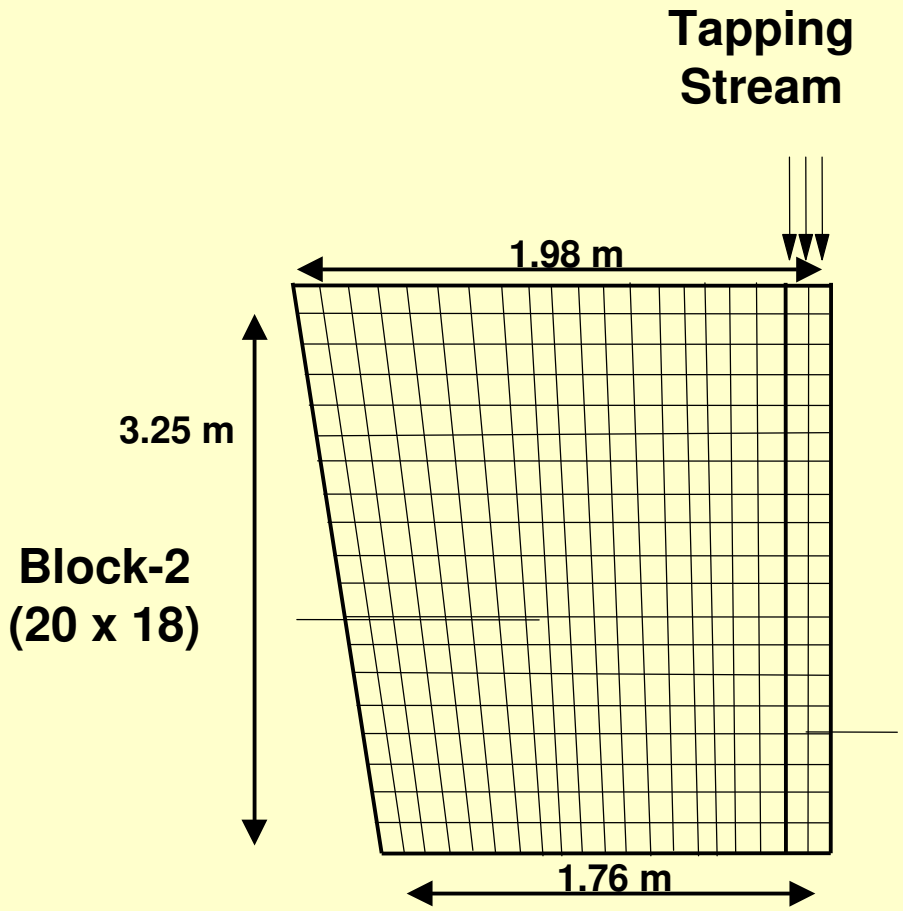
The Application of ChemApp in Steelmaking Process Models

N.Jones

- Ladle Filling – CFX/ChemApp
- RH Degassing – CFX/ChemApp
- Ladle Metallurgy Furnace – Aspen Custom Modeller/ChemApp

CFX Geometry- Ladle Filling



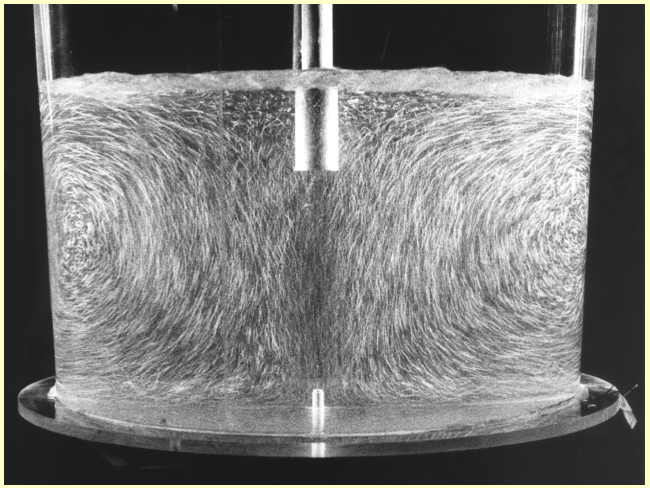
Key Features

- Expanding Grid
- 400 Cells
- Heat Loss Patches
- Slag & Glaze ‘Halo’

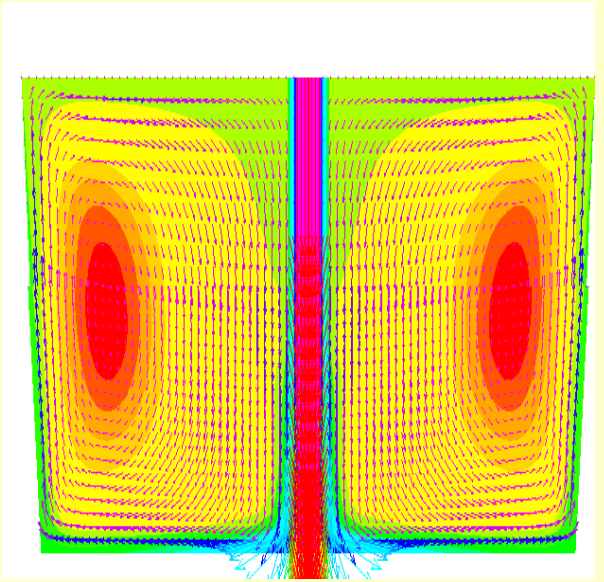
Assumptions

- Centre Line Symmetry
- Single Phase System
  (C,Mn,O,Si,Al,CaO,MnO,SiO_2,FeO,MgO,Al_2O_3)
- Alloys Positioned by Density
- Uniform/Homogeneous Slag Composition
- Uniform Coverage of Ladle Glaze

