
Carbon Peaking and Carbon Neutrality :

Efficient and clean energy utilization of organic solid waste

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Professor, Vice Dean

Project leader of National Key
Research & Development Project

Expert Group member of
National Key Research &
Development Plan Projects

Chairman of Global WtERT
Council

■ Research fields

- Efficient and clean energy utilization of wastes

■ Academic performance

Responsible for more than 10 national-level projects including the National Key R&D Plan Project, National Natural Science Foundation of China (NSFC) projects, National Science and Technology Support Project tasks, and the 973/863 Program sub-project. Published over 50 articles and authorized more than 20 invention patents.

■ Awards

- National Science and Technology Progress Team Award (2016)
- Second Prize of State Scientific and Technological Progress Award (2014, 2017)
- First Prize for Zhejiang Science and Technology Progress Award (2012, 2015)

With Prof. Themelis



2012



2013



2014



2015



2016



2017



2018

2019 ICSW-HK

International Conference on Solid Waste 2019
Asia-Pacific Symposium on Energy Utilization of Municipal Solid Waste for a Sustainable Development of City



2019.11.14 Hangzhou International Expo Center

Safe, clean, efficient treatment of solid waste is essential for sustainable development

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“Lucid waters and lush mountains are invaluable assets” China is densely populated, the large amount and wide range of organic waste have caused serious land and water pollution. Safe, clean, and efficient treatment is necessary for the construction of ecological civilization.

MSW



Domestic waste : **0.2 billion tons**
Municipal sludge : **40 million tons**

Industrial solid waste



Industrial organic waste:
0.1 billion tons

Hazardous solid waste



46 categories and 479
species, **over 40 million tons**

Multiple types, complex components, and significant differences in morphological and physicochemical properties

Efficient and Clean Energy Utilization Technologies for Organic Solid Waste

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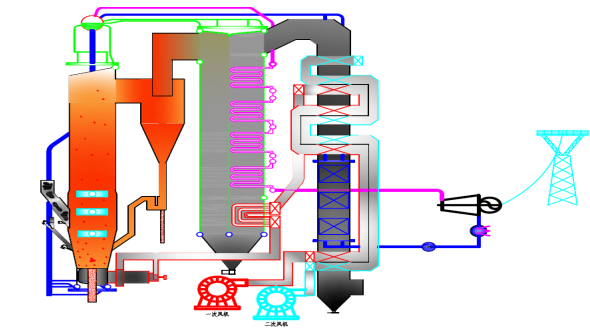
- ❑ **Mechanisms and key technologies for incineration**
 - ◆ MSW power generation technology
 - ◆ Drying and incineration technology for sludge
- ❑ **Mechanisms and key technologies for hierarchical thermal conversion**
 - ◆ Rotary segmented pyrolysis incineration
 - ◆ Small-scale oxygen controlled thermal conversion
 - ◆ Pyrolysis
- ❑ **Formation mechanism and control technology for key pollutants**
- ❑ **Advanced measurement technologies for incineration process**
 - ◆ Online rapid measurement of dioxins
 - ◆ Field parameters measurement of incineration process

Mechanisms and key technologies for MSW incineration

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Integrated power generation technology for mixed MSW by fluidized bed incineration

- Developed a full kit of waste incineration power generation equipment with independent intellectual property rights
- Built 43 domestic waste incineration power plants
- Leading the development of China's MSW incineration power generation industry with "Indigenous innovation" and "technological self-reliance"

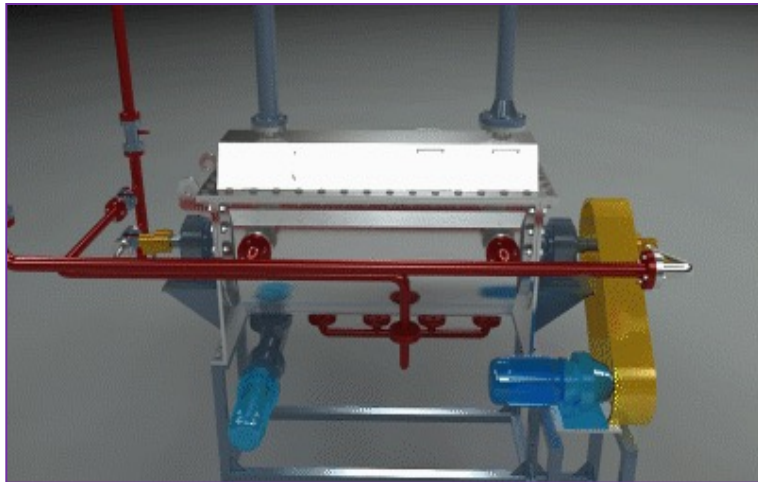
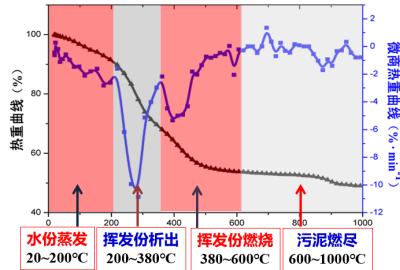
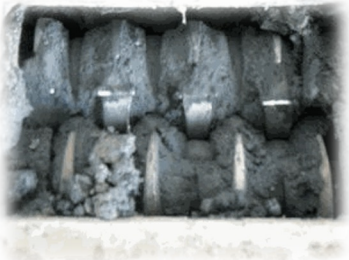


- The first MSW incineration power plant with fully independent intellectual property rights (put into operation in June 2002, annual power generation of 120 million kWh)
- **National Environmental Protection High tech Industrialization Demonstration Project**

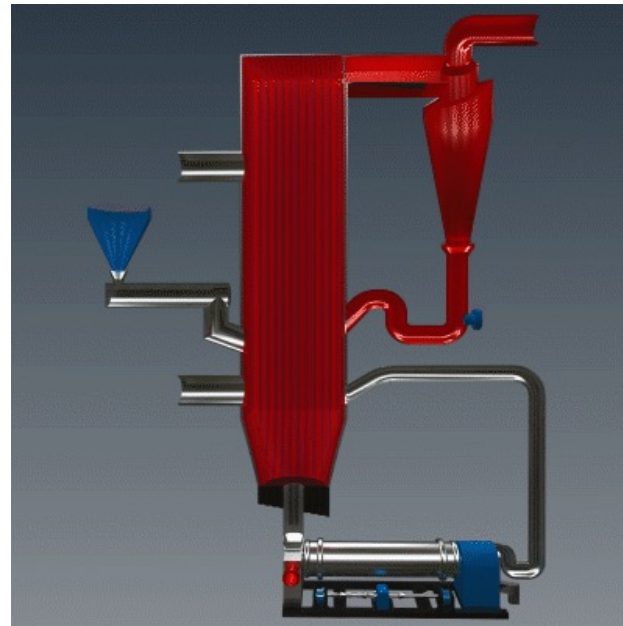
Mechanisms and key technologies for MSW incineration

Indirect drying incineration technology for urban sewage sludge

We have developed technology packages of agitated indirect thermal drying and complex cycle clean incineration power generation, put 112 sets into operation. It has a domestic market share of over 70%.



