NUMERICAL MODELLING OF PROTECTION AIR SYSTEM IN FRONT WALL FIRED BOILER OP650

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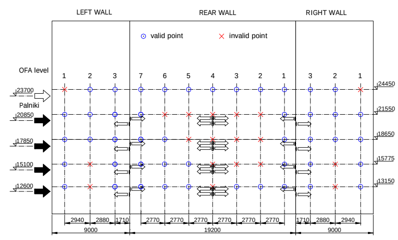
The aim of this study was numerical simulations, of protection air system in front wall fired boiler OP650 K5 in Rybnik Power Plant. Simulations of the furnace process with and without protection air system were done.

Measurement of boundary gas composition layer on left, rear and right wall in boiler for different cases of working boiler OP650 was done. Then numerical simulation of that different cases of working boiler was done to comparison measurement with simulations.

Schematic arrangement of points to probe boundary gas layer and protection air inlets (view from inside of the furnace)



Fuel for boiler OP650 was coal – characteristic parameters used: coal granulation as grain's share biger then *x*, coal analysis as recived state - lower heat value and elementary analysis.

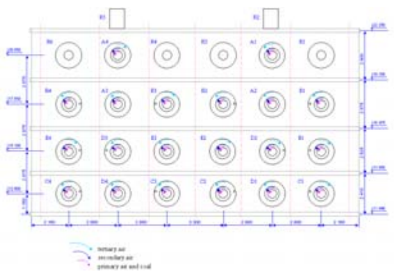
Coal granulation

x	R
µm	%
88	33,97
102	27,554
120	20,885
150	12,917
200	6,56

coal analysis as recived state

Q	A	W	C	H	S	O	N
kJ/kg	%	%	%	%	%	%	%
21224	21,2	12,55	56,6	3,2	0,200	5,800	0,450

Schematic arrangement of burners and OFA inlets on front wall of the boiler (view from inside of the furnace)

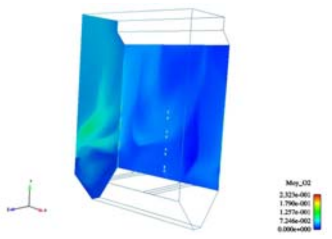


The four case (A, B, C, D) of working boiler was implemented for numerical modelling. In this case boiler worked with 160MW and 215MW nominal output with various mills (burners) worked and with or without Protection Air System (PAS).

Data sheet of parameters for different boiler work cases

Data	Unit	A	B	C	D
Working mills	-	A, B, C, E	A, C, D, E	B, C, D, E	B, C, D, E
Nominal output	MW	160	160	215	215
Primary air flow					
	kg/s	15,10	16,02	17,27	17,18
	kg/s	17,06	18,59	17,58	17,33
	kg/s	16,36	18,98	18,45	17,74
	kg/s	15,89	19,2	17,73	17,86
Coal flow					
	kg/s	3,51	3,35	5,5	5,44
	kg/s	4,93	4,41	5,59	5,45
	kg/s	4,03	4,56	4,81	5,05
	kg/s	4,13	4,4	5,32	5,19
Coal temperature	°C	114	108	116	113
Air temperature	°C	257	250	268	267
Opening of OFA inlets					
R1, 2	%	4,13	52,51	26,92	15,08
R 3, 4	%	28,68	68,51	51,81	40,29
R 5, 6	%	28,6	49,96	51,7	40,02
OFA air flow					
R1	kg/s	0,331	4,21	2,59	1,45
R2	kg/s	0,228	2,9	1,78	1,00
R3	kg/s	2,300	5,49	4,99	3,88
R4	kg/s	2,300	5,49	4,99	3,88
R5	kg/s	1,577	2,75	3,42	2,65
R6	kg/s	2,294	4,01	4,98	3,85
Tertiary air flow					
	kg/s	23,100	14,6	28,27	26,03
	kg/s	20,089	10,42	23,26	21,05
	kg/s	20,706	9,82	22,53	20,33
	kg/s	20,706	9,22	21,81	19,61
Secondary air flow	kg/s	21,55	21,55	25,86	25,86
PAS air flow	kg/s	0	16,33	0	15,8

Additional simulation of new concept of Protection Air System for B and D cases of working boiler was done. That modelling is signed with "N" letter, for example NB means modelling the new protection air system for conditions of working boilers described in case B.



