生活垃圾焚烧处理技术与发展

Waste to Energy Technology and Development

光大环境
EVERBRIGHT ENVIRONMENT

目　录 Contents

光大环境
EVERBRIGHT ENVIRONMENT

一、光大环境概况

- **中国光大环境有限公司[光大环境]，是光大集团的骨干企业，香港主板上市公司（HKSE:0257），有央企、上市公司、外资三重身份；2022年上半年收入逾214亿港币，总资产约2000亿港币。**
- **光大环境是中国首个一站式、全方位的环境综合治理服务商。**
- China Everbright Environment Co., Ltd.is the backbone enterprise of Everbright Group Municipal company (HKSE: 0257), with triple identities of central enterprise, listed company and foreign capital; 2022 in the first half of the year, the revenue exceeded HK $21.4 billion and the total assets were about HK $200 billion.
- Everbright Environment is China's first one-stop, comprehensive environmental management service provider.

光大環境 EVERBRIGHT ENVIRONMENT

环保能源	环保水务	绿色环保	装备制造	绿色科创	环境规划	光大照明	生态资源
●生活垃圾焚烧发电 ●餐厨处理 ●	● 污水处理 ● 流域治理	●生物质综合利用 ●危险废弃物处理 ●土壤修复	●生活垃圾焚烧炉设备 ●焚烧烟气处理设备 ●垃圾渗滤液处理设备	●科技研发 ●技术服务 ●成果转化	●设计规划 ●全厂设计 ●环保工程	●节能路灯 ●亮化工程 ●节能产品	●垃圾分类 ●再生资源

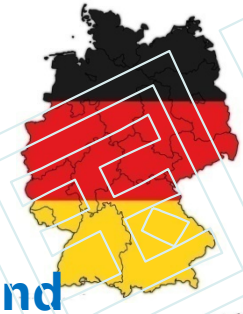
光大科技引领中国环保技术，技术研发、装备设计、生产技术服务

Technical research and development, equipment design, production technology services

- 光大环境是全国**最大的垃圾发电投资运营商。**
- 截止2022年6月，已有**540**环保和新能源项目，累计总投资超过**1540亿元**
- 落实垃圾发电项目超过**170**个，设计处理生活垃圾**150,000T/d**。

- Everbright Environment is the largest waste to energy project investment operator in China.
- As of June 2021, there are 540 environmental protection and new energy projects, with a total investment of more than 154 billion yuan
- More than 170 WTE projects have been implemented, and 150000 T/d of domestic waste dispose capacity has been designed

A 德国Germany



B 波兰Poland

C 越南Vietnam

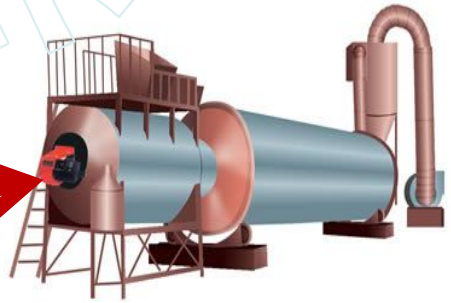
China
中国

光大环境主导产品与技术 Main products

自主研发生活垃圾焚烧炉
Self-developed waste incineration system

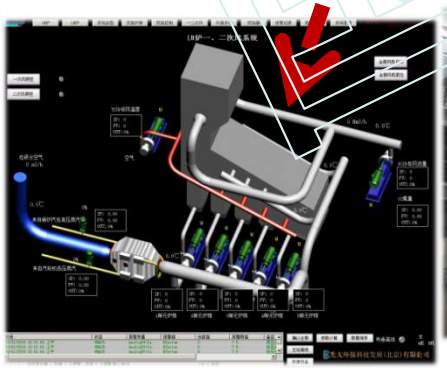
马丁炉
Imported Martin incineration system

生物质直燃水冷往复焚烧炉
Water cooled biomass Reciprocating incineration



危险废弃物焚烧逆流回转窑
Hazardous waste countercurrent rotary kiln

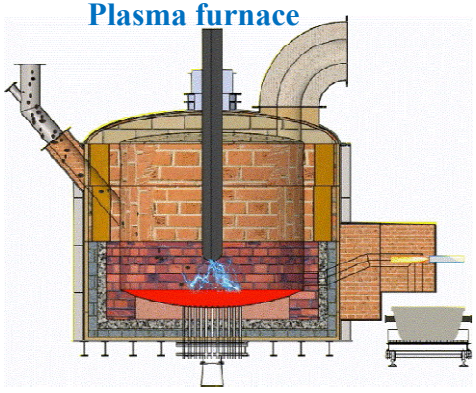
相关的自动控制
Related automation system



烟气净化
Flue gas purification system

渗滤液处理
Leachate treatment

等离子炉
Plasma furnace



江阴生活垃圾焚烧发电 **Jiangyin WTE project**

一期项目（First phase 2×400t/d）：2008年5月投运 Operating since May, 2008.

