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

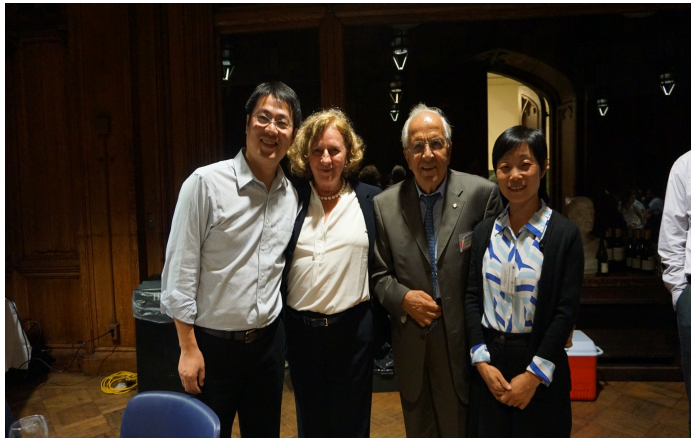
2013

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

"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

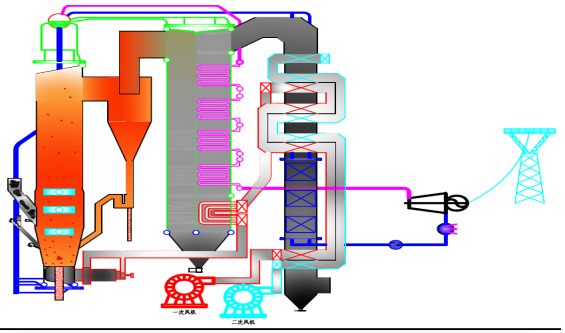
Efficient and Clean Energy Utilization Technologies for Organic Solid Waste

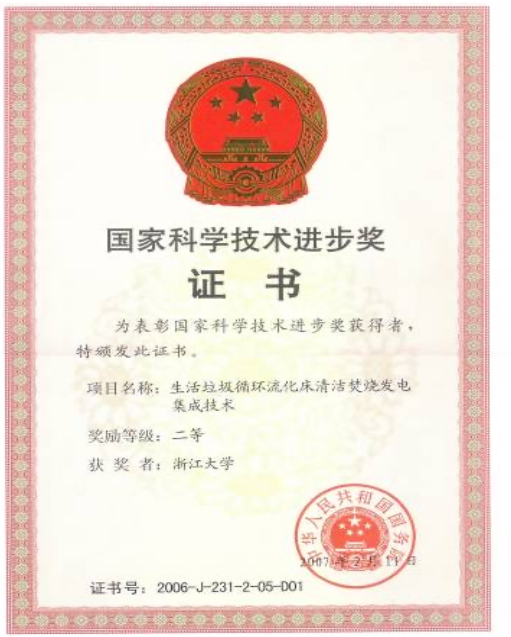
- Mechanisms and key technologies for incineration
  - MSW power generation technology
  - Drying and incineration technology for sludge
- Mechanisms and key technologies for hierarchical thermal conversion
  - Rotary segmented pyrolysis incineration
  - Small-scale oxygen controlled thermal conversion
  - 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

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"



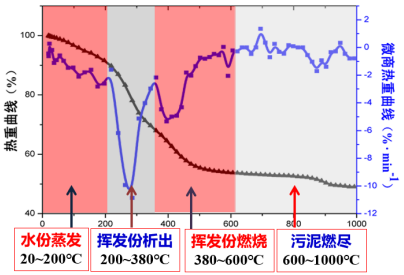


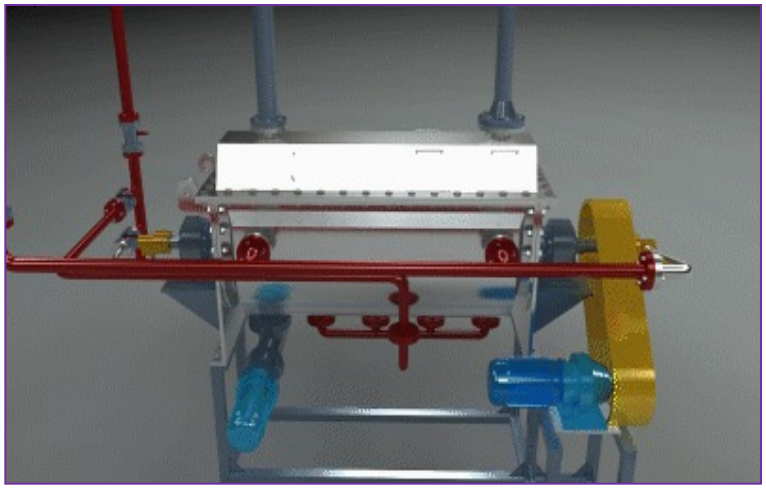
- The first MSW incineration power plant with fully independent intellectual property rights (put into operation in June 2002, annual power generation of 120 million kWh)
- National Environmental Protection High tech Industrialization Demonstration Project

Mechanisms and key technologies for MSW incineration

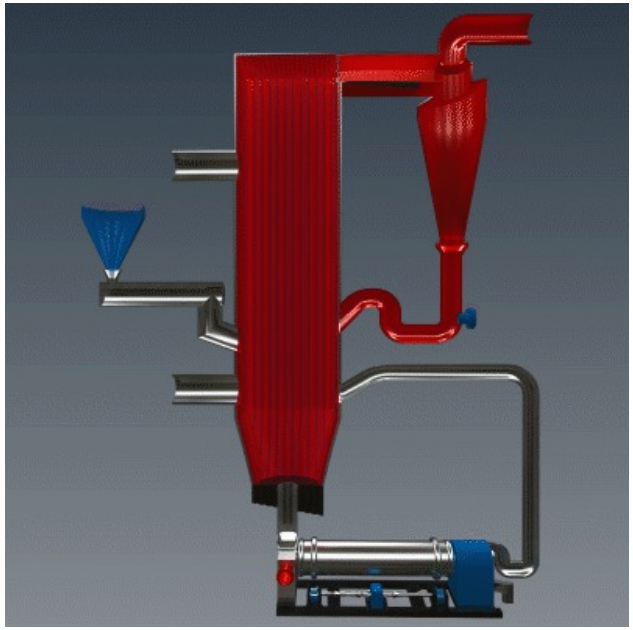
Indirect drying incineration technology for urban sewage sludge

