Article

Hazard-free treatment of electrolytic manganese residue and recovery of high concentration SO_2 using high temperature reduction roasting process

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Supplementary Materials for

Table. S1

Chemical composition of the EMR.

Element	S	Si	Ca	Al	Mn	Fe	Mg	K	Na
Content(wt.%)	10.63	9.26	8.63	3,32	2.08	1.84	1.29	0.80	0.40
Oxide	Ti	P	Sr	As	Pb	V	Zn	O	C
Content(wt.%)	0.18	0.13	0.08	0.06	0.05	0.04	0.02	47.77	13.34

Table. S2

Characteristics and particle size distribution of EMR（unit：mm）.

Water content	Bulk density	Particle size distribution (%)					
(%)	(kg/m^3)	>2.00	0.9~2	0.18~0.9	0.125~0.18	0.075~0.125	<0.075
7.5	1110	49.8	14.2	19.9	6.7	5.4	4

Table. S3

Test factor setting and level of response surface design.

Factor		Factor level	
Coding factor	-1	0	1
x_1: temperature (ºC)	900	1000	1100
x_2: EMR dosage (g)	10	15	20
x_3: coke dosage (g)	0	0.6	1.2

Table. S4

Volume integral value of SO_2 in calcination flue gas under different conditions.

	x_1	x_2	x_3	V_{SO_2}		x_1	x_2	x_3	V_{SO_2}
1	1000	10	0	2.7	10	900	10	0.6	2.2
2	1000	15	0.6	7.6	11	900	15	0	2.9
3	1000	15	0.6	7.6	12	1000	20	0	4.5
4	1100	10	0.6	2.3	13	1100	15	0	11.5
5	1000	10	1.2	4.3	14	1100	20	0.6	10.4
6	1000	20	1.2	8.9	15	1100	15	1.2	6.1

7	900	15	1.2	4.7	16	1000	15	0.6	7.6
8	900	20	0.6	3.7	17	1000	15	0.6	7.6
9	1000	15	0.6	7.6					

Table S5

Chemical composition analysis of EMR and DMR.

Type	Loss on ignition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
EMR	28.56	30.389	7.399	2.118	19.062	1.526
DMR	0.03	37.027	9.742	2.838	22.282	3.143
Type		K_2O	Na_2O	MnO	SO_3	Cl
EMR		1.276	0.760	2.621	35.710	0.0412
DMR		1.235	0.810	3.162	0.38	0.004

Table S6

Cement raw material batching scheme.

Scheme	Limestone	DMR	Shale	Iron ore	Fly ash
	80.28	9.54	3.11	2.93	4.14

Table S7

Chemical composition analysis of raw meal and clinker in proportioning scheme.

Type	L.O.I	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
Raw meal	29.9	16.149	6.358	8.683	63.546	1.054
clinker	0.29	16.356	6.577	6.468	65.997	0.901
Type	K_2O	Na_2O	MnO	SO_3	Cl	
Raw meal	0.895	0.133	0.780	0.24	0.012	
clinker	0.517	0.319	0.674	0.13	0.004	

Table S8

Heavy metal content of DMR（unit：mg/kg）.

Heavy metal	DMR	GB50295-2016 Clinker limit	Heavy metal	DMR	GB50295-2016 Clinker limit
Mn	34580	-	Be	Not detected	5
Cu	210	100	Sb	48	5
Pb	22	100	Co	240	50
Zn	260	500	Se	10	5
Cr	290	150	Sn	24.8	25
Cd	7.4	1.5	Tl	detected	2
Ni	670	100	Tl+Cd+Pb+15As	434.4	-
As	27	40	Be+Cr+10Sn+50Sb +Cu+Mn+Ni+V	38481	-
Hg	Not detected	Not detected			

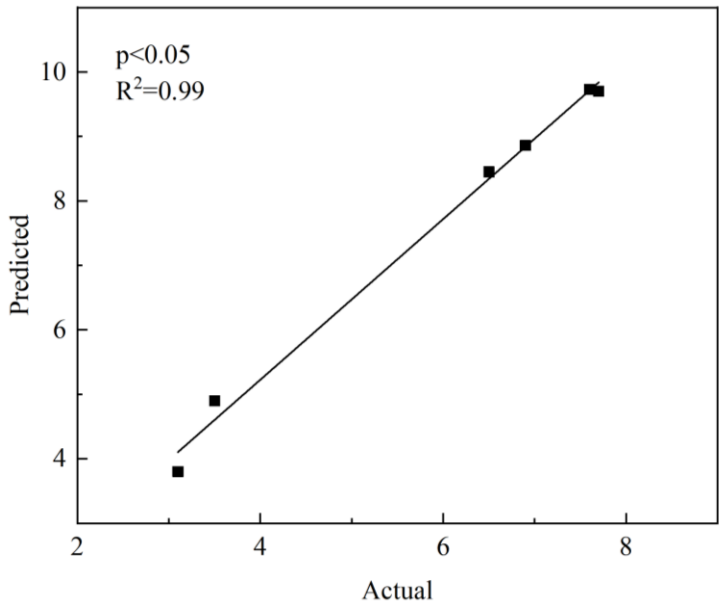


Figure S1. The studentized residuals and predicted response plot.