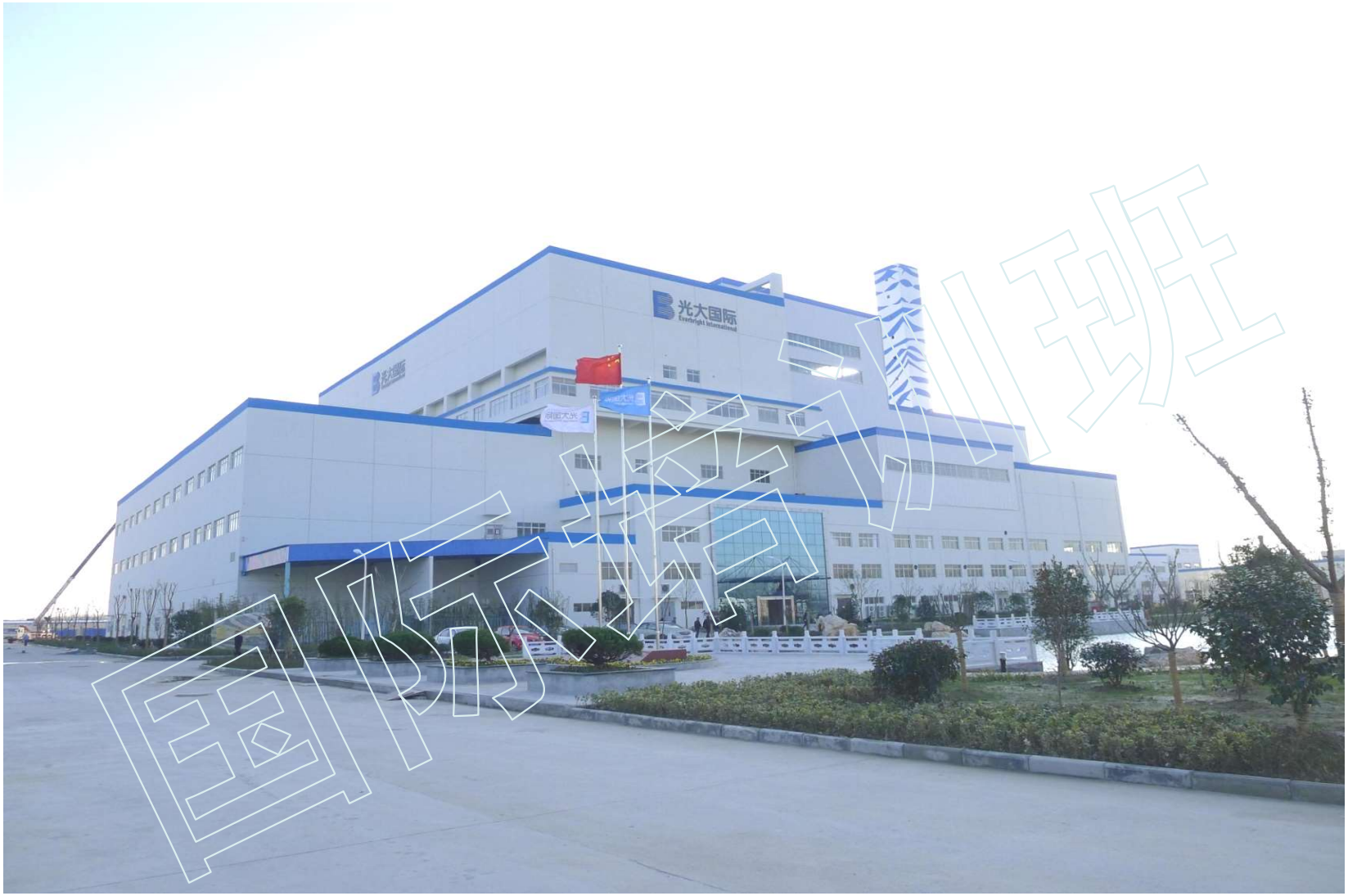
二期项目（Second phase 1×400t/d）：2011年3月投运 Operating since March, 2011.

三期项目（Third phase 2×500t/d）：2018年5月投运Operating since May, 2018.

镇江生活垃圾焚烧发电 Zhenjiang WTE project

一期项目（ First phase 3×350t/d **）：2011年8月投运** Operating since Aug. 2011.

二期项目（ Second phase 1×400t/d **）：2015年5月投运** Operating since May. 2015.



宿迁生活垃圾焚烧发电 **Suqian WTE project**

一期项目（First phase 2×300t/d）：2011年12月投运 Operating since Dec. 2011.