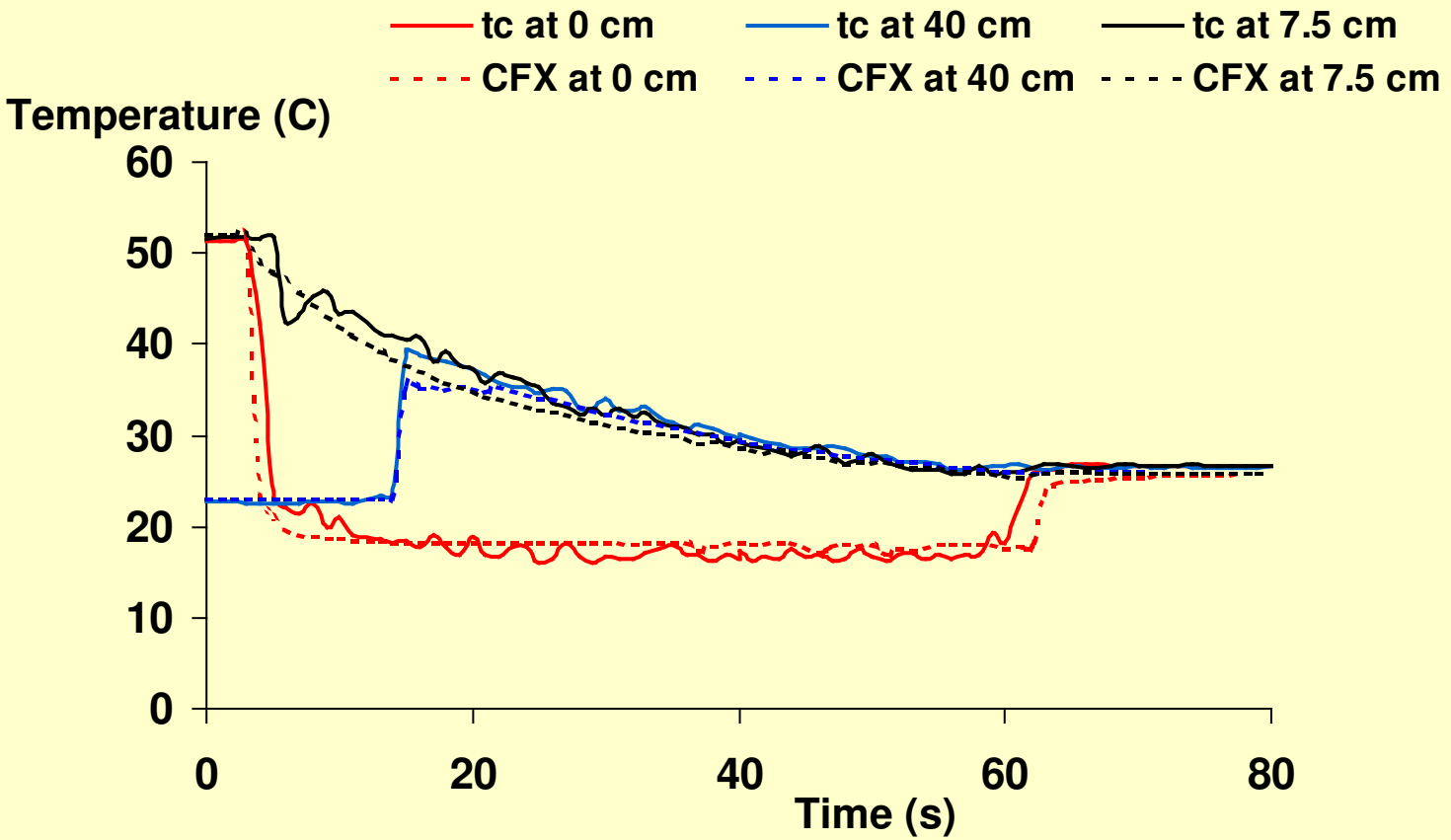
Fluid Flow Validation



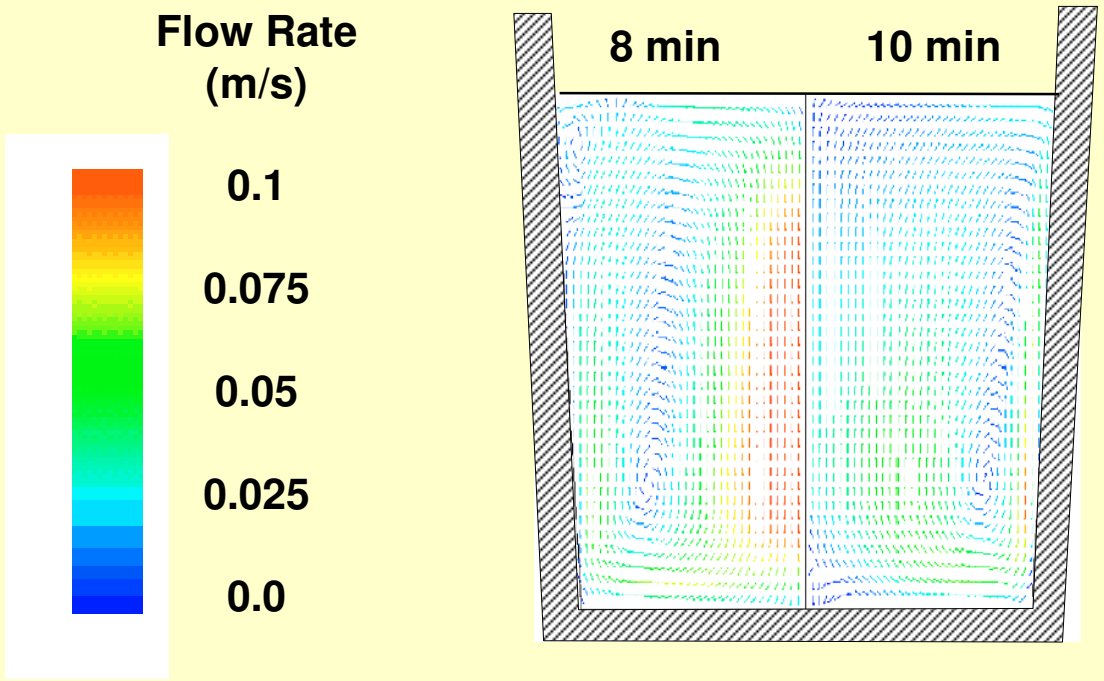
1/5 Scale Water Model



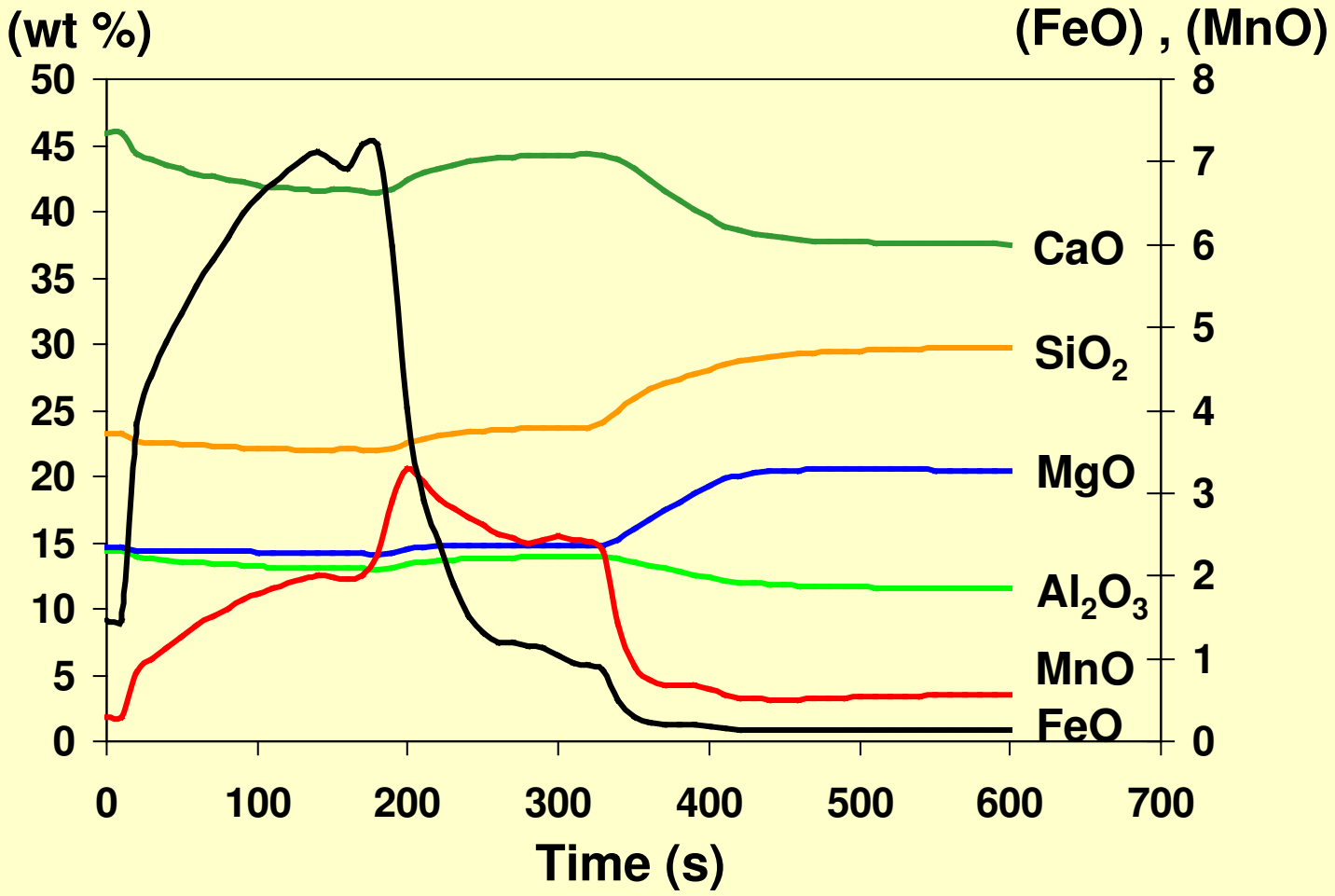
CFX - Velocity Field


tc at 0 cm
tc at 40 cm
tc at 7.5 cm
CFX at 0 cm
CFX at 40 cm
CFX at 7.5 cm
Temperature (C)
60
50
40
30
20
10
0
0
20
40
60
80
Time (s)