Agitated indirect thermal drying



Semi-adiabatic cycle fluidized bed incineration technology



Oxygen controlled thermal conversion of organic solid waste

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Rotary multi-stage pyrolysis incineration technology of hazardous waste

Has been applied in **49** hazardous waste pyrolysis and incineration disposal projects in **38 cities** in China (Is awarded the Second Prize of State Scientific and Technological Progress in 2017)



New Technology of Multi stage Pyrolysis Incineration: pyrolysis and incineration in kiln, gas phase space combustion, solid residue spouted rotating air distribution burn out. Achieved complete incineration of complex hazardous wastes.

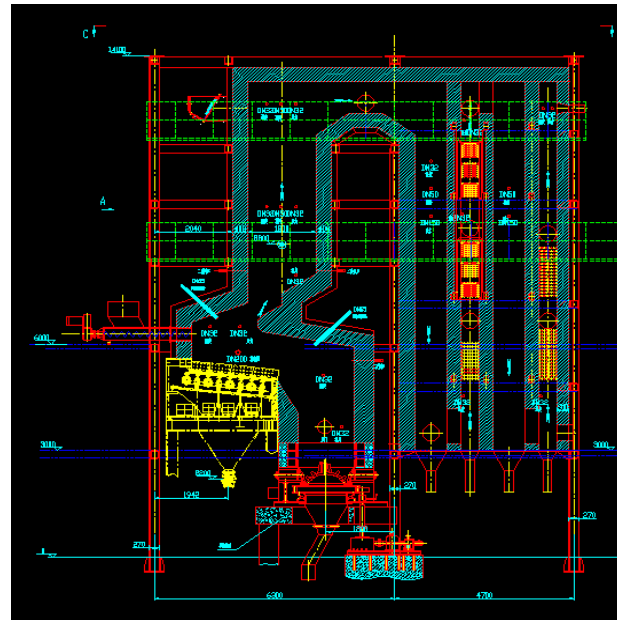
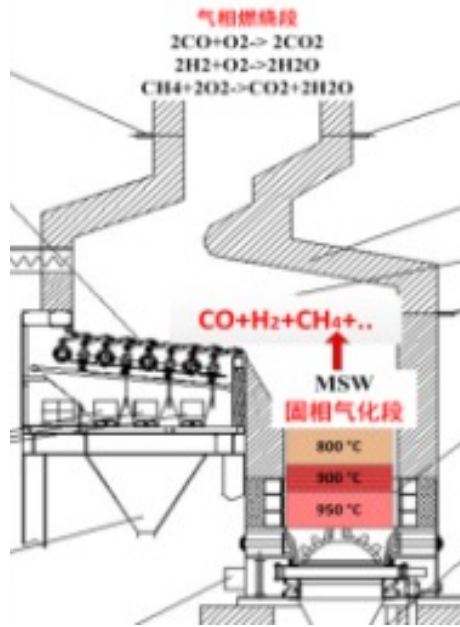
Oxygen controlled thermal conversion of organic solid waste

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Two-stage gasification-incineration technology for MSW

Based on a new pattern high-efficiency multiplex grate equipment of gasification and combustion, we have developed MSW thermal treatment technology suitable for rural and townlet areas.

(demonstration technique of The Belt and Road initiative International cooperation projects)



New pattern high-efficiency multiplex grate equipment of gasification and combustion

National Invention Patent(ZL 201210052901.6)

Pyrolysis is an emerging technology for high-value utilization of waste rubber and plastic

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- ❑ Thermoplastic accounts for about 94% of waste plastic, and is in the form of **physically mixed components**, leading to **difficulties for sorting and separation**.
- ❑ Pyrolysis oil is the key product of pyrolysis. Transforming waste plastics into **petrochemical products** through **pyrolysis** has higher atomic utilization efficiency.

Advantages of pyrolysis

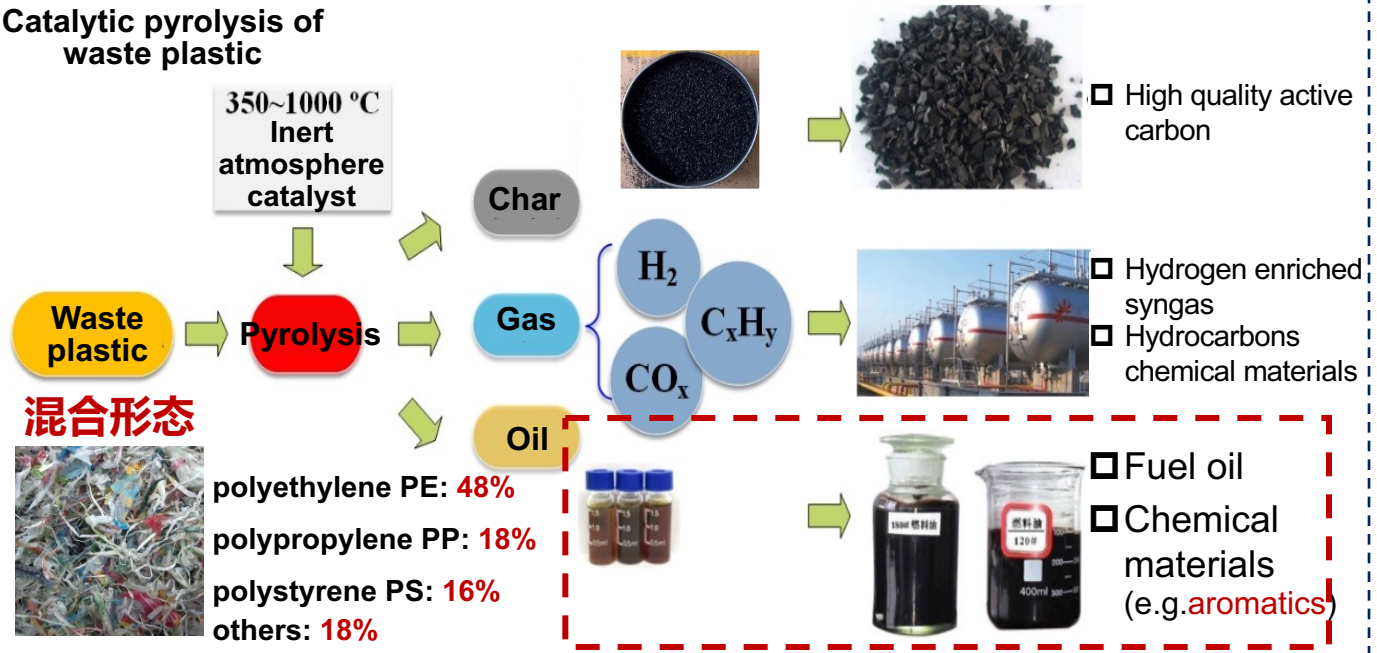
- ❑ Suitable for low-purity mixed feedstock
- ❑ High treatment capacity, high efficiency
- ❑ Low pollution, easy to control
- ❑ High products added-value



Features of waste plastic

- ❑ Complex components, difficulties in separation
- ❑ Low purity and high impurities concentration
- ❑ Resource utilization demand

