

ISSN 1001-9006
CN 51-1333/TM

2021
第35卷 总第140期

东方电机评论

DONG FANG DIAN QI PING LUN

中国发电设备专业技术期刊、首届《CAJ-CD规范》执行优秀期

《万方数据·数字化期刊群》全文收录

定价：8.00元

4



... %00

...
...
...

k l mn opq rst uvw

xyz ...

{ ... | } ~ |
... | } ~ |

...

...

...

...

... } ~

...p ... j

⊕

} £ ...

/ ¥ ...

} f \$ α ...

' " « < ...p > ' fil

fl ° - ... † ‡ ° - .

μ ° - ... | ¶ μ ° , , " » \$ α

‡ % ¿ À ...

DONGFANG ELECTRIC REVIEW



2021

2021-12-25 Vol. 35 No. 4
(Quarterly, since 1987)

CONTENTS



BASIC RESEARCH

- Random Vibration Life Analysis of A Fuel Cell Power System Support Structure
..... LUO Renchao, ZHANG Hao, PU Shouwu, et al(1)
- Analysis of Network Security Elements of Energy Equipment
..... YUAN Xiaoshu, WU Tong, LIU Yang, et al(6)
- Modeling of Steam Turbine Control and Protection System Based on Time Automata
..... MA Haiying, LI Yitong, YUAN Xiaoshu, et al(12)
- Study on the Aging Characteristics of the Main Insulation Composite Caterial of
the Large Generator Stator Bar under Multiple Working Conditions
..... PEI Jingke, LI Yuanjie, HU Bo, et al(18)
- Preparation and Properties of Hydrophobic Graphene/Cu-Ni Alloy with High
Heat Transfer Coefficient ZHANG Zhongwei, YANG Dashuai, HE Ping(23)

WIND POWER

- Research and Analysis on Assembly Dynamic Characteristics of Permanent
Magnet Direct Drive Wind Turbine
..... WANG Shijian, HE Qiyuan, DUAN Zhiqiang, et al(29)
- Application of VPN in Centralized Monitoring of WTCs
..... LI Shengru, WANG Mingjun(34)
- Development of CANopen Communication Function for Wind Power Converter
Control System HE Shengpeng, WU Xiaotian, BIAN Xiaoguang, et al(38)

THERMAL POWER/COAL-FIRED POWER

- Research on Development of Welding Automation of Power Generation Equip-
ment DONG Na, CHEN Yi, ZHANG Yuan, et al(42)
- Boiler Industry Import Large-calibre Pipe Procurement Dilemma and Counter-
measures LUO Lingli(47)
- Brief Introduction of Dongfang Ultra High Temperature Subcritical Blast Furnace
Gas Fired Boiler ZHENG Gang, RAN Shenming, ZENG Jie, et al(49)
- Method of Using Lapped Joint Profile Disk Milling Cutter to Decrease Deforma-
tion and Vibration of Thin Wall Part WANG Yingming(55)
- Analysis on the Requirements of Thermal Stress Ratcheting of ASME Code
..... LI Ting(59)
- 3D FEM Analysis about Stator Winding Force REN Panqiu(62)
- Overview of the Innovation-driven Development of Dongfang Electric in the 13th
Five-Year Plan YU Xiaobo, YIN Guojun(66)

TURBINE

- Research and Analysis of Steam Turbine Crisis Trip Device Based on High Fre-
quency Solenoid Valve Control LI Qing, LIU Jiong, SHAO Yi, et al(72)
- Advantages of Evaporative Cooling Technology in Large Generator-motor and Its
Simulated Test LIU Chuankun, ZHOU Guanghou, ZHANG Haibo, et al(76)

NUCLEAR POWER

- Project Management in Foreign Subcontracting Project WANG Zhijian(81)
- Development Status and Prospect of Small Modular Reactors
..... LUO Xiaoqiu, LIU Weidong, WANG Fang(85)
- NEWS IN BRIEF (28)(46)

EDITORIAL BOARD

Chairman: WANG Weimin

Vice Chairmen: DONG Na, YANG Yong

Members: MA Qingtian, WANG Xiaoliang, WANG Yu,
WANG Jianlu, WANG Zheng yuan, FANG Yu,
DENG Zhongyong, LE Jinsong, SHI Qinghua, GUANG Haijie,
LIU Shihong, LIU Taisheng, ZHANG Qide, ZHANG Guorong,
ZOU Jie, HE Wei, CHEN Wenxue, CHEN Jiefu,
YANG Wuyong, YANG Yaowu, YANG Huachun,
MIN Zesheng, WU Jiandong, ZHAO Yongzhi, ZHAO Shiquan,
HOU Xiaoquan, HE Jianhua, ZHONG Jie, GUO Yan,
TANG Hongju, XIE Guangyou, ZENG Mingfu, LAI Chengyi,
PAN Qiangang, HUO Suoshan

Chief Secretary: YANG Yong

Sponsor: Dongfang Electric Corporation

Chief Editor: WANG Weimin

Vice Chief Editors: DONG Na, YANG Yong

Executive Editor: WANG Weimin

English Editor: WANG Weimin

Edited and Published by:

Editorial Department of Dongfang Electric Review
No. 18 Xi Xin Avenue, Gao Xin Xi District, Chengdu,
Sichuan, P. R. China

Postal Code: 611731

Tel: 028-87898262 87898263 Fax: 028-87898267

E-mail: dfdqpl@dongfang.com

Overseas Distribution by:

China National Publishing Industry Trading Corporation
(P. O. Box 782, Beijing, P. R. C.)

1	1	2	1	1	1	1
1.			611731	2.		618000

Workbench
Miner

PSD Miner
U469.72 TM911.4 A 1001-9006 2021 04-0001-05

Random Vibration Life Analysis of A Fuel Cell Power System Support Structure

*LUO Renchao*¹, *ZHANG Hao*¹, *PU Shouwu*², *ZHANG Tinghua*¹, *LIU Yanping*¹,
*WANG Liang*¹, *CHENG Youxing*¹

(1. Dongfang Fuel Cell Technology Co. , Ltd. , 611731, Chengdu, China;
2. Dongfang Turbine Co. , Ltd. , 618000, Deyang, Sichuan, China)

Abstract: In recent years, fuel cell attracts people' s attention with its zero emission. The vehicle fuel cell power system support structure is fixed together with the vehicle frame. The system support structure carries the static and dynamic loads of the entire fuel cell, so its structural performance determines the stability of the fuel cell system under on-board conditions. This paper uses Workbench to analyze the random vibration of a fuel cell system support structure. The analysis shows that the fuel cell system can pass the durability random vibration test. The system support structure meets the vehicle durability requirements which damage assessment is based on with Gaussian distribution and miner' s linear cumulative damage law.

Key words: carbon neutrality; fuel cell power system; random vibration; PSD; Miner; damage

2020 9 22

2060 2030 " " 2060

2021 - 09 - 24

2019ZDZX0002

1987 - 2017

2025
20% 2035
2021 - 2035
ü
2



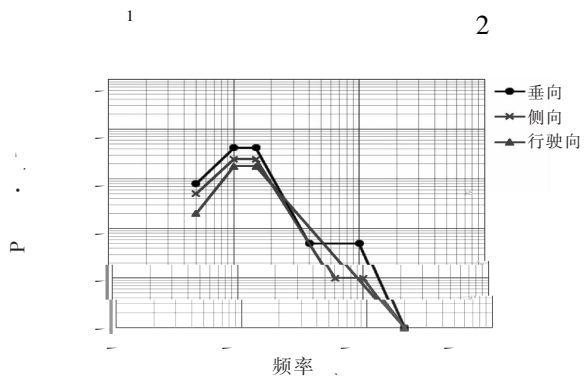
$$S_{out} \omega = \left(\frac{a_{out}}{a_{in}} \right)^2 S_{in} \omega \quad 9$$

$$\frac{S_{out} \omega}{a_{in}^2} = \frac{S_{in} \omega}{a_{out}^2} \quad 10$$

$$S_{xx} f = \int_{-\infty}^{+\infty} R_{xx} \tau \cdot e^{-i f \tau} d\tau \quad 10$$