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

- **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)


国家科学技术进步奖

证 书

为表彰国家科学技术进步奖获得者，特颁发此证书。

项目名称：危险废物回转式多段热解焚烧及污染物协同控制关键技术

奖励等级：二等

获 奖 者：浙江大学

2017年12月6日

证书号：2017-J-231-2-05-D01

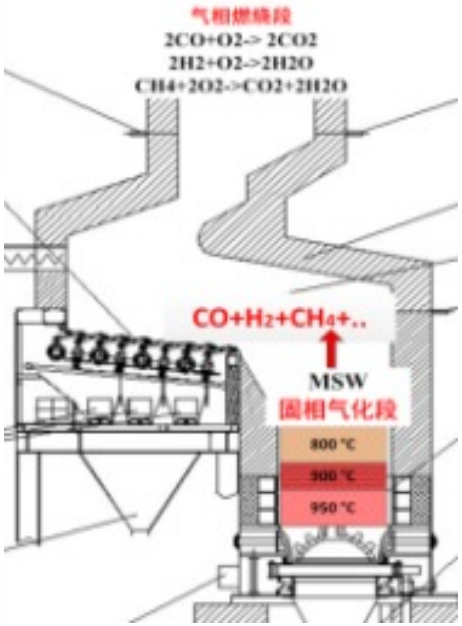
New Technology of Multi stage Pyrolysis Incineration: pyrolysis and incineration in kiln, gas phase space combustion, solid residue spouted rotating air distribution burn out. Achieved complete incineration of complex hazardous wastes.

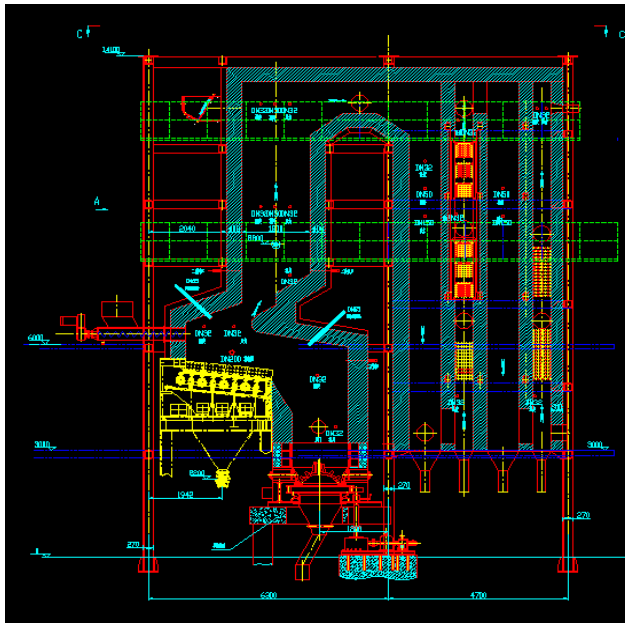
Oxygen controlled thermal conversion of organic solid waste

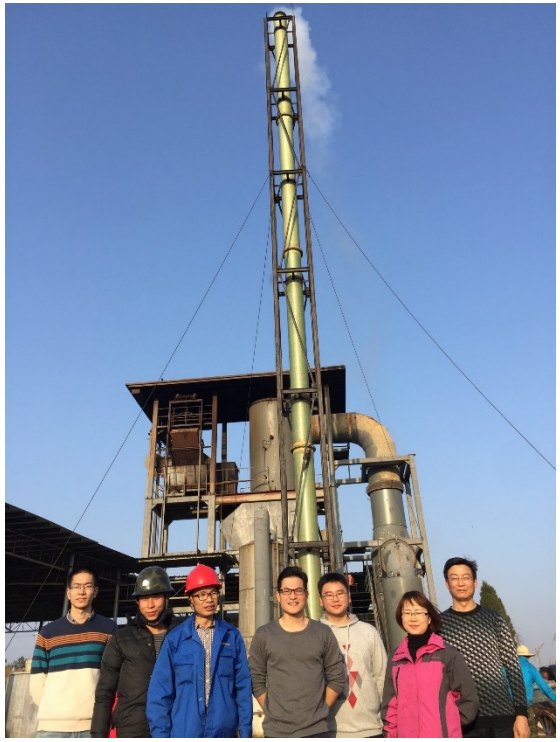
- **Two-stage gasification-incineration technology for MSW**