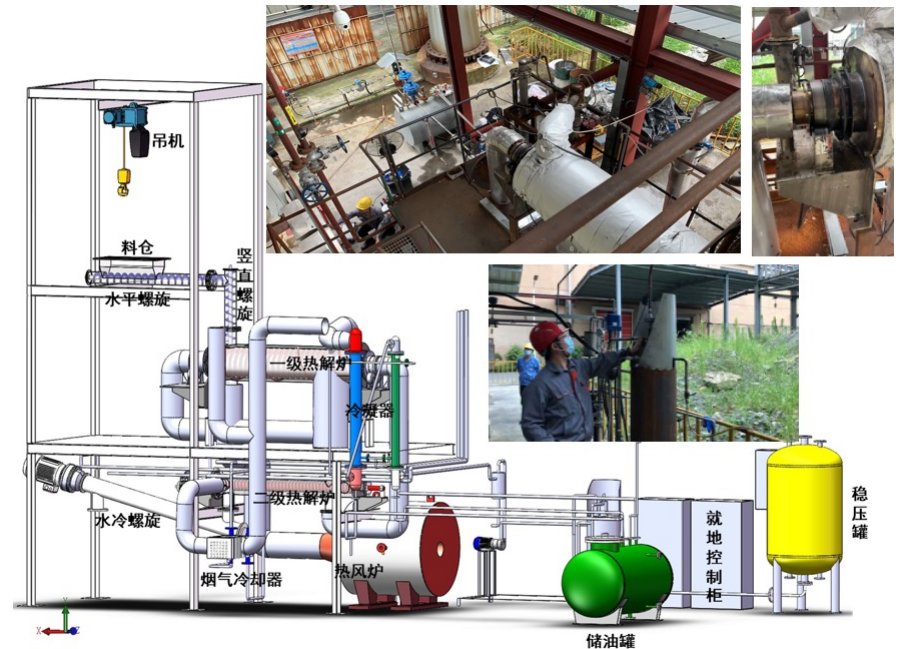
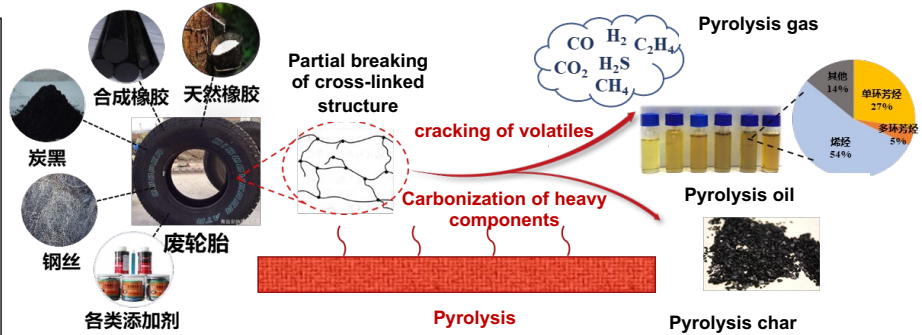
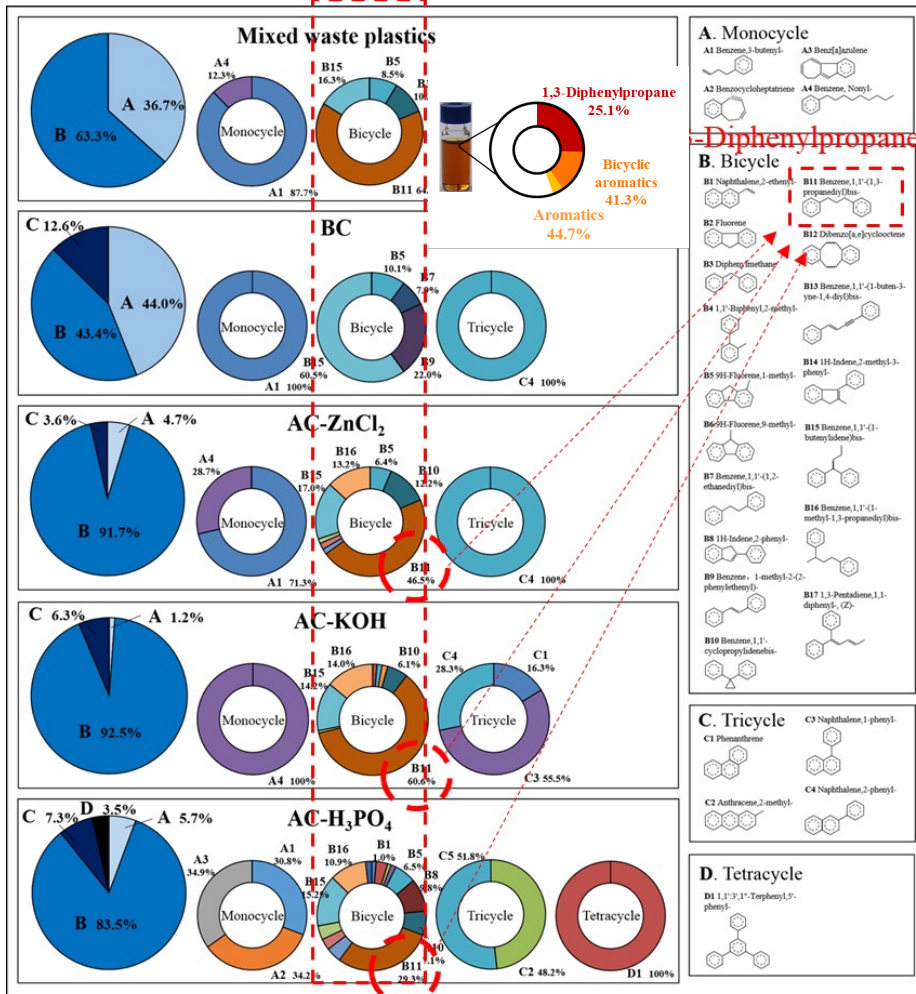
Catalytic pyrolysis of waste plastic