二期项目（Second phase 1×400t/d）:2017年投运Operating since 2017.

苏州生活垃圾焚烧发电 Suzhou WTE project

一期项目（First phase 3×350t/d）：2006年7月投运 Operating since July,2006.

二期项目（Second phase 2×500t/d）：2009年6月投运 Operating since June,2009.

三期项目（Third phase 3×500t/d）：2013年1月投运 Operating since Jan.2013.

四期项目（Forth phase 6×750t/d）：在建 Under construction

宁波生活垃圾焚烧发电 **Ningbo WTE project**

一期项目（First phase 2×500t/d）：2014年1月投运 Operating since Jan.2014.

二期项目（Second phase 1×500t/d）：2015年9月投运 Operating since Sep.2015.

南京生活垃圾焚烧发电 **Nanjing WTE project**

一期项目（First phase 4×500t/d）：2014年6月投运 Operating since June,2014.

二期项目（Second phase 3×750t/d）：2017年3月投运 Operating since March,2017.

吴江生活垃圾焚烧发电　Wujiang WTE project (2×750t/d)

2016年9月投运　Operating since Aug.2016.

杭州生活垃圾焚烧发电 **Hangzhou WTE project (4×750t/d)**

2017年11月投运 **Expected to operate in Dec.2016.**

二、生活垃圾焚烧简介
Introduction of waste incineration

1、生活垃圾特性
Domestic waste features

2、生活垃圾处置方式
Waste disposal methods

3、焚烧原理
Principle of waste combustion

4、焚烧设备
Incineration equipments

1.1 生活垃圾特性 Domestic waste features

1）生活垃圾概念Domestic waste concept：

人们在日常生活中或日常生活服务的活动中产生的固体废物

Solid waste produced from people’ s living activity

不同于：工业垃圾、建筑垃圾、医疗废弃物和危险废弃物

Different from: industrial waste， construction waste, medical waste, hazardous waste

2）生活垃圾分类 waste classification：

生活垃圾物理化学成分是选择处置工艺的重要依据

Physical composition is a very important basis for waste treatment

中国大陆地区对生活垃圾物理成分划分为：

Mainland China distributes waste into :

- 有机物 (可燃物)： 厨余、纸类、纤维、布、竹木、绿化废物、塑料、橡胶

Organics(combustible):kitchen waste, paper, fiber, cloth, wood, green waste, plastic, rubber

- 无机物 (灰 分)： 玻璃、金属、渣土、砖瓦、陶瓷、灰尘

Inorganics(ash)： glass, metal, residue earth, Brick and tile, ceramic, dust

- 水 分 Mositure

生活垃圾主要成分热值（kcal/kg)

Heat value of domestic waste Composition

成 分Composition	热 值Heat value
塑 料 Plastic	7,800
橡 胶Rubber	5,600
木 料Wood	4,500
布、皮革Cloth, Leather	4,200
纸 类 Paper	4,000
绿化废料Green waste	1,500
食品垃圾Food waste	1,100
厨 余Kitchen waste	800-1,000

3）生活垃圾产量: Domestic waste production

- 影响生活垃圾产生量的基本要素是人口数量、国民经济发展水平及不同地区不同的生活习惯

  The basic factors affecting waste production are human population, economic development and different living habits

- 随着人口数量增加，生活水平的提高，生活垃圾产量也逐年增加

  Waste production increases annually with increasing of population and improvement of living standards

- 大城市生活垃圾人均日产量1-2kg/d•人

  Usually daily production in large cities: 1-2kg/d per person

4）垃圾含水量：Waste moisture content

中国城市垃圾含水量一般在40-60%，具有明显的季节特征

Chinese municipal waste contains about 40-60% moisture, which varies through seaons

- 垃圾含水量影响垃圾热值，含水量高则热值低，含水量低则热值高

  Moisture concentration affects heat value, the higher concentration, the lower heat value

- 垃圾含水分分为外在水分和内在水分

  Moisture contained in waste includes two part: external and internal

  外在水分：垃圾表面水分，水与物料之间的结合程度较低，易于脱除

  External moisture: mositure on the surface of waste ,not binding with other components, easy to remove