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

- 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

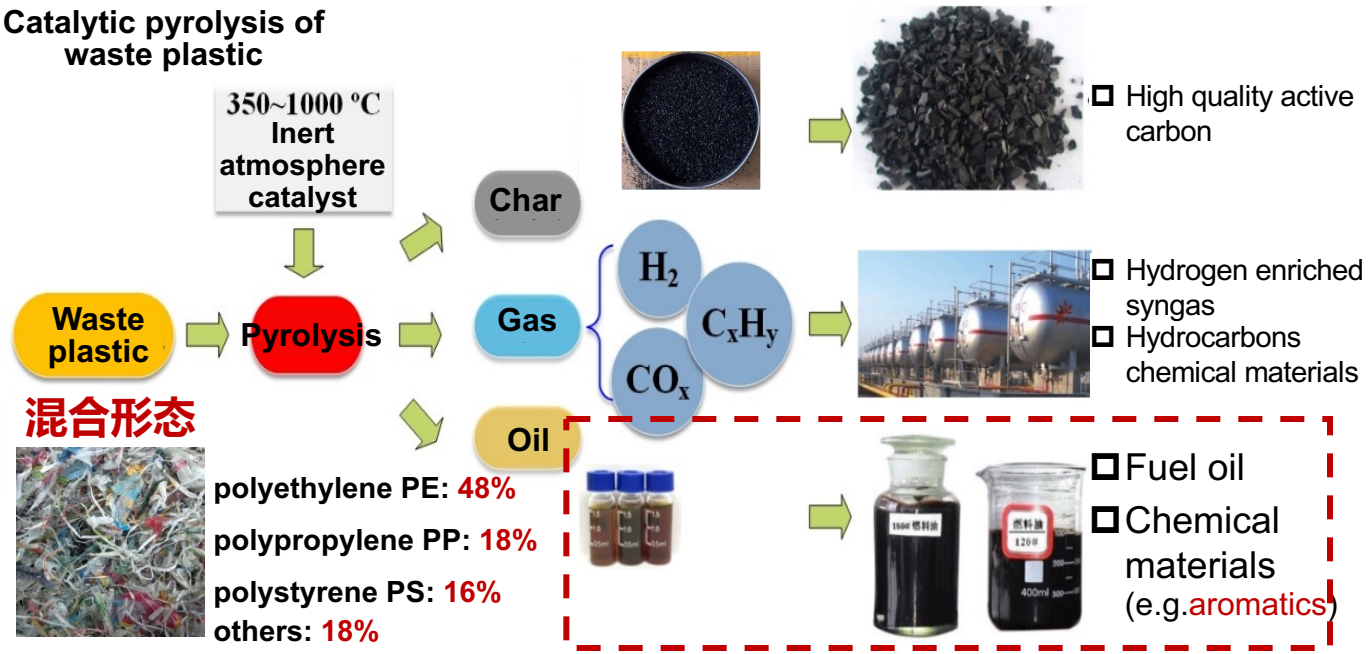
- Suitable for low-purity mixed feedstock
- High treatment capacity, high efficiency
- Low pollution, easy to control
- High products added-value

suitable

Features of waste plastic

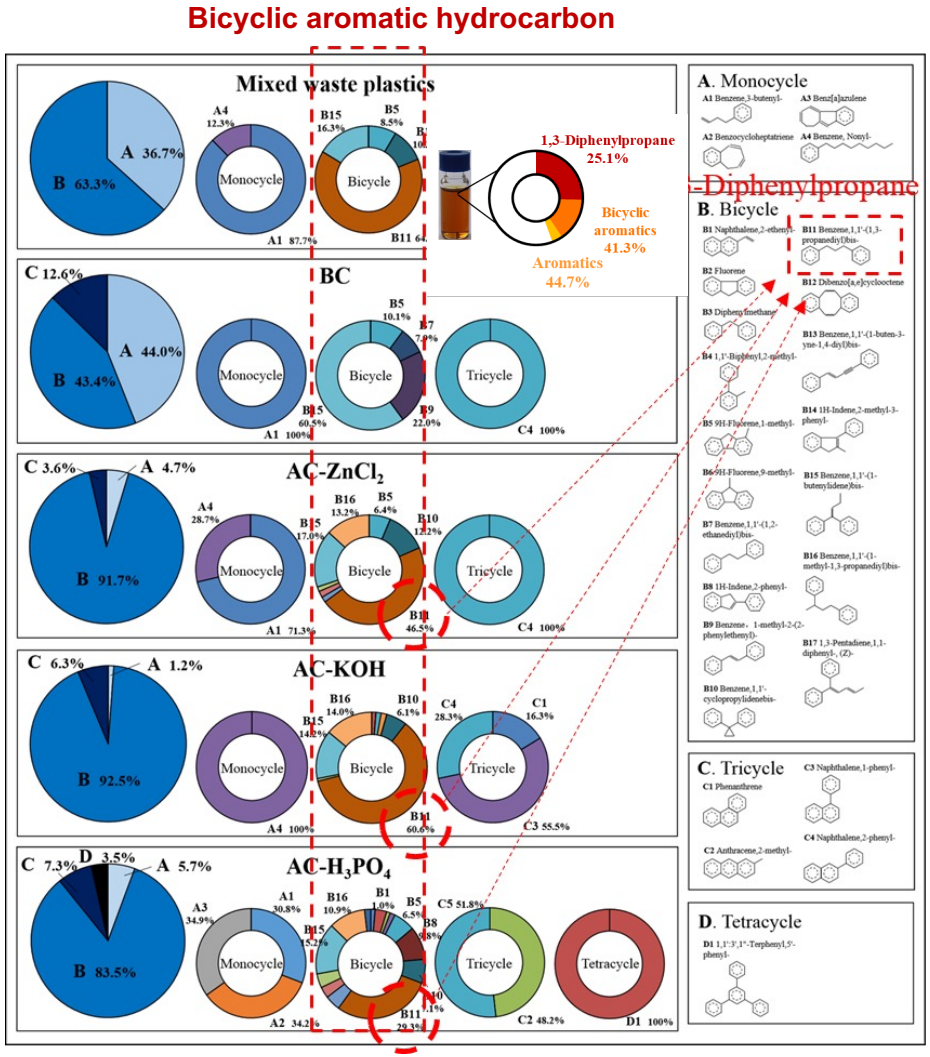
- Complex components, difficulties in separation
- Low purity and high impurities concentration
- Resource utilization demand