Oxygen controlled thermal conversion of waste rubber and plastic

Carbonization and pyrolysis for chemical materials

Bicyclic aromatic hydrocarbon

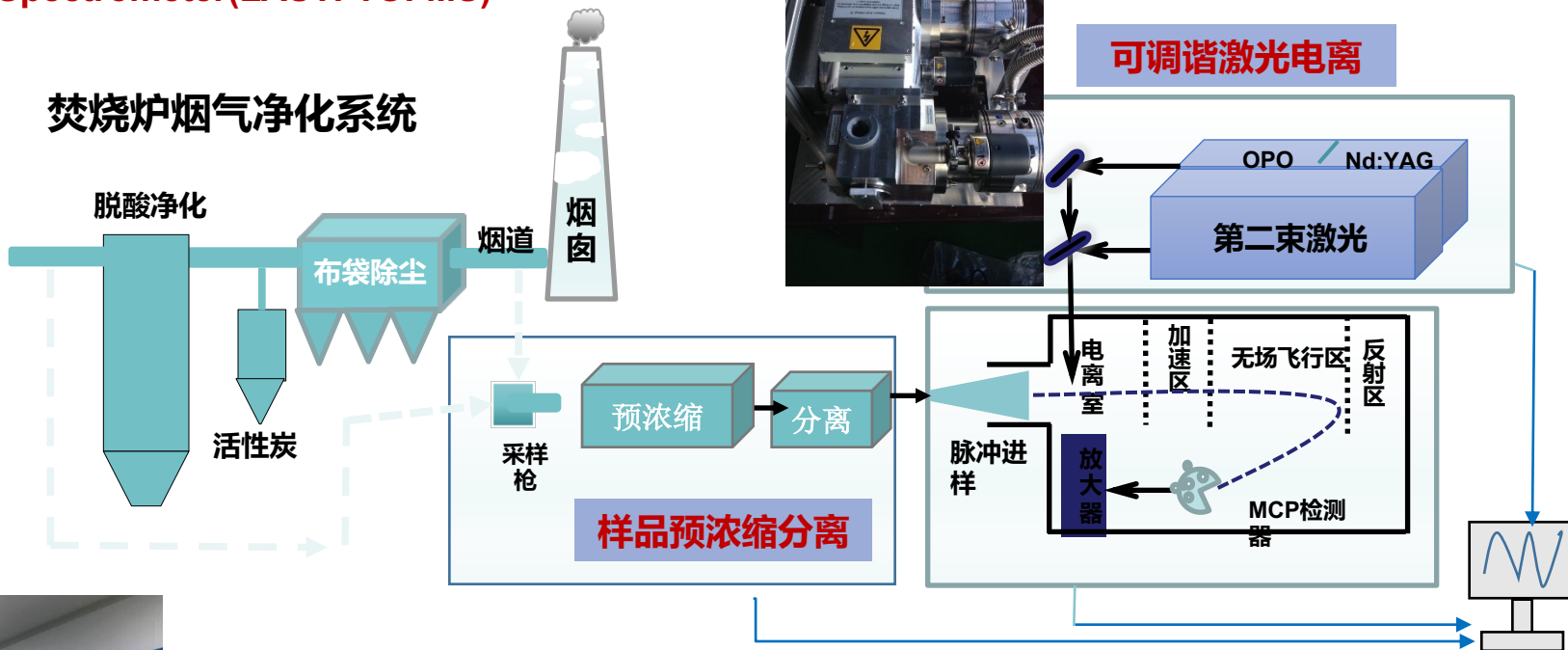


BTX from mixed waste plastic pyrolysis

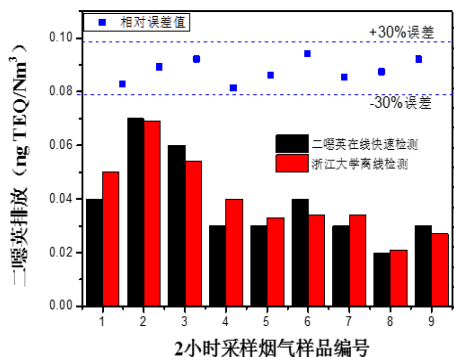
Waste tire pyrolysis

Advanced measurement technology for incineration process

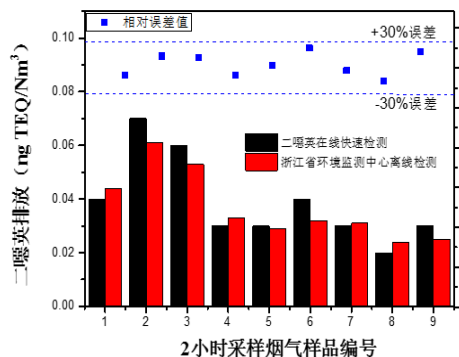
Laser Tunable Ionization – Time-of-Flight Mass Spectrometer(LASTI-TOFMS)



与浙江大学离线检测比对



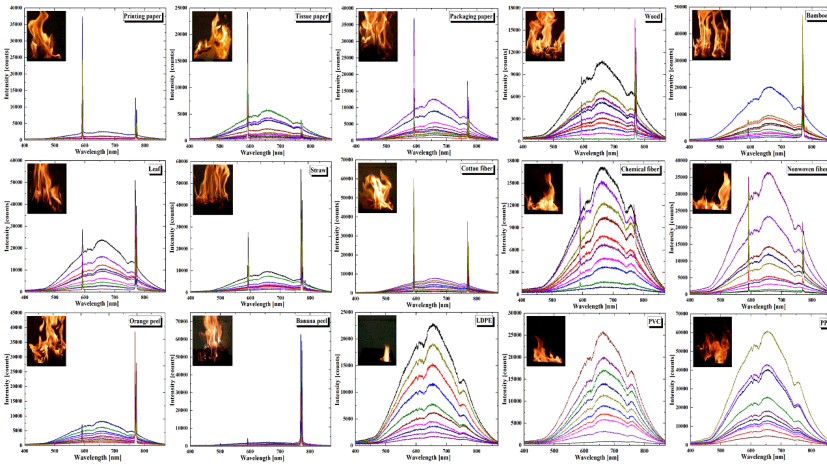
与浙江省环境监测中心离线检测比对



数据采集、模型计算、系统控制

The relative errors between results gained from this instrument and other offline methods are **lower than 30%**.

Intelligent Optimization Control of Incineration Process



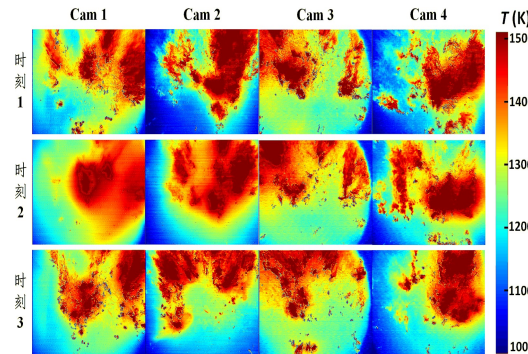
火焰的光谱发射率

$$I(\lambda) = \frac{\varepsilon(\lambda)c_1\lambda^{-5}}{\pi[\exp(c_2/(\lambda T)) - 1]}$$

