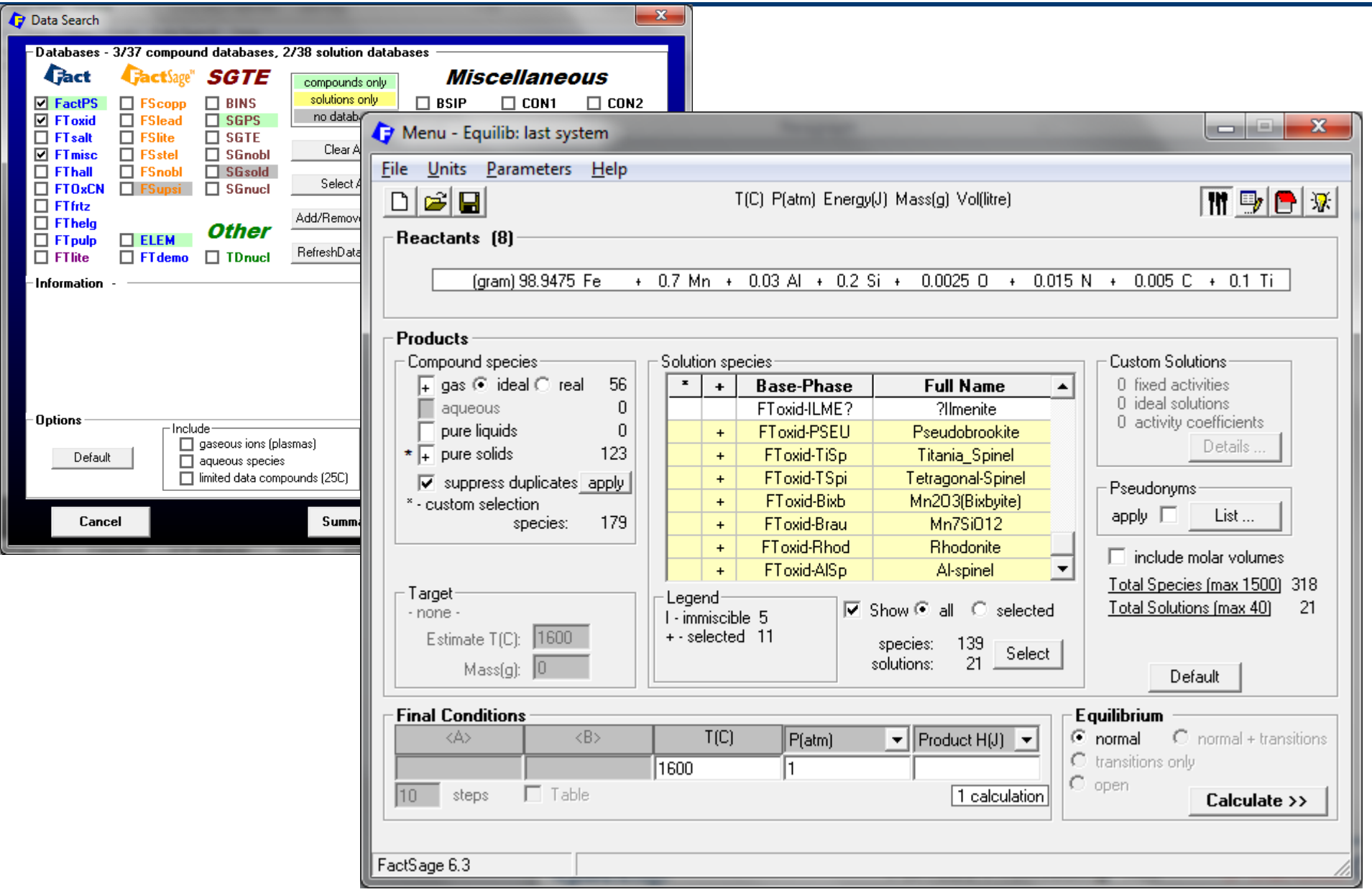
```
+ 1.2284E-02 gram  ASlag-liq#1
  (1.2284E-02 gram, 1.5945E-04 mol)
          (1550 C, 1 atm,      a=1.0000)
          ( 63.328      wt.% Al2O3
          + 33.369      wt.% CaO
          + 6.3444E-03 wt.% FeO
          + 3.9494E-05 wt.% Fe2O3
          + 3.2969      wt.% MgO
```