Catalytic pyrolysis of waste plastic

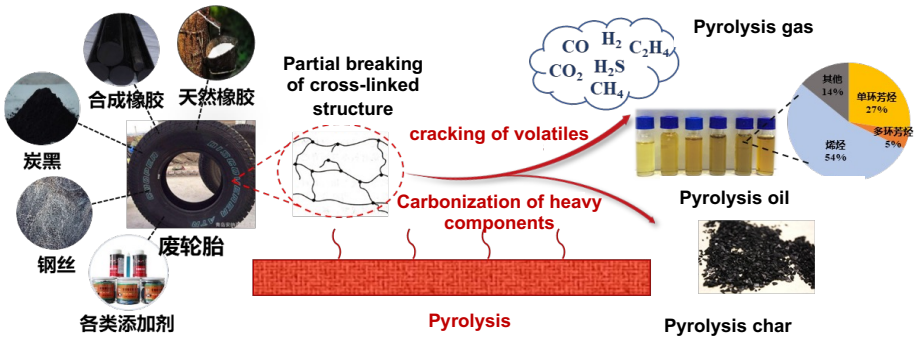


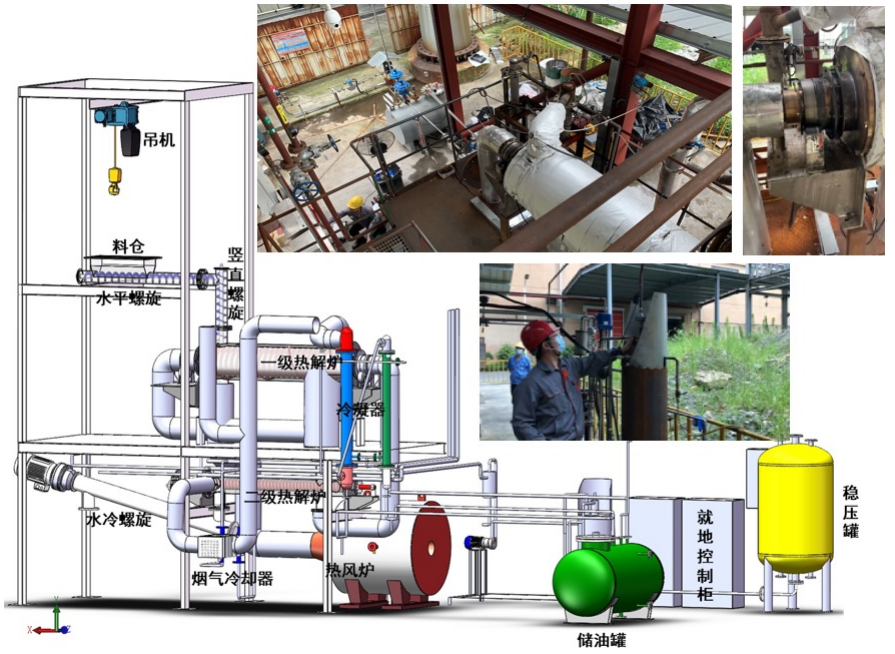
Oxygen controlled thermal conversion of waste rubber and plastic