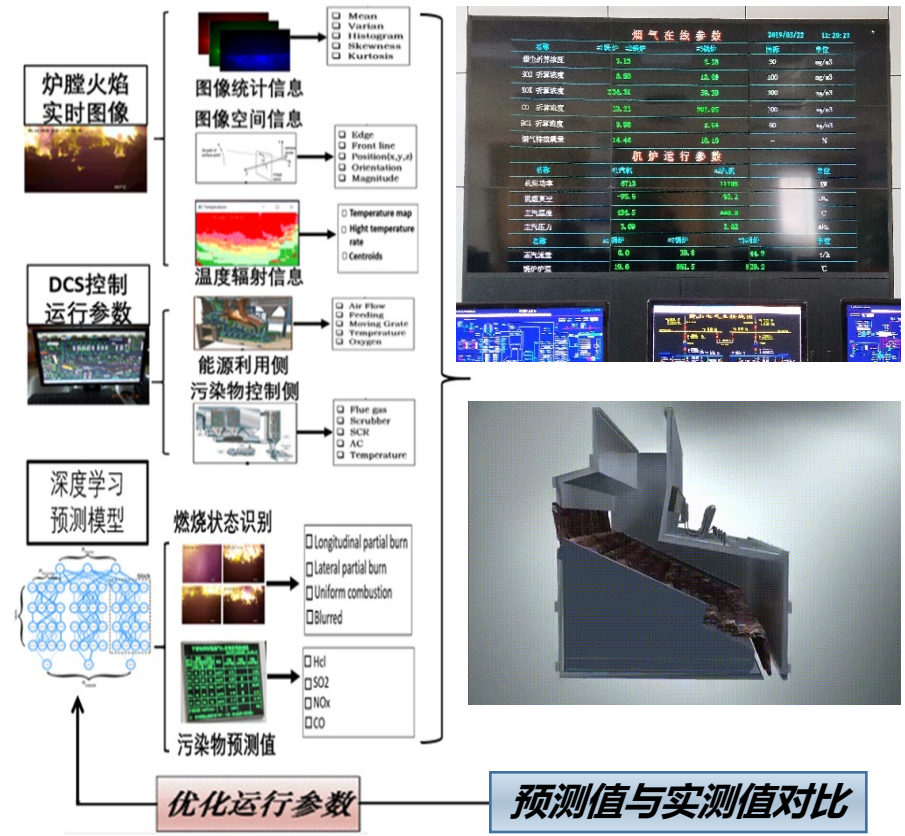
> 火焰的光谱发射率，也就是碳黑颗粒云团的光谱发射率，可如下表示：
 $\varepsilon(\lambda) = 1 - \exp(-\kappa X)$

$\kappa = M\lambda^{-1.23}$

与波长无关的系数

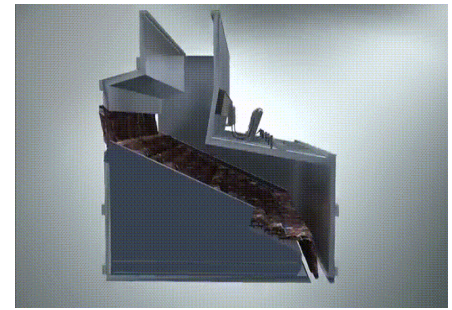


$$I(\lambda) = \frac{[1 - \exp(-M\lambda^{-1.23})]c_1\lambda^{-5}}{\pi[\exp(c_2/(\lambda T)) - 1]}$$



烟气在线参数				
氧量	21.50	21.50	21.50	%
氧量偏差	0.00	0.00	0.00	%
氧量报警	20.50	22.50	20.50	%
氧量报警	20.50	22.50	20.50	%
氧量报警	20.50	22.50	20.50	%
氧量报警	20.50	22.50	20.50	%

机炉运行参数				
炉膛温度	871.3	111.0	111.0	°C
炉膛压力	95.0	95.0	95.0	Pa
炉膛负压	95.0	95.0	95.0	Pa
炉膛压力	95.0	95.0	95.0	Pa
炉膛压力	95.0	95.0	95.0	Pa
炉膛压力	95.0	95.0	95.0	Pa

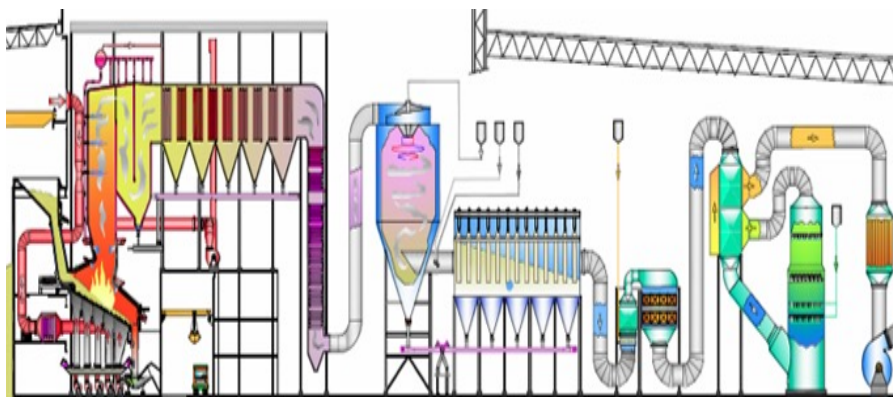


Multi data coupling incineration diagnose process

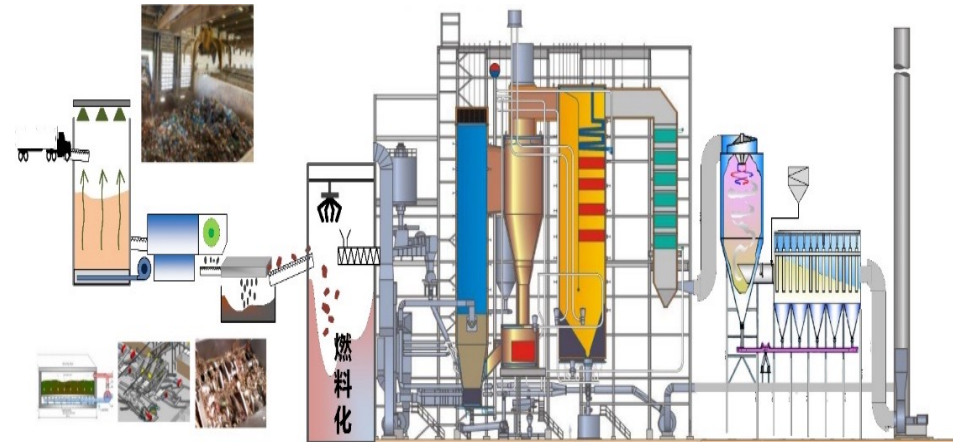
- Established dynamic indicators to characterize the incineration characteristics of organic solid waste
- Established multi data coupling incineration diagnose technology for organic solid incineration process

□ Key technologies and equipment for efficient, clean and stable incineration of organic solid waste

- ZJU , Ever Bright, CECEP, Jinjiang, ENFEI, etc.
- Development of co-incineration mechanisms and key technologies and equipment for multiple organic solid wastes
- Have constructed high-parameter grate incinerator power plant (900 t/d)
- Have constructed circulating fluidized bed power plant (800 t/d)



Air-cooled grate incinerator equipment with self-cleaning effect and large tilt angle



Circulating fluidized bed incinerator with high parameters

Fluidized bed MSW incineration power generation system with the highest parameters in China

- MSW fuel pretreatment technology with bio-drying + mechanical sorting: garbage truck + refuse warehouse + coarse crushing + drying bin + mechanical sorting + product warehouse ;
- Pretreatment equipment: treatment capacity of 1000 t/d for each line, RDF heating value of **2516kcal/kg**, granularity < 90 mm ;