  内在水分：垃圾各组分毛细作用吸附的水分，结合程度较大，较难脱除

  Internal : mositure absorbed by capillarity of waste components ,hard to remove

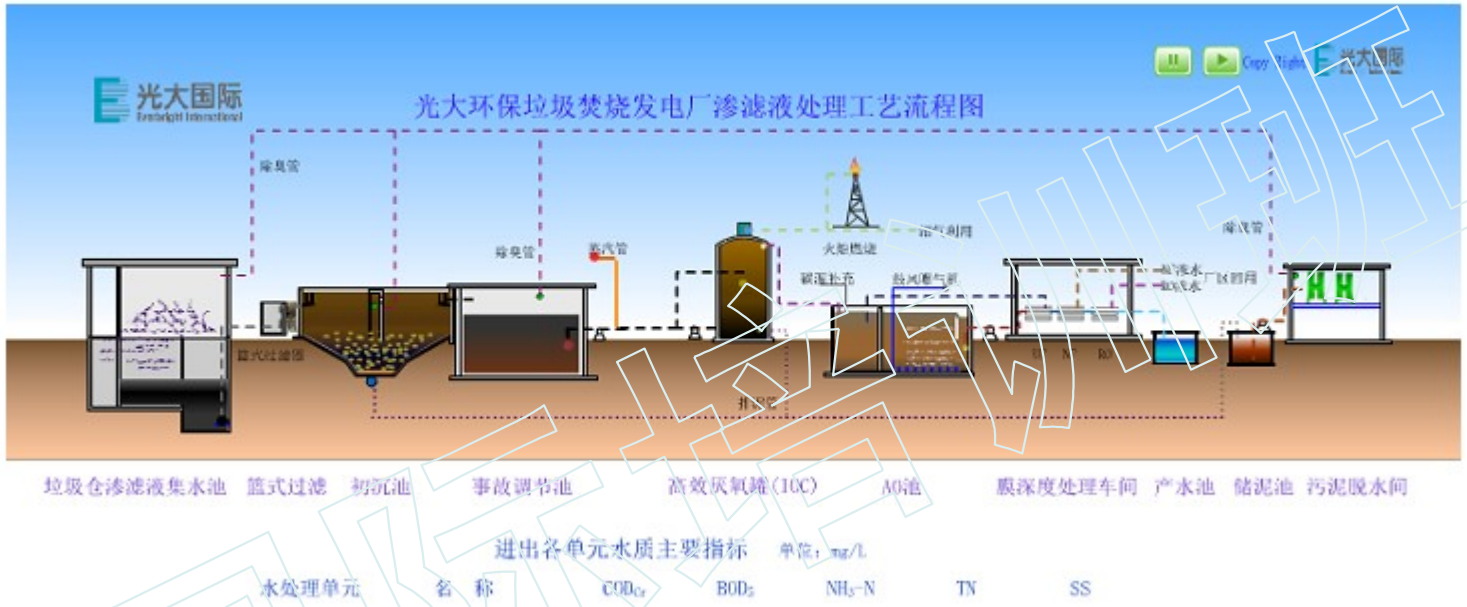
- 生活垃圾含水量主要来自瓜果、蔬菜等厨余物以及雨水侵蚀等

  Mositure in the waste mostly comes from fruits, vegetables ,other kitchen waste and rain.

5）生活垃圾堆积密度：生活垃圾原始堆积密度为0.15-0.5t/m³，典型值为 0.35t/m³

Waste Packing density: the original packing density is 0.15-0.5t/m³, typical value : 0.35t/m³

6）垃圾渗滤液 Leachate



- **垃圾有机成分中含有的水分，在收集、运输、处置过程中发生的物理变化及化学生物反应而渗沥出来的水**

  During the process of collection, transportation and treatment of waste, the mositure contained in the organic components seeps out through physical, chemical and biological reaciton

- **垃圾渗滤液是高污染性、高浓度及多种病原微生物的有机废液，是二次污染源之一**

  Landfill leachate is a kind of organic liquid waste with high pollution, high concentration and a variety of pathogenic microorganisms, it’ s a secondary pollutant

1.2 生活垃圾的化学特性 Chemical features of waste

生活垃圾的化学特性主要指生活垃圾的元素分析，挥发分、灰分、热值等。
化学特性均按重量百分比计
Chemical features of waste mainly imply the elemental analysis, volatile matter, ash, heat value and so on, those features are all measured by weight percentage

由某城市生活垃圾基础分析：Analysis of some typical municipal solid waste

1）垃圾组成分析 Composition analysis

	混合样 mixture	沙土 sand	玻璃 glass	金属 metal	纸 paper	塑料 plastic	橡胶 rubber	布 cloth	草木 grass and trees	厨余 Kitchen waste	白塑料 White plastic	
收到基成分含量 Composition as received basis		8.73%	0.94%	0.78%	16.88%	15.51%	0.00%	5.17%	12.45%	38.43%	1.12%	总水分 Moisture content
总成分分析 total composition analysis	100.00%	5.61%	0.84%	0.69%	8.65%	8.29%	0.00%	3.01%	6.55%	11.14%	0.85%	54.37%
干基成分 Composition as dry basis	100.00%	12.30%	1.85%	1.50%	18.96%	18.17%	0.00%	6.60%	14.35%	24.42%	1.85%	
可燃组分干基成分 Combustible component as dry basis					22.47%	21.55%	0.00%	7.82%	17.02%	17.02%	2.20%	