Carbonization and pyrolysis for chemical materials



BTX from mixed waste plastic pyrolysis

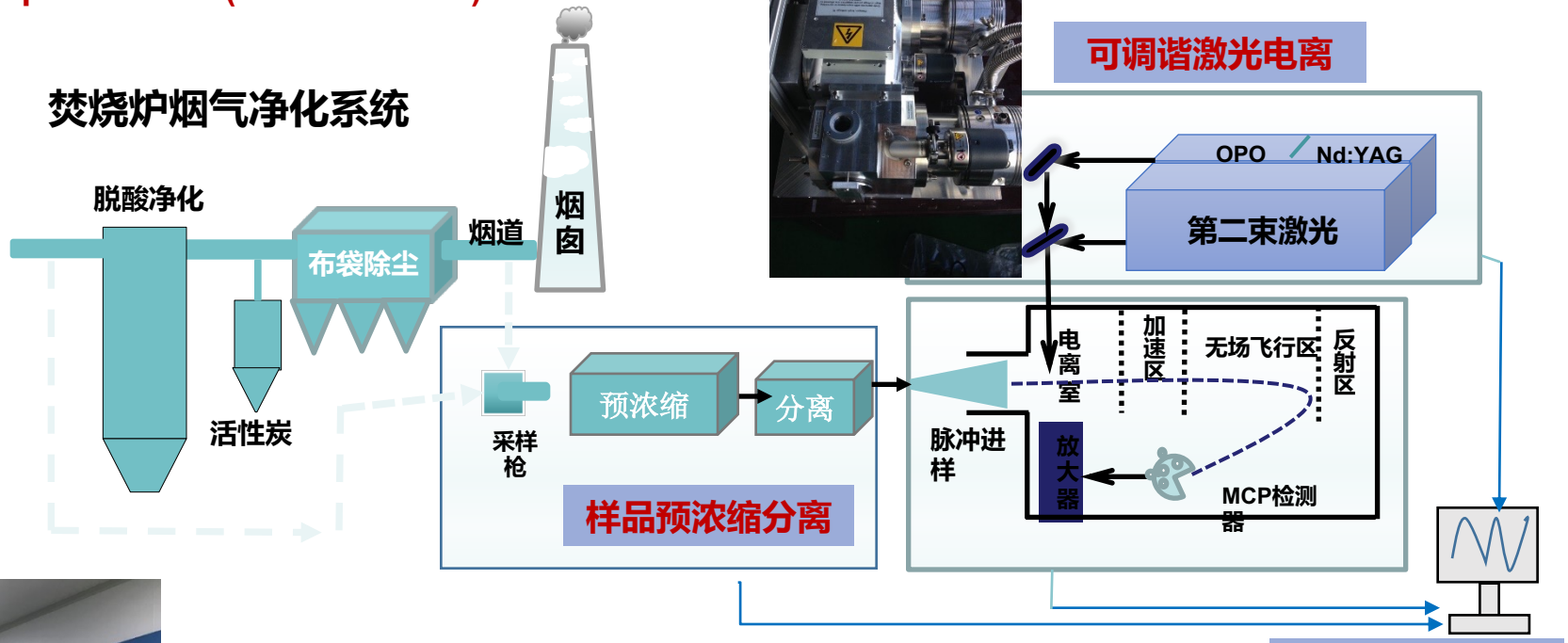


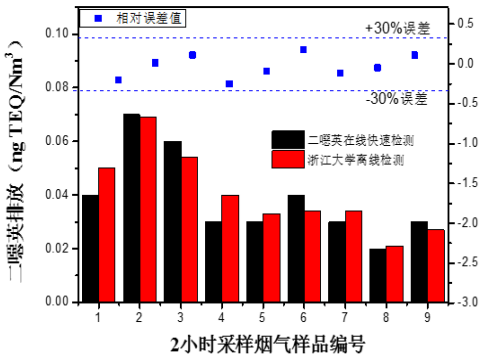


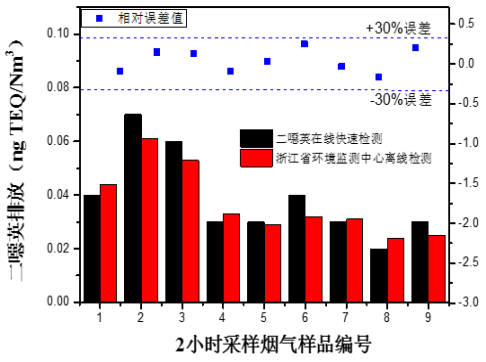
Waste tire pyrolysis

Advanced measurement technology for incineration process

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



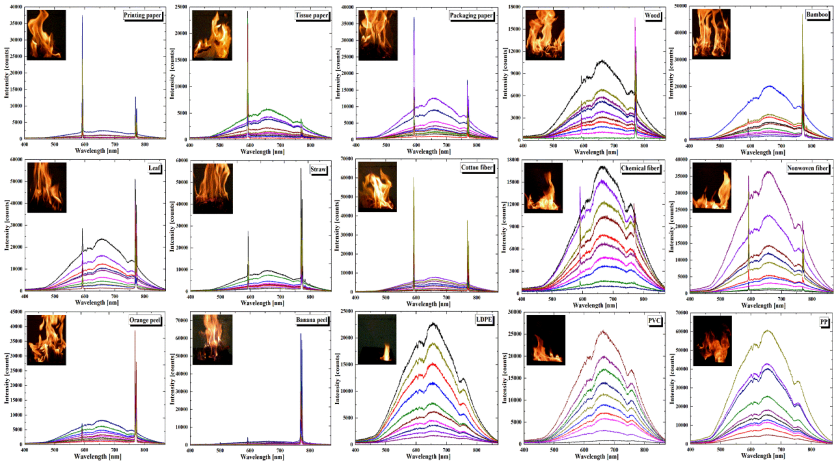




数据采集、模型计算、系统控制

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：

$$\varepsilon(\lambda)=1-\exp(-\kappa X)$$

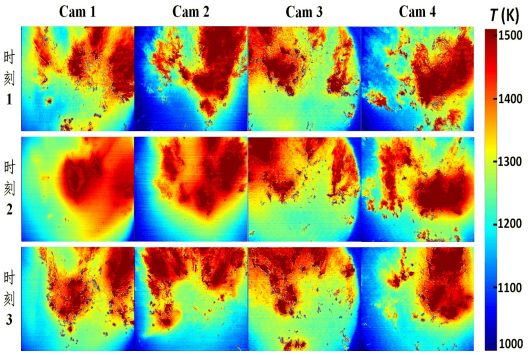
光程长度

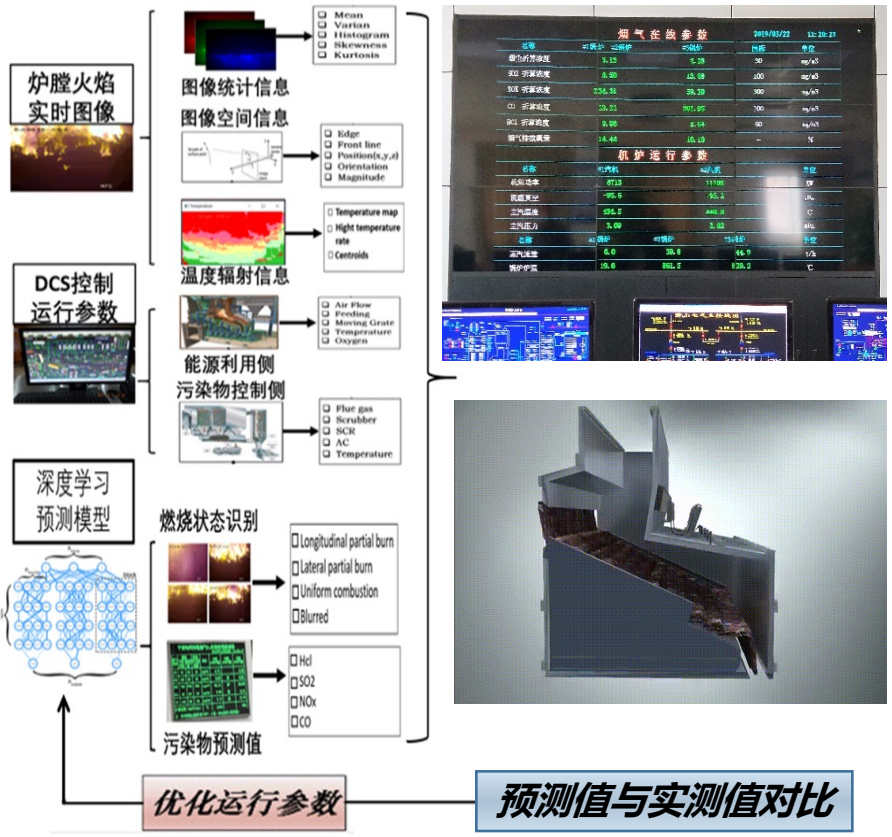
$$\kappa=M\lambda^{-1.23}$$

吸收系数

与波长无关的系数

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



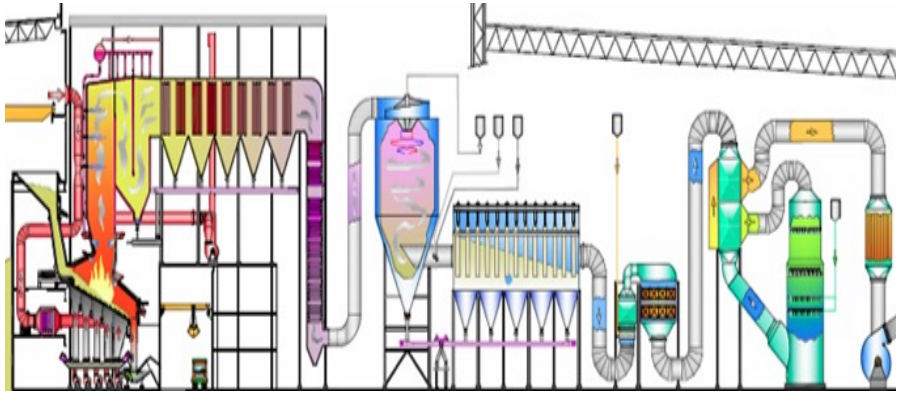


Multi data coupling incineration diagnose process