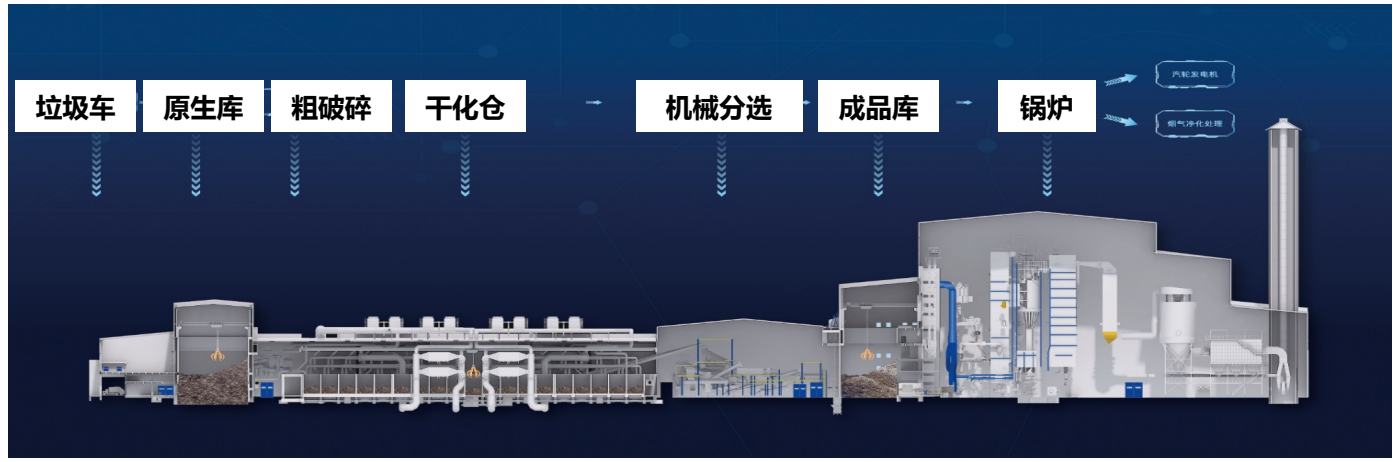


表 (-) 垃圾检测结果

样品编号	检测项目	单位	干重	湿基
LJ00209712017	含水率	%	/	14.57
	灰分	%	34.57	29.80
	挥发性	%	65.43	56.03
	碳	%	37.3	31.9
	氮	%	5.25	4.50
	硫	%	0.29	0.25
	热值高位	MPJ/kg	16.63	/
	热值低位	Cal/g	3978	/
	热值高位	MPJ/kg	/	12.91
	热值低位	Cal/g	/	3086

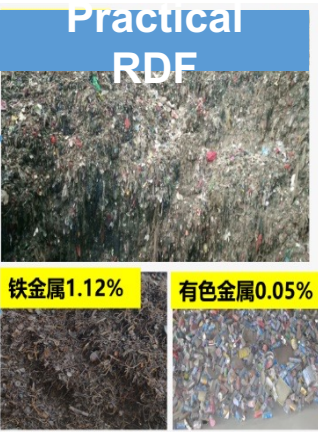
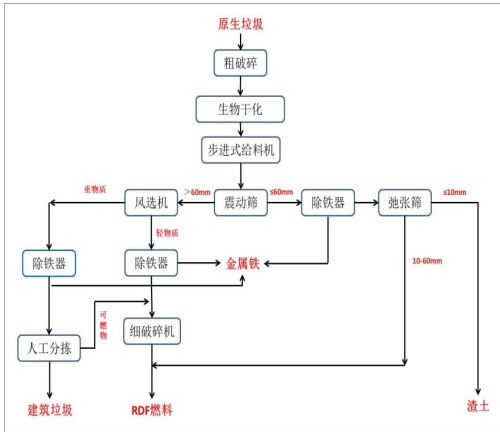
备注: 应客户要求本报告用于提供非标准单位 Cal/g.

***** 盖章处 *****

编制人: [Signature] 审核人: [Signature] 批准人: [Signature]

检测日期: 2023年7月29日

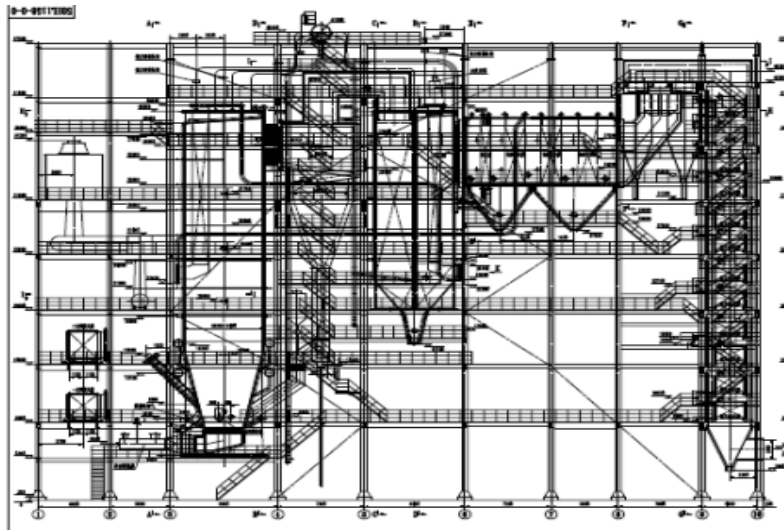
检测单位: 浙江浙大环能检测有限公司 (检验检测机构章)



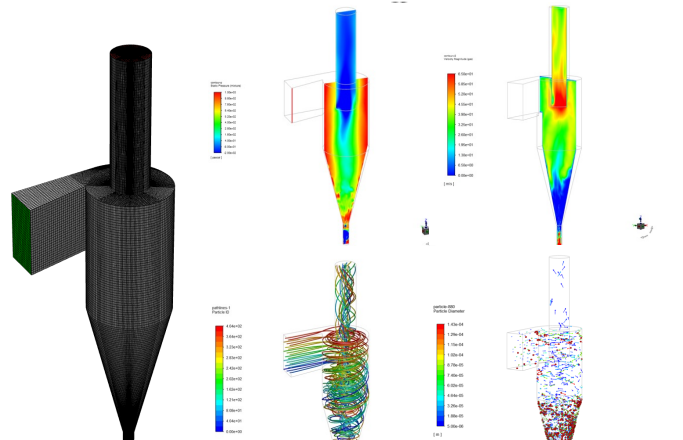
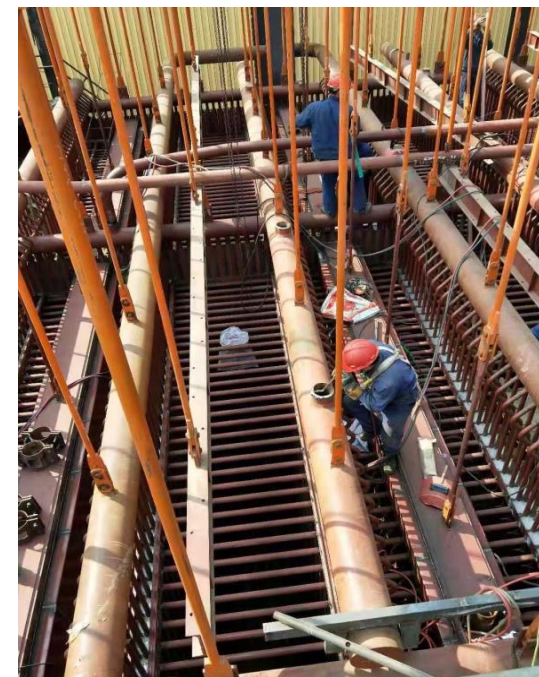
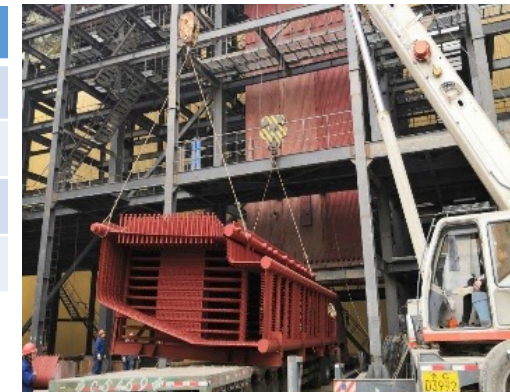
- 铁金属1.12%
- 有色金属0.05%
- 砖头等13.96%
- 腐殖土等17.5%

