9006
CN 51-1333/TM

20
第3 卷 总第1

評論

QI PING LUN

设备专业技术期刊、首届《CAJ-CD规范》执
《CAJCED》期刊源
收录
据库》期刊源
刊数据库》（维普网）

二〇二二年六月

公开 ISSN 1001-9006 36卷第2期（总第142期）
CN 51-1333/TM 出版

中国东方电气集团有限公司
四川省动力工程学会 主办

18650

611731

18650 :

B D A B C

0 0 1C/3C A B D 1 000

( ) A2
NMP (Celgard2300) PVDF(HSV900)
CMC SBR 10 μm
16 μm

1.2

1

		%		(g/1540.25mm^2)		%	(g/1540.25mm^2)		(μm)	(μm)
A		94.00	Super-P	0.325	A2	97.50	0.136/0.145	A1	15	16
B	: =9:1	94.00	Super-P	0.33	A2	97.50	0.136/0.145	A1	15	16
C	: =9:1	94.00	Super-P	0.33	A2	97.50	0.136/0.145	A1	15	16
D	: =9:1	94.00	Super-P	0.33	A2	97.50	0.136/0.145	A1	15	16

1.3

1 A
PVDF 95% 2% 3%
16 m

2 B
+ 9 1 PVDF 95% 2% 3%
16 m

3 C
+ 9 1 PVDF 95% 2% 3%
16 m

4 D
+ 9 1 PVDF 95% 2% 3%
16 m

5 A2 CMC SBR
94.5% 1.5% 2.5%
10 m

18650
18650

2

2.1

2

	%			
	A	B	C	D
2A	100.00	100.00	100.00	100.00
6A	99.40	100.10	98.80	99.30
8A	99.10	100.60	97.50	100.00
10A	98.40	100.80	92.60	100.60
15A	89.50	100.10	57.90	100.10
20A	59.60	100.10	31.10	99.20

2 B D
20A
100% A
20A
60% C 20A
30%

PH

2.2

3

	%			
	A	B	C	D
-10	77.90	82.40	83.60	66.80
0	88.20	89.40	89.50	83.70
	100.00	100.00	100.00	100.00
45	104.30	105.20	105.60	105.30

3 A B C 0
10

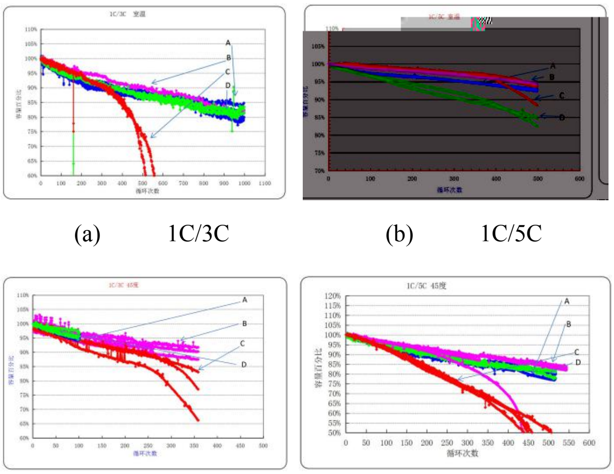
B C

5%

D

A

2.3



(a) 1C/3C (b) 1C/5C

(c) 45 1C/3C (d) 45 1C/5C

1

45

1C 3C 5C

1 1C/3C A

B D

1 000 C 300

45 1C/3C

45 1C/5C

C

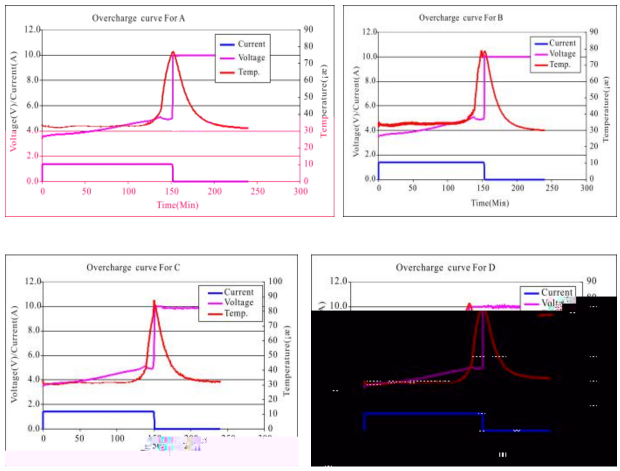
3

55

3.1

4

							(g)				
	(V)	(C)	(V)	(V)	(min)						
A	10	0.7	9.998	3.403	240.000	No	46.290	46.288	No	No	Pass
B	10	0.7	9.999	3.442	240.000	No	46.269	46.268	No	No	Pass
C	10	0.7	10.018	3.417	240.000	No	46.494	46.492	No	No	Pass
D	10	0.7	10.024	3.445	240.000	No	46.065	46.062	No	No	Pass



2

120 SEI

200

4 2

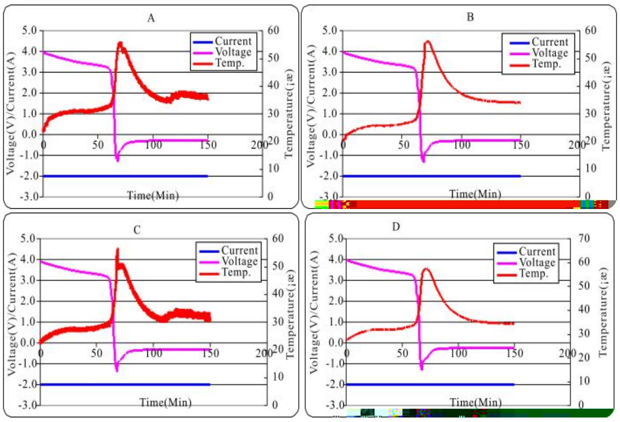
70~80

4

3.2

5

S/N	(C)	(V)	(V)	(A)	(min)	(Ah)				
A	1	4.202	-1.315	-2.000	150.000	1.071	No	No	No	pass
B	1	4.204	-1.331	-1.999	150.000	1.072	No	No	No	pass
C	1	4.202	-1.388	-2.000	150.000	1.062	No	No	No	pass
D	1	4.202	-1.320	-2.001	150.000	1.070	No	No	No	pass



3

5 3

60

50

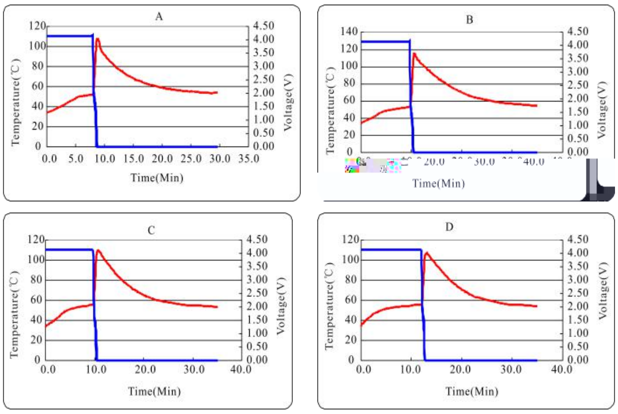
55

5

3.3 55

6

		(V)		(mΩ)		(g)					Result
A	4.171	0.220	20.90	≥250Ω	51.240	49.051	115.8	Yes	No	No	Pass
B	4.169	0.218	20.60		51.124	48.979	108.1	Yes	No	No	Pass
C	4.167	0.011	21.40		50.795	50.794	113.4	Yes	No	No	Pass
D	4.168	0.005	20.70		51.734	50.024	108.3	Yes	No	No	Pass



4

6 4

120

4

18650

1 B D

C

2 A B C

D

3 1C/3C A B D

1 000 C

8

東方電氣評論 2022.6.25
DONGFANG ELECTRIC REVIEW
第36卷Vol.36总第142期

611731

SHEPWM
MATLAB

:
TM 46 A 1001-9006 2022 02-0005-04

(DEC Academy of Science and Technology Co., Ltd., 611731, Chengdu, China)

[1-2] SHEPWM

[3-4] PWM

SHEPMW

(Selective Harmonic Elimination PWM, SHEPWM)

PWM [5-7] (Total Harmonic Distortion, THD)

2022-03-16
1991 2016

7 Δ ṿ ɣ

Â

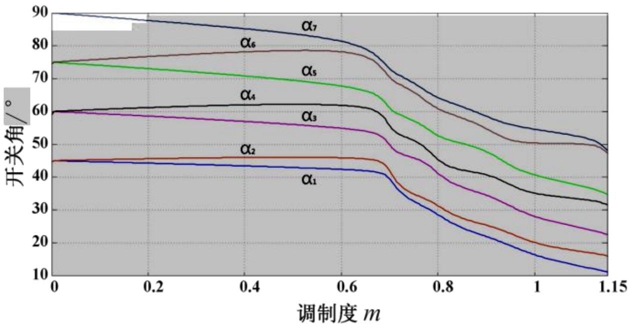
N = 7 Δ = 3 5

= 0 Δ ṿ ^{0} = [42°, 48°, 57°, 63°, 72°, 78°, 87°] Δ = 0.005 №

0 h 1.15 ≠ Matlab fsolve

[0, 1.15]

3 Â



3 PWM

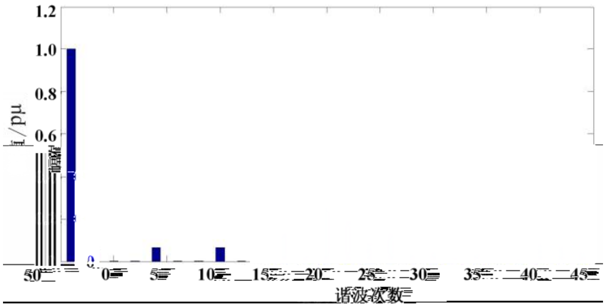
$\alpha_1 < \alpha_2 < \ldots < \alpha_N$ Â

1.15 Â

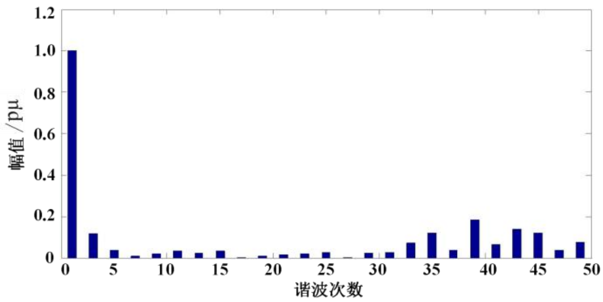
M = U_{L-L} / U_{dc} = 1.732/2 ≈ 1

SHEPWM SVPWM

2



4 SHEPWM FFT (m=1.0)



5 SHEPWM FFT (m=1.0)

4

SHEPWM

THD MATLAB

SHEPWM

[1] , . [J]. , 2011, 26(1):92-99

[2] Blaabjerg F, Chen Z. Power Electronics for Modern Wind Turbines[J]. Synthesis Lectures on Power Electronics, 2006, 1(1):1-68