2

GB 38031 - 2020



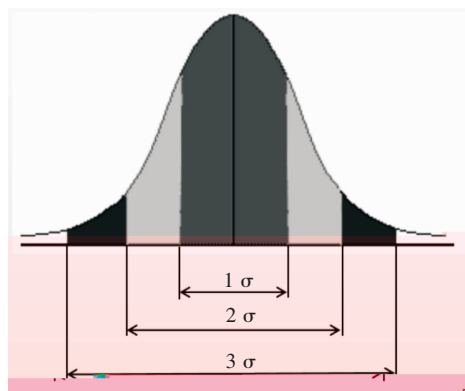
3

Steinberg

Miner

1 3 68.3%

1 ~2 27.1% 2 ~3 4.33% 3 100% - 99.73% = 0.27%

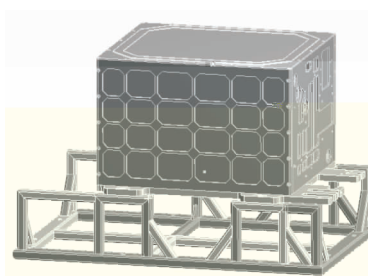


Miner

$$D = \frac{n_1}{N_1} + \frac{n_2}{N_2} + \frac{n_3}{N_3} \quad 11$$

4

4 4 10

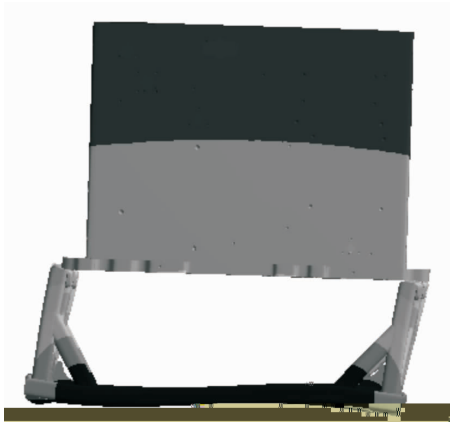


4

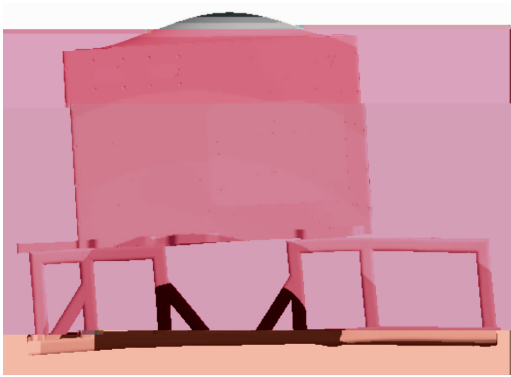
5

1 5~8
43.4 Hz

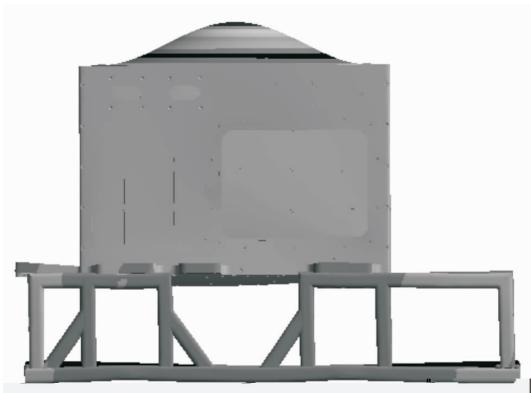
1	/Hz
1	43.4
2	74.2
3	98.2
4	205.6



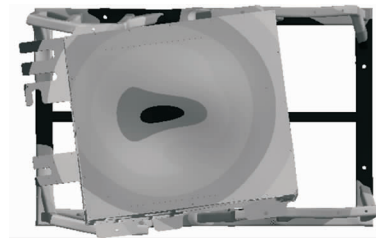
5 1



6 2



7 3



8 4

6

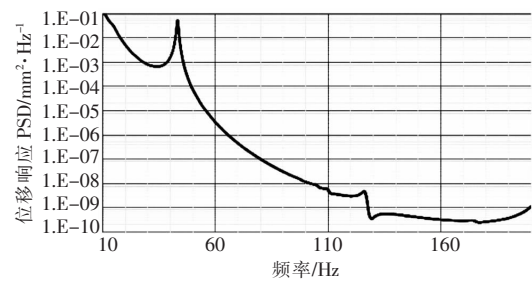
GB

38031 - 2020

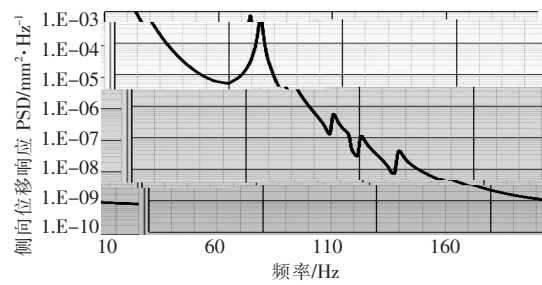
9~11

1

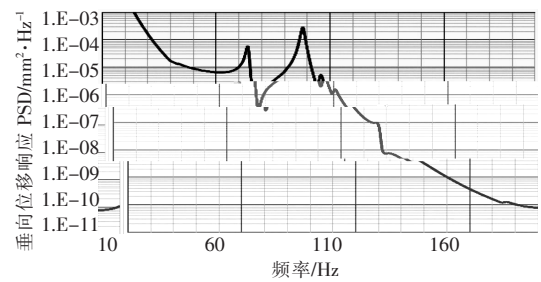
2



9



10



11

2

3

3

Q235

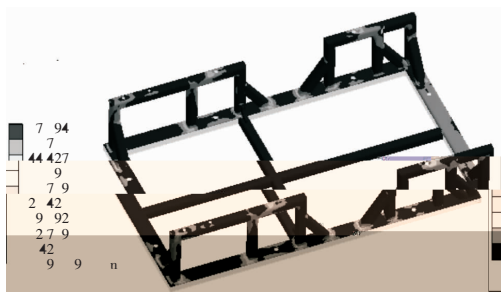
2

3

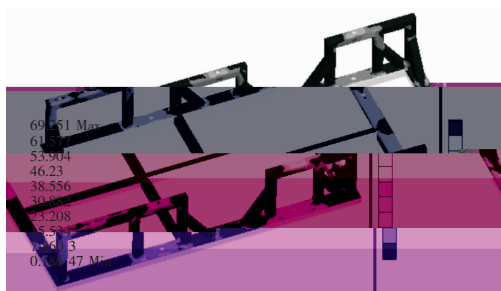
σ /MPa	0.2
183.3	235
57.1	235
69.3	235



12 3



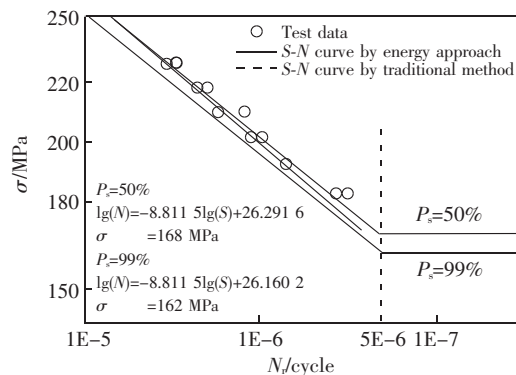
13 3



14 3

50% 99% 15
99% S - N 12

$$\lg N = -8.811 5 \lg S + 26.160 2 \quad 12$$



15 Q235 S-N 4

8

$$T = 4 \times 10^6$$

$$V_0^+ = 5 \text{ Hz}$$

$$n_1 = 0.683 \times T \times V_0^+ = 1.366 \times 10^7$$

$$n_2 = 0.271 \times T \times V_0^+ = 5.42 \times 10^6$$

$$n_3 = 0.043 3 \times T \times V_0^+ = 8.66 \times 10^5$$

12
10⁷
11
3
0.52 0.75

3

1	N_1	2	N_2	3	N_3
61.1	+∞	122.2	+∞	183.3	1.65×10^5
19.1	+∞	38.1	+∞	57.1	+∞
23.1	+∞	46.2	+∞	69.3	+∞

9

7

Q235

GB 38031 - 2020

11

5

	1 *	2	3	3
1.	611731	2.	100824	3. 710049

TP393

A

1001-9006 2021 04-0006-06

Analysis of Network Security Elements of Energy Equipment

YUAN Xiaoshu^{1*}, *WU Tong*², *LIU Yang*³, *GUAN Xiaohong*³

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

2. National Energy Administration Information Center, 100824, Beijing, China;

3. Xi'an Jiaotong University, 710049, Xi'an, China)

Abstract: The intensification of cyberspace security confrontation gradually extends network security attacks from information domain to physical domain, network attacks from information systems to control systems and finally to energy equipment. The security elements of information system and control system are relatively clear, while the network security research of energy equipment is still relatively lacking. This paper analyzes the network security elements of energy equipment with the goal of ensuring the availability of energy equipment, and discusses the differences and relationships between energy equipment security and information system security and control system security.

Key words: energy equipment; cyber-physical systems; confidentiality; integrity; availability; network security

“ ”

IEC 62443¹

2.0²

“ ”

2021-08-23

1973-

18

2019YFG0534

2013

yuanxs@dongfang.com

765

7-8

765

85%

765

9

2021 5 7

Colonial Pipeline

5

1

1.1

9

17

5 13

2015 12 23

140

60

500

10-11

1.2

3-5

2017 7

3

Staggs
Windshark

2017 11

Windworm Telnet FTP

41

40

Windpoison ARP

2017 2 22

6

Bundeswehr 2017
2014

2019 3 7 -3 9

90

2017

3

1 000

3 7

2018 6 8

12

ISA99/IEC 62443 - 1 - 1

Confidentiality

1

2

3

Integrity

Availability

/

2

2.1

ISO/IEC 13335 - 1 2004

Confidentiality

Integrity

Availability

13

16 - 17

3

3.1

3.2

systems CPS

18 - 20

cyber-physical

21

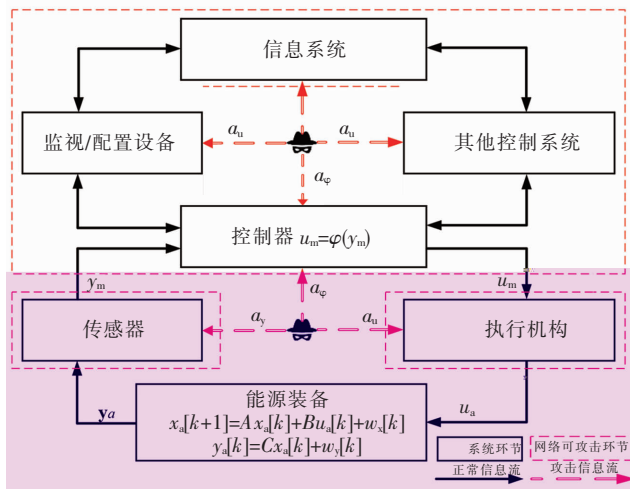
2

22

CPS

23

1.1



2

$$x_a(k+1) = Ax_a(k) + Bu_a(k) + w_x(k) \quad 1$$

$$y_a(k) = Cx_a(k) + w_y(k)$$

$$x_a(k) \in \mathbb{R}^n \quad y_a(k) \in \mathbb{R}^m$$

$$u_a(k) \in \mathbb{R}^l \quad A \in \mathbb{R}^{n \times n}$$

$$B \in \mathbb{R}^{n \times l} \quad C \in \mathbb{R}^{m \times n}$$

$$w_x \in \mathbb{R}^n \quad w_y \in \mathbb{R}^m$$

$$w_x \in \mathbb{R}^n \quad w_y \in \mathbb{R}^m$$

$$Q \quad R$$

$$Q \in \mathbb{R}^{n \times n} \quad R \in \mathbb{R}^{m \times m}$$

$$u_a(k)$$

1 R. S. H Piggin. Development of industrial cyber security standards IEC 62443 for SCADA and Industrial Control System security C IET conference on control and automation 2013 Uniting problems and solutions. IET 2013 1-6

2 GA/T 1390.5-2017
5 S

3 Liang G Weller S R Zhao J et al. The 2015 Ukraine Blackout Implications for False Data Injection Attacks J . IEEE Transactions on Power Systems 2017

4 Haes Alhelou H Hamedani-Golshan M E Njenda T C et al. A survey on power system blackout and cascading events Research motivations and challenges J . Energies 2019 12 4 682

5 Sullivan J E Kamensky D. How cyber-attacks in Ukraine show the vulnerability of the US power grid J . The Electricity Journal 2017 30 3 30-35

6 Staggs J Ferlemann D Sheno S. Wind farm security attack surface targets scenarios and mitigation J . International Journal of Critical Infrastructure Protection 2017 17 3-14

7 J . 2019 5 72-74

8 Oxford Analytica. Massive Venezuela blackout will fuel anger and fear R . Emerald Expert Briefings oxan-es

9 Vaz R. Venezuela's power grid disabled by cyber attack R . Green Left Weekly 2019 1213 15

10 FBI Deputy Director Paul M. Abbate's Remarks at Press Conference Regarding the Ransomware Attack on Colonial Pipeline EB/OL . https://www.fbi.gov/news/pressrel/press-releases/fbi-deputy-director-paul-m-abbates-remarks-at-press-conference-regarding-the-ransomware-attack-on-colonial-pipeline

11 FBI Statement on Compromise of Colonial Pipeline Networks EB/OL . https://www.fbi.gov/news/pressrel/press-releases/fbi-statement-on-compromise-of-colonial-pipeline-networks

12 Cyberspace Operations EB/OL . https://www.jcs.mil/Portals/36/Documents/Doctr-ine/pubs/jp3_12.pdf

13 ISO/IEC 13335-1 2004 - 1 S

14 ISA99/IEC 62443-1-1 - 1-1 S

15 9 GB/T 14099.9-2006 S .2006

16 Drias Z Serhrouchni A Vogel O. Analysis of cyber security for industrial control systems C 2015 International Conference on Cyber Security of Smart Cities Industrial Control System and Communications SSIC . IEEE 2015 1-8

17 Fan X Fan K Wang Y et al. Overview of cyber-security of industrial control system C 2015 international conference on cyber security of smart cities industrial control system and communications SSIC . IEEE 2015 1-7

18 National Institute of Standards and Technology NIST Cyber Physical Systems PWG. Framework for Cyber-Physical Systems. 2017

19 Song K Anderson K Lee S H. An energy-cyber-physical system for personalized normative messaging interventions Identification and classification of behavioral reference groups J . Applied Energy 2020 260 114237

20 2016

21 2017 R . 2017-03

22 Tang Yi Chen Qian Li Mengya et al. Overview on cyber-attacks against cyber physical power system J . Automation of Electric Power Systems 2016 40 17 59-69

23 J . 2019 45 1 5-24

Workbench

1 GB 38031-2020 S .2020

2 J . 2016 4 35-38

3 .70 MPa

基于时间自动机的汽轮机控制保护系统建模

马海迎¹ 李奕彤¹ 袁晓舒^{2*} 桑梓^{2*} 何立栋¹

1.

210094 2.

611731

近年来 汽轮机控制保护系统面临的安全威胁引起了学术界及工业界的广泛重视 不同于以往针对通信协议的攻击 攻击者逐渐将目标转移到控制器本身上来 为了应对这种新的威胁 学者们开始研究如何对控制器建立有效的模型去刻画 分析这种攻击对系统运行的影响 进而设计及时 有效的防御策略 本文在总结相应研究的基础上 提出一种基于时间自动机的形式化方法对汽轮机控制保护系统进行建模 同时借助 UPPAAL 软件 对建立的模型进行仿真及验证 研究表明 本文提出的模型可以较好地描述汽轮机控制保护系统的工作过程 为后续安全问题研究奠定基础

汽轮机控制保护系统 时间自动机 UPPAAL

TP393

A

1001-9006 2021 04-0012-06

Modeling of Steam Turbine Control and Protection System Based on Time Automata

MA Haiying¹, LI Yitong¹, YUAN Xiaoshu^{2*}, SANG Zi^{2*}, HE Lidong¹

(1. Nanjing University of Science and Technology, 210094, Nanjing, China;

2. Academia Sinica of Dongfang Electric, 611731, Chengdu, China)

Abstract: In recent years, the safety threat of steam turbine control and protection system attracts extensive attention from academia and industry. Different from the previous attacks on communication protocols, the attacker gradually shifts the target to the controller itself. In order to deal with this new threat, scholars begin to study how to establish an effective model of the controller to describe and analyze the impact of this attack on the system operation, and then design timely and effective defense strategy. On the basis of summarizing the relevant research, this paper proposes a formal method based on time automata to model the turbine protection system. At the same time, UPPAAL software is used to simulate and verify the established model. The results show that the proposed model can describe the working process of steam turbine control and protection system well, and lay a foundation for subsequent safety research.