Fluid Flow Vectors - CFX



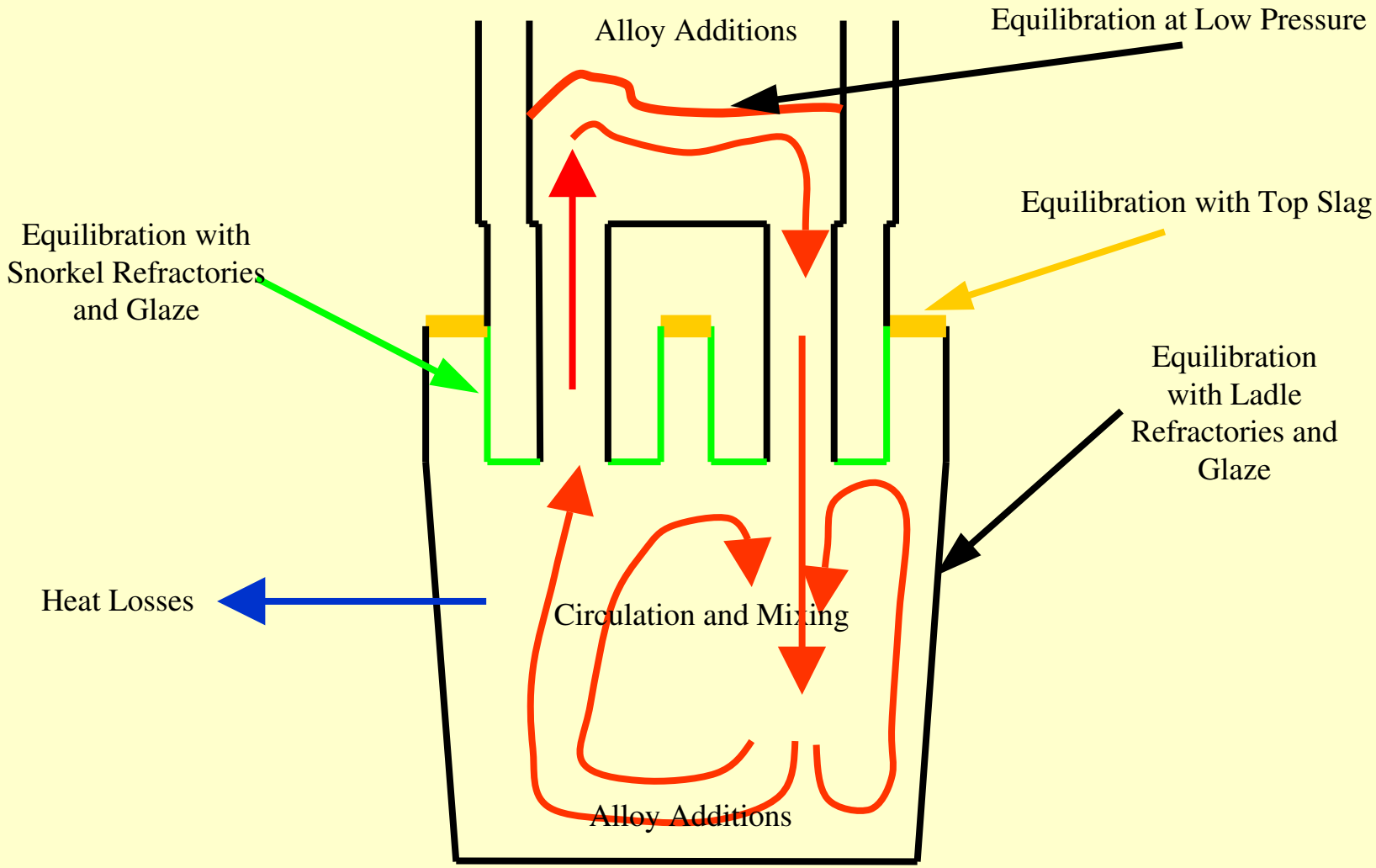
Slag Development



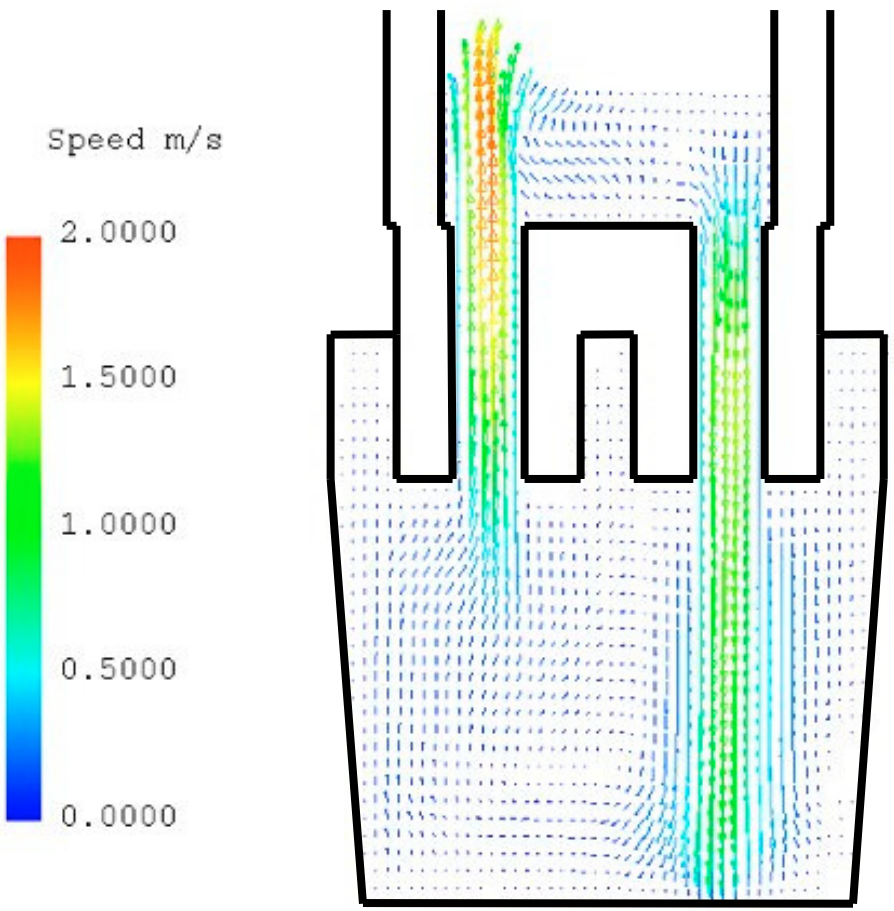
Global Equilibrium / Validation

Final Steel Analysis							
		[O] ppm	[%C]	[%Mn]	[%Si]		
Calculated		34.83	0.824	0.702	0.231		
Measured	Post Stir	88	0.78	0.59	0.23		
	LAF 1	44	0.797	0.578	0.22		
Final Slag Analysis							
		(%MnO)	(%SiO_2)	(%Al_2O_3)	(%FeO)	(%MgO)	(%CaO)
Calculated	Post Stir	0.57	29.79	11.53	0.14	20.45	37.53
	LAF 1	0.25	42.39	6.49	0.06	8.87	41.95
Measured	Post Stir	4.6	39.7	4.1	1.1	16.6	33.3
	LAF 1	5.7	42.5	3.4	2.3	9.9	35.8