[3] . [J]. , 2011, 26(9):167-174+189

[4] , , . [J]. , 2011, 31(30):30-38

[5] , . SHEPWM [J]. , 2011, 26(9):183-189

[6] , , SHEPWM [J]. , 2004, 19(1):16-20+54

[7] , , SVPWM SHEPWM [J]. , 2007(16):72-77

[8] . SHEPWM [D]. , 2012

4

300 45 1C/3C 45 1C/5C

[1] . [J]. , 2011, 35(1): 12-14

[2] . [J]. , 2019 (8):39-41

[3] , , . [J]. , 2020, 44(9):1383-1386

[4] , , . [J]. , 2017, 47(6):347-350

[5] , , . [J]. , 2021, 25(3):136-142

[6] , , . [J]. , 2018, 42(3):343-346

[7] , , . [J]. , 2019, 43(7):1223-1225+1229

[8] , , . NCM [J]. , 2020, 41(6):881-887

[9] , , . 18650 [J]. 2017, 27(7):1602-1607

[10] , , . 18650 [J]. , 2021, 21(1):124-132

[11] , , . 18650 [J]. , 2019, 43(1):67-70

[12] . 18650 [J]. 2020 (12):17-18

[13] , , . NCR18650A [J]. , 2020, 8(6):455-461

1,2 1,2 1,2 3

1. 611731 2. 611731
3. 611730

“ ”

TP274 A 1001-9006（2022）02-0009-07

1,2 1,2 1,2 3

(1. Energy equipment Cyber security Key Laboratory of Sichuan Province, 611731, Chengdu, China;

2. DEC Academy of Science and Technology Co.,Ltd., 611731, Chengdu, China;

3. University of Electronic Science and Technology of China, 611730, Chengdu, China)

2022-04-21

2019YFG0534

(1994) 2020

[1]

1.1

Caesar

16

19

1949

20 60

1985 12

TCSEC [2]

20 90

TCSEC ITSEC

1996 1998

1999 12 ISO

ISO/IEC 15408

2005 ISO 27000

1999 9

GB 17589-1999

2001 ISO/IEC 15408

GB/T 18336-2001[3]

2002-2006

GB/T 18238 GB/T 15843

1.2

[4]

ISO 27001:2005

[5]

[6]

1.3

1

[7]

2

Discretionary Access Control, DAC

Mandatory Access Control, MAC [8]

DAC MAC

Role-Based Accesss Control, RBAC [9]

3 [10]

[11]

[12-13]

4

ISO/IEC 15408

[14]

[15]

20 70

8B 8 1~

Cyberspace Security” Network Security”

2.2

Network security ISO/IEC 27033-1:2015 [18] [19] [20] [21]

2.3

VPN [22] 1

3

3.1

21 ... Cyberspace Security ...

2003 ...

2008 ... 54 ...

2011 ... [23]

2012 ...

2016 11 ... Cybersecurity Law of the People's Republic of China ...

ISO ... 2012 ... ISO/IEC 27032:2012 ... [24] ...

2020 ... ISO/IEC TS 27100:2020 ... [25] ...

3.2

ISO/IEC 27032 2012 ...

ISO/IEC 27000:2009 ... information security ... "in the Cyberspace" ...

"Cybersafety" ... ISO ...

2020 ... ISO/IEC TS 27100:2020 ...

Cybersecurity ... Cyberspace Security ... Network Security ...

Cyber ... 1948 ... (cybernetics) ... Kubernetes ... (rudder ... steersman) ... cyber ... [26]

ISO ... cyberspace ... [25] ... 2 ...

[illegible]

1, 2 1, 2 1, 2

1. 611731 2. 611731

MATLAB/Simulink

MATLAB/Simulink

TP274 A 1001-9006 2022 02-0016-05

1,2, 1,2, 1,2

(1. Energy equipment Cyber security Key Laboratory of Sichuan Province, 611731, Chengdu, China;

2. DEC Academy of Science and Technology Co.,Ltd., 611731, Chengdu, China)

[2]

[1]

DEH

Automatic Generation Control AGC

Coordinated Control System CCS

2022-04-21

2019YFG0534

(1994) 2021

[3]

[4]

[5]

Generalized Dynamic Fuzzy Neural Network

GD-FNN

[6]

[2]

[7]

st em f

$$J\frac{\mathrm{d}\omega}{\mathrm{d}t}=M_{st}-M_{em}-M_{f} \quad (4)$$

2.5

$$\frac{V_{fd}}{e_{f}}=\frac{1}{K_{e}+sT_{e}} \quad (5)$$

fd f e

e

3

[9]

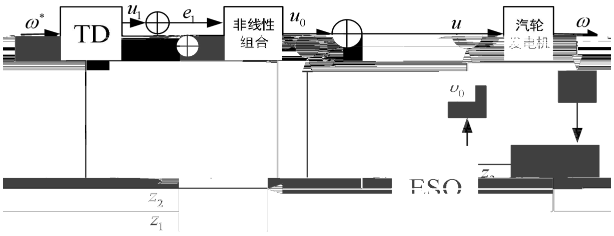
“ ”

[10]

,

0, 1, 2, 3

ADRC 2



2

3.1

PID

:

0

, 2, 0,

1 1 2

2 2 (6)

1 2

1, 2, ,

2

0 2

1 0

1 8| | (7)

2 0 1 /2

0 , 2 1 ,

/ , 1 ,

,

, /2 (8)

3.2

$$\frac{1}{2},\quad \frac{1}{4}, \tag{9}$$

$$fal(e,a,d)=\begin{cases}\dfrac{e}{\delta^{a-1}}, & |e|\le d\\ |e|^{b}\,\text{sign}(e), & |e|>d\end{cases} \tag{10}$$

ADRC

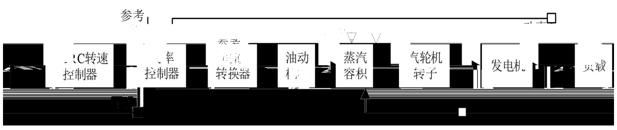
3.3

TD ESO

$$\begin{cases}u_0=k_p\,fal(e_1,\alpha_1,d)+k_d\,fal(e_2,\alpha_2,d)\\ e_1=u_1-z_1\\ e_2=u_2-z_2\end{cases} \tag{11}$$

ESO

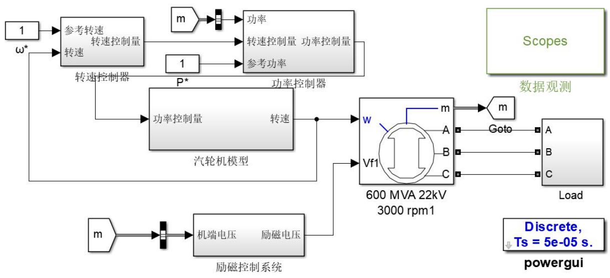
3



3 ADRC

4

ADRC
Matlab/Simulink
4



4

1

/W	600E6
/V	22E3
/Hz	50
/V	0

ADRC

PI

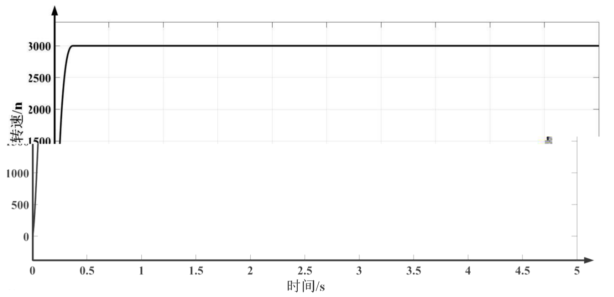
4.1

5 6 ADRC

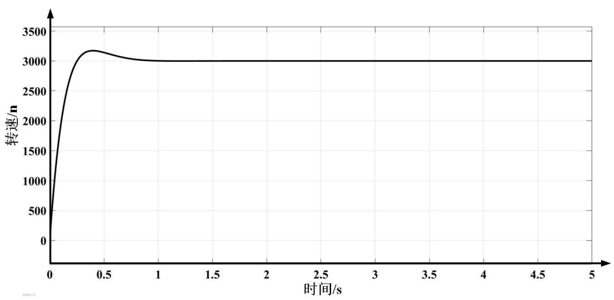
PI

3 000 r/min ADRC

PI



5 ADRC



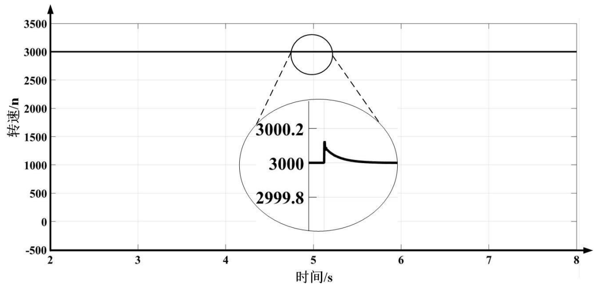
6 PI

4.2

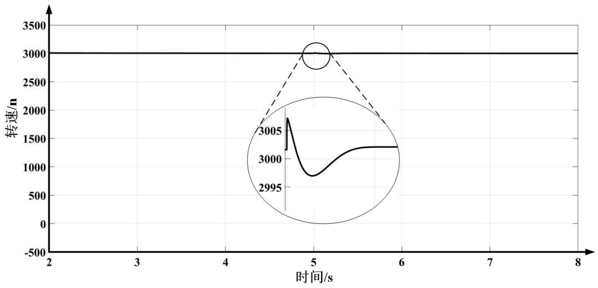
7 8

ADRC

PID



7 ADRC



8 PI

5

[1] , , .
[J]. , 2021(6):5-8

[2] , , .
[J]. , 2020, 41(9):1312-1319

[3] , , . [J]. , 2021, 35(4):6-11

[4] , , . PID [J]. , 2020, 15(S1): 149-156

[5] . [D]. ( ), 2007

[6] . [J]. 2008, 30(11):86-89

[7] , , .
[J]. , 2020(10): 219-222

[8] .
[J]. , 2018, 32(2):15-20+28

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[M] : , 2008:255-261

15

[22] , , . [J]. , 2012, 35(4):109-112+116

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[24] ISO/IEC 27032:2012, Information technology — Security techniques — Guidelines for cybersecurity[S]

[25] ISO/IEC TS 27100:2020, Information technology — Cybersecurity — Overview and concepts [S]

[26] . (cyberspace) [EB/OL]. https://xueshu.blogchina.com/606177333.html

[27] , . [J]. , 2019, 5(3):4-18

[28] , , . [J]. : , 2016, 46(2):125-164

[29] , , .
[J]. , 2019, 43(4):495-504

[30] , , . [J]. : , 2016, 46(8):939-968

[31] , , . [J]. , 2016, 22(1):10-13+18

[32] , , .
[J]. , 2013, 11(11):106-109

[33]

DONGFANG ELECTRIC REVIEW 2022.6.25 第36卷Vol.36总第142期

AspenPlus

1 2 1 2

1. 611731 2. 611731

AspenPlus

/

CO H_2

ER / ER 0.35 / CO

AspenPlus

X703 A 1001-9006 2022 02-0021-07

1, 2, 1, 2

1. Dongfang Electric Clean Energy Technology Chengdu Co.,Ltd., 611731, Chengdu, China;

2. DEC Academy of Scince and Technology Co.,Ltd., 611731, Chengdu, China

[1-3]

.

.

. Mountouris .

2022-02-22

2020YFG0393

1985 2008 .