Key words: steam turbine control and protection system; time automata; UPPAAL

" " " "

2021 - 11 - 19

61973163

ZKZF200001

1998 - 2020

1999 - 2021

1973 - 2013

yuanxs@ dongfang. com

1985 - 2012

sangzi@ dongfang. com

1

1 UPPAAL

1.1

8

Alur Dill

1994

2

3

4-5

MATLAB

6

TA

$$TA = N L_o E$$

I ⁹

1 N

7

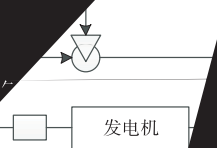
2 $L_o \in N$

3 $E \subseteq N \times B \quad C \times \Sigma \times 2^C \times N$

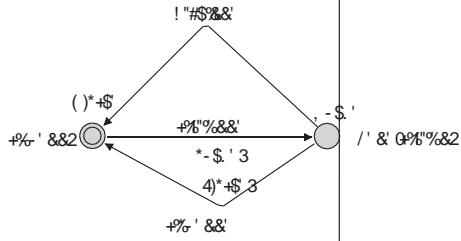
4 $I \ N \rightarrow B \ C$

1.2 UPPAAL

121370188010889973011909481054821601109#33870400



" Ã ° 8 á ãâ...á ãâ ò f ^ ! ê "
÷ E ! Ñ I á @ Ñ f ^ ! ' } á 8 é 2 â f
Æ ~ ! Ñ á o n â â ê



n â, ÷ E ™
Û Ñ E ó Û Ñ E ÷ 2 f Æ ~ ! Ñ N Ñ ê
J o Ÿ (Ô ! ÷ 2 ú ï > 1 â ^ I Û f # e ™ !
! â â Í f } Û Ñ E f ^ 8 a ï f ^ !
â 8 È } f Å ° ï á ã â ... 2 ? á ã â
ò ê ^ # ! á " Û Ñ E ! @ 4 Ñ I á :
} @ Ñ f ^ ! ' } á 8 é 2 â f Æ ~ ! Ñ
á o n â â ê

& , " + , / & , " + . 0
& () % * +
! " # \$ %
, " # \$ %

UPPAAL

4.1

10 ~ 11

start1 1

Close1

open1

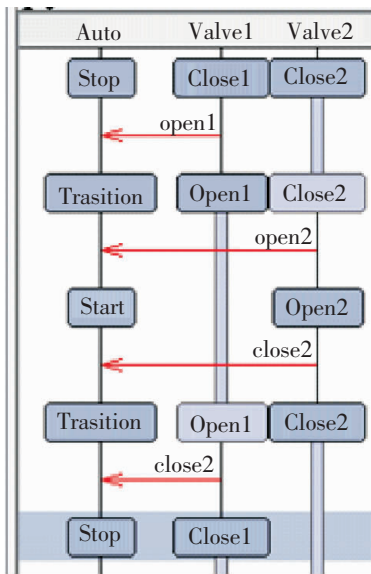
Stop

Trasition

```

(Stop, Close1, Close2, Slow, T_low, V_short, P_low, Close3)
open1: Valve1 → Auto
/*
(Transition, Open1, Close2, Slow, T_low, V_short, P_low, Close3)
open2: Valve2 → Auto
(Start, Open1, Open2, Slow, T_low, V_short, P_low, Close3)
close2: Valve2 → Auto .
(Transition, Open1, Close2, Slow, T_low, V_short, P_low, Close3)
close1: Valve1 → Auto
(Stop, Close1, Close2, Slow, T_low, V_short, P_low, Close3)
Auto
    
```

10



11

start2 = 1

Close2

Open2

open2

$rpm = 3\ 000$

Start

stop2 =

1

close2

stop1 = 1

close1

4.2

4.1

$rpm = 3\ 000$ $T = 150$ $V = 13$ $P = 330$

urget = 1

12 ~ 14

3 300

Slow

Fast

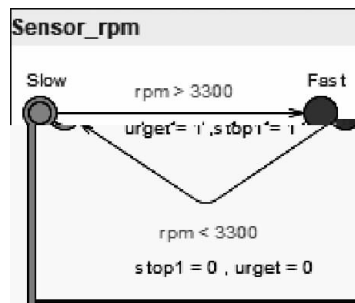
stop1 = 1

urget = 1

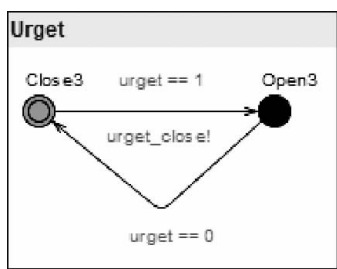
Close3

Open3

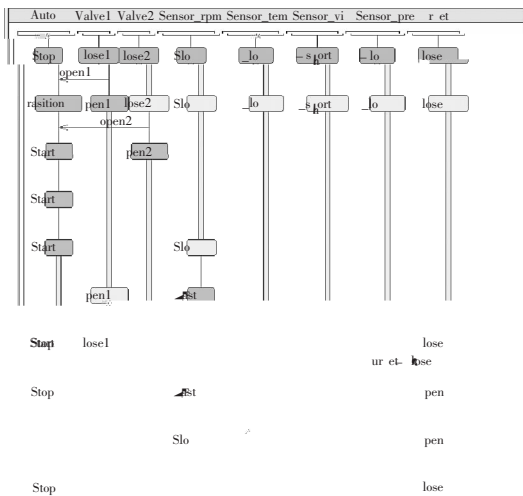
urget_close



12



13



14

4.3

UPPAAL

Auto Valve1 Valve1
15



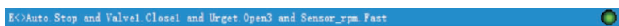
15

Auto Valve1 Valve1
16



16

Sensor _ rpm. Fast Urget.
Open3 17



17

Sensor_tem. T_low Urget.

Open3 18



18

Sensor_pre. P_low Urget.

Open3 19



19

Sensor_vib. V_long

Urget. Open3

20



20

5

UPPAAL

1 . " " R .

2020.2

2 . J .

1995 Z4 15-18

3 .600 MW J .

2016 45 4 304-308

4 .1 000 MW D .

2012

5 . D .

2018

22

TQ326.9

A

1001-9006 2021 04-0018-05

Study on the Aging Characteristics of the Main Insulation Composite Material of the Large Generator Stator Bar under Multiple Working Conditions

PEI Jingke, LI Yuanjie, HU Bo, ZHANG Yue, LIANG Zhiming, LIU Hongyi

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

Abstract: Aiming at the thermal/oxygen aging of the main insulation composite material of generator stator bar, artificial accelerated simulated aging experiments under high temperature and high temperature/oxygen environment were carried out respectively. Studies show that oxygen accelerates the aging degradation reaction of the free radical reaction mechanism caused by high temperature during the aging process, generates a large number of free radicals during the aging process, and accelerates the destruction of the molecular network structure. The participation of oxygen accelerates the rapid decrease of free radical content and aggravates the aging degree of materials. As the aging progresses, the interaction force between different phase structures decreases, resulting in a large number of fragmented structures on the surface. This study provides the basic data of material evolution for the life assessment of large generator insulation system and promotes the improvement of the accuracy of the assessment.

Key words: main insulation; epoxy composite; aging

SEM	EPR	FTIR	
1			
1.1			
	5 cm × 5 cm		
	DHG	XGQ-2000	
1000		SLQ-	
	150 °C	60 h	5 h
		12	
	1		
	/°C		/h
	150	5 10 15 20 25 30	
	+	35 40 45 50 55 60	

1.2

	EPR	
BRUKER EPR EMX PLUS		
	FTIR	Thermo Fisher
Scientific Thermo Scientific™ Nicolet™ iS50		
400 ~ 4 000 cm ⁻¹	2 cm ⁻¹	
X	XPS	Thermo
Fisher Scientific EscaLabXi + X		
C N O		
	SEM	FEI Nova
NanoSEM 450		

KEYENCE VHX-
2000 100 300 500 700

2

2

EPR 1 1

50 ~ 60 h

EPR 12.0 mT

11 G

3

EPR

$$N = A_{\text{radical}} \exp(-t/\tau_{\text{radical}}) - k_{\text{radical}} + N_{\text{residual}} \quad 1$$

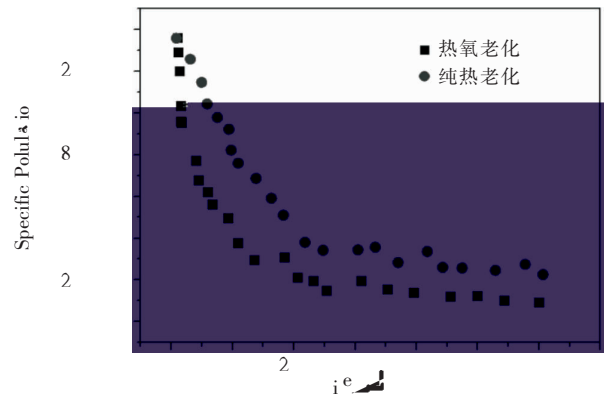
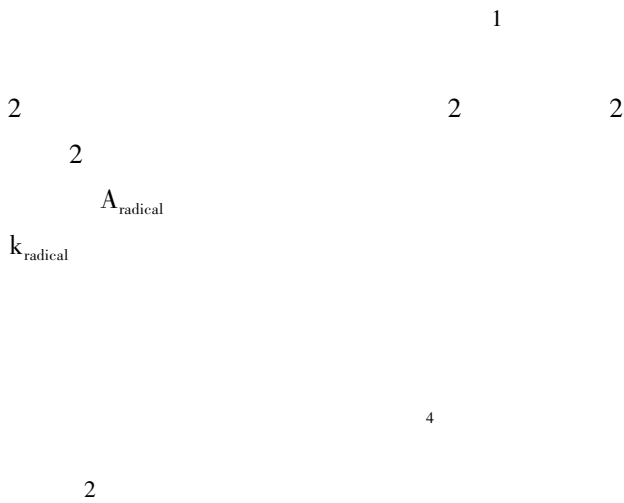
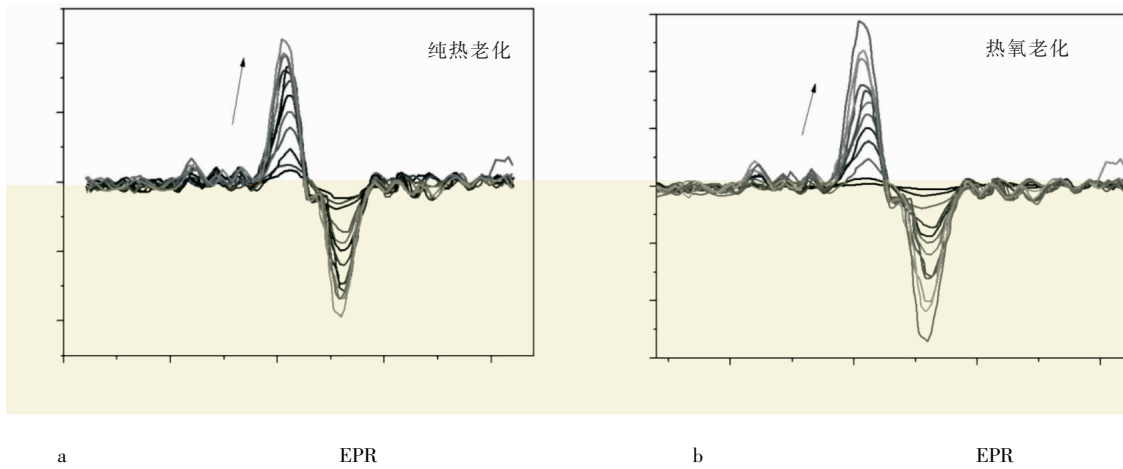
3 490 G ~ 3 545 G

A_{radical}

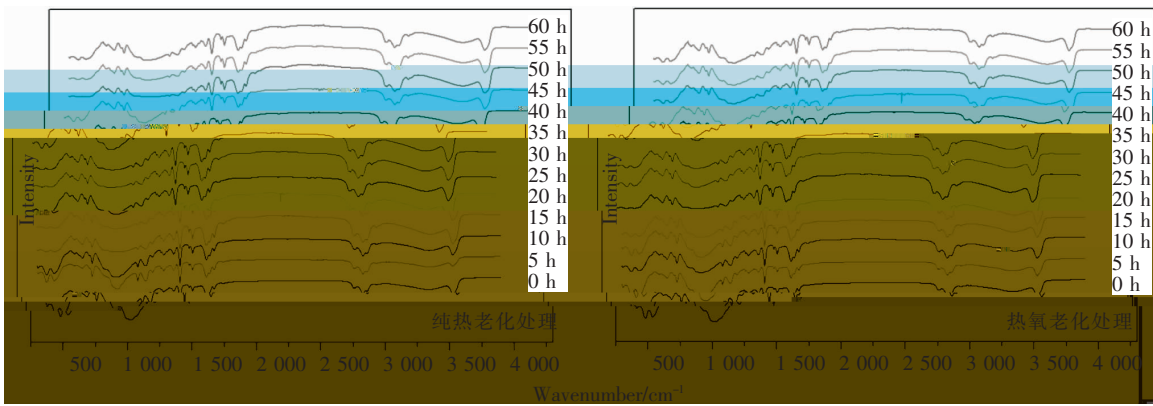
k_{radical}

τ_{radical}

h



Samples	A_{radical}	τ_{radical} h	k_{radical} h ⁻¹	N_{residual}
	9.198×10^6	23.492 8	5 849.9	2.365×10^6
	9.783×10^6	35.837 2	7 639.2	3.009×10^6



1 040 cm⁻¹ 1 188

cm⁻¹ C-H XPS

 C-H 4

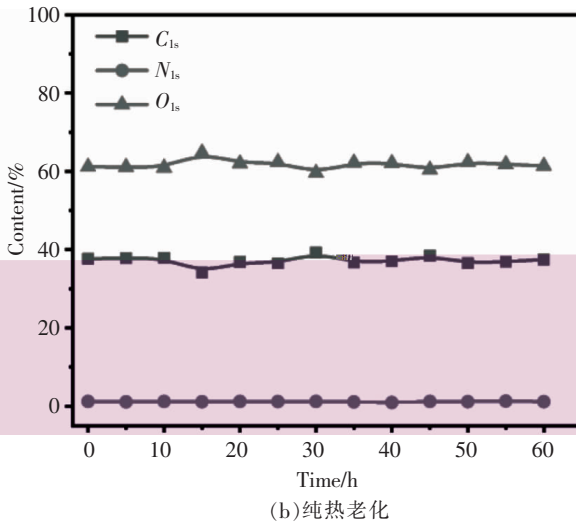
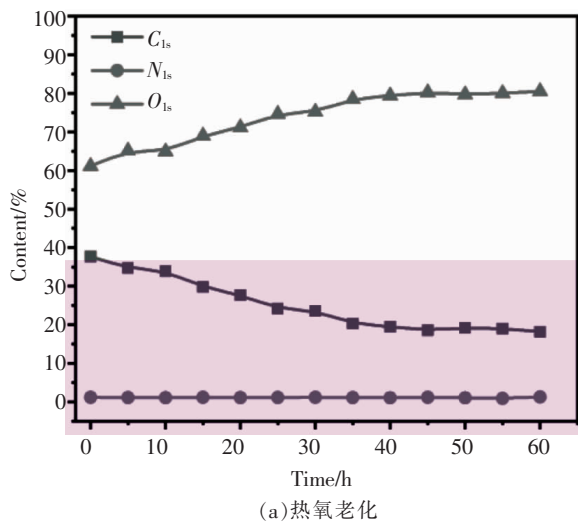
C N O