Chemical & Physical Processes – RH Degasser

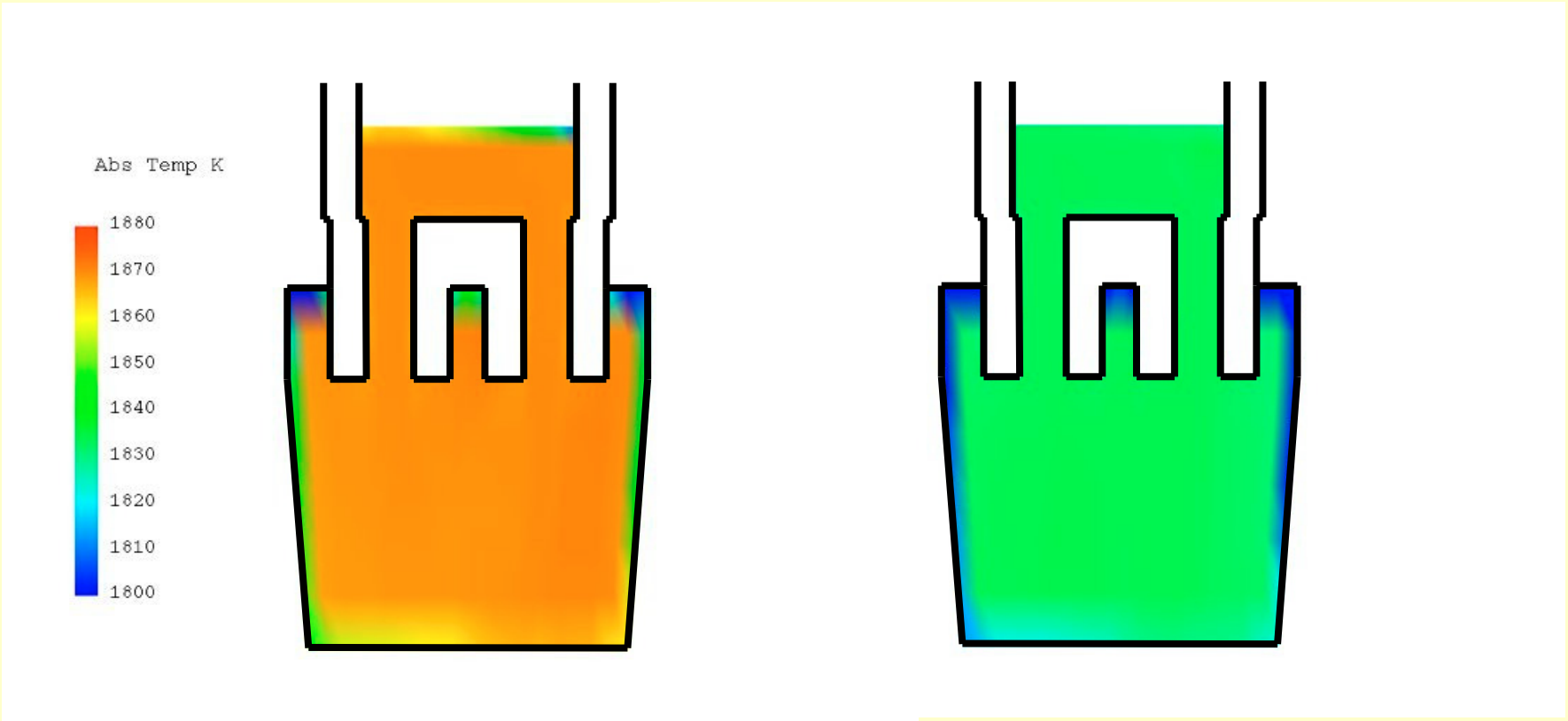


Velocity Vectors

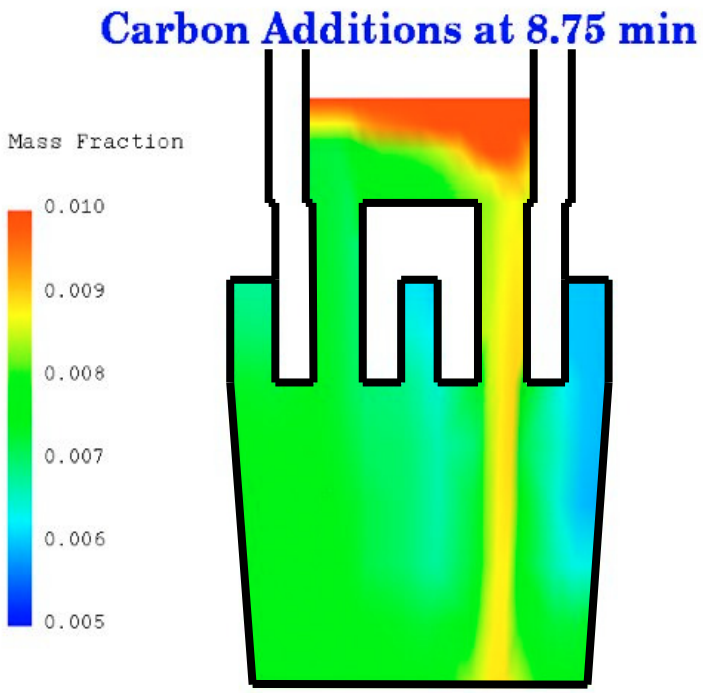


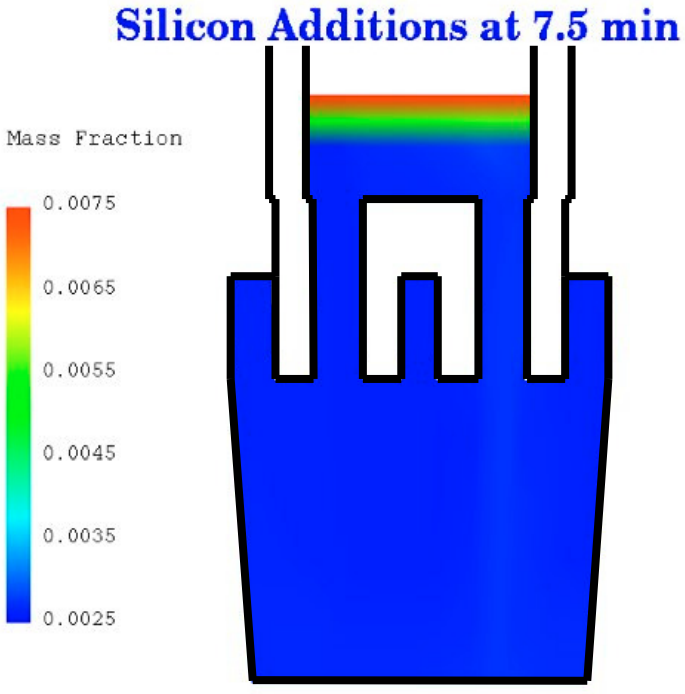
Process Temperature

Initial **22 minutes**

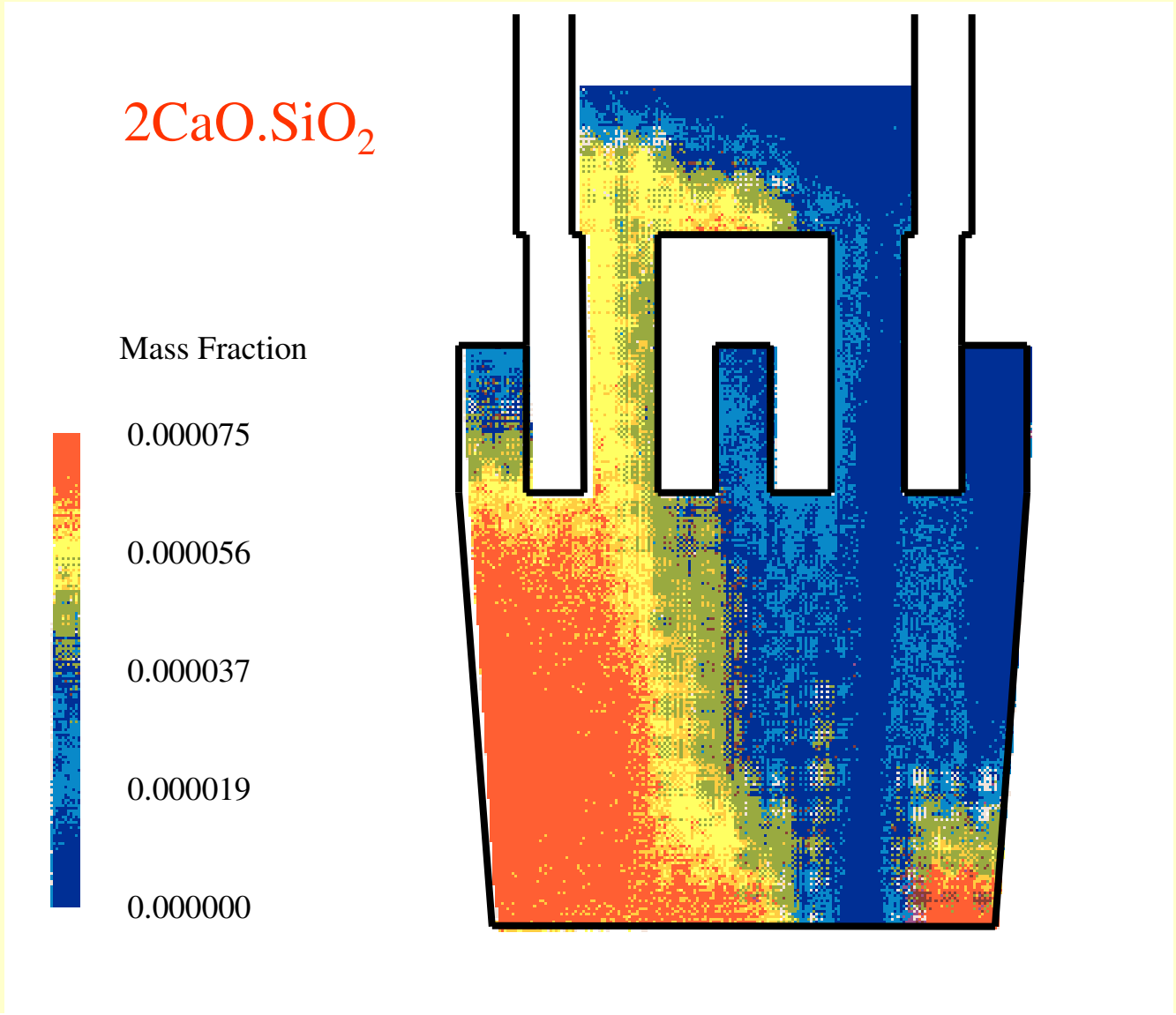


Additions


Carbon Additions at 8.75 min
Mass Fraction
0.010
0.009
0.008
0.007
0.006
0.005


Silicon Additions at 7.5 min
Mass Fraction
0.0075
0.0065
0.0055
0.0045
0.0035
0.0025

Solid Inclusions at 12 minutes



Validation – Top Slag

		Top Slag and Glaze Composition - wt%				
		CaO	SiO_2	Al_2O_3	MgO	FeO
Actual, Start	Top Slag	41.6	34.5	13.2	8.2	1.0
Calc. Glaze Composition	Glaze	21.0	11.2	46.5	2.5	17.2
Actual, End Degassing	Top Slag	38.3	33.8	15.2	9.8	1.1
Equil. Top Slag plus Glaze	Top Slag (1)	38.8	30.9	18.4	7.4	0.4
	Top Slag (2)	39.1	31.3	17.5	7.8	0.4
	Top Slag (3)	38.6	31.4	17.8	7.6	0.4
Model, End Degassing	Top Slag	39.3	31.4	17.3	7.6	2.5