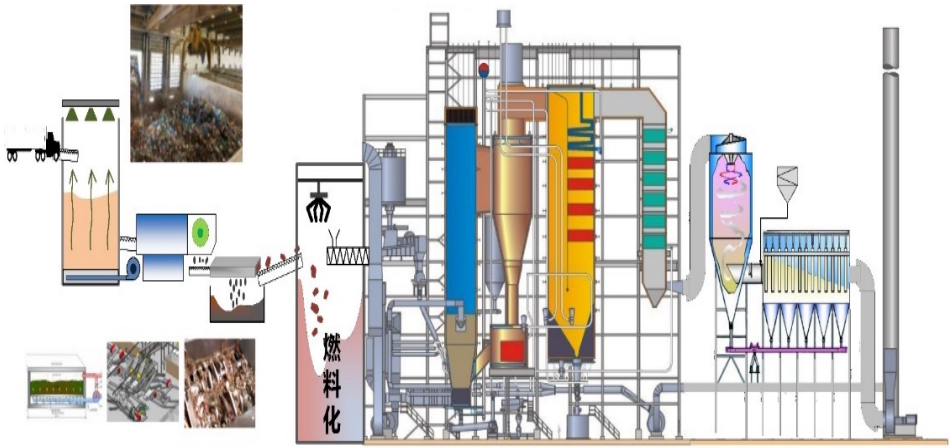
- **Established dynamic indicators to characterize the incineration characteristics of organic solid waste**
- **Established multi data coupling incineration diagnose technology for organic solid incineration process**

National Key R&D Plan Project

- **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)



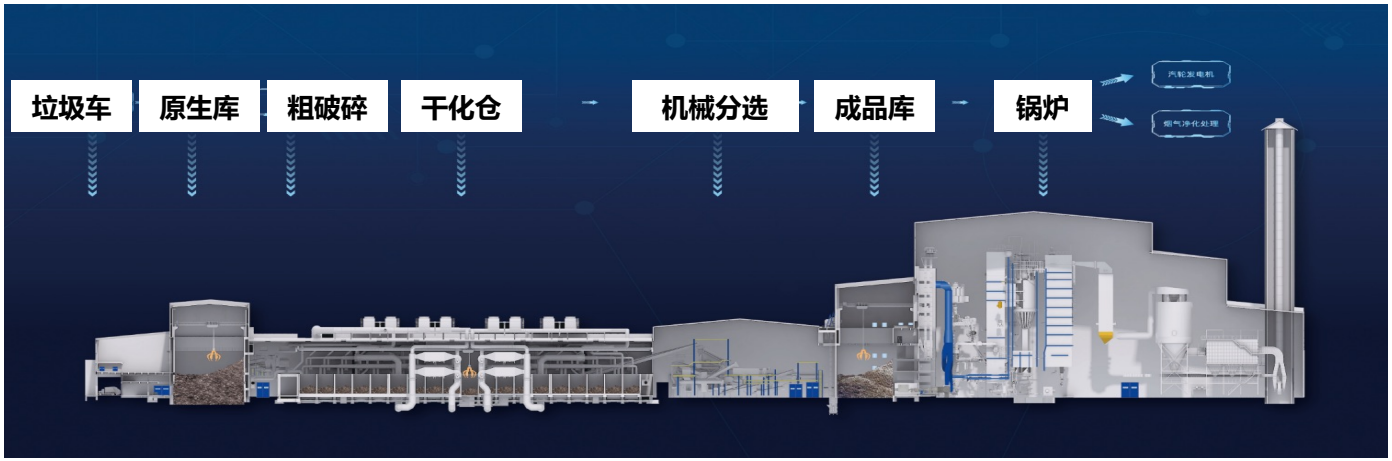
Air-cooled grate incinerator equipment with self-cleaning effect and large tilt angle



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（一）垃圾检测结果

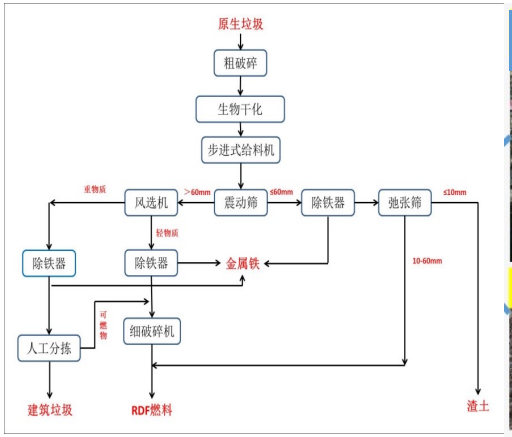
样品编号	检测项目	单位	干基	湿基
LJ20220712017	含水率	%	/	14.37
	灰分	%	34.57	29.60
	可燃物	%	65.43	56.03
	碳	%	37.3	31.9
	氢	%	5.25	4.50
	硫	%	0.29	0.25
	恒容高位发热量	MJ/kg	16.63	/
		Cal/g	3978	/
	恒容低位发热量	MJ/kg	/	12.91
		Cal/g	/	3086