O

C

6

EPR

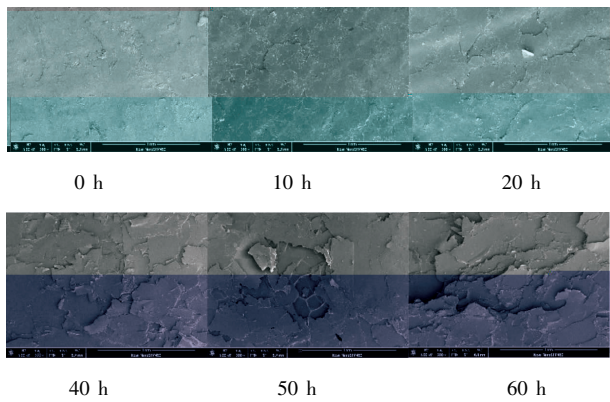
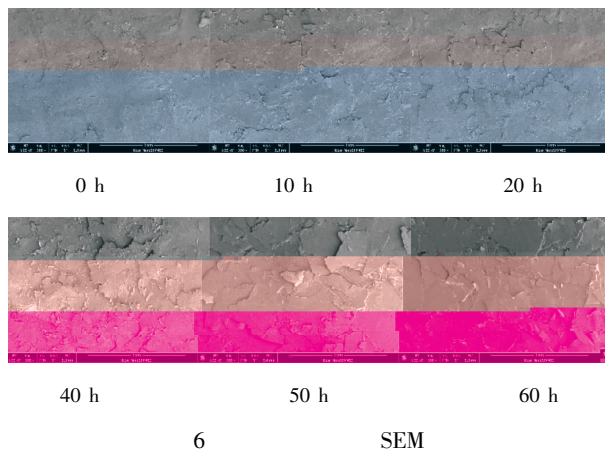


4

SEM

5

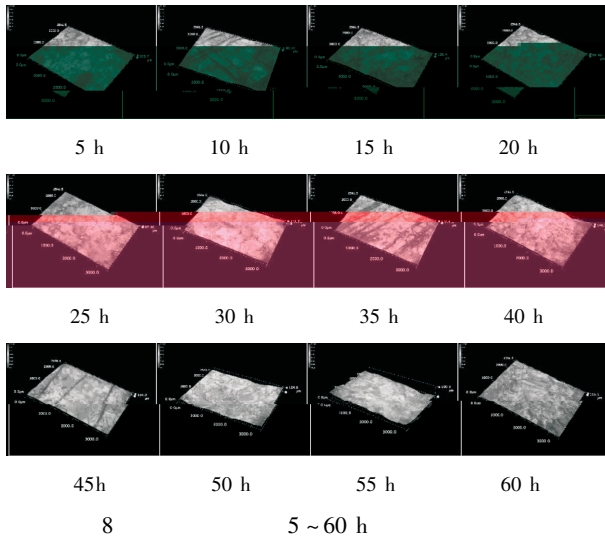
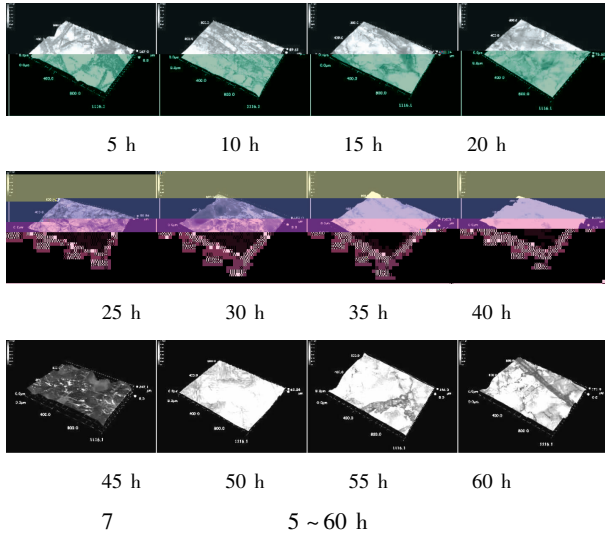
6



7 8

100X 300X 500X 700X

100X



EPR XPS

-
- 1 A. Maxwell W. R. Broughton et al. Review of Accelerated Ageing Methods and Lifetime Prediction Techniques for Polymeric Materials R . National Physical Laboratory NPL Middlesex 2005
 - 2 Singh B Sharma N. Mechanistic implications of plastic degradation J . Polymer Degradation and Stability 2008 93 3 561 – 584
 - 3 Pierangiola Bracco Luigi Costa et al. A review of experimental studies of the role of free-radicals in polyethylene oxidation J . Polymer Degradation and Stability 2018 155 67 – 83
 - 4 . J . 2009 38 3 47 – 53
 - 5 Damian C Espuche E Escoubes M. I



611731

PECVD

2021 - 10 - 22

1984 - 2011

OM Olympus
 DP71 Raman Labram HR800-UV-
 NIR 532 nm 10% - 10mW

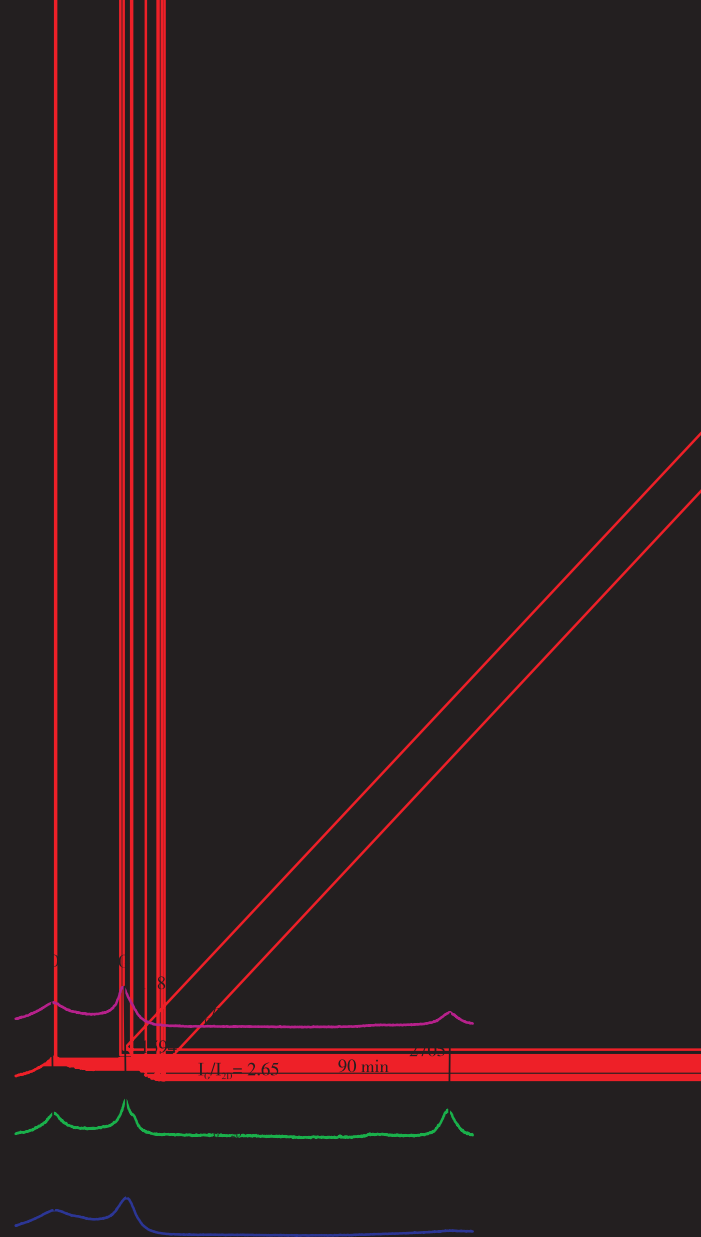
Attension Theta

D20 mm × 1 mm × 600 mm

2

2.1

			12-15
		15	1
			800 °C
			D
	G		2D
		700 °C	
			D
		C	
15	1 000 °C	I_G / I_{2D}	0.67
1			I_G / I_{2D}

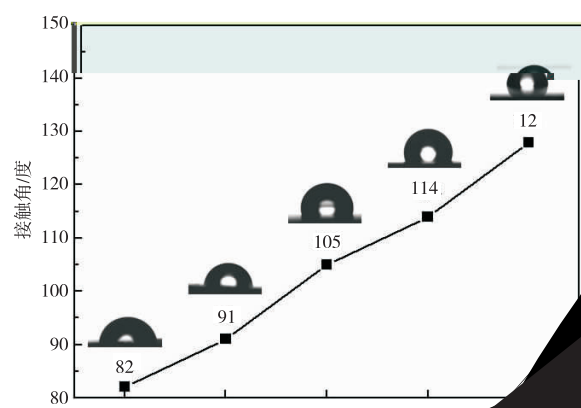


6
 800 °C 20 secm
 56 scem 60 W
 2.6

11 21-22
 I_D / I_{2D}

7
 128° 1 000 °C

91°
 82°



- 2 1321
- 3 Ahmed M Kishi N Soga T. Large scale bi-layer graphene by suppression of nucleation from a solid precursor J . RSC Adv. 2015 5 53 42645 –42652
- 4 Kumar A Khan S Zulfequar M et al. Low temperature synthesis and field emission characteristics of single to few layered graphene grown using PECVD J . Applied Surface Science 2017 402 161 –167
- 5 Raman R S Banerjee P C Lobo D E et al. Protecting copper from electrochemical degradation by graphene coating J . Carbon 2012 50 11 4040
- 6 David L Bhandavat R Kulkarni G et al. Synthesis of Graphene Films by Rapid Heating and Quenching at Ambient Pressures and Their Electrochemical Characterization J . ACS Applied Materials & Interfaces 2013 5 3 546 –552
- 7 Reina Alfonso Jia Xiaoting Ho John Nezych Daniel Son Hyungbin Bulovic Vladimir Dresselhaus Mildred S. Kong Jing. Large Area. Few-Layer Graphene Film #01598331 7.7655002 69.720009 TD (6)Tj /F6.720009 TD !.549999 0 TD ()Tj 1 Tf 0 Tr 7.3

Ansys Workbench

TB12

A

1001-9006 2021 04-0029-05

Research and Analysis on Assembly Dynamic Characteristics of Permanent Magnet Direct Drive Wind Turbine

WANG Shijian, HE Qiyuan, DUAN Zhiqiang, WANG Mingkun, ZHOU Junpeng

(Dongfang Electrical Machinery Ltd., 618000, Deyang, Sichuan, China)

Abstract: This paper describes the use of Ansys Workbench finite element software to build a permanent magnet direct-drive generator assembly model, using electromagnetic coupling to calculate the natural frequency of the generator assembly, that is, considering the uniform magnetic pull of the rotor permanent magnet and stator core, And the influence of eccentric magnetic pull due to deformation of the machining, assembly, rotor bracket and stator bracket itself. The accuracy of the method is verified by comparing the calculated results with the measured results of the modal test.

Key words: finite element method; electromagnetic coupling; dynamic characteristics; modal test

1

4

2

5

ANSYS

3

2021 - 09 - 24

1988 - 2019

1

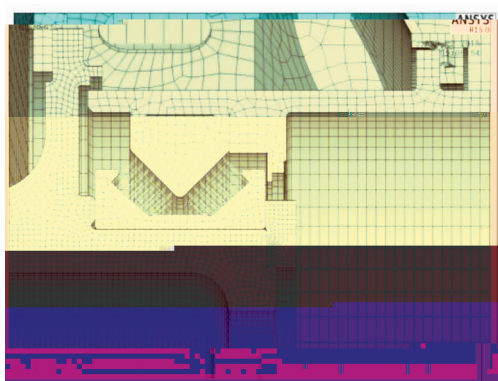
$$M \ddot{x} + C \dot{x} + K x = 0 \quad 1$$

$$-\omega^2 M + K \varphi = 0 \quad 2$$

$$-\omega^2 M + K + K_D \varphi = 0 \quad 3$$

K

1.1



2

1 Bonded

2 Frictional

1

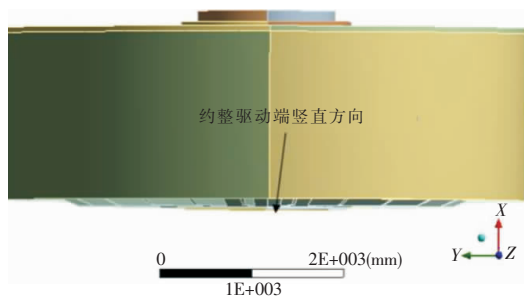
1

mm

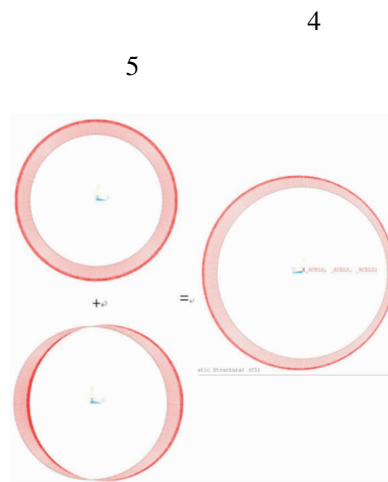
	0.742 5	0.525
	0.435	0.23
	0.742 5	0.525
	0.357 5	0.165
	0.5	0.3