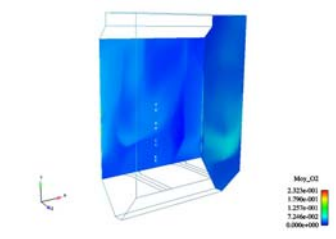
O_2 concentration in boundary gas layer on left, rear wall - case A

Measured O_2 concentration in boundary gas layer - case A
(view from inside of the furnace, grey layer- point's coordinates)

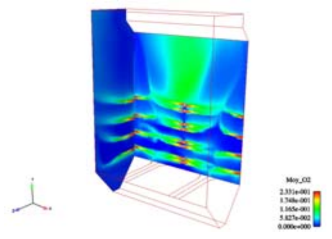
Left Wall			Rear Wall							Right Wall			
3	2	1	7	6	5	4	3	2	1	1	2	3	
8,3	10,2		0,7		0	0,4	0,4	0,8	5,6		0,4	0,4	24450
	10,5	17,2	3,4						1,6	11	0,4	11	21550
5	0	9,4	2,4	11					2,2	6,7	0,4		18650
7		9,7	1,7	1,1	2,6				2,4	6,7		2	15775
13,3		15	0,7	0,4	3,3		2,2	3,7	0			11	13150
7530	4590	1710	-8100	-5400	-2700	0	2700	5400	8100	1710	4590	7530	

Results of modelling O2 concentration in boundary gas layer - case A
(view from inside of the furnace, grey layer- point's coordinates)

Left Wall			Rear Wall							Right Wall			
3	2	1	7	6	5	4	3	2	1	1	2	3	
3,74	4,82	3,7	3,32	2,5	2,67	1,65	1,84	1,5	1,73	1,82	2,29	2,45	24450
3,75	5,37	4,27	3,28	2	2,77	2,71	2,14	1,12	1,86	2,32	2,87	3,29	21550
4,98	6,17	3,82	2,91	2,26	2,81	2,8	1,36	0,61	1,96	2,54	2,92	3,88	18650
5,51	6,12	5	2,48	2,78	1,88	1,88	1,43	0,41	2,08	3,75	4	5,1	15775
3,26	2,1	1,36	1,68	1,86	1,93	1,88	1,68	2,33	2,08	3,5	4,37	2,26	13150
7530	4590	1710	-8100	-5400	-2700	0	2700	5400	8100	1710	4590	7530	



O_2 concentration in boundary gas layer on right, rear wall-case A



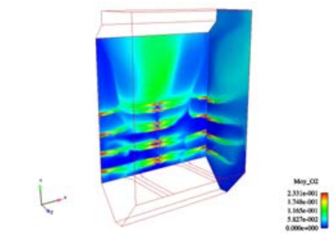
O_2 concentration in boundary gas layer on left, rear wall – case B

Results of modelling O2 concentration in boundary gas layer - case B
(view from inside of the furnace, grey layer- point's coordinates)

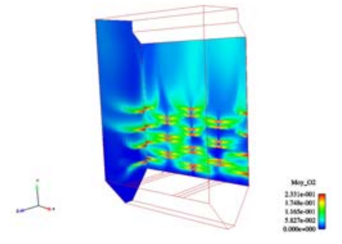
Left Wall			Rear Wall							Right Wall			
3	2	1	7	6	5	4	3	2	1	1	2	3	
2,48	1,5	1,01	1,31	3,29	6,82	11,09	5,73	2,8	2,3	3,37	5,51	5,59	24450
2,56	6,4	4,4	5,56	7,51	11,71	7,12	11,01	6,97	6,27	5,31	6,05	3,36	21550
3,7	4,75	3,71	4,47	1,46	8,37	1,12	10,37	0,54	4,39	3,53	4,82	4,2	18650
1,31	3,44	0,14	5,86	7,39	9,67	1,25	9,28	2,17	1,49	5,39	2,31	4,83	15775
0,31	0	0,33	3,11	5,15	8,95	1,13	10,38	5,05	7,01	1,79	2,79	1,92	13150
7530	4590	1710	-8100	-5400	-2700	0	2700	5400	8100	1710	4590	7530	

Measured O_2 concentration in boundary gas layer - case B
(view from inside of the furnace, grey layer- point's coordinates)