Fluidized bed MSW incineration power generation system with the highest parameter in China

- Domesticated circulating fluidized bed MSW incinerator (1000t/d) with the **highest temperature (520°C) and pressure (7.9MPa)** ;
- Co-incineration ratio of industrial waste and biogas residue **>25%** ;



Item	Value
Capacity (t/d)	1000
Steam temperature (°C)	520
Steam pressure (MPa)	7.9
Excess air coefficient	1.3



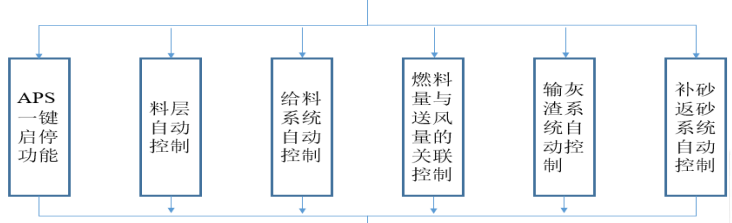
Optimization of structure design

Fluidized bed MSW incineration power generation system with the highest parameter in China

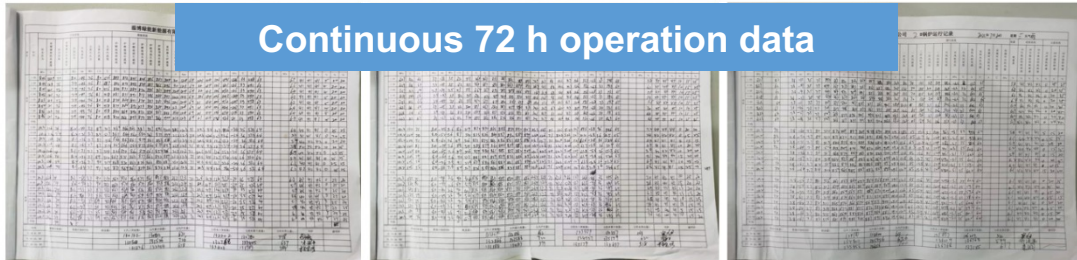
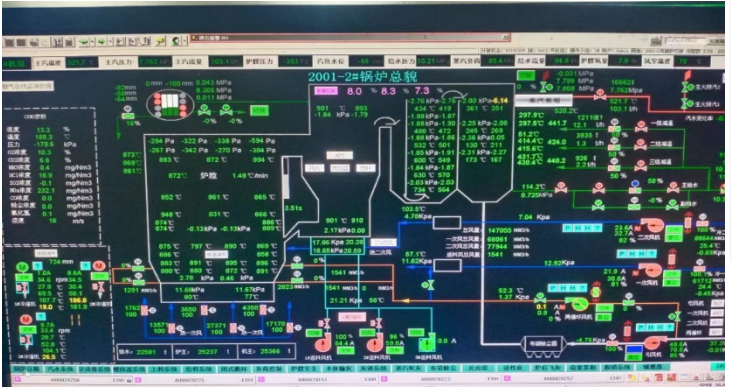
- Flue gas purification process : SNCR + bag dust collector + SDA semi-dry and dry desulphurization + mechanical ash-transferring +fly ash solidification system; flue gas pollutant emissions below EU 2010 emission standards, the TEQ of dioxins **0.0027 TEQ ng/Nm³** ;
- Started operations on Nov. 10th, 2021. Up to Oct. 30th, 2022, have treated 0.64 million tons MSW, supplied **188.5 million kWh** of energy to the grid, realized a new output value of **171.03 million yuan**.

Automatic intelligent control

2020年课题组对临淄示范工程锅炉自动控制逻辑程序进行完善优化，从单一的设备启停，到辅助系统的顺序控制，再到各个系统间的协调控制，直至最终的负荷自动控制程序，并最终形成锅炉整个的一键启停。



锅炉APS一键启停、联锁保护、自动吹扫、自动点火、投料控制、FSSS等锅炉安全保护已实现功能并正常投入，实现了锅炉的自动控制功能。



Continuous 72 h operation data

山东鲁南热电有限公司

文件号: LSHN-TH-0001
发布日期: LSHN-TH-2022-0107

一、 锅炉性能测试报告

测试序号	测试日期	测试地点	测试人员
001	2022.01.12	临淄示范工程	李强
002	2022.01.13	临淄示范工程	李强
003	2022.01.14	临淄示范工程	李强
004	2022.01.15	临淄示范工程	李强
005	2022.01.16	临淄示范工程	李强
006	2022.01.17	临淄示范工程	李强
007	2022.01.18	临淄示范工程	李强
008	2022.01.19	临淄示范工程	李强
009	2022.01.20	临淄示范工程	李强
010	2022.01.21	临淄示范工程	李强
011	2022.01.22	临淄示范工程	李强
012	2022.01.23	临淄示范工程	李强
013	2022.01.24	临淄示范工程	李强
014	2022.01.25	临淄示范工程	李强
015	2022.01.26	临淄示范工程	李强
016	2022.01.27	临淄示范工程	李强
017	2022.01.28	临淄示范工程	李强
018	2022.01.29	临淄示范工程	李强
019	2022.01.30	临淄示范工程	李强
020	2022.01.31	临淄示范工程	李强

测试结论: 锅炉性能良好, 各项指标均符合设计要求。

测试人员: 李强 (签字)

审核人员: 李强 (签字)

批准人员: 李强 (签字)