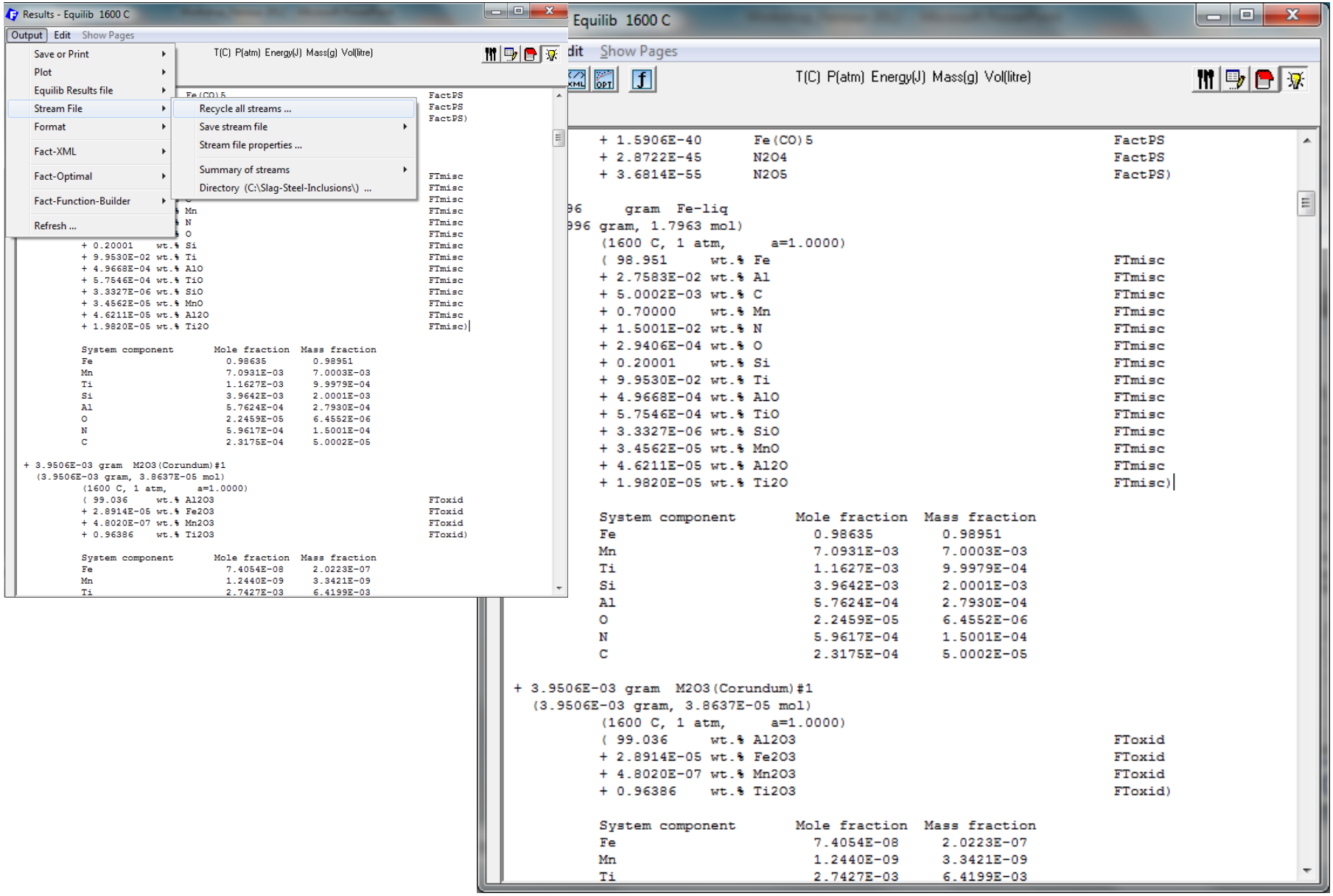


Reoxidation direction