Left Wall			Rear Wall							Right Wall			
3	2	1	7	6	5	4	3	2	1	1	2	3	
1,9	1,9		7		7,7	0,6	6	2,5	1,3		1,8	0,6	24450
6,3	3,6	11,7	7,4						11,1	2,5	3,2	6	21550
11	6,4	13	4	0					0	8,5	1	16	18650
11		8	9,4	0,6	0				6,4	10,9		9	15775
11		11,6	0	11,1	6,9		13,5	6,4	9,4			10,9	13150
7530	4590	1710	-8100	-5400	-2700	0	2700	5400	8100	1710	4590	7530	



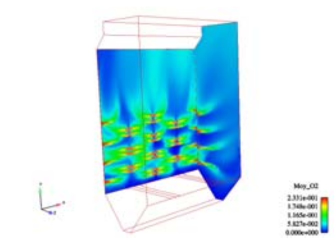
O_2 concentration in boundary gas layer on right, rear wall – case B



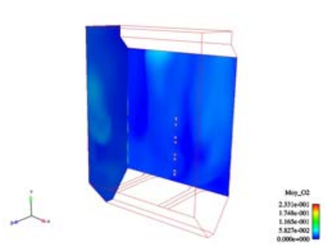
O_2 concentration in boundary gas layer on left, rear wall – case NB

Results of modelling O2 concentration in boundary gas layer - case NB
(view from inside of the furnace, grey layer- point's coordinates)

Left Wall			Rear Wall							Right Wall			
3	2	1	7	6	5	4	3	2	1	1	2	3	
2,63	1,96	1,29	3,15	3,28	5,54	5,74	5,63	3,89	5,07	3,67	3,86	3,93	24450
2,38	6,13	5,32	9,01	2,35	10,11	3,23	6,95	3,04	9,12	6,5	3	3,2	21550
2,24	6,75	6,04	10,51	2,91	3,56	2,12	2,56	1,28	8,25	3,97	4,65	3,2	18650
0,79	1,1	5,96	11,76	5,32	9,04	3,36	3,46	1,58	4,19	1,83	6,68	3,41	15775
0,49	1,43	0,15	5,06	4,11	9,54	4,85	1,82	6,84	10,66	2,83	2,73	1,73	13150
7530	4590	1710	-8100	-5400	-2700	0	2700	5400	8100	1710	4590	7530	



O_2 concentration in boundary gas layer on right, rear wall – case NB



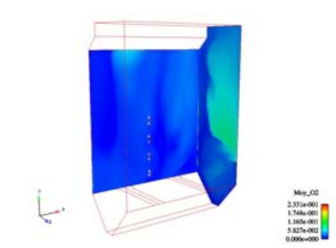
O_2 concentration in boundary gas layer on left, rear wall – case C

Measured O_2 concentration in boundary gas layer - case C
(view from inside of the furnace, grey layer- point's coordinates)

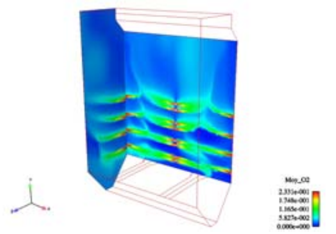
Left Wall			Rear Wall							Right Wall			
3	2	1	7	6	5	4	3	2	1	1	2	3	
2,2	1,8		1,8		2	2,5	3	2,8	0		0	0	24450
	3,5	18,7	0						0	8,1	7,1	0	21550
0	0,5	6,5	0	8,7					0	0	12,1	0	18650
0		11,1	0	7	0				1,8	2		0	15775
0		0	8,2	12	0		2,2	3	0			13	13150
7530	4590	1710	-8100	-5400	-2700	0	2700	5400	8100	1710	4590	7530	

Results of modelling O2 concentration in boundary gas layer - case C
(view from inside of the furnace, grey layer- point's coordinates)

Left Wall			Rear Wall							Right Wall			
3	2	1	7	6	5	4	3	2	1	1	2	3	
3,79	1,7	0,98	0,62	0,87	1,95	1,82	1,66	2,75	2,86	1,47	6,14	5,84	24450
2,93	2,16	0,98	0,4	0,57	1,56	2,02	1,11	2,75	2,48	1,12	6,9	6,75	21550
3,17	3,07	1,12	2,56	0,8	1,41	1,25	0,16	1,95	2,24	0,86	7,77	7,99	18650
1,56	1,07	1,32	1,28	1,41	1,27	1,44	0	1,09	1,51	1,62	2,36	4,63	15775
1,83	1,76	1,4	1,44	1,64	1,36	1,3	0,84	1,6	0,31	1,4	3,2	2,28	13150
7530	4590	1710	-8100	-5400	-2700	0	2700	5400	8100	1710	4590	7530	