2）垃圾工业分析 Industrial analysis

	挥发分 volatiles	固定碳 Fixed carbon	灰份 ash	水份 moisture
干基可燃物工业分析 Combustible as dry basis		8.73%	0.94%	0.78%
垃圾干基工业分析 Analysis as dry basis	100.00%	5.61%	0.84%	0.69%
收到基工业分析 Analysis as received basis	100.00%	12.30%	1.85%	1.50%

3）垃圾元素分析 Elemental analysis

	C(%)	H(%)	N(%)	S(%)	O(%)	Cl(%)	Hg(ppm)	Cd(ppm)	Pb(ppm)	Cr(ppm)	As(ppm)
干基可燃组分元素分析 Combustible component as dry basis	42.74%	5.51%	0.92%	0.14%	27.32%	0.26%	0.26	0.09	71.46	162.78	0.71
垃圾干基元素分析 Analysis as dry basis	36.05%	4.65%	0.78%	0.12%	23.04%	0.22%	0.22	0.08	60.27	137.30	0.55
收到基元素分析 Analysis as received basis	16.45%	2.12%	0.35%	0.05%	10.51%	0.10%	0.10	0.03	27.50	62.65	0.25

1.3 垃圾热值 Waste heat value

垃圾热值：单位质量的垃圾完全燃烧释放的热量

Waste heat value : total heat released during fully combustion of per unit mass waste

1）垃圾热值分高位热值和低位热值 High heat value(HHV) and Low heat value(LHV)

高位热值HHV（Qg）：垃圾完全燃烧后，焚烧产物中水蒸气冷凝结为水时释放的热量

The total heat released when after complete combustion ,the producted water vapour condensed into liquid

低位热值LHV（Qd）：垃圾完全燃烧后，焚烧产物中水分保持蒸汽状态时释放的热量

The total heat released when after complete combustion the produced water vapour stays as steam

二者差异在于水分蒸发的蒸汽潜热是否放出（蒸汽潜热一般取2512KJ/Kg即600Kcal/Kg）

The difference is whether the latent heat is released(the latent heat is usually 2512KJ/Kg,or 600Kcal/Kg)

2）低位热值经验公式：LHV Empirical formula

一般采用四种经验计算模型： Usually have four models

①门捷列夫模型 Mendeleev model：Qd=81C+246H+26S-26O-6W Kcal/Kg

②Steuer模型 Steuer model： Qd=81C+291H+26S-30.562O-6W Kcal/Kg

③Vonroll模型 Vonroll model： Qd=83C+224H+25S+15N-26O-6W Kcal/Kg

④Dulong修正模型 Dulong modified model：Qd=81C+288.5H+22.5S-42.8O-6W Kcal/Kg

1.3 垃圾热值 Waste heat value

3）相同元素，不同计算模型，热值计算值如下：

For same elements and different models ,heat value calculates as below:

垃圾元素分析 Waste element	C%	H%	O%	N%	S%	Cl%	水份	灰份
含量content	18.85	2.66	13.16	0.42	0.09	0.35	42.8	23.3

垃圾热值计算 Heat value calculation

序号number	单位unit	门捷列夫类型 Mendeleev model	Steuer模型 Steuer model	Vonroll模型 Vonroll model	Dulong模型 Dulong model
热值 heat value	Kcal/kg	1584.6	1644.2	1570	1476.2
误差 error	%	—	3.8	0.9	6.8