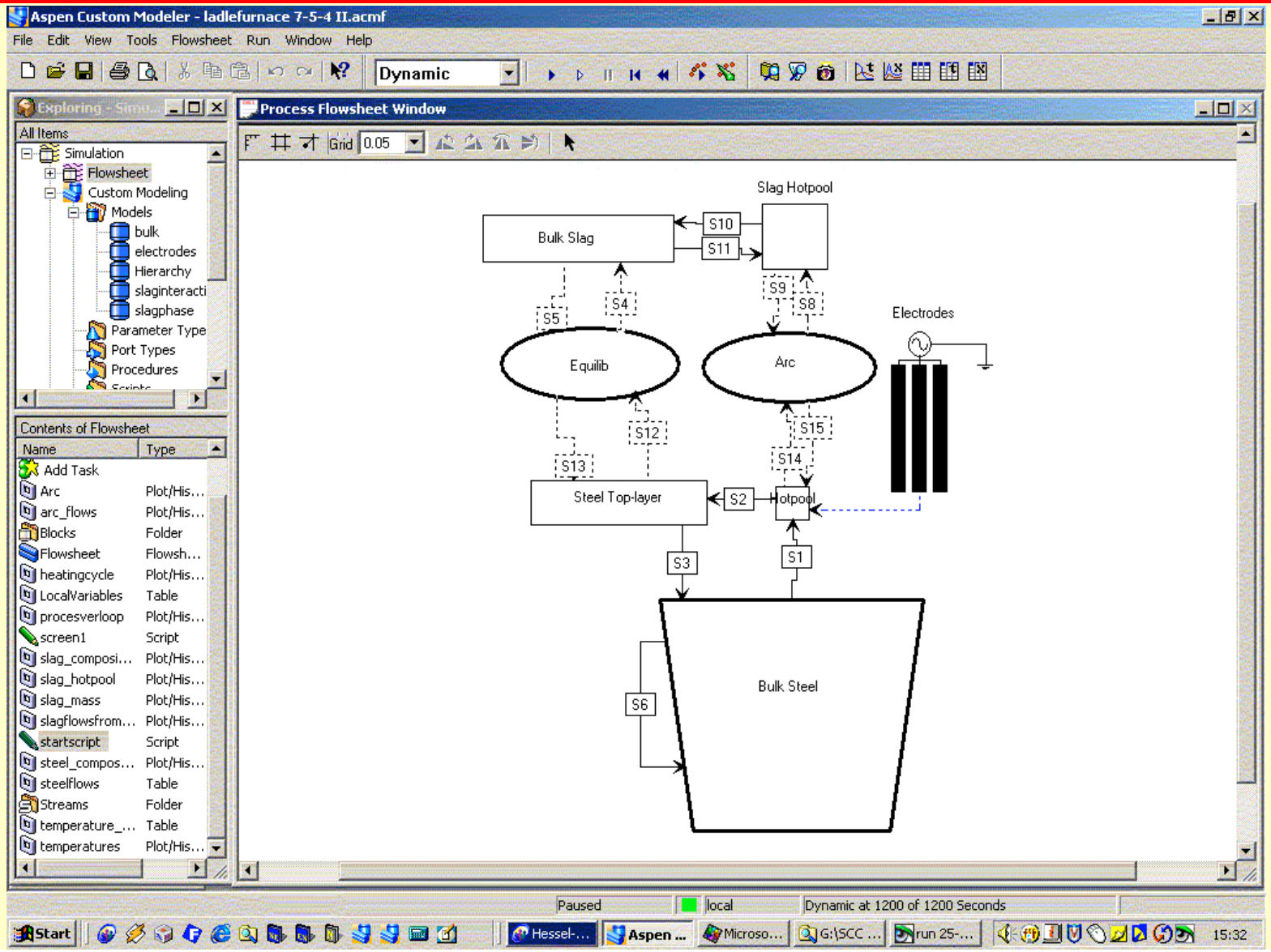
Top Slag (1) : 1 tonne start top slag plus 100 kg liquid glaze (each leg)
Top Slag (2) : 1 tonne start top slag plus 200 kg liquid glaze (each leg)
Top Slag (3) : 2.5 tonne start top slag plus 200 kg liquid glaze (each leg)

Validation - Metal

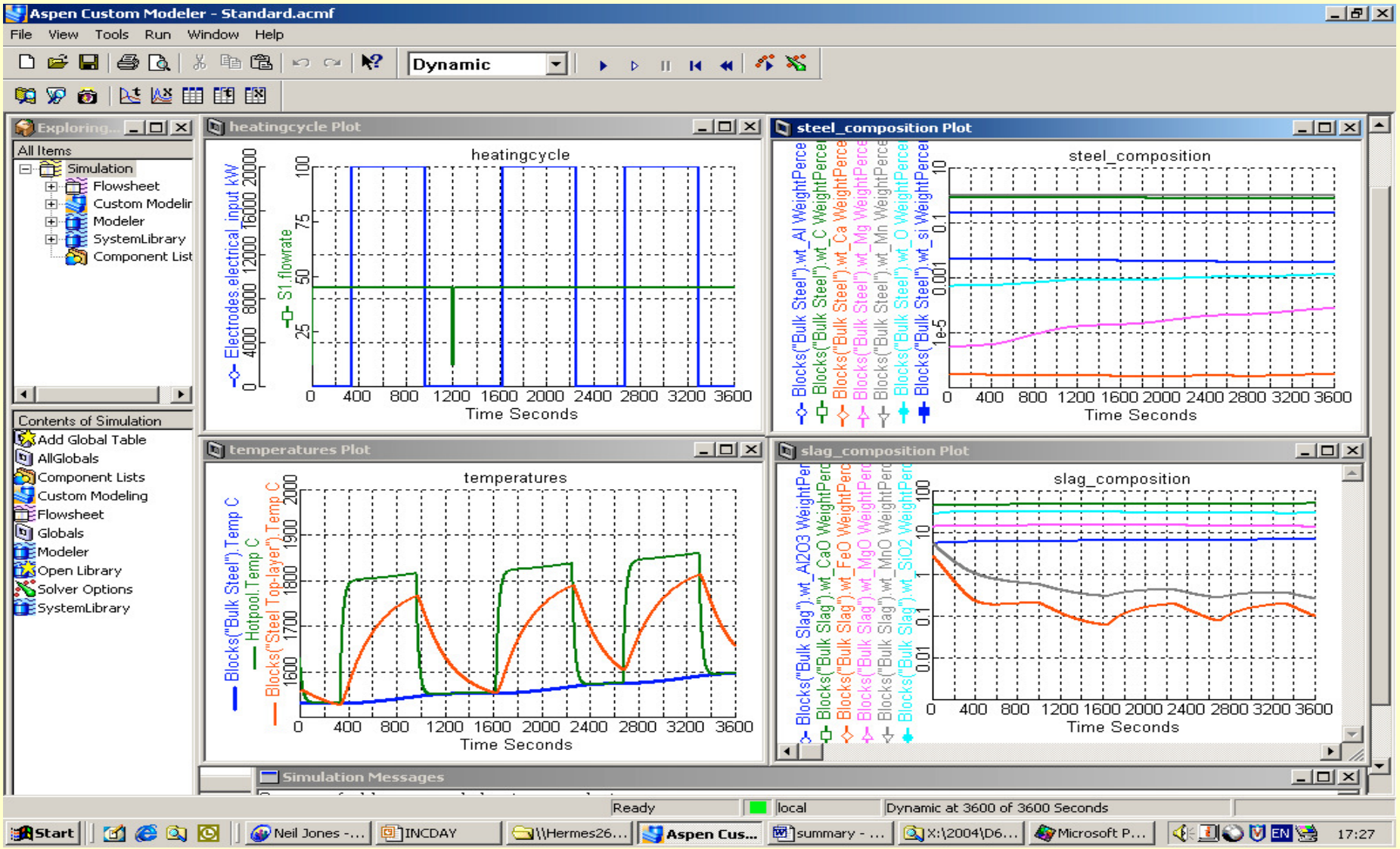
		Steel Composition wt%				
		C	Si	Mn	O ppm	Al ppm
Pre-Degassing	Actual	0.58	0.26	0.99	31.5	
During Degassing	Calc. At 600 secs	0.72	0.29	0.985	20.5	3.5
End Degassing	Calc. At 1300 secs	0.72	0.29	0.985	18.1	4.2
End Degassing	Actual	0.73	0.28	0.99	17.3	