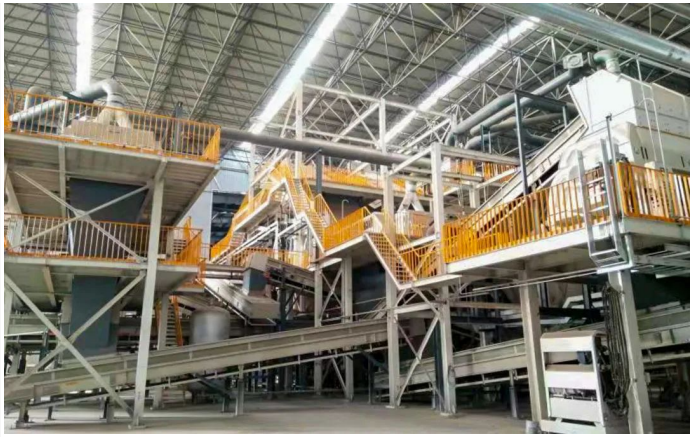
备注：按客户要求本报告干使用基特单位 Cal/g。

**** 报告结束 ****

编制人： 审核人： 批准人： 批准日期：2022年7月18日

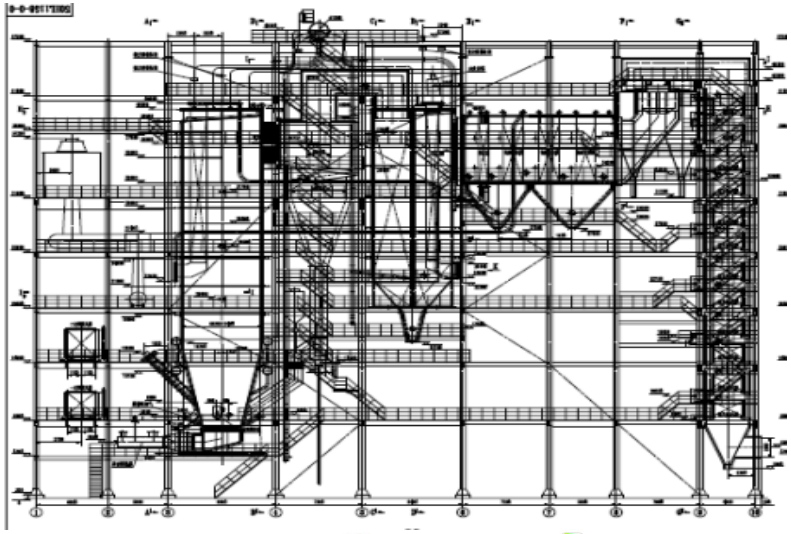
浙江嘉达环境新材料有限公司（检验检测专用章）



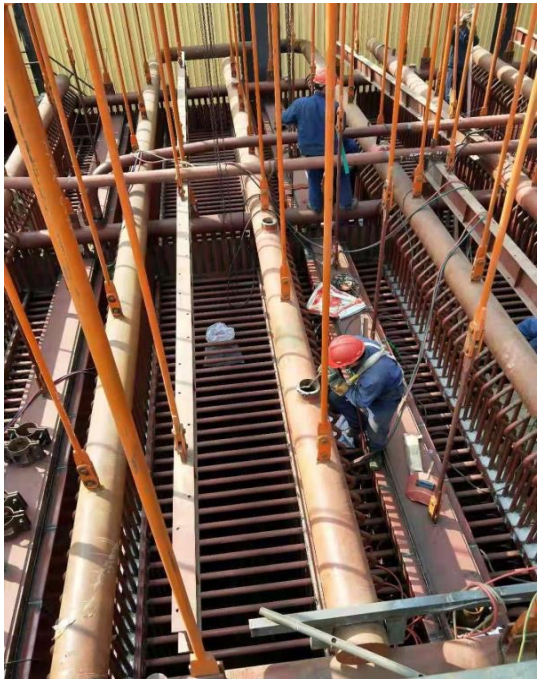


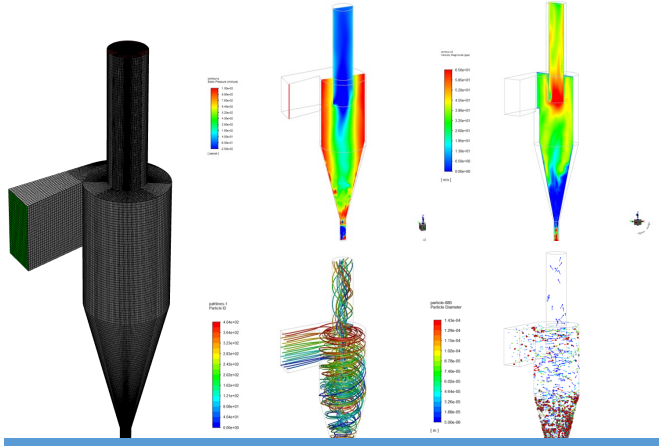
Fluidized bed MSW incineration power generation system with the highest parameter in China

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



Item	Value
Capacity (t/d)	1000
Steam temperature (℃)	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

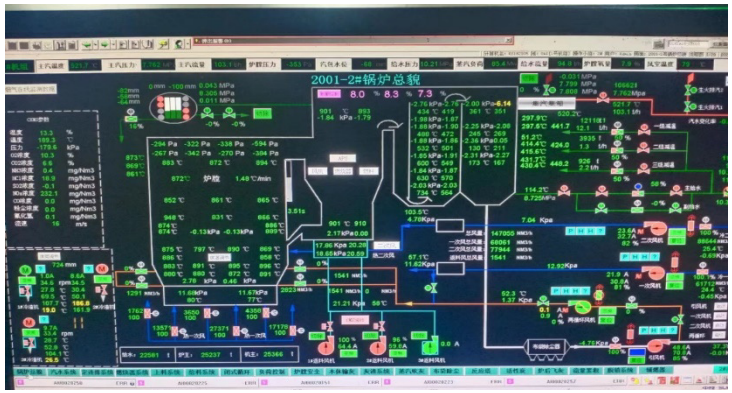
- Flue gas purification process： SNCR + bag dust collector + SDA semi-dry and dry desulphurization + mechanical ash-transferring +fly ash solidification system; flue gas pollutant emissions below EU 2010 emission standards, the TEQ of dioxins **0.0027 TEQ ng/Nm^3** ;
- Started operations on Nov. 10th, 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

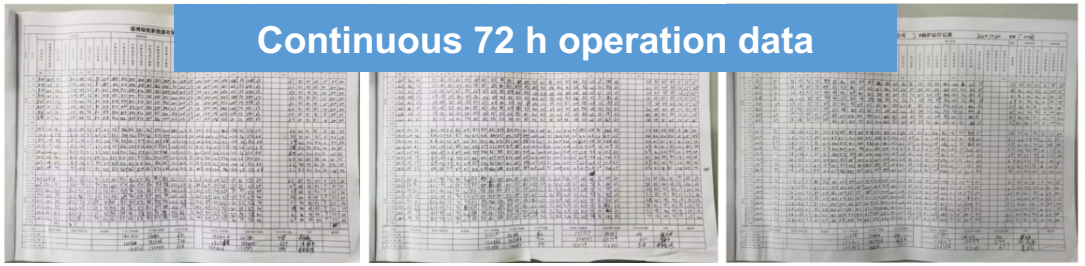
2020年课题组对临淄示范工程锅炉自动控制逻辑程序进行完善优化，从单一的设备启停，到辅助系统的顺序控制，再到各个系统间的协调控制，直至最终的负荷自动控制程序，并最终形成成锅炉整个的一键启停。