O_2 concentration in boundary gas layer on right, rear wall – case C



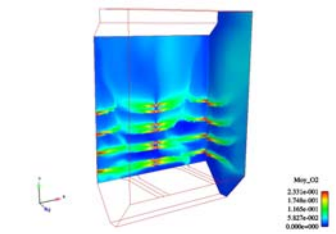
O_2 concentration in boundary gas layer on left, rear wall – case D

Results of modelling O2 concentration in boundary gas layer - case D
(view from inside of the furnace, grey layer- point's coordinates)

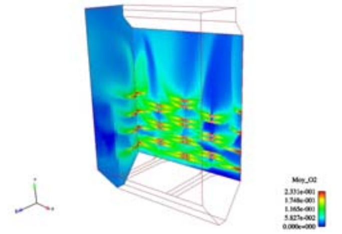
Left Wall			Rear Wall							Right Wall			
3	2	1	7	6	5	4	3	2	1	1	2	3	
3,41	2,96	1,87	2,4	3,27	2,72	2,53	4,59	4,49	2,66	3,14	5	5,15	24450
4,03	7,01	5,29	6,17	4,7	11,37	2,27	11,33	4,01	6,43	4,99	5,68	4,54	21550
3,85	6,31	3,71	4,83	6,52	8,33	2,11	9,7	8,59	4,72	3,77	6,99	4,11	18650
1,52	6,87	5,41	11,24	11,06	8,51	1,81	7,15	7,93	9,97	5,29	6,96	3,57	15775
3,13	5,02	2,88	3,77	4,68	9,46	1,97	2,89	5,04	6,86	3,86	2,02	3,76	13150
7530	4590	1710	-8100	-5400	-2700	0	2700	5400	8100	1710	4590	7530	

Measured O_2 concentration in boundary gas layer - case D
(view from inside of the furnace, grey layer- point's coordinates)

Left Wall			Rear Wall							Right Wall			
3	2	1	7	6	5	4	3	2	1	1	2	3	
0	4,8		0		0	6,5	0	0	1,7		9,7	3,7	24450
	1,5	18	0						0	12	7,4	0	21550
10,5	0	10,5	0,6	7,3					11,1	0	0	3,1	18650
15,8		14,5	7,9	0	16				1,7	4,7		8	15775
6,1		3,2	0	0	0		0	0	11,5			8,2	13150
7530	4590	1710	-8100	-5400	-2700	0	2700	5400	8100	1710	4590	7530	



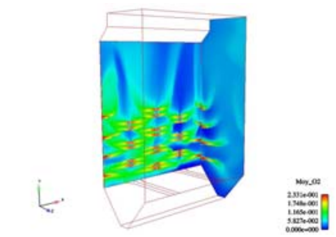
O_2 concentration in boundary gas layer on right, rear wall – case D



O_2 concentration in boundary gas layer on left, rear wall – case ND

Results of modelling O2 concentration in boundary gas layer - case ND
(view from inside of the furnace, grey layer- point's coordinates)

Left Wall			Rear Wall							Right Wall			
3	2	1	7	6	5	4	3	2	1	1	2	3	
4,39	4,49	4,04	7,41	3,75	5,72	3,66	5,7	1,7	5,22	4,09	4,2	4,53	24450
3,31	5,45	7,92	11,74	4,5	12,87	4,87	6,28	2,1	5,69	7,13	4,03	4,85	21550
2,31	5,47	6,88	9,54	3,28	10,79	5,39	9,62	15,34	10,45	4,33	3,79	4,5	18650
0,48	2,63	7,54	10,31	7,26	10,73	5,45	8,57	9,13	7,96	2,94	7,1	4	15775
2,58	5,67	4,99	9,74	6,44	7,86	9,67	6,65	6,73	10,28	2,33	3,13	4,06	13150
7530	4590	1710	-8100	-5400	-2700	0	2700	5400	8100	1710	4590	7530	



O_2 concentration in boundary gas layer on right, rear wall – case ND

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