EPJ [4]

CO

[5]

ASPEN PLUS O_2 CO_2

O_2 CO H_2 72% CO H_2 82.1% CO_2 CO H_2 82.4% H_2O CO_2

CO H_2

O2

1.614 m³/kg CO_2 [6]

AspenPlus

AspenPlus

1

1.1

AspenPlus

LTZ HTZ

H_2O CO CO_2 CH_4 N_2 O_2 C S COS SO_2 H_2S AspenPlus

RK-Soave

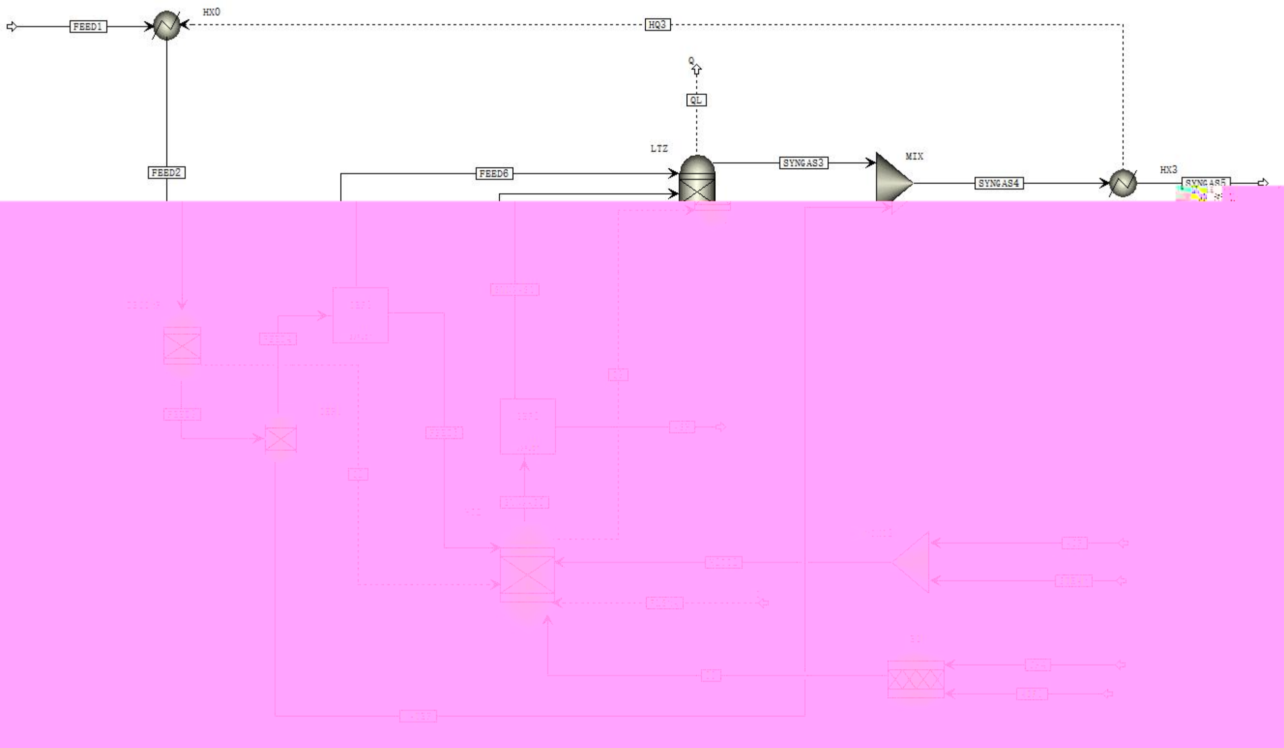
FEED1 HCOALGED

DCOALLIGT ASH

1 1

1 AspenPlus

O	Aspen Plus	
HX0	HEATER	
HX3	HEATER	
DECOMP	RYIELD	
HTZ	RGIBBS	
LTZ	RGIBBS	
B1	RSTOIC	
SEP1	SEP	
SEP2	SEP	
SEP3	SEP	
MIX	MIXER	
MIXO2	MIXER	



1

1.2

2

2

		/%			/(kJ/kg)			/%		
						C	H	O	N	S
	6.65	71.64	9.98	11.73	21.97	48.73	6.54	26.95	0.85	0.29

3

3

CO	0.221 3	0.227 7
H_2	0.159 1	0.151 3
CO_2	0.094 8	0.099 8
N_2	0.399 8	0.4
H_2O	0.124 2	0.120 6
SO_2	0.000 7	0.000 6

3

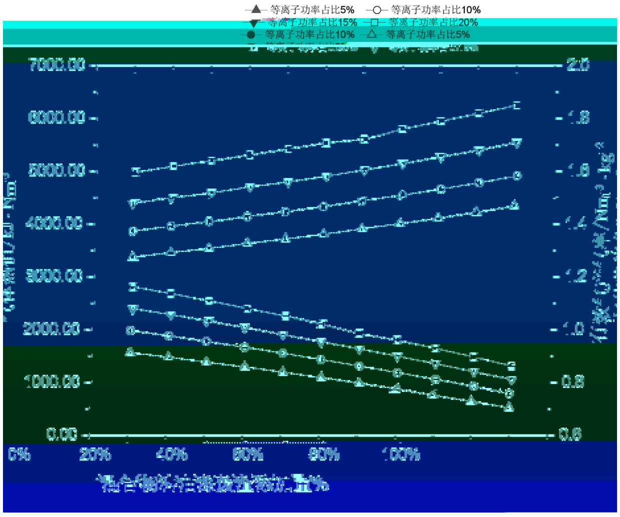
2

Ⴖ

20% 1.16 Nm^3/kg

C H CO

H_2 CO H_2



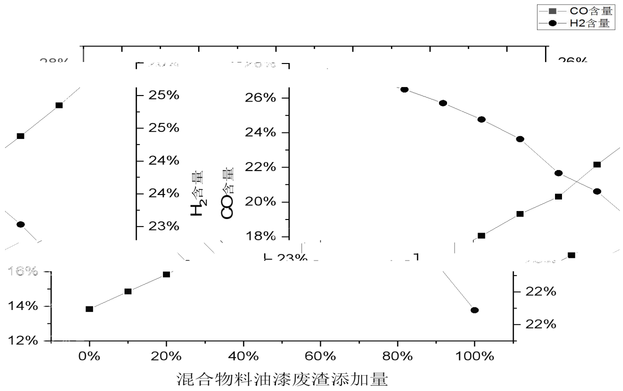
2

2 3

CO H_2

2 3 20%

4 979 kJ/Nm^3 6 247 kJ/Nm^3 CO



3 20%

3

H_2 CO

80% CO

H_2

CO

H_2

CO H_2

SiO_2 Al_2O_3

=

Fe_2O_3 MgO

2.2

79%

ER ǘ

. ǯ ER

. /

.

. /

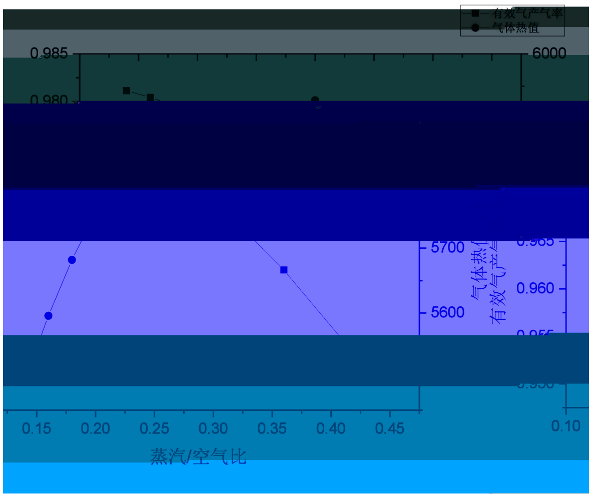
Ꞇ 40% 100 kg/h

H_2

H_2

/

H_2



6 /

/

7 7 / CO

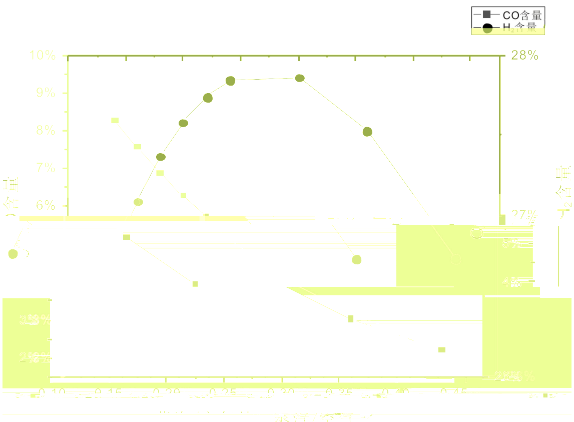
8.28% 2.21% H_2 26.77%

27.86% 26.73%

H_2 CO_2

CO

H_2 CO



7 /

3

1 .

CO H_2

2 / .

/

CH_4

/ CO H_2

/ CO

/

3

4 /

5 .

[1] . [J].
, 2002, 3(3):65-68
[2]
[D]. : , 2009
[3] , , . .
[J]. . , 2012, 32(12):20-24
[4] MOUNTOURIS A, VOUTSAS E, TASSIOS D. Solid waste plasma gasification: equilibrium model development and energy analysis[J]. Energy Conversion and Management, 2006, 47(13-14):1723-1737
[5] . .
.2005
[6] , , . ASPEN PLUS
. [J]. . 2014,36(2):1-5

P Fe_3O_4

510620

HER

HER HER

Fe_2O_3

P Fe_2O_3 Fe_3O_4@P

Fe_3O_4@P Fe_2O_3

Fe_3O_4 P

TQ426 A 1001-9006 2022 02-0028-05

(Guangzhou Power Supply Bureau, Guangdong Power Grid Co., Ltd.,510620,Guangzhou,China)

2022-01-19

GZHKJXM20200090

1981 2006

[1-2]

HER

Pt, Ru

[3-4]

HER

Mo Co Ni Fe

[5-9]

Fe

-

Fe P

(TMPs)

[10-12]

[13-15]