2.2

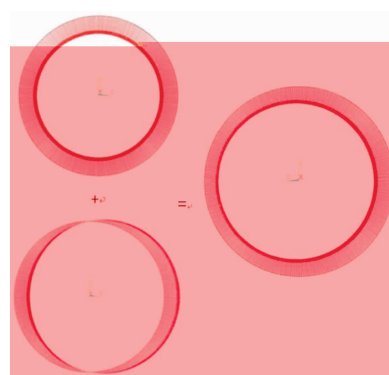
3



3



4



5

2

	N/mm ²	kg/mm ³	
QT400	1.69×10^5	7.1×10^{-9}	0.27
Q345E	2.10×10^5	7.85×10^{-9}	0.3
QT400	1.69×10^5	7.1×10^{-9}	0.27
Q345E	2.10×10^5	7.85×10^{-9}	0.3
/	1.5×10^5	5.9×10^{-9}	0.21
/	1.5×10^5	7.0×10^{-9}	0.21
Q345E	2.10×10^5	7.85×10^{-9}	0.3

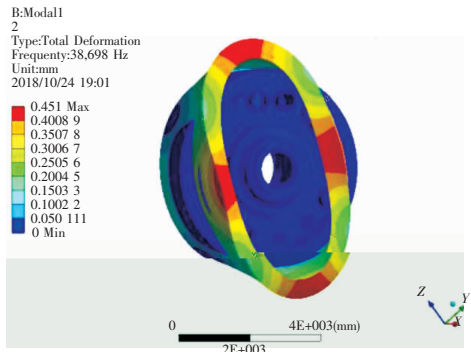
2.3

ANSYS

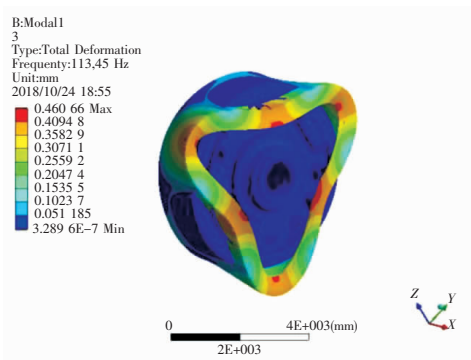
6 ~ 9

3

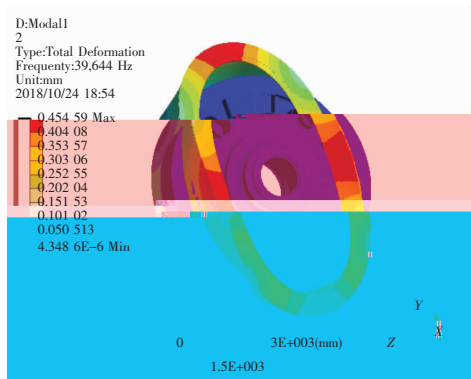
	3	Hz
1	38.698	39.644
2	113.45	107.66



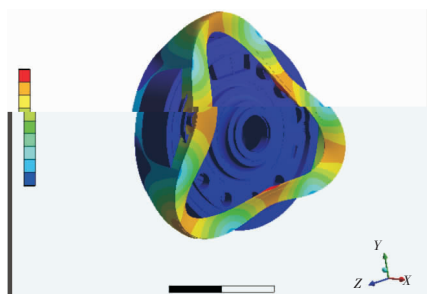
6 38.698 Hz



7 113.45 Hz



8 39.644 Hz



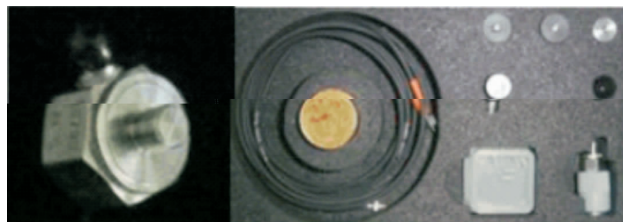
9 107.66 Hz

3

3.1

10 PCB

A B C



a PCB



b

c

10

3.2

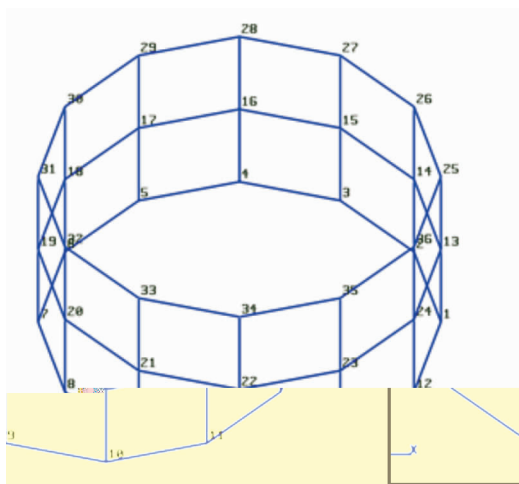
modal test

SIMO

"

"

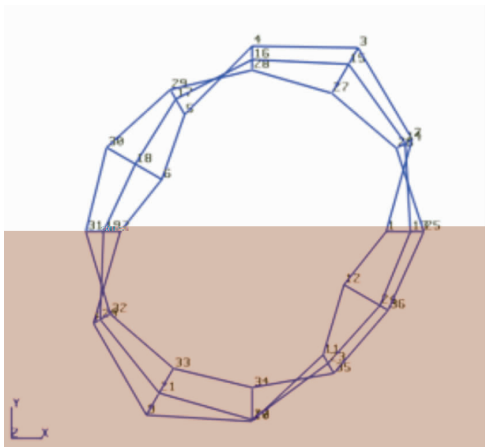
11



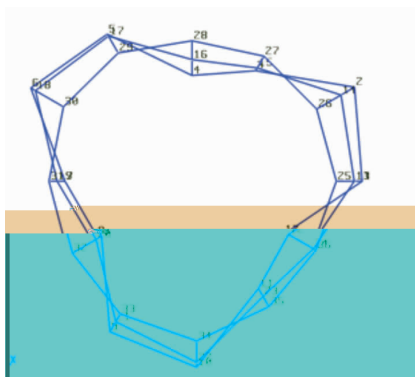
11

3.3

	12	13
	4	
	Hz	
1	40.1	
2	103.9	



12 40.1 Hz



13 103.9 Hz

4

5

6

5

Hz

1	40.1	38.698	39.644
2	103.9	113.45	107.66

6

%

1	-3.50	-1.14
2	9.19	3.62

6

8

12

7

9

13

5

5

1

2

2

3.62%

9.

19%

3

4

46

VPN		
	1	2
1.	618000	2. 735000

VPN

VPN

SCADA

TM614

A

1001-9006 2021 04-0034-04

Application of VPN in Centralized Monitoring of WTGs

LI Shengru¹, WANG Mingjun²

(1. Dongfang Electric Automatic Control Engineering Co., Ltd., 618000, Deyang, Sichuan, China;

2. Jiuquan Vocational Technical College, 735000, Jiuquan, Gansu, China)

Abstract: It is essential for off-site monitoring of WTGs to enhance remote management of wind farms, to reduce WTG operation and maintenance costs, to check and eliminate potential safety hazards. A remote monitoring center can not only achieve cost-saving purposes through a virtual private network (VPN), but also meet the requirements of the State Electricity Regulatory Commission's "Safety Protection Regulations for Secondary Power Systems". This paper analyzes and discusses the remote monitoring and safety of WTGs through VPN.

Key words: virtual private network (VPN); remote monitoring; WTG; network security; SCADA

SCADA

SCADA

SCADA

1

APP
SCADA

"

2021-06-01

1984-2007

"

2.1 VPN

VPN

1

VPN
Internet

2

Internet

VPN

Internet

" "

" "

VPN

Virtual Private

Access VPN

Network

1

3

SCADA

4

VPN

1

2 VPN

VPN

VPN

Internet

VPN

VPN

5

Internet

VPN

É = ! 6 Û s r è ê

%& (#) &

* +, - . / 0 1
! " # ! " # \$ %

+) "\$ 0 1 2
"\$

& ' () * ; - (;
+) . /

n ã, ÿÿª • ÿ Û ö ¥ n

ä%ä, Z W ò ð ó ð É r G â 5 Û ¾ †

G â ! (@ Z É _ ^ 1 É r £ ò á °

É r ~ " ¾ † á \ ¾ † ° % ! . 5 0 á W Z W

ô ò ð ó ð T f É r " Ã G â ! [F á Ê C ... 5

Û ... É Ç # Ð T f ... t ° # Ð T f # e ! ¾ † ê

ç © ñ G â U ° ' { « ¨ ¾ † þ à ò Ì

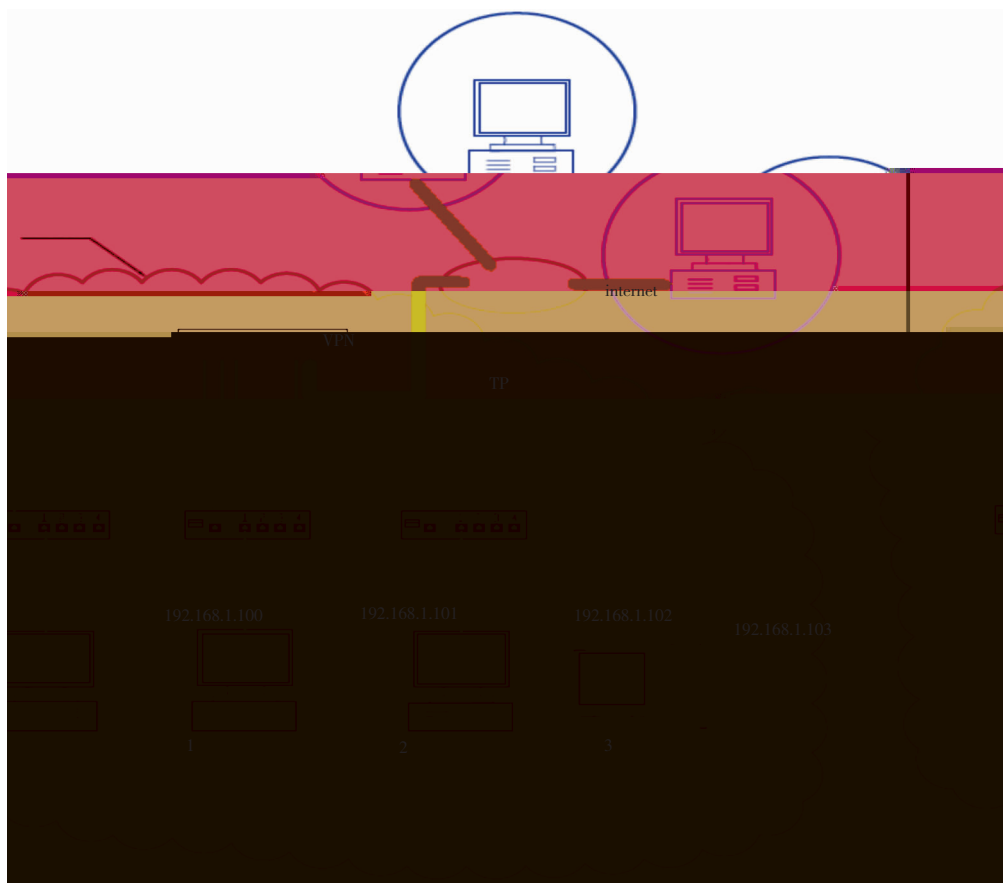
¼ Ž á W Z W ñ ¥ h Ñ É 8 Ê œ ö ¥ ê Å » G

â ü ¶ ì ì N Z " á © ½ © e Ý ü l á

» ¶ `ª ÿ, è ! G â ... " ! ÿ Û ¨ « á •

1 Ÿ É © 513281.018867 0 TD (!) Tj 1.037735 0 TD (!) Tj 0.056603 0 TD (G) Tj 6".056604 0 TD (â) Tj 0 Tj 1.047169 0

4 VPN 5 VPN
VPN VNC VNC SCADA
SCADA



2 VPN

3

VPN VPN
VPN VPN

2 . R .2005
3 . J .
2013 32 6 23 - 25
4 . Internet SCADA
J . 2006 17 89 - 93
5 . IPSec VPN J .
2014 22 20 139 - 141 + 145
6 . VPN
J . 2011 3 30 - 31
7 . VPN J .
2015 17 19 81
8 . J . .2018 9
68 - 71

1 . J .
2014 6 137

CANopen

611731

CANopen

TMS320F28377D CAN

Controller Area Network

CANopen

PLC Programmable Logic Controller

CANopen

PLC CAN

TM614 TP273

A

1001-9006 2021 04-0038-04

Development of CANopen Communication Function for Wind Power Converter Control System

HE Shengpeng, WU Xiaotian, BIAN Xiaoguang, PU Xiaomin, ZHOU Honglin

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

Abstract: The intelligence of wind power system is an important trend, so the development of an independent, flexible and open converter communication system becomes an important task. CANopen communication has the advantages of simple hardware structure, strong anti-interference ability, and high real-time performance, so it is widely used in the field of industrial control. This paper developed CANopen communication function based on the CAN(Controller Area Network) module of TMS320F28377D, so that it could be used in wind power control systems with PLC (Programmable Logic Controller) as the main controller. Finally, the reliability and accuracy of the developed communication function were verified through experiments.