4）三角图计算垃圾低位热值

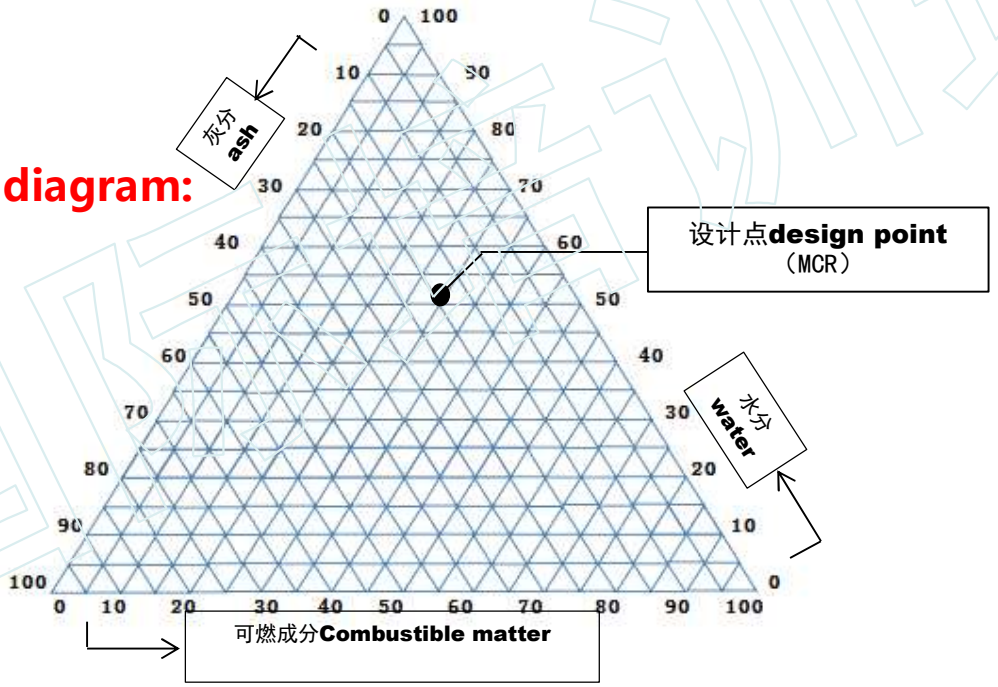
Triangle diagram for waste calorific value

根据垃圾的可燃成分、水分和灰分，估算垃圾低位热值的方法。

该方法计算结果误差较大，作为粗略估算用。

There is too much deviation when using triangle diagram to calculate the waste calorific value

三角图: Triangle diagram:



计算公式 Formula： Q_d=45B-6W

B ：可燃成分 Combustible matter content

W：水分 water content

1.3 垃圾热值 Waste heat value

5）影响垃圾热值的主要因素：Main factors which affect waste heat value

- 垃圾的物理成分和元素Waster content and element compositon
- 灰分的影响The influence of the ash

一般估值：灰分减少1%，垃圾热值增加1%。

Estimate：Ash content decreased by 1%, waste calorific value increased by 1%.

- 水分的影响 The influence of the water

单位含水率减少1%，垃圾热值增加150-165kJ/kg。

Estimate：Water content decreased by 1%, waste calorific value increased by 150-165kJ/kg.

6）垃圾热值分为: Waste calorific value can be divided into:

原生垃圾热值：进厂垃圾热值;

Native waste calorific value： waste calorific value when into the factory ;

入炉垃圾热值：进厂垃圾在垃圾仓储存5-7天后投入料斗的热值。

Calorific value into the furnace : waste in the bunker store for 5 to 7 days ,then put them into the furnace

2、生活垃圾处置方式 Waste disposal methods

- 目前生活垃圾处置有三种方式：填埋、堆肥、焚烧
  At present there are three ways for waste disposal : landfill, composting, incineration
- 焚烧是生活垃圾最终处理方法：减量化、无害化、资源化
  Waste Incineration is the final processing method : reduction, harmless and recycling
- 垃圾焚烧能满足所有的排放标准及占地面积小的优点，但存在：
  Emissions of waste incineration can meet all standards and cover an small area but there is:

  公众接受程度：反对者认为垃圾焚烧会产生对公众健康有害的二次污染，尤其是二噁英。
  Public acceptance: opponents think waste incineration will produce secondary pollution that is harmful to public health, especially the dioxin.



（1）卫生填埋法 Landfill

- 使用最广，但填埋场选址较难
  The most widely used, but the landfill location selection is more difficult
- 要有理想的自然地理，地址条件，占地面积大
  Must have the ideal natural geography, address terms, covering an area of large
- 远离城市、收集运输成本高
  Away from the city, collect high transport costs
- 填埋场库底用HDPE 材料防止浸出液的渗漏
  Landfill with HDPE material at the bottom to prevent leakage of leachate
- 后期管理工作量大，需要对填埋单元压实、覆盖，进行雨水导流，对渗滤液和沼气处理 Late management workload is huge, need to landfill unit compaction, cover, water diversion, the leachate and gas processing

苏州垃圾填埋场沼气发电

Suzhou landfill biogas electricity generation system

（2）堆肥处理 Composting process

- 成本高 High cost
- 工艺较复杂 Process is complicated
- 肥效较低 Exploiting efficiency is low

（3）焚烧 Incineration

垃圾是放错地方的宝物 Waste is treasure which is misplaced

焚烧是生活垃圾最终处理方法：减量化、无害化、资源化

Waste Incineration is the final processing method : reduction, harmless and recycling

生活垃圾具备焚烧的条件：Living garbage burning of conditions:

可燃成份 ≥ 25%	Combustible matter ≥ 25%
水　份 ≤ 50%	Water content ≤ 50%
灰　份 ≤ 60%	Ash content ≤ 60%