P

P

P

Fe_2O_3 Fe_3O_4

1

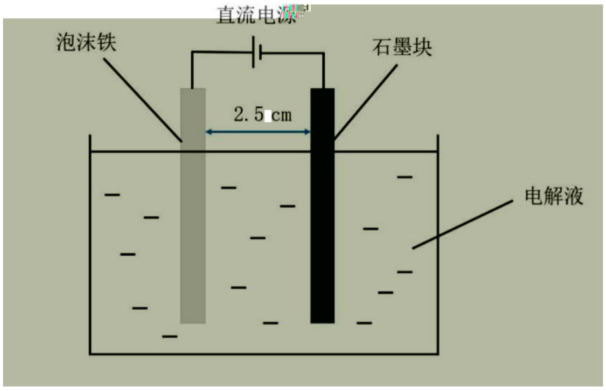
1.1 Fe_3O_4

Fe_2O_3

0.5 wt% + 3 vol% +

2.5 cm

1



1

1

50 V 5 min

4h

Fe_2O_3 NaH_2PO_2

1:5

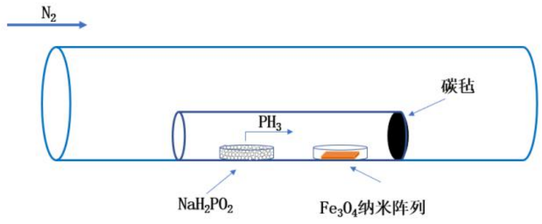
2

P

P NaH_2PO_2

Fe_2O_3

P



2 P

NaH_2PO_2

PH_3 PH_3 P H_2

NaH_2PO_2 PH_3

PH_3

PH_3 PH_3 P

H_2 Fe_2O_3 P Fe_3O_4

$$2NaH_2PO_2 ==== Na_2HPO_4 + PH_3$$

$$2PH_3 ==== 2P + 3H_2$$

$$3Fe_2O_3 + H_2 ==== 2Fe_3O_4 + H_2O$$

KOH

15

2 /min 350

2 h

P Fe_3O_4

1.2

XRD Rigaku D/max 2500

PC X Fe_2O_3

P Fe_3O_4@P

Cu Kα λ=1.540 6 Å

40 kV 20 mA 4°/min

5~85° ZEISS Gemini

300 Fe_2O_3

P Fe_3O_4@P

CHI660E

P Fe_3O_4 1 ×

1cm

Hg/HgO

50 mL 1.0 mol/L

30 min

Hg/HgO

LSV LSV Tafel

EIS

- I-t

2

2.1 XRD

3 Fe_2O_3 Fe_3O_4@P

XRD

45.37° 65.72° 82.91°

3 a XRD 29.71° 34.85°

43.23° 53.92° 62.90° Fe_2O_3

112 211 220 024 224

3 b XRD 32.45° 37.24°

38.35° 44.34° 56.83° 63.41° Fe_3O_4

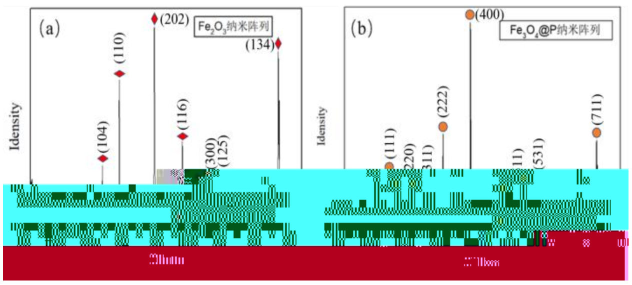
220 311 222 400 511 440

P

XRD Fe_2O_3 Fe_3O_4

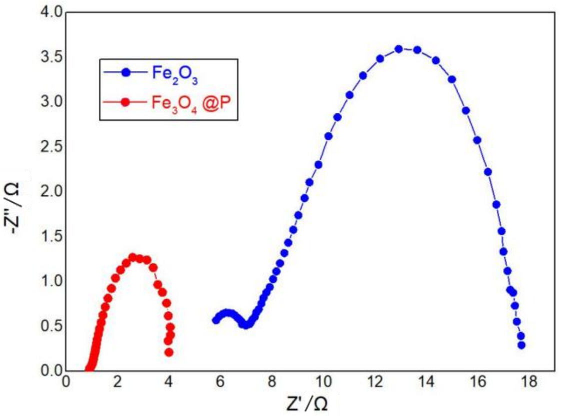
Fe_2O_3 Fe_3O_4

P



a Fe_2O_3 b Fe_3O_4@P

3 XRD



8 Fe_2O_3 Fe_3O_4@P EIS

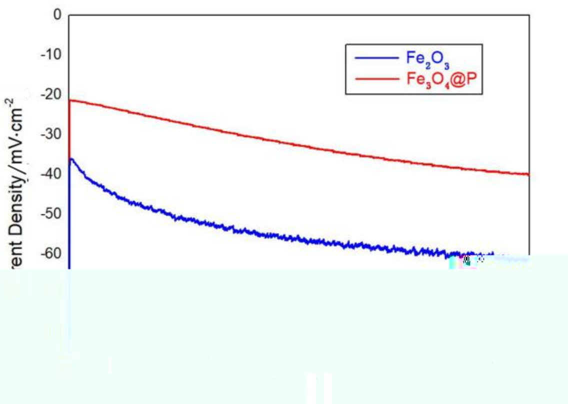
10 mV/cm^2

9 Fe_2O_3

Fe_3O_4@P

Fe_3O_4@P

Fe_2O_3 P



9 Fe_2O_3 Fe_3O_4@P I-t

3

Fe_2O_3

Fe_2O_3 Fe_3O_4 P

Fe_3O_4@P Fe_2O_3

[1] CHEN Y, RONG J, TAO Q, et al. Modifying microscopic structures of MoS2 by high pressure and high temperature used in hydrogen evolution reaction [J]. Electrochimica Acta, 2020, 357:136868

[2] MUGHERI A Q, ALI S, NAREJO G S, et al. Electrospun fibrous active bimetallic electrocatalyst for hydrogen evolution [J]. International Journal of Hydrogen Energy, 2020, 45(41): 21502-21511

[3] GUO Z, LI W, HE Y, et al. Effect of Cd source on photocatalytic H2 evolution over CdS/MoS2 composites synthesised via a one-pot hydrothermal strategy [J]. Applied Surface Science, 2020, 512:145750

[4] CAI Y, KANG H, JIANG F, et al. The construction of hierarchical PEDOT@MoS2 nanocomposite for high-performance sup@

1 2 1 1 1 1

1. 614200 2. 611731

80
80 g/L 2 h 1.3 1.5
1.6 93% 95%

X705; TQ125.3 A 1001-9006 2022 02-0033-04

1, 2, 1, 1, 1, 1

(1.Emei Semiconductor Material Institute, 614200, Emeishan, Sichuan, China;

2.DEC Academy of Science and Technology Co., Ltd., 611731, Chengdu, China)

CdTe 240

-

γ

[1]

Te “

”

[2-4]

Cd

2021-11-18

1984 2007

1

1.1

1.2

99.999%

1

1

	Te	Cd	
	53.16%	46.83%	0.001%

1.3

$CdSO_4$ H_2TeO_3 Na_2SO_3

$CdSO_4$

[4-5]

$$CdTe + H_2SO_4 + 3H_2O_2 \rightarrow CdSO_4 + H_2TeO_3 + 3H_2O \quad (1)$$

$$Na_2SO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + SO_2\uparrow \quad (2)$$

$$SO_2 + H_20 \rightarrow H_2SO_3 \quad (3)$$

$$H_2TeO_3 + 2H_2SO_3 \rightarrow Te\downarrow + 2H_2SO_4 + H_2O \quad (4)$$

$$Na_2S + H_2SO_4 \rightarrow Na_2SO_4 + H_2S\uparrow \quad (5)$$

$$CdSO_4 + H_2S \rightarrow CdS\downarrow + H_2SO_4 \quad (6)$$

1.4

98% AR H_2O_2 30%

Na_2SO_3 AR Na_2S AR

2

80

93% 80

2.2

0.2 mm

H_2SO_4 1: 6

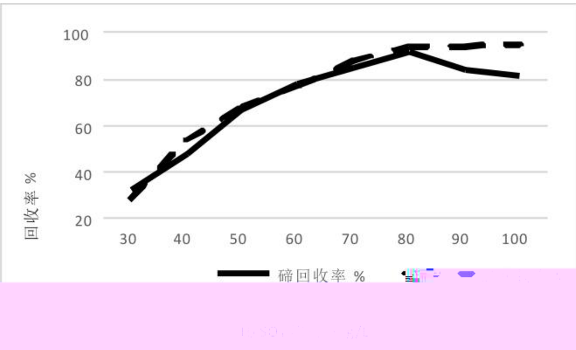
80 2h 30%

/ 1.3 Na_2SO_3

1.5 Na_2SO_3 /

Na_2S 2.4 Na_2S /

3



3 H_2SO_4

3

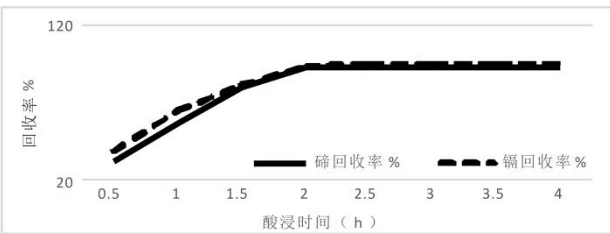
30 g/L

80g/L 30%

92% 90 g/L

80g/L

2.3



4

0.2mm

H_2SO_4 80g/L H_2SO_4

1:6 80 30%

/ 1.3

Na_2SO_3 1.5 Na_2SO_3 /

Na_2S 2.4 Na_2S /

4

4

0.5

2 30%

94% 2

2

2.4

0.2 mm

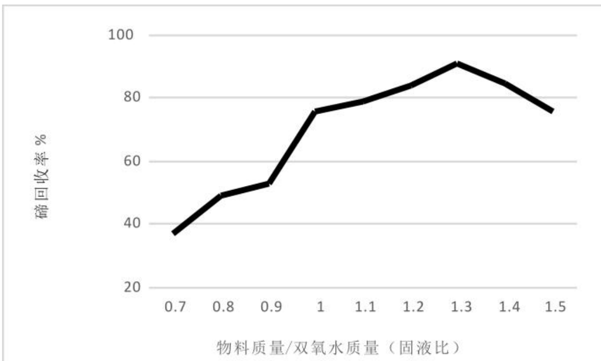
H_2SO_4 80 g/L H_2SO_4

1: 6 80 2h

Na_2SO_3 1.5 Na_2SO_3 /

/

5



5

5

0.7 1.3

37% 92%

1.3

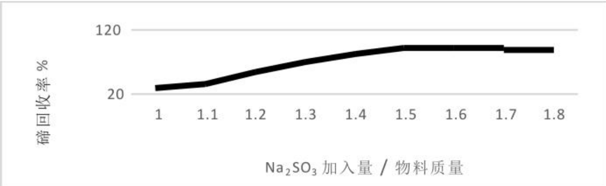
2.5 Na_2SO_3

H_2TeO_3 $CdSO_4$

Na_2SO_3 H_2TeO_3

Na_2SO_3

6



6 Na_2SO_3

6

H_2TeO_3 Na_2SO_3

Na_2SO_3

1 1.5 28% 93%

Na_2SO_3

Na 2

Na_2SO_3

1.5

2 Na

Na_2SO_3	Na ppm
1.5	132
1.6	435
1.7	1 342
1.8	5 428

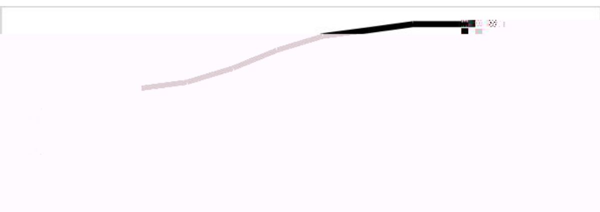
2.6 Na_2S

$CdSO_4$

Na_2S

Cd^{2+} Na_2S

7



7 Na_2S

7

$CdSO_4$ Na_2S

Na_2S ‘

430223

X

TL353.13 A 1001-9006(2022)02-0037-04

, , ,
(Dongfang Electric (Wuhan) Nuclear Equipment Co., Ltd., 420223 Wuhan, China)

[1]

X

2022-04-20
1987 2010

1

1.1

Z2CN19-10+N_2

1

1 Z2CN19-10+N2

wt%

C	Cr	Ni	Si	Mn	S
≤0.035	18.50 20.00	9.00 10.00	≤1.00	≤2.00	≤0.015
P	Cu	B	N	Co	
≤0.030	≤1.00	≤0.0018	≤0.080	≤0.06	

1.2

52 mm D3400 mm

1 m

20 mm

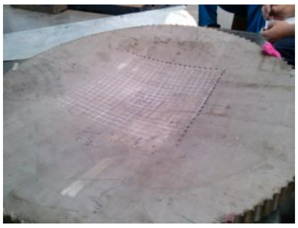
31 mm 400 mm

1

19 mm 34 mm

2

400 ×8h



1

2

1.3

1.3.1

4

1

2

3

4

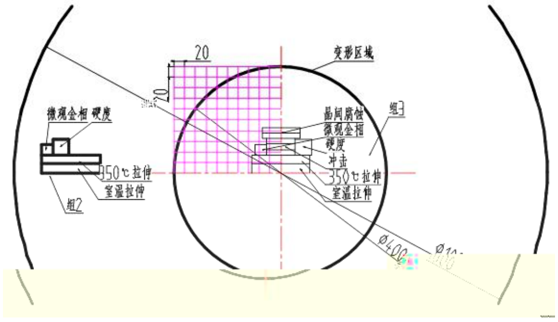
3 4 RCC-M M3310(2000 +2002)