Ferro-alloys after 420 seconds

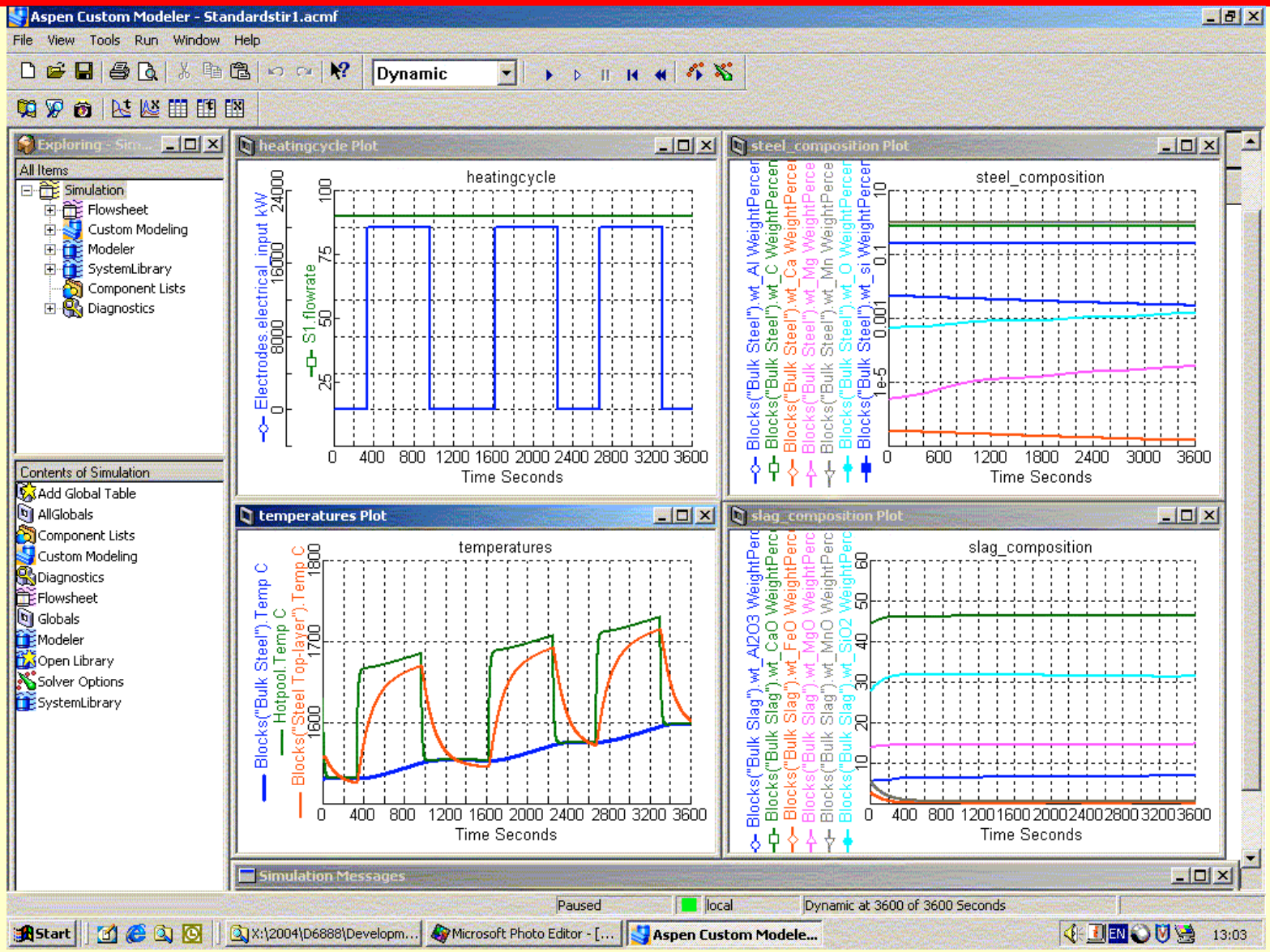
LMF – ASPEN/CHEMAPP



Standard Heat/Stir



Double Stir Rate



Slag FeO vs Heat Cycle