日期: 2022.01.31

Boiler performance test report

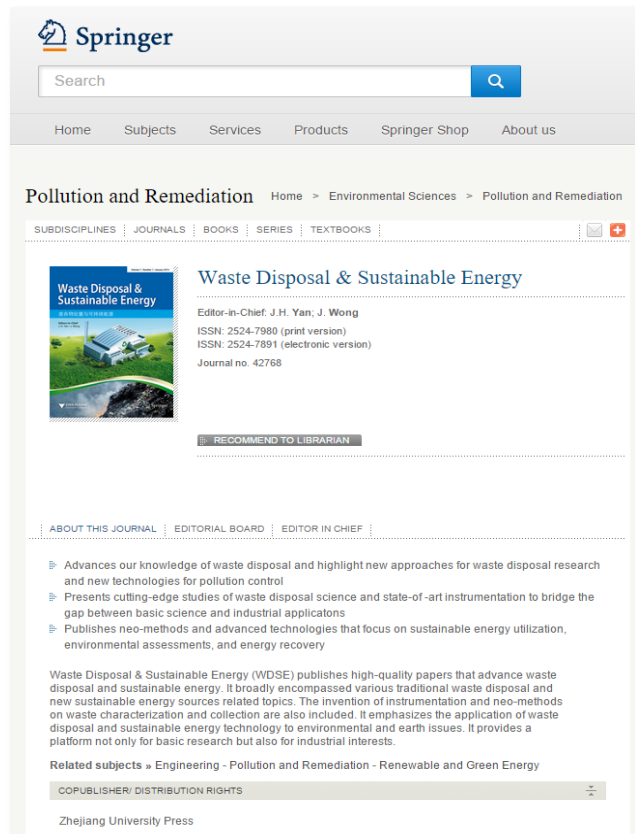


Editor-in-chef : Jianhua Yan

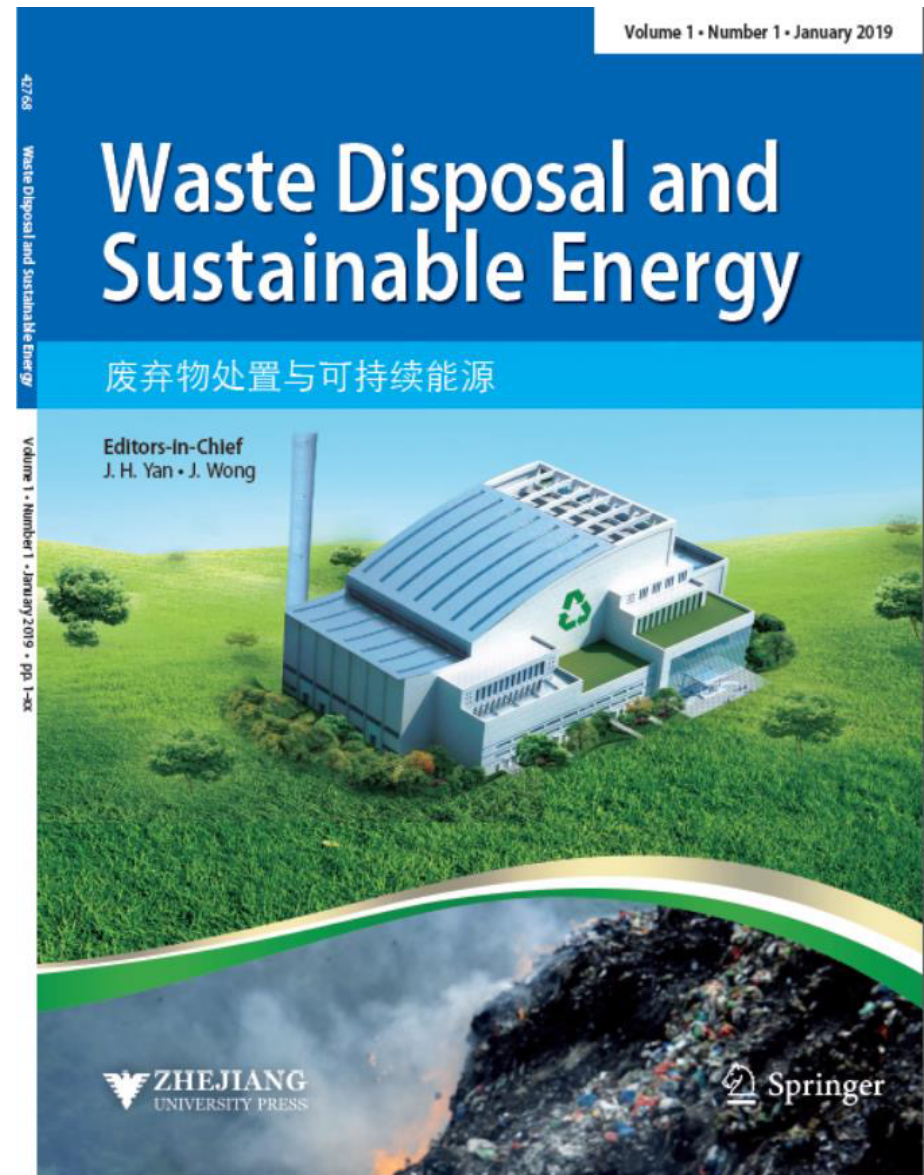
ISSN Electronic: 2524-7891

ISSN Paper: 2524-7980

Selected as a High Starting Point New Publication Project for the 2020 Excellent Action Plan of Chinese Science and Technology Journals (30 in total)



The screenshot shows the Springer website interface for the journal 'Waste Disposal & Sustainable Energy'. At the top, there is a search bar and navigation links for Home, Subjects, Services, Products, Springer Shop, and About us. Below this, the breadcrumb trail reads 'Pollution and Remediation > Home > Environmental Sciences > Pollution and Remediation'. A menu bar includes 'SUBDISCIPLINES', 'JOURNALS', 'BOOKS', 'SERIES', and 'TEXTBOOKS'. The main content area features a thumbnail of the journal cover, the title 'Waste Disposal & Sustainable Energy', and the Editor-in-Chief 'J. H. Yan, J. Wong'. It also lists the ISSN for both print (2524-7980) and electronic (2524-7891) versions, along with the journal number 42768. A 'RECOMMEND TO LIBRARIAN' button is present. At the bottom, there are links for 'ABOUT THIS JOURNAL', 'EDITORIAL BOARD', and 'EDITOR IN CHIEF'. A list of journal features includes: 'Advances our knowledge of waste disposal and highlight new approaches for waste disposal research and new technologies for pollution control', 'Presents cutting-edge studies of waste disposal science and state-of-art instrumentation to bridge the gap between basic science and industrial applications', and 'Publishes neo-methods and advanced technologies that focus on sustainable energy utilization, environmental assessments, and energy recovery'. A descriptive paragraph states that the journal publishes high-quality papers on waste disposal and sustainable energy, covering traditional and new sustainable energy sources. Related subjects include 'Engineering - Pollution and Remediation - Renewable and Green Energy'. The footer identifies the copublisher as Zhejiang University Press.



The journal cover features a blue header with the title 'Waste Disposal and Sustainable Energy' in large white font. Below the title is the Chinese translation '废弃物处置与可持续能源'. The cover art depicts a modern industrial facility with a large green recycling symbol on its side, set against a backdrop of green hills and a clear sky. In the foreground, a large pile of waste is shown, with a green and white curved graphic element separating it from the rest of the cover. The top right corner indicates 'Volume 1 • Number 1 • January 2019'. The left side of the cover has vertical text: '42768 Waste Disposal and Sustainable Energy' and 'Volume 1 • Number 1 • January 2019 • pp. 1-xx'. The Editors-in-Chief are listed as 'J. H. Yan • J. Wong'. The Springer logo is in the bottom right corner, and 'ZHEJIANG UNIVERSITY PRESS' is in the bottom left corner.

THANK YOU