1.3.2

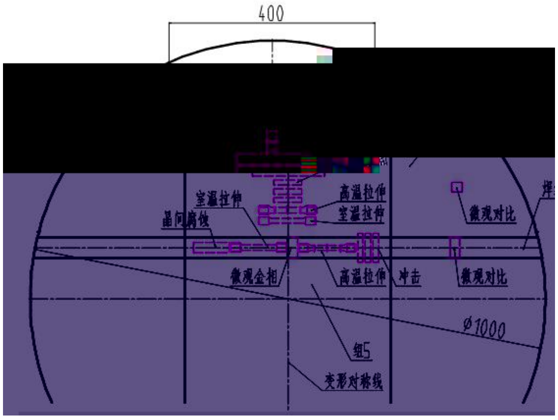
1

5

4



3



4

1.4

1.4.1

2

2

				350			
	Rp0.2/MPa	Rm/MPa	A/%	Rp0.2/MPa	Rm/MPa	/J	/HB
	≥210	≥520	≥40	≥125	≥394	≥60	/
1	248	563	62.5	133	417	272,274,277	/
	261	576	60.0	132	412	293,271,274	/
2	325	575	58.5	235	430	/	180
	275	575	59.5	185	435	/	172
3	350	566	59	266	433	317,323,341	216
	447	616	48.5	367	464	297,300,309	228
4	301	587	59	213	435	353,349,352	235
	309	606	57.5	213	440	333,411,365	225

2

(1) 350

($€‡— s (4 Ò

(2)

)0

2.4

1 2 4 4

4 1 2 4

	1	2	3	4	5
1	516	505	502	516	574
1	-327	-198	-349	-387	-388
2	-617	-579	-570	-	-
4	477	-	-	-	-

MPa

3 5

5 3

	1	2	3	4	5	6	7	8	9	10
O	-459	-	-	-	-	-	-	-	-	-
A	-450	-15	-151	-509	80	225	-217	493	-123	-25
B	-404	-367	-368	-313	-309			-	-	-
E	-488	-400	11	328	467	195	117	-39	231	187
F	-353	-268	-354	-466	-652	-592	-658	-615	-636	

MPa

2.5

4 1

2

[4] 2

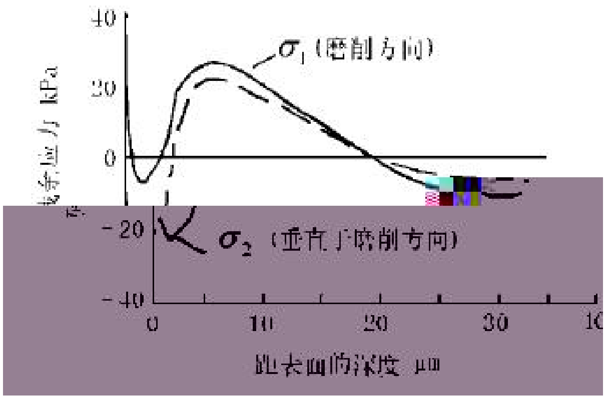
5

[5]

30kPa 6

MPa

( )



6

5 493 MPa,

20%

620 MPa 574 MPa

476 MPa

493 MPa

3

20 mm 30 mm

400 mm X

(1) 350

350

(2)

(3)

(4)

ER316H

511455

ER316H
ER316H

ER316H

TG441.8 A 1001-9006 2022 02-0041-03

, ,
(Dongfang Electric (Guangzhou) Heavy Machinery Co.,Ltd., 511455, Guangzhou, China)

ER316H

R R

2022-04-20

1991 2015

1 5# 6# 7#

1

ER316H TIG

7-20 L/mn

690 ±15

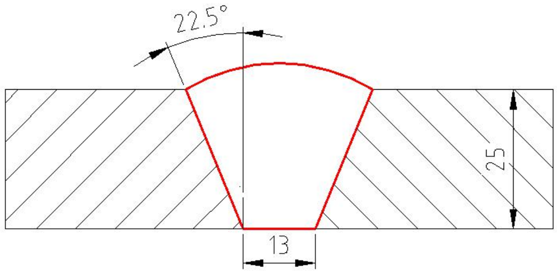
ER316H

2

AWS B4.0M-2000 ASTM E21-1998

1# 2# 3# 4#

ER316H



1

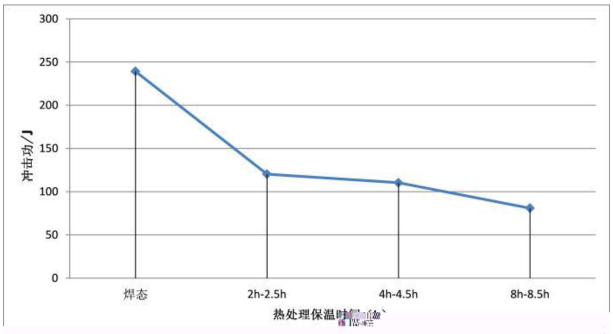
1 ER316H

wt%

	C	S	Si	Mn	P	Cr	Ni	Mo	Cu	Co	Pb
ER316H	0.51	0.001	0.47	1.61	0.005	18.48	12.76	2.35	0.02	0.01	0.001
	Sn	**As**	**Sb**	**Bi**	**Al**	**V**	**Nb**	**N**	**B**	**Ca**	
ER316H	0.001	0.001	0.001	0.001	0.03	0.01	0.01	0.050	0.0001	0.001	

2

1# 350 450 515 530 m 3



3

TIG

248 J

8 h-8.5 h

86 J 65%

[2] 4

a

b

4

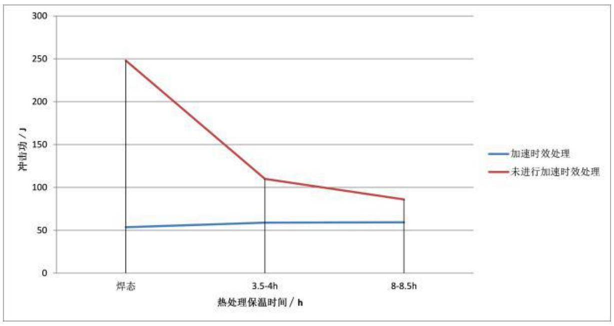
ER316H

5# 6# 7# 750 /100h

1 5

1 5

5



5

750 /100h

σ [3]

6

6

2.3

AWS B4.0M

4

180°

60

1,2

1. 611731 2. 643001

660 MW

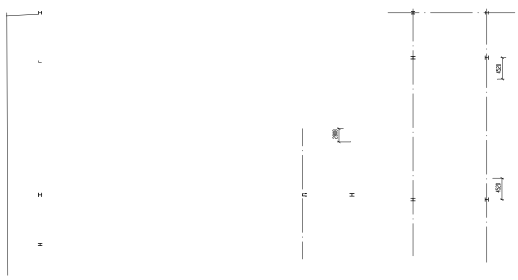
TK223 A 1001-9006 2022 02-0044-06

1,2

1. Clean Combustion and Flue Gas Purification Key Laboratory of Sichuan Province, 611731, Chengdu, China;

2. Dongfang Boiler Group Co.,Ltd., 643001, Zigong, SiChuan, China

1

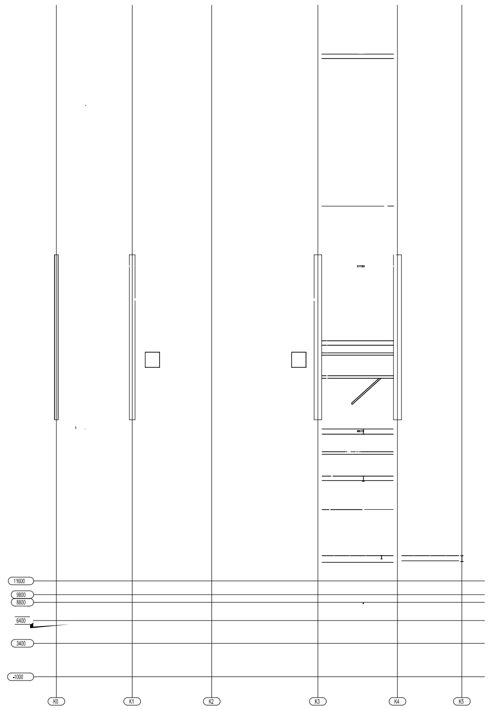


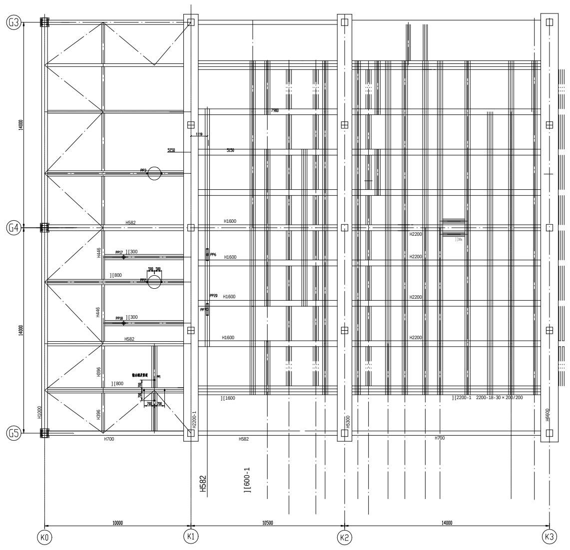
1

2022-04-20

1982 2005

2 3





5.1.1

50 m

50 m

0 m

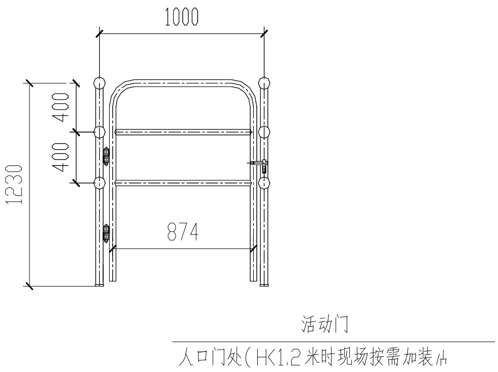
50 m

4.3

“ ”

1

10



ơ ʞ p ɠ ḣ ɛ ά ά Ꚋ þ "

“ 2025 ”

[8]

70%-80%

1

4
[9]

(1)

(2)

(3) (MOM)

(4)

2

2.1

2.1.1 (VPI)

2.4 kV/mm~3.2 kV/mm

2.1.2

[10] /

[11]

(1) WBS

(Automated Guided Vehicle AGV)

1

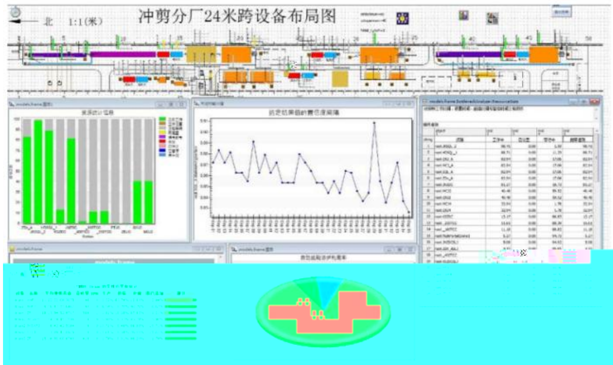
1 1 1

40 ;

60 ;