Key words: CANopen; converter; PLC; CAN

2021 -05 -21

2020YFG0315

1992 - 2020

3 CAN

Devicenet CANopen SDS 4-5 CANopen
CAL

6

7

CANopen

TMS320F28377D

CAN CANopen PLC
Programmable Logic Controller

1

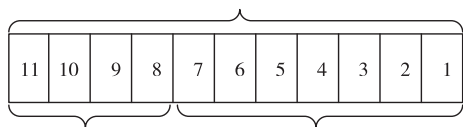
2025



		32	
	SDO		32
		SDO	
3	PDO	PLC	
	PDO	TPDO	
RPDO	PDO	8	
PDO			
4	PLC		SYNC
		PDO	

3 CANopen

	CANopen	11	CAN-
ID	COB-ID	Communication	Object
Identifier			
		4	
7			
3			



5

PLC主控制器



	1	1	1	2	3	4	4	4
1.				611731	2.			618000
	3.			611731	4.			618000

2021 - 11 - 04

1980 - 2010

" "

6 17

2

3

4

5

23% 6% 70%

6

" "

1

7

8

9

1 + + + +

1

1

2



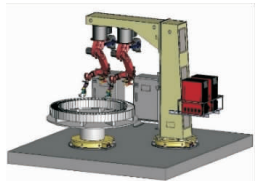
"

"

2.1

1

1

	14 m × 14 m × 5 m	GMAW GTAW GMAW	1 2 3	30%	
	6 m × 6 m × 5 m	GMAW	1 2 3	35%	
TIG	6 m × 6 m × 5 m	TIG	1 2 3	45% 50%	

2.2

2

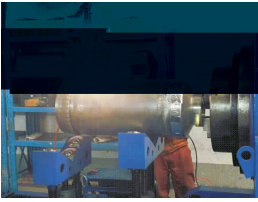

2

2.3



2

2

	1		1/24	
	2	80%		
	3			
	4	90%		
TIG	1		1/4	
	2		1/5	
	3		RT	
	4	60%	99%	

2.4

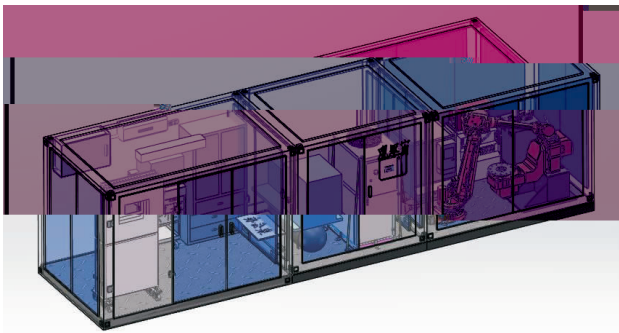
3

" "

3

1

" "



3

2

" "

3

4

5



SA - 335P92

F426

A

1001-9006 2021 04-0047-02

Boiler Industry Import Large-calibre Pipe Procurement Dilemma and Countermeasures

LUO Lingli

(Dongfang Boiler Group Co. , Ltd. , 611731, Chengdu, China)

Abstract: This paper analyzes the procurement status and difficulties of imported large-diameter pipes (SA-335P92 and other materials), puts forward countermeasures, achieves good results, saves procurement cost and ensures delivery cycle.

Key words: imported large-diameter pipes; procurement difficulties; measures; results

1

20% ²

SA- 335P92

IBF

60%

¹

720

JFE

1

SA- 335P92

SA- 335P92

Vallourec Deutschland GmbH

"

"

"

"

NIPPON

STEEL CORPORATION

"

"

JFE Steel Corporation

"

JFE" IBF S.

P. A

"

IBF"

Wyman Gordon

Fordings Inc

"

"

Forgiatura

Morandini S. r. l

"

"

101%

2021 - 10 - 18

1970 - 1991

1

3

2

D720

60%

D720

1

SA-335P92

3% ~ 5%

2

3

3

D720

4

6

5

4

IBF

2

SA-335P92

2020 3

5

SA-335P92

P92

2020 6 30

Reisholz

4

Reisholz

2020 10

2020 12

SA-335P92 2 ~ 3 t

6 2021 1

1 2021 06 30 2021 12

30 2021 SA-335P92

1.2

1 2	1 2	1 2	1 2	1 2	1 2	1 2
1.	611731	2.	643001			

17.5 MPa/571/569 °C

NO_x

TM621

A

1001-9006 2021 04-0049-06

Brief Introduction of Dongfang Ultra High Temperature Subcritical Blast Furnace Gas Fired Boiler

ZHENG Gang^{1,2}, RAN Shenming^{1,2}, ZENG Jie^{1,2}, YANG Zhangning^{1,2}, PAN Shaocheng^{1,2},
YIN Chaoqiang^{1,2}, LIU Yugang^{1,2}, MO Chunhong^{1,2}, XU Yangyang^{1,2}, YI Zezhong^{1,2}, LIU Yi^{1,2}

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

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

Abstract: This article introduces the design scheme of ultra-high-temperature subcritical (17.5 MPa/571/569 °C) gas fired boiler developed by Dongfang Boiler Group Co., Ltd. and its design features are introduced and summarized. The development and design of the gas fired boiler can meet the needs of the development of the gas fired boiler with larger capacity and higher parameters, and improve the unit efficiency and power plant economy.

Key words: ultra-high-temperature subcritical; gas fired boiler; furnace type selection; Low-NO_x combustion technology

88.7%¹

7-8

2-3

2018

4

5

1

100 MW

3 6

37%³

2021-02-24

1979-2013

1
1.1 3
CO 20% 1.6 ~ 1.8 1 m³
N₂ CO₂ 0.595 ~ 0.85 m³
2 800 ~ 3 800 kJ/Nm³ 1.6 ~ 1.8 m³

1 9
2 10
4

1

N ₂	H ₂	O ₂	CO	CO ₂	CH ₄	C _m H _n			H ₂ S
							kJ/Nm ³	mg/Nm ³	mg/Nm ³
			%						
51.3	3.8	0.1	22.1	22.7	0	0	~ 3 200	< 10	-
27.8	2.3	0.1	53	16.6	0.2	0	~ 7 000	< 10	-
4.9	59	0.5	5.8	4	24.1	1.7	~ 17 500	< 10	≤ 50

1.2 2 NO_x
CO 50/100 mg/Nm³ 3% O₂
50% 6 500 ~ 7 800 kJ/
Nm³ 1 2 BMCR

1.3 85%
16 000 ~ 18 500 kJ/Nm³
H₂ CH₄
1 800 °C

		100 MW	135 MW
/t h ⁻¹		330	440
/MPa a		17.6	17.6
/°C		571	571
/t. h ⁻¹		276	408
/°C		352	359
/°C		569	569
/MPa a		3.92	3.96
/MPa a		3.72	3.76
/°C		281	291

3 50% ~ 100% BMCR
60% ~ 100% BMCR

2 ± 5 °C
+ 5/ - 10 °C

2.1 4
2.1.1 2.1.3
100 ~ 135 MW

BMCR 2

2.1.2 1 90%
140 °C

SA - 213TP347H

4

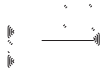
-

5

SCR

6

SCR



55 ~ 80

MW 150 MW

1 .2012 12
R .2012
2 . 2 J .
2019 9 64 -68
3 .
J . 2018 8 63 -64 +137
4 D .
2017

5 .135 MW -
J . 2014 45 4 23 -26 +44
6 .
J . 2015 12 35 -38
7 .100 MW
J . 2019 10 70 -73
8 .110 MW
J . 2019 6 5 -8 +28
9 . J .
2015 44 3 21 -27
10 .
J . 2014 28 3 169 -172
11 .
J . 2019 2 60 -64
12 .
D . 2018

48

2021

2021

1

1 . 2019 24

SA-335P92

EB/OL . [http //www. mofcom. gov. cn/ article/b/e/201906/20190602872648. shtml](http://www.mofcom.gov.cn/article/b/e/201906/20190602872648.shtml) 2019

2

2019 3 EB/OL . [http //gss. mof. gov. cn/gzdt/zhengcefabu/ 201905/t20190513_3256788. htm](http://gss.mof.gov.cn/gzdt/zhengcefabu/201905/t20190513_3256788.htm) 2019.

5

SA-335P92

欢迎投稿 欢迎订阅

2021 - 07 - 01

1987 - 2010

$$n_2 = 190 \sim 220 \text{ r/min}$$

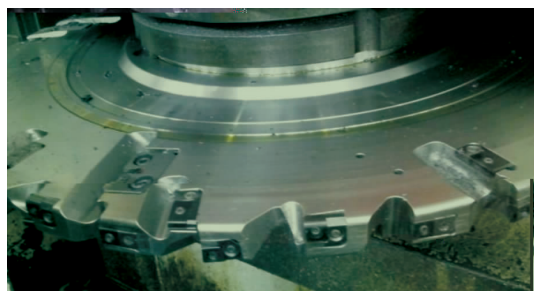
$$f_{r2} = n_2 \times Z/60 \approx 15.8 \sim$$

18.3 Hz

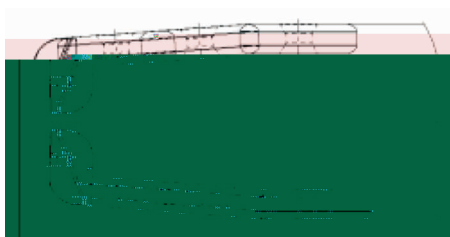
2

2.1

20 50



4



5

2.3

8

0.01 mm

0.02 mm

2.4

2.4.1

$\varphi_1 =$

160 m/min

500 mm

$L_1 = 110 \text{ mm}$

$L_2 = 90 \text{ mm}$

$\varphi_2 = \varphi_1 + 2L_1$

$+2L_2 = 900 \text{ mm}$

2.2

2.4.2

" "

1.2

4

5

31.8Hz

$f_{r2} \approx 15.8$

-18.3Hz

0.005 mm



ASME

TH121

A

1001-9006 2021 04-0059-03

Analysis on the Requirements of Thermal Stress Ratcheting of ASME Code

LI Ting

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

Abstract: This paper discusses the requirements of thermal stresses ratcheting of ASME Code, compares the differences between the mechanism of shakedown and of thermal stresses ratcheting, and clarifies the condition under which thermal stresses ratcheting should be analyzed, which provides references for engineering design.

Key words: shakedown; thermal stress ratchet; design by analysis; pressure vessel

$$\sigma_1 \leq 2\sigma_s$$

$3S_m$ ASME

-2100 - 1¹

$3S_m$

EN13445 - 3 2014²

C7. 7 CODAP -

2000³ C10. 1. A2

ASME¹

EN13445²

CODAP³

ASME -3400 a

$3S_m$

ASME -1300

Shakedown

¹

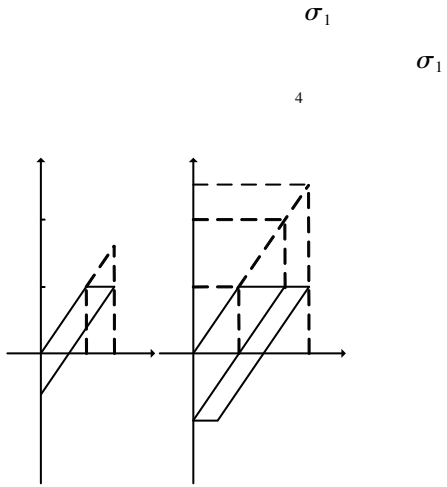
ASME

1

2021 - 01 - 08

1983 - 2007

1



Miller

ASME

0.9

TM153

A

1001-9006 2021 04-0062-04

3D FEM Analysis about Stator Winding Force

REN Panqiu

(Dongfang Electric Machinery Co., Ltd., 6W)

i

3

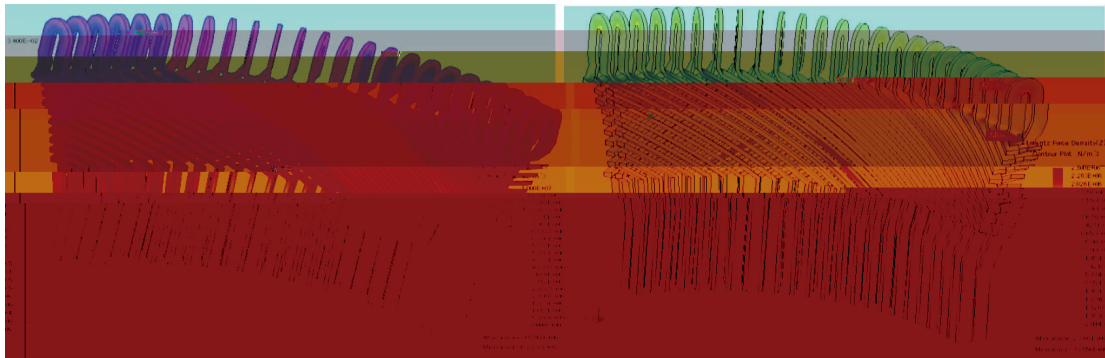
S2 S3

S1

1

3

1



3

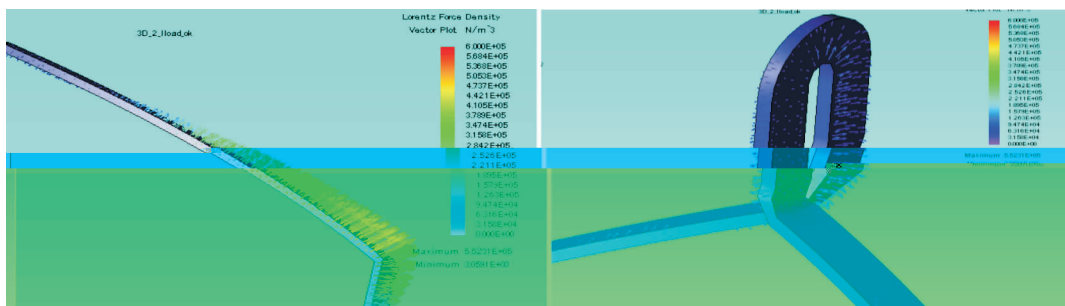
1

	1	2	3	4	5	6	N/m^3
<i>X</i>	3.90E6	4.57E6	6.17E5	7.16E5	5.79E5	6.75E4	
<i>Y</i>	2.22E6	1.75E6	-1.88E5	6.40E5	3.39E5	-1.34E4	
<i>Z</i>	1.95E6	2.54E6	3.80E5	1.89E5	-3.15E4	-5.08E3	
	-0.014 4	-0.722 63	4.47E5	6.90E4	-5.57E4	5.31E4	