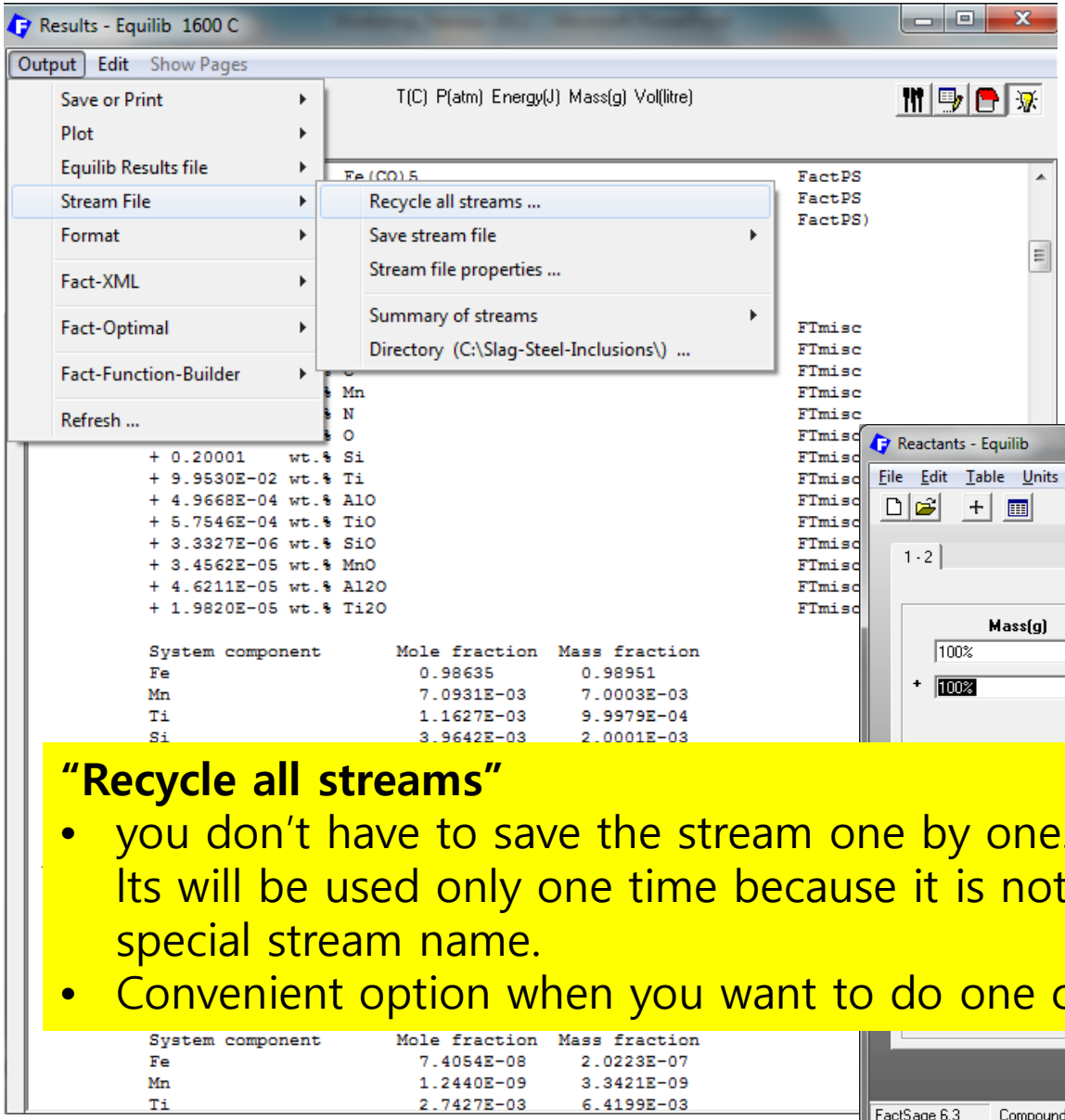
Ex4-2. Reoxidation of Al killed Ti bearing steel