- **生活垃圾热值分高位热值HHV和低位热值LHV，我们所说的热值一般为低位热值，当低位热值: Waste calorific value points, high calorific value HHV and low calorific value LHV, what we call the calorific value is generally low calorific value LHV**

低于low than	800 kcal/kg,	不能达到自燃要求 Uncombustable
位于equal	800 - 1,200 kcal/kg	需投辅助燃料达到稳定燃烧 Combustable with auxiliary fuel
高于high than	1,200 kcal/kg	不需要投辅助燃料燃烧 Combustable without auxiliary fuel

- **焚烧炉设计热值: Incinerator design for calorific value range**

  设计热值为投运后第10 – 12 年的热值 Design heat value is the calorific value of 10-12 years

  在开始投运到达到设计热值时，为保证MCR工况应适当超机械负荷 When not meet the design heat value, in order to ensure the MCR point we should overload mechanical load

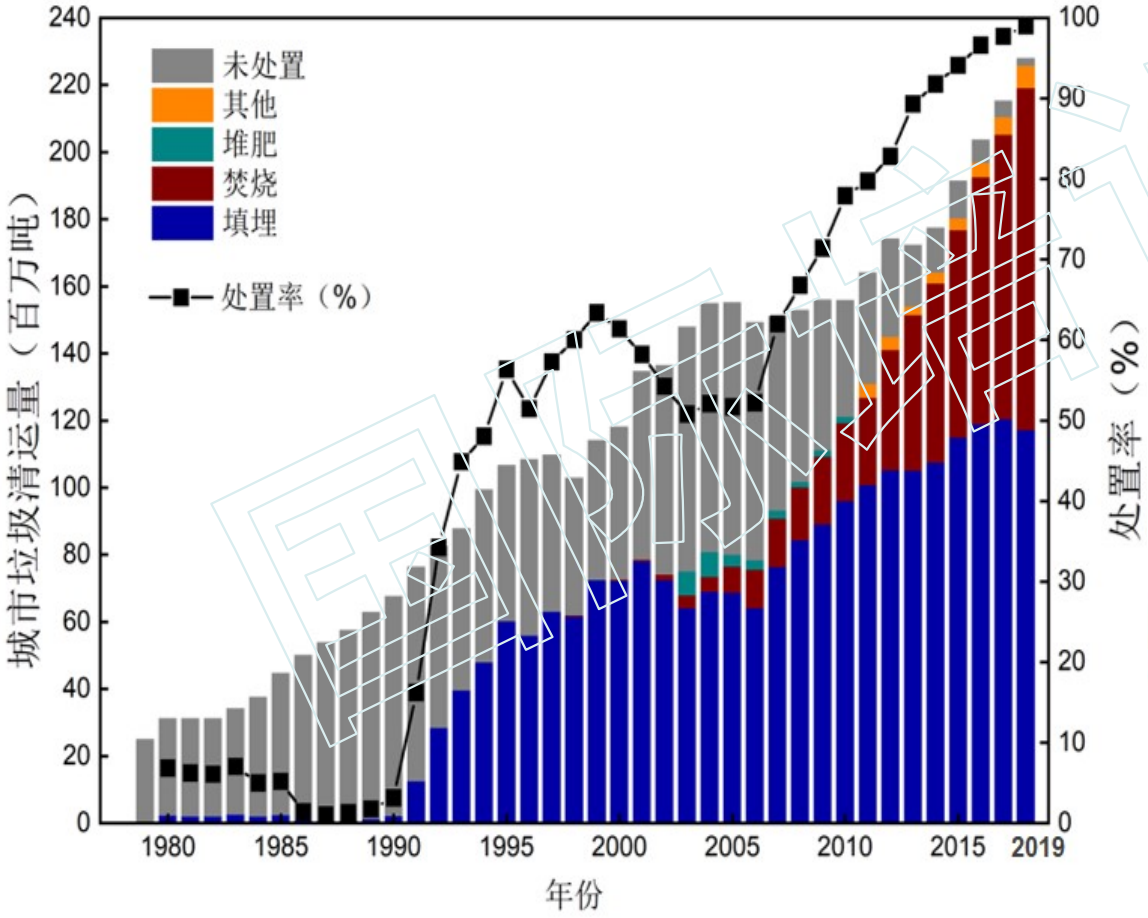
  当达到设计热值后，为保证额定垃圾处理量，应适当超热负荷 When meet or beyond the design heat value, in order to ensure throughput we should overload thermal load

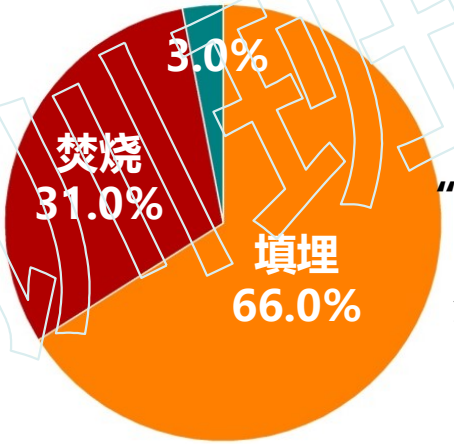
因此，焚烧炉的设计应有一定超机械负荷与超热负荷的能力。

Therefore, the design of the grate must have mechanical overload and thermal overload capacity.