40 AGV 4

3



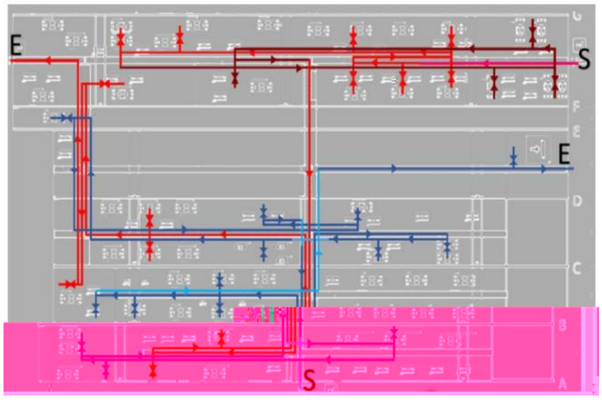
1

(2)

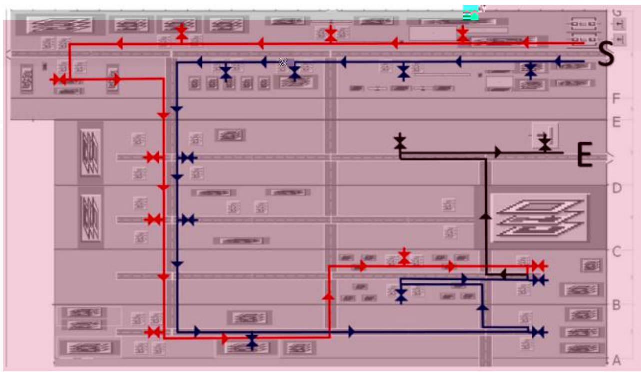
( )

( )

2 3



2



3

2.1.3

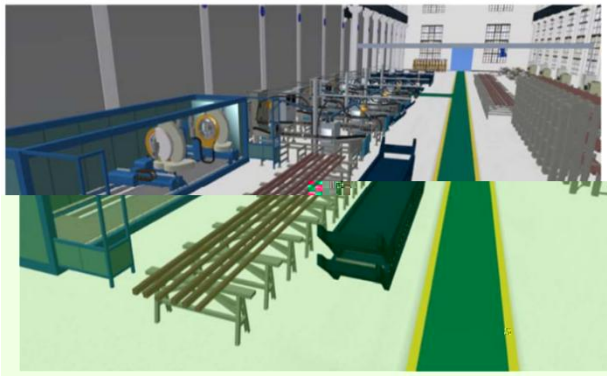
1:1

[12] PostEngineer

4 5

2.2

( )



4

5

2.2.1

(1)

(2)

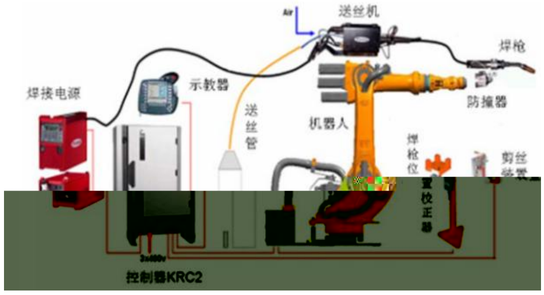
9 12

;

(3)

50%~72%

3~4 98%



6

2.2.2 AGV

400t

(1)

PLC ;

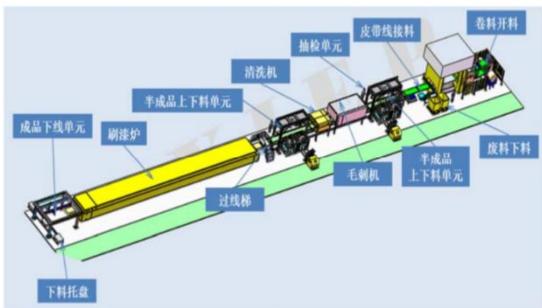
AGV

(2) Hymmen Hymmen

(3)

(4)

AGV



7

2.2.3

3D

0.1

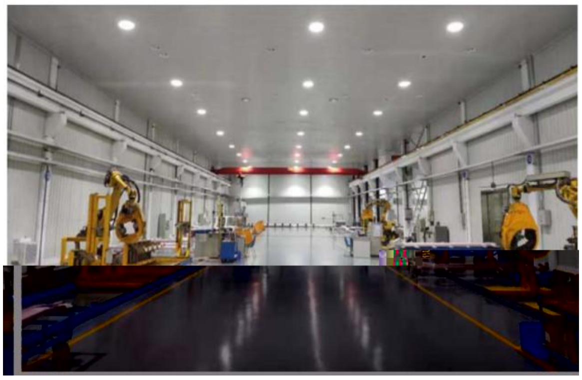
2.3

2.3.1

I

[13]

[14]



11

12 VPI

(1)

VRM

7 m

0.1 mm 4

15

MOM MOM

(2)

APP PDA

APP

WIFI MOM PDA

;

PDA

DM

(3)

MOM

2.3.4

80

MOM

LED

[15]

3

,

600 MW

18 14

48.2% 31.9%
30.7% 20%
57.3%

28%
21.3% 54.8%
VPI

25%
45%
35% 55%
33.5%

[1] ANNUNZIATA M EVANS P. Ilndustrial lnternet: pushing the boundaries of minds and machines[J]. General Electric 2012(1-2): 1-23
[2] KAGERMANH HELBIG J HELLINGERA et al. Recommendations for lmplementing the strategic niative NDUSTRIE 4.0:Securing the future of German manufacturing industry ; final report of the Industrie 4.0 working group[M]. Berlin:Forschungsunion 2013
[3] 2025[EB/OL]. [2015-05-08]. http:/lwww.gov.cn /zhengcelcontent/2015/05/19/content_9784.htm
[4] , , . —— [J]. 2017, 23(1):1-9
[5] , , , , . [J]. 2016 22(5):1220-1228
[6] . i5 [J]. 2017 46(1):1-8
[7] , . [J]. 2018 54(16):11-23
[8] . 4.0[J]. 2015(25):1-3
[9] —— [J]. 2016(9) : 1-5
[10] . [J]. , 2018(4) : 10-15
[11] . 4.0 [J]. , 2018(15) : 65-66
[12] , , . [J]. , 2017(24) : 9-12
[13] . [J]. 2017(9): 28-35
[14] , , . [J]. ( ), 2017(2):128-133 +140
[15] , . [J]. , 2016(9):2108-2117

40

5

4

[1] , , . [J]. , 2011, 32(10):813-816
[2] , . [J]. , 2011, 28(1):11-15+41
[3] , , . sss [J]. , 2007, 228(6):213-216+220
[4] , . sss [J]. , 2010, 10(21):5145-5150
[5] , . sss [J]. , 2007, 234(8):101-103

261400

TM62 A 1001-9006 2022 02-0057-04

(Huadian Laizhou Power Company Co., Ltd., 261400,Laizhou, Shandong, China)

1

1

1

1	
2	aServer-R-2105 V6.0
3	V6.0 V3.0
4	1000MW
5	Cloudera's Distribution Including Apache Hadoop(CDH)
6	Kubernetes(k8s)
7	
8	
9	M420

2

1

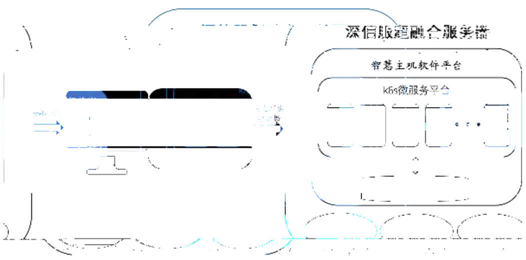
aServer-R-2105

V6.0
V6.0 V3.0

CDH
k8s CDH

[3]

k8s

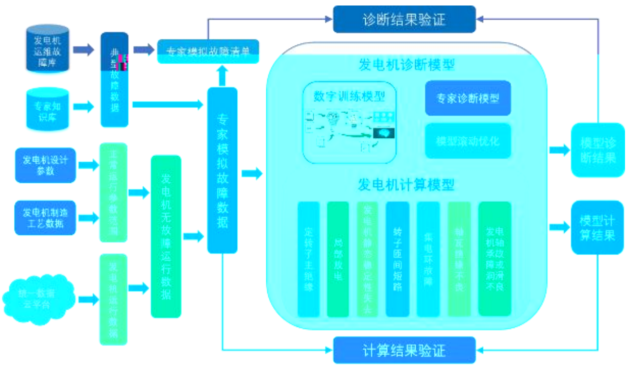


1

1 000 MW

web

3



2

2

3.1

1 000
MW

——

1 000 MW

7

3.2

95%

3.3

n1

n2

n3 n3 ≤ n2 n3 ≤ n1

n2 ≤ n1

$$=\frac{n2}{n1}\times 100\% \quad (1)$$

$$=\frac{n3}{n1}\times 100\% \quad (2)$$

n2 n1

$$=\frac{n1}{n2}\times 100\% \quad (3)$$

$$=\frac{n3}{n2}\times 100\% \quad (4)$$

95%

90%

4

100 kW

30

50

30

5

80

5

5

3

3 web

3

3

1	30	1 000	962	931	96.2%	93.1%
2	30	1 000	953	927	95.3%	92.7%
3	30	1 000	957	924	95.7%	92.4%

5

[1] , , . [J]. , 2019, 48(10): 8-14

[2] . [D]. : ( ), 2018:3-4

[3] . Storm Kafka [J]. ,2021,34(5): 33-34+36

[4] , , . [J]. , 2021, 51(3): 1017-1025

43

GB/T 4334 “ E ”

3

+ +

650 ×2 h

3

ER316H

690 ±15

1 ER316H

2 ER316H

3 ER316H

[1] . [J]. , 2011(35):91

[2] , , . 800MPa [J]. , 2020, 41(5):91-96+102

[3] IB AHIM O H IB AHIM I S KHALIFA T A F.Effect of Aging on the Toughness of Austenitic and Duplex Stainless Steel Weldments [J Journal of Materials Science and Technology, 2010 26(9) : 810-816

611731

TM621 A 1001-9006 2022 02-0061-04

, ,
(Dongfang Electric(Chengdu) Engineering & Consulting Co.,Ltd., 611731,Chengdu, China)

2021 ”
10 2030
35% ,
6 h
40% “
[1] ” 2

2021 1519 “

2022-04-01

1983 2008

“ ”

2016 1

25%THA

[2]

1

2 × 330 MW

DG 1025/18.2- 6

π 2016 7

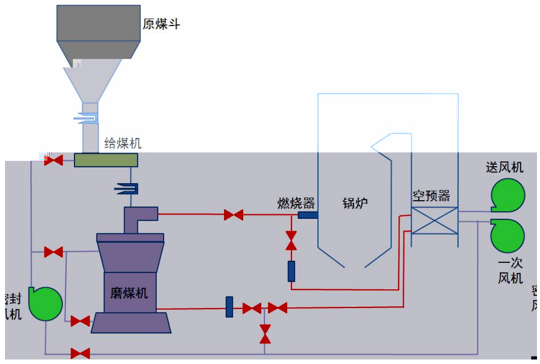
-

1

1

			1	2
M_{ar}	%	5.5	17	17
A_{ar}	%	28.19	25	28
C_{ar}	%	52.67	47.01	43.5
H_{ar}	%	3.22	3.21	3.21
O_{ar}	%	8.43	5.53	6.04
N_{ar}	%	0.75	0.75	0.75
$S_{t,ar}$	%	1.34	1.5	1.5
V_{daf}	%	31.38	34	35
$Q_{net,ar}$	kJ/kg	20 223	18 280	17 080
HGI	/	76.0	55	55

1



1

HP MPS ZGM MPS-HP- E MPS170-HP- MPS

[3]

1

4

2

2

-	
-	MPS170HP—
-	SLK310 ( )
	5
t/h	43.58
t/h	60.58
Pa	6160
rpm	34.45
	≤90
-	
t/h	0.072
-	
-	YMPS450—6
kW	355
A	49.4