4

22 m

5



5

2.3

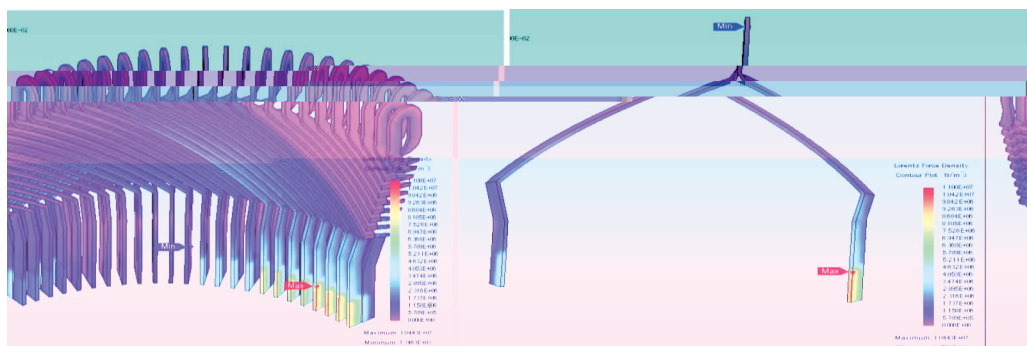
0.9

6

$1.04 \times 10^7 \text{ N/m}^3$

0.9

2



6

0.9

2

0.9

		N/m^3					
		1	2	3	4	5	6
X		4.89E6	5.07E6	7.98E5	1.17E6	7.93E5	5.34E4
Y		3.18E6	4.16E6	6.94E5	1.04E6	2.22E4	5.21E3
Z	/N/m^3	-0.813 3	-2.049 4	-1.79E5	-5.69E4	-5.16E5	-3.32E4

1

2

0.9

0.9

10%

1

0.9

10%

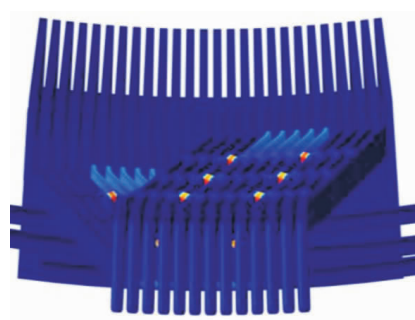
3

2021 - 08 - 30

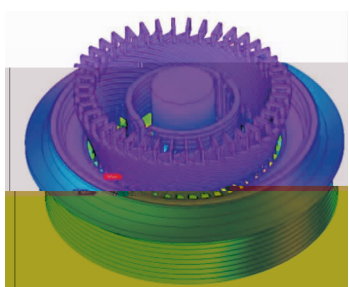
1964 - 1996



1



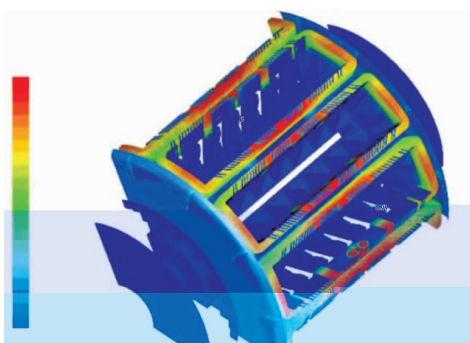
6



2



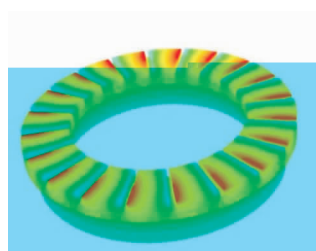
7



3



8



4



5

2

" "

1 000

MW 9 ~ 10

1 750

MW 11

12

10 MW

13

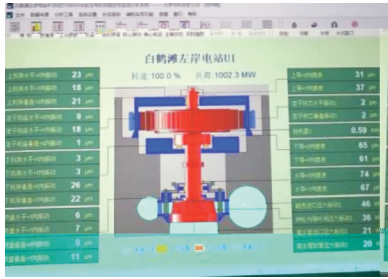
" "

14

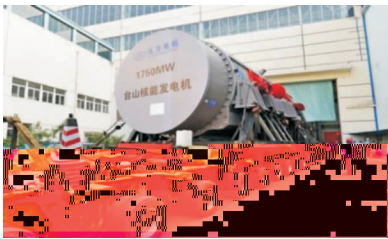
" "



9 1 000 MW



10 1



11 ERP1 750 MW



12



13 10 MW

MVar

50 MVar

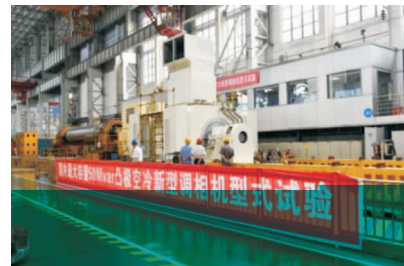
16



14



15 300 MVar

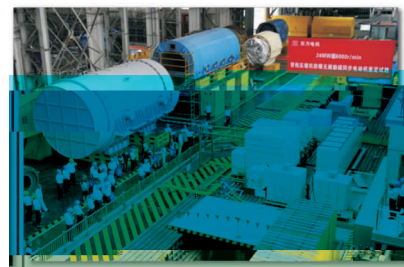


16 50 MVar

24 MW 6 000 r/min

33

17



17 24 MW

300

15

50 MVar

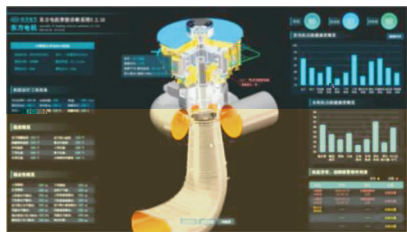
50 Hz	60 Hz	2	4	90%
4				
300 MW			600 MW	" "
165 MW			6 MW ~	
3	21			

3

" "

3.1

18 ~ 19



18



19

3.2

" "

20 ~ 21

9 000	12 000
620%	56.6%

4.1

" " "



20



21

3.3

DF - 300

22



22 DF300

4

" "

" 10

23



23 " "

4.2

" "

56 24 ~ 26

2 1 1

22

2 4 2

6

5.3

" " " "

" "

" " "

"

" "

5.4

"

"



65

1986 269 - 299

2

2

J .

1991 2 13 - 25

3

J .

1992 2 23 - 28

4

3D

J .

1995

3

6 21 - 24

5

. Pro/ENGINEER

J .

2007 2 31 - 38

6

. ElecNet

J .

2009 1 14 - 18

7

-

J .

1993 5 25 - 29

8

J .

1993 6 14 - 19

1

M .

TM62

A

1001-9006 2021 04-0072-04

Research and Analysis of Steam Turbine Crisis Trip Device Based on High Frequency Solenoid Valve Control

LI Qing, LIU Jiong, SHAO Yi, LI Liang

(Dongfang Electric Automatic Control Engineering Co., Ltd., 618000, Deyang, Sichuan, China)

Abstract: In this paper, a new type of high frequency solenoid valve structure and the working principle, to establish the simulation model of solenoid valve, by means of the mechanical parts of the electromagnetic loop, and the coupling between the hydraulic system simulation, the solenoid valve static and dynamic simulation results more accurate, and the applications of the high frequency solenoid valve to a steam turbine crisis trip device, completed by simulation software based on steam turbine critical of the high-frequency solenoid valve control block device simulation model is established, through the simulation of various working conditions is critical in the interrupt turbine working state, It is further verified that the critical block device of steam turbine based on high frequency solenoid directional valve has high dynamic characteristics.

Key words: high frequency solenoid valve; coupling simulation; crisis trip device

AST

2021 - 09 - 24

1983 - 2010

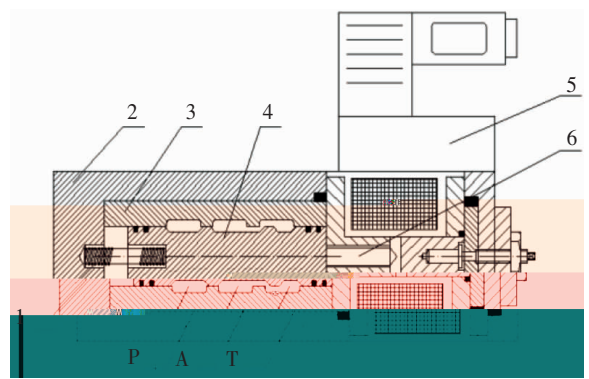
“ ” “ ” “ ” “ ” “ ”

4

$$\left\{ \begin{aligned} \frac{di}{dt} &= \frac{1}{Lx + i \frac{\partial Lx}{\partial i}} u - Ri - i v \frac{\partial Lx}{\partial x} \\ F_m &= -\frac{\phi}{\mu_0 S} \\ m\ddot{x} &= F_m - F_{spring} \pm F_w - F_z \\ F_w &= C_d C_v d P \sin 2\theta x \end{aligned} \right.$$

1

1



- 1 -
- 2 -
- 3 -
- 4 -
- 5 -
- 6 -

1

5

4

1

T A

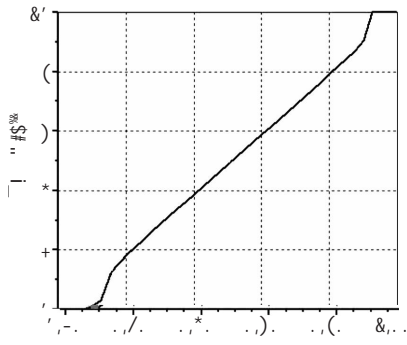
6

4

P A

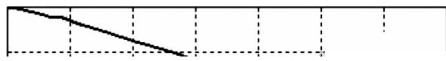
2

4



3

4



1

-

4

5

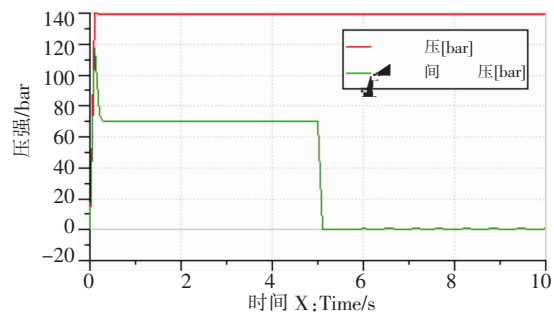
t_{off}

t_{on}



5

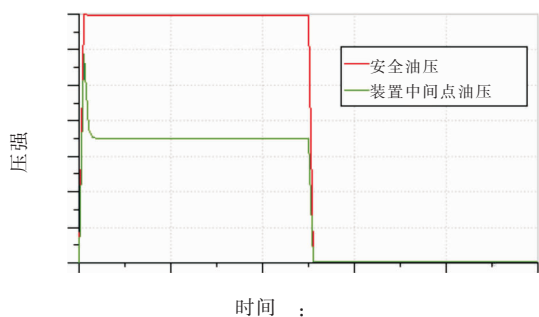
140 bar
4
5 s
4
0.2 s
139.6 bar
4
0.2 s
0.1 bar
4
0.3 s
69.8 bar
4
0.2 s
0.5 bar
9



11

2

5



9

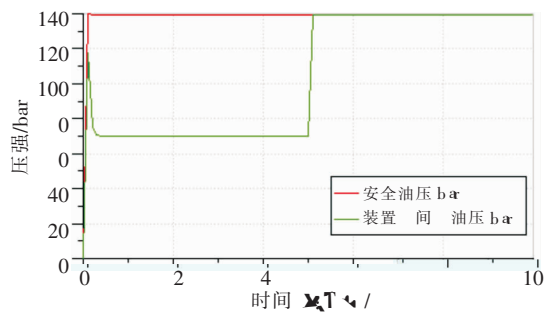
1

2

SV1 SV2 5

SV1

SV2 0.2s 139.1bar
10



10

1

SV3 SV4 5 s

SV1

SV2 0.2 s 0.7 bar
11

1 J .
2000 4 5-6
2 Ansoft AMESim
J . 2008 9 104-105+108
3 J .
2004 15 84-88
4 M .
2005.6
5 M . 2002
6 M . 2008
7 S . 2006 DL/T996
-2006

TM311

A

1001-9006 2021 04-0076-05

Advantages of Evaporative Cooling Technology in Large Generator-motor and Its Simulated Test

LIU Chuankun, ZHOU Guanghou, ZHANG Haibo, JIANG Bo

(Dongfang Electrical Machinery Co., Ltd., 618000, Deyang, Sichuan, China)

Abstract: Stator coils of large turbo-generators are water-cooled. Traditional hollow strand is made of copper with low loss, but the inner wall of hollow strand is scaled and corroded. It is easy to cause strand blockage or even water cut-off and stator temperature is too high to cause major accidents. To solve this problem, hollow strand of stainless steel can be used to avoid strand blockage. Hollow strand of stainless steel has the advantages of high voltage withstand grade of main insulation, high mechanical strength and good aging resistance. The stator winding is analyzed by using different strand sizes, arrangement and cross-sectional area of upper and lower layers as well as hollow strand made of stainless steel and copper by finite element method. The purpose of replacing copper hollow strand with stainless steel is achieved by optimizing design.