- APS一键启停功能
- 料层自动控制
- 给料系统自动控制
- 燃料量与送风量的关联控制
- 输灰渣系统自动控制
- 补砂返砂系统自动控制

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

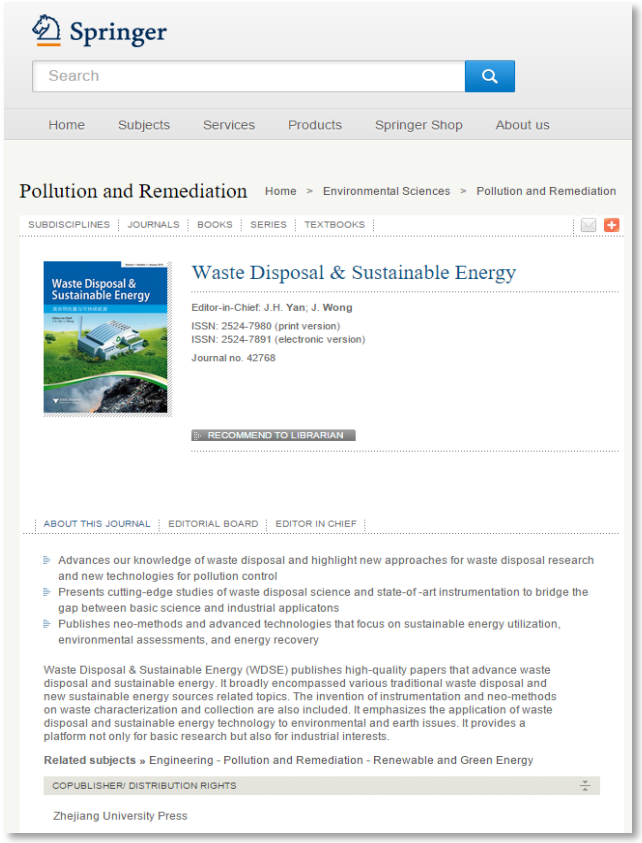


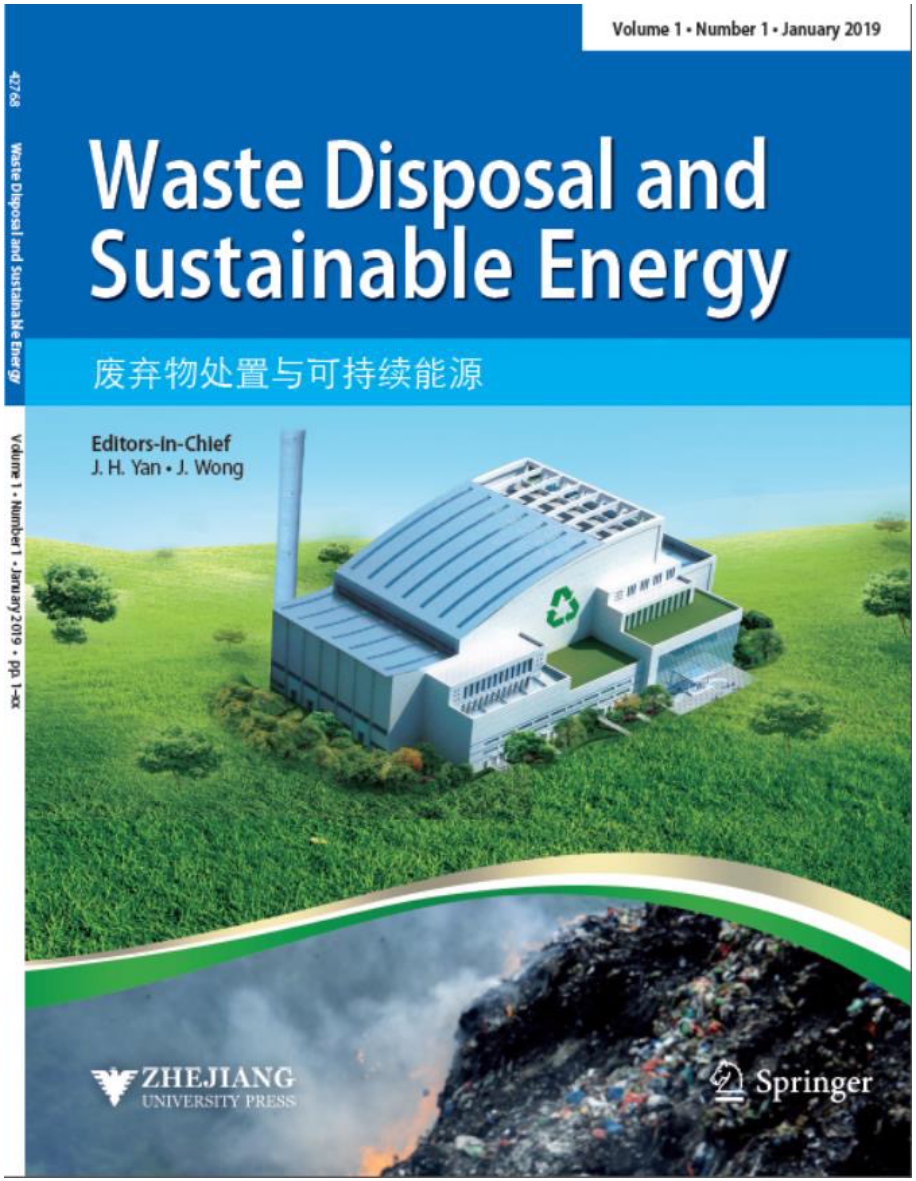
Boiler performance test report

International journal

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)





THANK YOU