$_{90}$ 22% 4

BMCR

2

[4]

75%

1

$_{90}$

[4]

$_{90}$

[5]

$_{90}$ [6]

$_{90}$ 12~18%

2

“ ”

“ ”[7]

10%

3

1

3

3

		1
$_H$	0.97	0.78
$_R$	1.059	1.072 0.944 $_{90}$=13%
$_M$	0.99	0.91
$_A$	0.97	0.95
$_g$	1.0	1.0
$_e$	0.95	0.95
$_{si}$	1.07	1.07
$_M$ t/h	50.6	38 34.5 $_{90}$=13%

HGI $_M$

38t/h $_{90}$=21% 4

BMCR

$_{90}$=13% 34.5t/h 5

$_{90}$

2

DL/T 5145

1

100%THA 25%THA

4

4

				100%THA	25%THA
1		Δ ü	kg/kg	0.12	0.12
2		ev	kJ/kg	316.5	316.5
3		2		65	65
4		rc		0	0
5		ag2	kJ/kg	108.0	160.0
6		1	kg/kg	1.61	2.39
7		a2	kJ/(kg·)	1.014	1.014
8		f	kJ/kg	72.3	72.3
9		dc	kJ/(kg·)	1.101	1.101
10			kJ/kg	25	25
11		mac	kJ/kg	15	15
12		s	kJ/kg	0.65	0.71
13		1		297.5	228
14		ag1	kJ/(kg·)	1.030	1.024
15		2	g/kg	86	61
16		dp		50	44
17			-	1.638	2.50
18		M,d	t/h	30.5	21.1

100%THA 70%

25%THA 2

25%THA

25.23 t/h 21.39 t/h

4

1

90

2

3

[8]

4 “

”

5 40%~25%THA

SCR

6

[1] . 2021-2022 [DB/OL]. https://cec.org.cn/detail/index.html?3-306171, 2022-01-27

[2] , , . [J]. ,2018,47(5):1-7

[3] , , . MPS-HP- [J]. , 2014,34(9):725-730

[4] DL/T 5145-2012, [S]

[5] , . [M]. : 2010.8

[6] . [J]. , 2014, 35(2):31-33

[7] , , , , . [J]. , 2019,25(2):139-143

[8] . [J]. , 2019(1):1-4+10

1 1 1 2

1. 618000 2. 100022

6.5 4.5

0.8 0.9

TH113 A 1001-9006 2002 02-0065-04

[1], [1], [1], [2]

1.Dongfang Turbine Co.,Ltd., 618000, Deyang, Sichuan, China; 2.Beijing EMAX Technology Co.,Ltd., 100022, Beijing, China)

-

-

API684

[5-6]

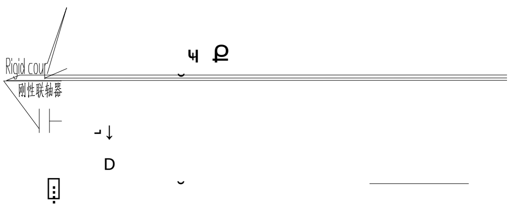
1

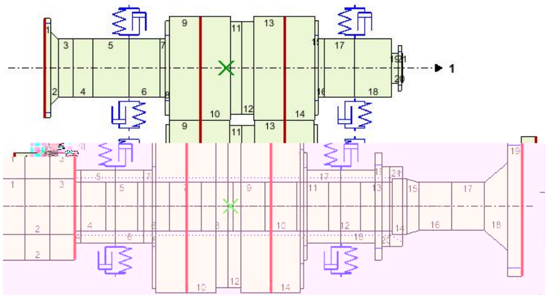
- -

45 MW 1

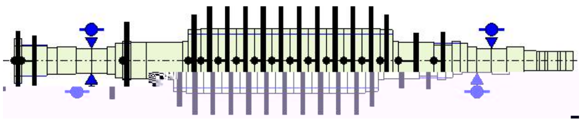
5 025 rpm

3 000 rpm





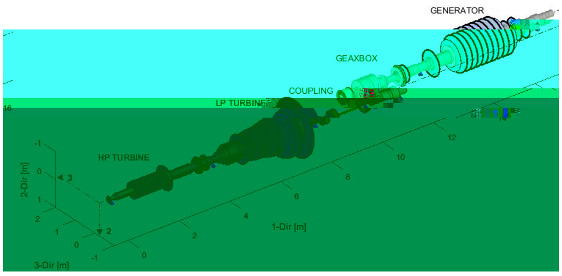
b



c

3

4



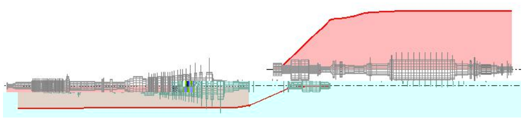
4

2

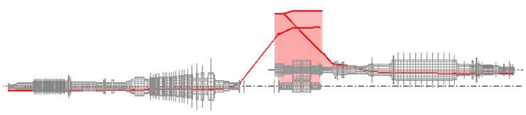
- -

API684

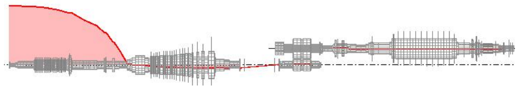
5



a 12.3Hz



b 55.6Hz



c 114.3Hz

5

API684

10% - -

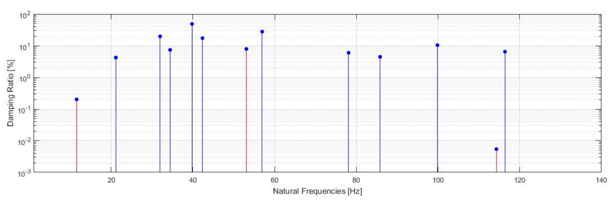
3

- -

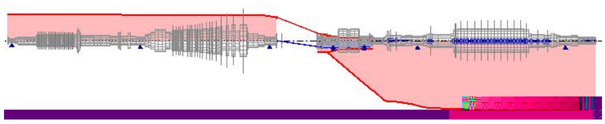
3.1

6 a

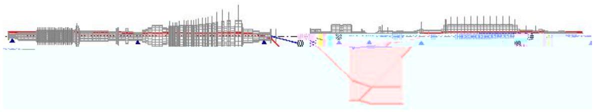
6 b 6 c



a -



b 11.5Hz



c 53.1Hz

6

6 a

6 a

6 a
6 b 6 c

6 a

6.5
4.5

3.2

618000

TK26 A 0001-9006 2022 02-0069-02

, , , , ,
(Dong fang Steam Turbine Corporation, 618000 De yang , Si chuan, China)

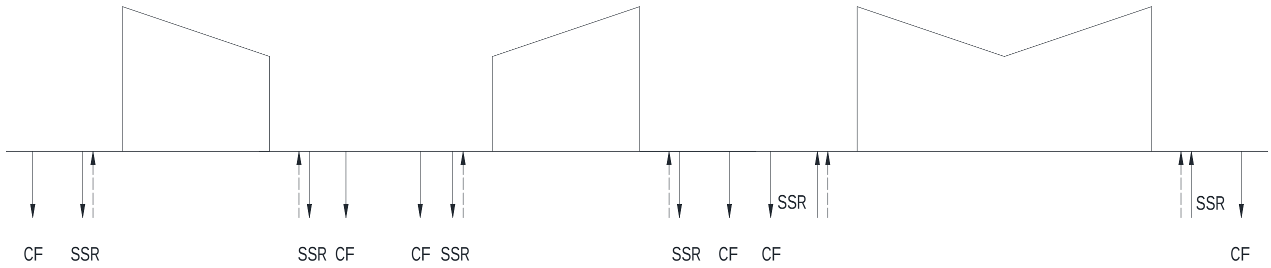
[2]

[1]

1

1

2021-10-11
1987 2013
1983 2006
1967 1988
1990 2012
1984 2006



1

2

-

611731

“ ”

-

TM611.31 A 1001-9006 2022 02-0071-04

(Dongfang Electric Co.,Ltd.,611731,Chengdu,China)

2035 2050

[1] “ ”

2×460 MW (F)

2021-10-25

(1982) 2005

1

1.1

11

6

8

8
2018 7
790.22 MW 7 425 MW (
)365.22 MW
2018 806.64 kWh
6.04% 15 516.8 MW
3.03% 787.8 kWh
4.51% 15 545 MW 3.91%

1.43 kWh 567.66 kWh 138.93
kWh 98.62 kWh 0.177 2% 70.3734% 17.223
3% 12.226 0% 3.36% 6.01% 7.20%
4.69%

1.2
[2-3]
2020 18 650 MW
“ ” 6.9% 2025
20 500 MW “ ”
2.4% 2030
22 000 MW “ ”
1.4% 1

1 MW

	2015	2020	2025	2030
( )				
	12 990	18 650	20 500	22 000
		7.5	2.4	1.4

2020 2025 2030 “ ” “
” “ ”

2020 2025 2030
5 174 MW 5 740 MW 6 160
MW 2020 2025 2030
3 272 MW 3 616 MW 3
903 MW 2

2 MW

	2015	2020	2025	2030
	/	5 174	5 740	6 160
(%)		/	2.1	1.4
	/	3 272	3 616	3 903
(%)		/	2.01	1.53

1.3
1

2025 10
3 970 MW A1 #1 (210 MW)
B #2 (350 MW) 2018 11
560 MW A1 #2 #3 (2×210
MW) B #1 (350 MW) 2019
770 MW A2 (2×330 MW)
2023 660 MW
C (3×660 MW) 2025
1 980 MW
2 460 MW 2
180 MW “ ”

2
2 472.52 MW
2020

2 400 MW
2021
2 460 MW -
2021

3×700 MW H -
2022 6 2022 12 2023 6

2 9F -
2022
1.4

2022 2025 2030
15 749 MW 16 399 MW 18 124
MW 2022 2025 2030
15 422 MW 16 072 MW 17 797
MW

2

2.1

60t/h

2.2

2 460 MW -

8' DWRKt5-$-a$gY$@D 1'bAAU" QP$ -$9 pY@` bAAU" Q†$~P• p

2

2022 2025

2030 15 422 MW 16

072 MW 17 797 MW

3 756 MW 2 879 MW 3 299 MW

555 MW 766 MW 1 053 MW

“ ” “ ”

“ ”

3

SO_2 NO_x

80%

SO_2 NO_x

4

2 460 MW -

4

[1] , , .
[J]. , 2021, 15(3):69-73
[2] , , . [J]. ,
2020,29(1):54-57
[3] , , .
[J]. , 2020, 28(4):90-96
[4] . [J]. , 2020(4):
309-314
[5] , , . [J].
, 2016, 29(1):9-11

70

DCS

4

[1] , , . 1 000 MW
[J]. , 2016, 49(6):43-47
[2] , . 600 MW [J].
, 2015, 37(6):62-63+71+79

618000

TM312 A 1001-9006 2022 02-0075-03

, ,
(Dongfang Electric Machinery Co., Ltd., 618000, Deyang, Sichuang, China)

,

1

1.1

40

10 20 40

4 2 1

2021-10-28
1985
1975
1984

2

		MPa	MPa
	17 ( )	84	163.3
	22 ( )	43	
	17 ( )	532	490
	22 ( )	404	

2.2

Q345 S-N

17

4 , 40

22

400

2.3

22

500 ,

,

3

2~4 1

(1)

/ ..... (1)

:

j:

:

: 1 2~4

: 1 2

j

1 58

58/3=19 1

19 1 4

18 3

2 68

68/3=22 2

22 180°

2 4

j+1

: 1 1

2

j-1

1 58

58/3=19

1

18 4 4

14 3

[3] 4

2 68

68/3=22 2

21 5 4

16 3 5

16

1

2

550000

TV734.1 A 1001-9006 2022 02-0078-03

(SPIC Guizhou Jinyuan Co.,Ltd., 550000, Guiyang, China)

1.86×10^8 m^3,

117 m

35 MW 70 MW

50 MVA 10.5/110 kV 110 kV

“ ” [1]

“ ”

1

“ ”

“ ”

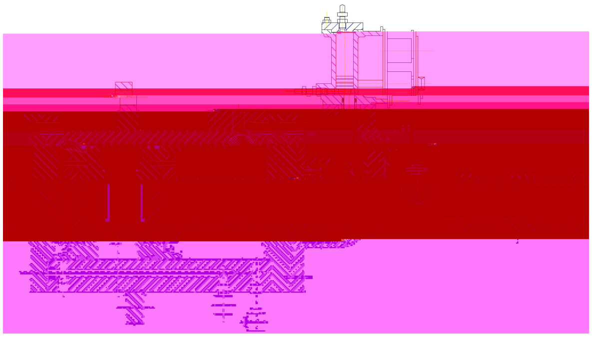
“O”

“O”

2022-04-20

1972 1994

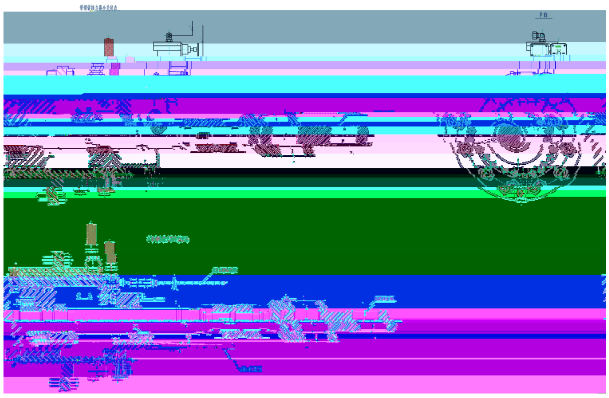
1



1

2

2



2

6.3 MPa 16 MPa

3

[2]

1#

550000

1 2007 4 27 2011 2 A
2020

2020

1.1 1

1

	˧ β	˜ ᾰ
˜		HLD41-WJ-81
₮ ʐ	kW	2 632
	m³/s	5.08
	m	61.57
	m	59.5
	m	58.6
	r/min	750
	r/min	1421
ʐ	t	9.5˙ 11.4
	cm	81

1.2 2

2

	˧ β	˜ ᾰ
˜		SFW2500-8/1730
w	kW	2 500
	kVA	3 125
˧	V	6 300
	A	286.4
w		0.8˙ U˜
	r/min	750
	r/min	1 421
		3
		Y
		F/F
	Hz	50

2 1#

Ꭰ 1# G 2007 4 27 ˘ ∆ ʯ ˘ p U˘ ƞ Â2011 2 A ḱ˘ ̀E˜ ˘ ḱ ˜ ˘ 500 kW ˘ ʐ 60 Ņ˘ ˩ ṿ Ƕ ˘ ɤ ˜ ˘ ψ ʐ Â ḱ ˧ β ẘ ĭ ˘ ʯ W . ₌ ʐ ˘

' Ӎ˘ 1˜ ű Ả Â 2011 11 ḱ ˧ β ̀P ˘ ű ╠ ʐ ... h β 1.8 mm˘ ɥ ʐ Ӎ ˥ №Â ḱ ˧ β № ɥ˘ G 1# ű ʐ ˘ ʐ ű ĭ ˘ ʐ ĭ ʐ Ѣ Â U ű ɿ γ Ӎ '

ˆ 1˜ ˘ ĭ Â

ˆ 2˜ h ɤ , γ ⁝ ʐ Â

ˆ 3˜ Ӎ˘ à Ⱶ ɤ ʐ˘ ʐ ɥ˜ 1.8 mm ẁ ˘ ' Ӎ ʐ ʐ ĭ ʐ Â

ű U˘ 1# ű ˘ ˜ 1# 2 000 kW ˘ ˧ 2 340 KW ˘ Â ' 6 ˘ 2016 3 ̀P ḱ˘ ḱ ˧ β Ѣ ₌ ₮ ʐ ĭ ˘ . ʐ ˘ ʐ

Â2020 ∆ ₌ 1˜ ű ḱ ɛ̇ ˘ ḱ ╠ ɿ ˜ № ˘ ╠ ɿ ʯ Â

3

1# ɥ ḱ ĭ ˘ ẘ Ѣ ű ₮ ʐ˘ ɿ Ƕ ˘ ɤ ɿ ˘ ˜ № ˘ ₌ Ӎ '

ˆ 1˜ ű ṗ ˘ o Â

ˆ 2˜ ű Â

ˆ 3˜ ˩ ˜ ɥ Ѣ Â

ˆ 4˜ ˜ ḱ ņ Ӎ Â

ˆ 5˜ L ʐ ˘ Ḡ ʐ β ̀E ...

2020 3

4

2011 1# 2 500 KW 2 340 KW 2

2 340 KW

1

2

3

Re Re [1]

1 [1]

$$x = (v_2^2 - v_5^2)/2g - \sum h_{2-5} / (v_2^2/2g) \quad (1)$$

2----

5----

2

5

1# 72 h

2 850 kW 500 kW

3 4

3

			25%Ne	50%Ne	75%Ne	100%Ne
1	%	8.1	37.2	53.8	69.2	82
2	m	327.8	327.8	327.8	327.8	327.8
3	m	263.9	263.9	263.9	263.9	263.9
4	ώ	0	0.028	0.019	0.023	0.013
5	ώ	0	0.001	0.002	0.003	0.003
6	ώ	0	0.003	0.001	0.001	0.001
7	ώ	0	0.023	0.024	0.025	0.021
8	ώ	0	0.004	0.006	0.008	0.007
9	ώ	0	0.011	0.007	0.009	0.009

4

				25%Ne	50%Ne	75%Ne	100%Ne
1	Ṇ	17.5	30.2	30.9	34.6	37.8	38.6
2	Ṇ	16.3	34.9	34.9	35.6	38.5	39
3	Ṇ	14.7	40.4	40.8	40.8	40.7	40.7
4	Ṇ		46.3	49.5	49.7	52.1	55.7

6

1#

[1] , . [M]. , 1991

1, 2 1, 2 1, 2 1, 2 1, 2 1, 2

1. 611731 2. 643001

TM615 A 1001-9006 2022 02-0084-05

[1,2], [1,2], [1,2], [1,2], [1,2], [1,2]

(1. Clean Combustion and Flue Gas Purification Key Laboratory of Sichuan Province, 611731, Chengdu, China;

2. Dongfang Boiler Group Co., Ltd., 643001, Zigong, Sichuan, China)

[1]

2022-04-20

1983 2008

， ，

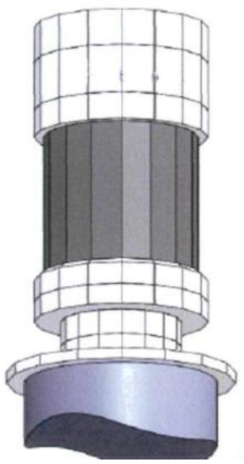
[2-4]

-

1

1.1

1

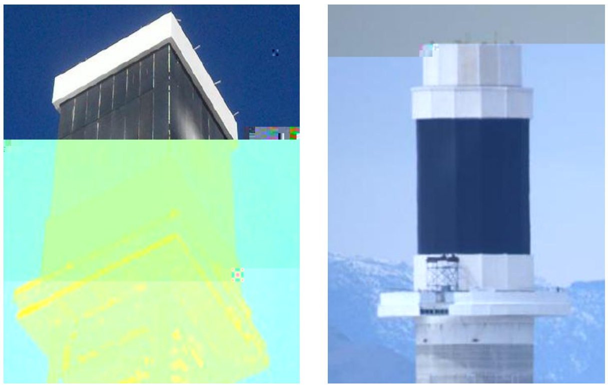


1

[5]

1.2

2



2

2

[6]

1 2

1

		650	1 000
kg/m³		220 240	220 270
MPa		≥ 0.65	≥ 0.65
MPa		≥ 0.33	≥ 0.33
%		≤ 2.0	≤ 2.0
%		≥ 98	≥ 98
	400	≤ 0.100	≤ 0.100
W/m · K	600	≤ 0.130	≤ 0.130
	MPa	≥ 0.4	≥ 0.4
16h	MPa	≥ 0.35	≥ 0.4

GB/T10699-2015

[7] 650 1 000 ,

98%

2

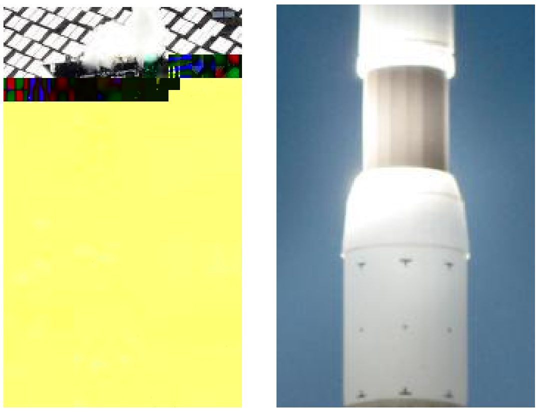
	1 260	1 400	1 400
kg/m³	≥ 280	≥ 280	≥ 280
%	≤ 2.5	≤ 2.5	≤ 2.5
At( ) ×24h	1 100	1 200	1 200
%	≤ 1	≤ 1	≤ 1
%	≤ 1	≤ 1	≤ 1
MPa	≥ 0.65	≥ 0.65	≥ 0.65
W/m · K 500	≤ 0.135	≤ 0.135	≤ 0.135
% Al_2O_3	≥ 43	≥ 50	≥ 35
% SiO_2	≥ 55	≥ 48	≥ 48
% Al_2O_3+ SiO_2	≥ 99	≥ 99	——
% Zr O_2	——	——	≥ 15

3

3.1

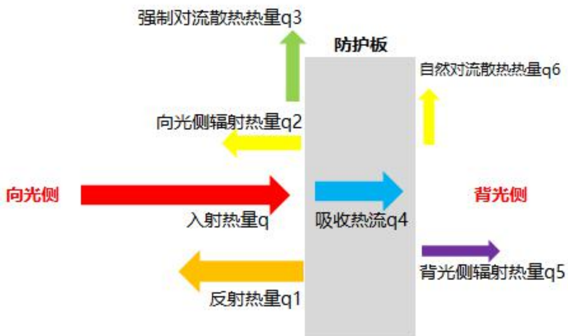
3

[8]



3

4



4

1

2

3

4

4

6

5

= 1+ 2+ 3+ 4 1

4= 5+ 6 2

ρ ε

1 2 4

ρ ε

3

$$V_H = V_{10}\left(\frac{H}{10}\right)^{\alpha} \quad (3)$$

10- 10m m/s

H- m/s

|

3

[9]

$$Nu=0.664Re^{1/2}Pr^{1/3} \quad 4$$

Nu-

Re-

Pr-

4

$$q_4 = A\frac{\lambda(Tw-Ti)}{\delta} \quad (5)$$

, m^2

λ W/ m·K

w i

mm

6

$$Nu = C(Gr\,Pr)^n \quad 6$$

C n -

Gr-

Pr-

5

kW/m^2

( )

ρ(0.75 0.8)

400 kW/m^2

800~900

" ≤

1/2

40°

Å dz Å