Key words: hollow strand; large turbine generator; optimal design

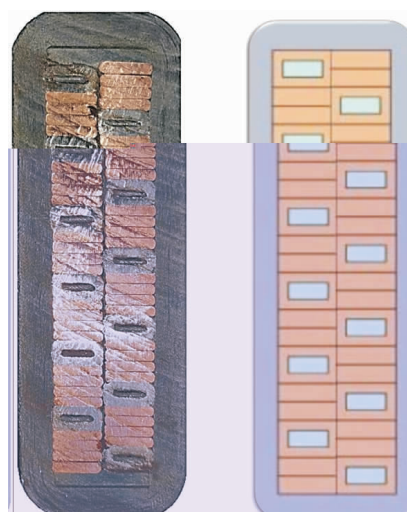
2021 -04 -06

1980 - 2002

1970 - 1995

1 2 1 4
2a

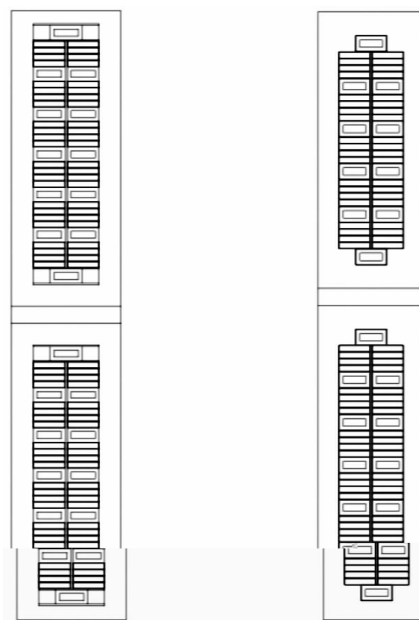
2b



1

2

1



a

b

2

1 4

1

3

3

1

1

/

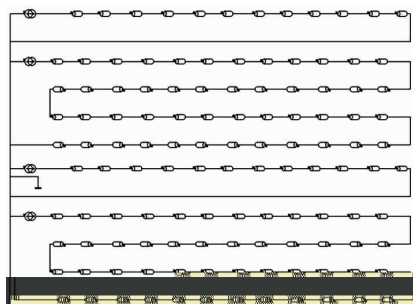
1

2

v_r v_0
 A σ
 5 AB CD
 Dirichlet AE BF
 Neumann
 540°

In U R
 R

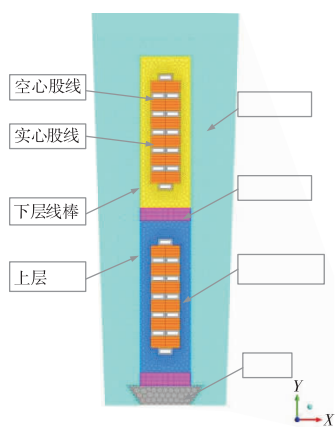
6



6

2.3

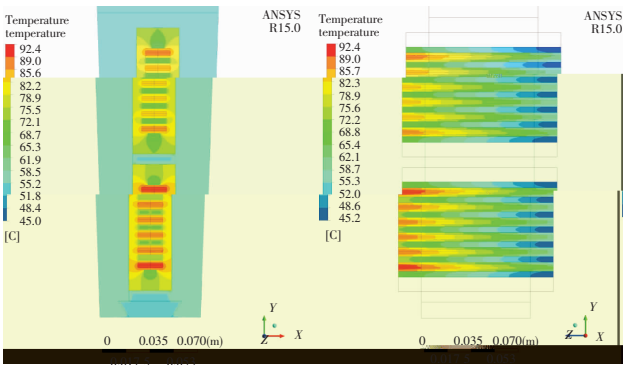
7



5

/	1	2	
℃	45.0	45.0	45.0
℃	70.7	68.5	71.8
℃	73.5	72.3	74.5
℃	83.5	84.6	92.4
℃	68.2	66.9	69.6
℃	69.8	70.6	72.1
℃	79.2	82.1	88.4

3



4

9 40 ℃

4

1

1 J . 1981 3 1-7+2

2 J . 2018 32

1 64-69

3 M . 1 . 1992

4 Kenichi Hattori . J . 2006 2

5 M . 2000

2

1 2

欢迎投稿,欢迎订阅!

618000

A

PMBOK

PMBOK

F426

A

1001-9006 2021 04-0081-04

Project Management in Foreign Subcontracting Project

WANG Zhijian

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

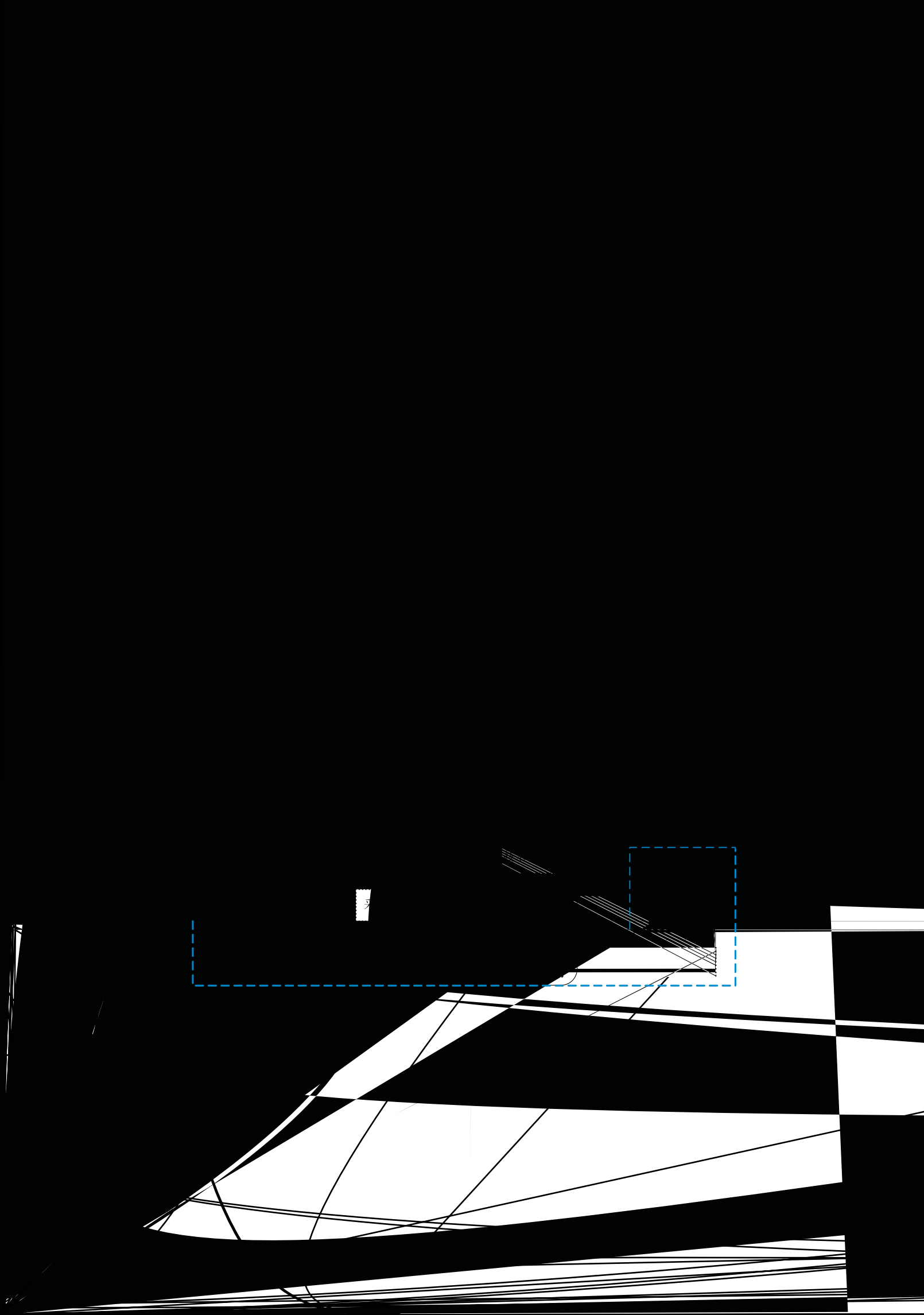
Abstract: This article is based on the excitation system subcontracting project between DFEM and company A, in which, theory and management tools of project management in PMBOK and supply chain management are introduced in the execution of foreign subcontracting project to make sure the scope, schedule, quality of the product and service of the sub-contract project could fully satisfy the need of the main contract project.

Key words : e o j

2021 - 09 - 24

1986 - 2009

2018



3

3.1

40

1

1

0.9	0.05	0.09	0.18	0.36	0.72
0.7	0.04	0.07	0.14	0.28	0.56
0.5	0.03	0.05	0.1	0.2	0.4
0.3	0.02	0.03	0.06	0.12	0.24
0.1	0.01	0.01	0.02	0.04	0.08
0.05/	0.1/	0.2/	0.4/	0.8/	

4.2

3.2

NFF NFT

TG

" "

A

5

5.1

A

4

4.1

2

A

NFF

NFT

-

NFF NFT

A

A

A
MIS

A

2

	C	D
	C	D
	C	D
		D C
A		C D
C	D	

" "

5.2

MIS

" "

- 1 . J .
2001 3 8 - 9 + 12
- 2 . K D .
2012
- 3 . M . 2000
- 4 . M . 2004

41

1	CANopen	CAN	D .
	2008		
2			J .
	2006 4 89 - 92		
3	CANopen	DSP	J .
	2016 7 120 - 121		

- 4 CANopen Device Profile and Motion Control. CiA Draft Standard Proposal402 S . Version 4.02 2002
- 5 Copley Controls Corp. CANopen Programmer' s Manual S . Version 3 2006
- 6 . CANopen
J . 2018 32 2 11 - 14
- 7 . CANopen J .
2020 33 1 72 - 74



611731

9Tj 1.0219D8 0 TD (°)Tj 1.0219n8 0 TD ()Tj 1.0t8 0 TD (f)Tj 1.0221ì8 0 TD ()Tj 1.9}8 0 TD (\$)Tj 1.041 Tf 0 Tr68.830188 0 0 8.83

2021 - 09 - 24

1990 - 2012

CAREM	ACP100	2007	2017	2020	5	22
				RITM-200M		
	ACP100	2010	2012	Afrikantov OKBM		KLT-
2016			40S			
	2017	"	"	"	"	"
		2019	6	RITM-200M		"
	36	2022	2			
CAREM		CNEA	ACPR50S			
	2014			2015	12	
FCD	2019	11	ACPR50S			
		Techint	"	"	ACPR50S	
			2016	9		
2020	4	2022			11	
			"		ACPR50S	"
	1				ACPR50S	
	MW e		2019	4		
ACP100	100				3	
CAP200	200				24	15
DHR	400 MWt		2022			
CAREM	30					
RITM-200	50 × 2					
ELENA	68 kWe				2	
KARAT-45/100	45/100					
RUTA-70	70 MWt					
UNITHERM	6.6					
VK-300	250					
mPower	195 × 2					
NuScale	50 × 12					
SMR-160	160					
W-SMR	225					
DMS	300				3	HTR – PM
IMR	350				HTR-PM	
SMART	100					2006
UK-SMR	443					
		2	KLT- 40S	2006 – 2020		2012 12
RITM-200M	ACPR50S		KLT- 40S		FCD	HTR-PM
Afrikantov OKBM						
						2021

3

	MW _e
HTR-PM	210
GTHTR300	300
GT-MHR	285
MHR-T	205.5 × 4
MHR-100	25 ~ 87
A-HTR-100	50
HTMR-100	35
PBMR-400	165
SC-HTGR	272
Xe-100	35

300 SVBR-100
300
4 BREST-OD-
BREST-OD-
Rosatom
2018
Glavgoexpertiza
SVBR-100
2027
AKME
Rostechnadzor 2015 AKME
SVBR-100
2022
4

	MW _e
BREST-OD-300	300
SVBR-100	100
4S	10
LFR-AS-200	200
LFR-TL-X	5 ~ 20
SEALER	3
EM2	265
SUPERSTAR	120
WLFR	450

5 IMSR
IMSR
Terrestrial Energy
6
IMSR
CNSC
2018
Terrestrial Energy 2017
CNL
11
IMSR
12

20

	MW _e
5	
IMSR	190
CMSR	100 ~ 115
CA Waste Burner	20
ThorCon	250
FUJI	200
Stable Salt Reactor	37.5 × 8
LFTR	250
Mk1 PB-FHR	100
MCSFR	50 &

eVinci 6
Westinghouse Electric Corporation
2024 2019
3 1 290
2022 eVinci

	MW _e
6	
eVinci	0.2 ~ 15

4

4.1

6-7

120	30	5 - 6	2 - 3	4%	8	ACP100
					500	10
					2050	
					16 GW	160 ACP100

5		
"	"	28

4.2

Ux	2030	
8.8 GWe	2040	22.1
Rolls-Royce	2035	
5280		
	2050	
25%		
	20	
	20	20
	~ 30	
400 ~ 600		
2050		
200		
	2050	

1 IAEA. Status of Small and Medium Sized Reactor Designs