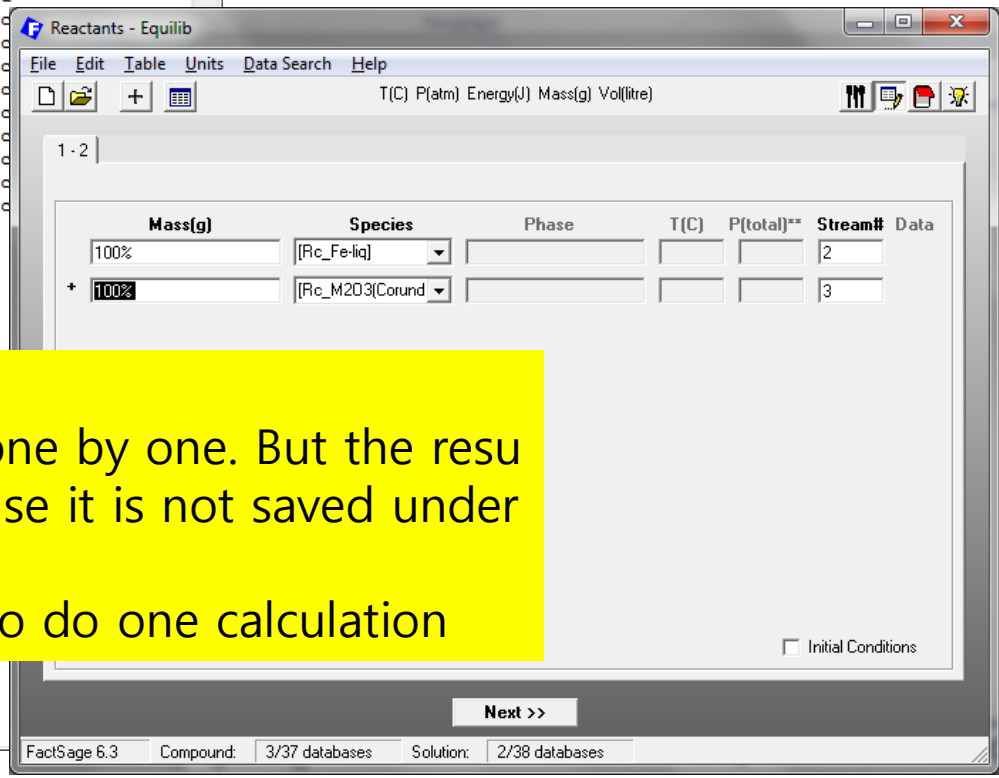


Ex4-2. Reoxidation of Al killed Ti bearing steel



Ex4-2. Reoxidation of Al killed Ti bearing steel

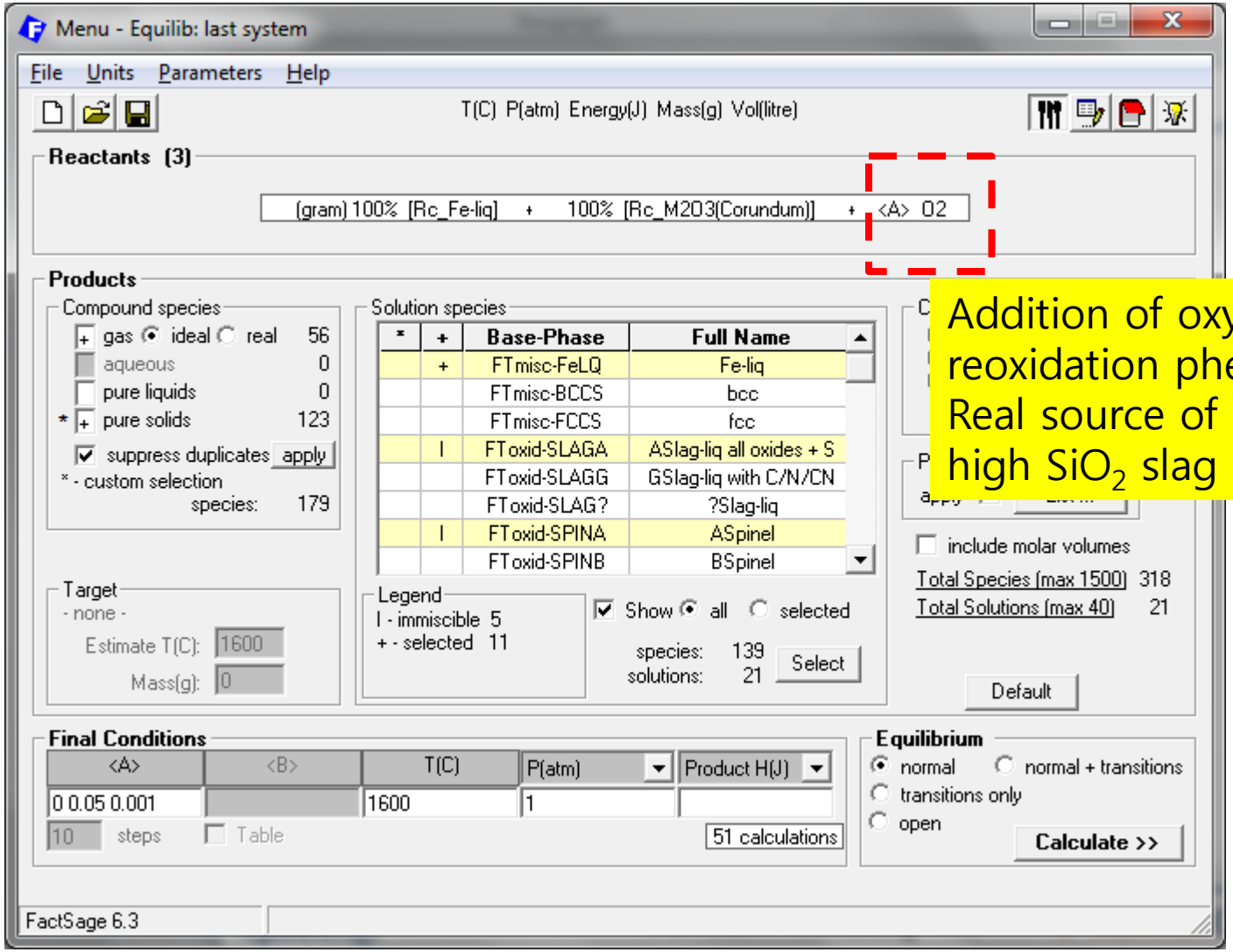




"Recycle all streams"

- you don't have to save the stream one by one. But the resu lts will be used only one time because it is not saved under special stream name.
- Convenient option when you want to do one calculation

Ex4-2. Reoxidation of Al killed Ti bearing steel



Addition of oxygen to simulation reoxidation phenomena.
Real source of oxygen could be high SiO_2 slag or refractories

Ex4-2. Reoxidation of Al killed Ti bearing steel

This calculation shows that mixed inclusion of Al2O3(s) and liquid (Al2O3-TiO2-Ti2O3) can be formed by the reoxidation of Al-killed Ti bearing steel.
→ Nozzle clogging.