垃圾焚烧已是我国主流无害化处理技术

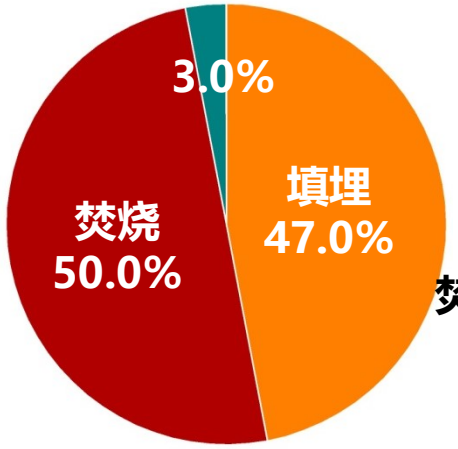
waste incineration has already been the most used technology in China, occupied more than 50% of the total treatment capacity





“十二五”垃圾

焚烧占31%



“十三五”垃圾

焚烧规划 > 50%

3、焚烧设备 Incineration equipments

- 按燃烧方式不同分为：机械炉排炉、流化床、回转窑和等离子气化炉四种，

  其中机械炉排炉占比例最大。

  According to different combustion mode is divided into: mechanical grate furnace, fluidized bed, rotary kiln and plasma gasifier furnace, Among them the largest percentage is the mechanical grate .

- 机械炉排炉按结构型式和运动方式分：

  According to the structure and motion of the mechanical grate can be divided into :

顺推往复炉排炉：

垃圾移动与炉排运动方向一致 如光大自主研发炉排

Forward pushing grate :

The waste and grate movement is in the same direction, like EB grate

逆推往复炉排炉：

垃圾移动与炉排运动方向相反 如马丁炉

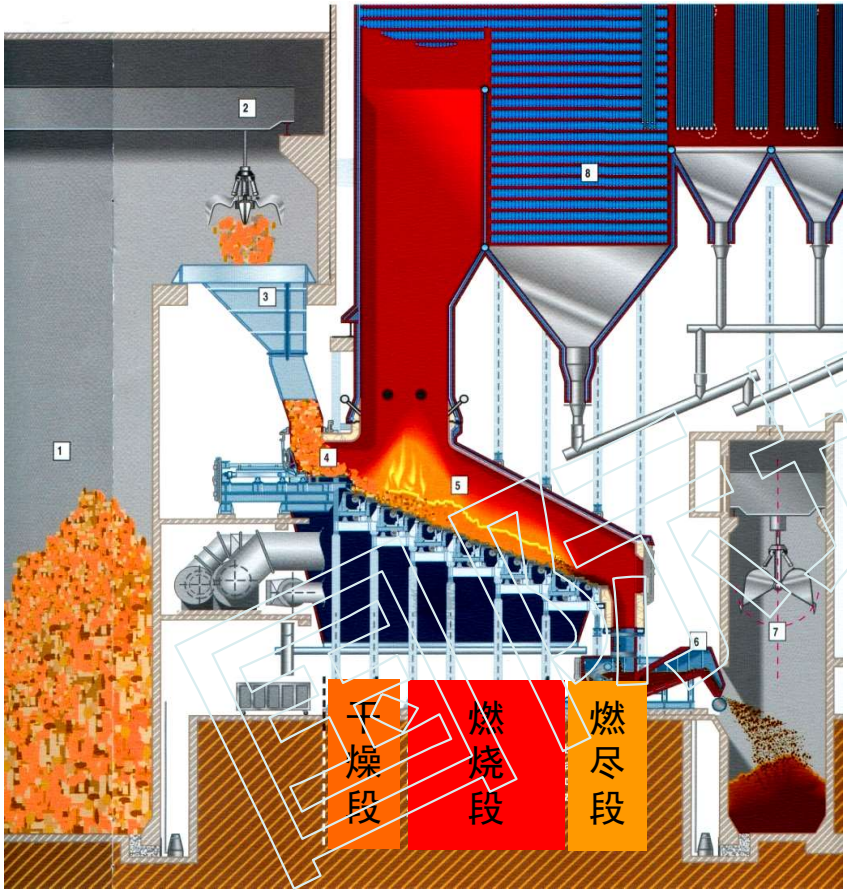
Reverse-acting grate :

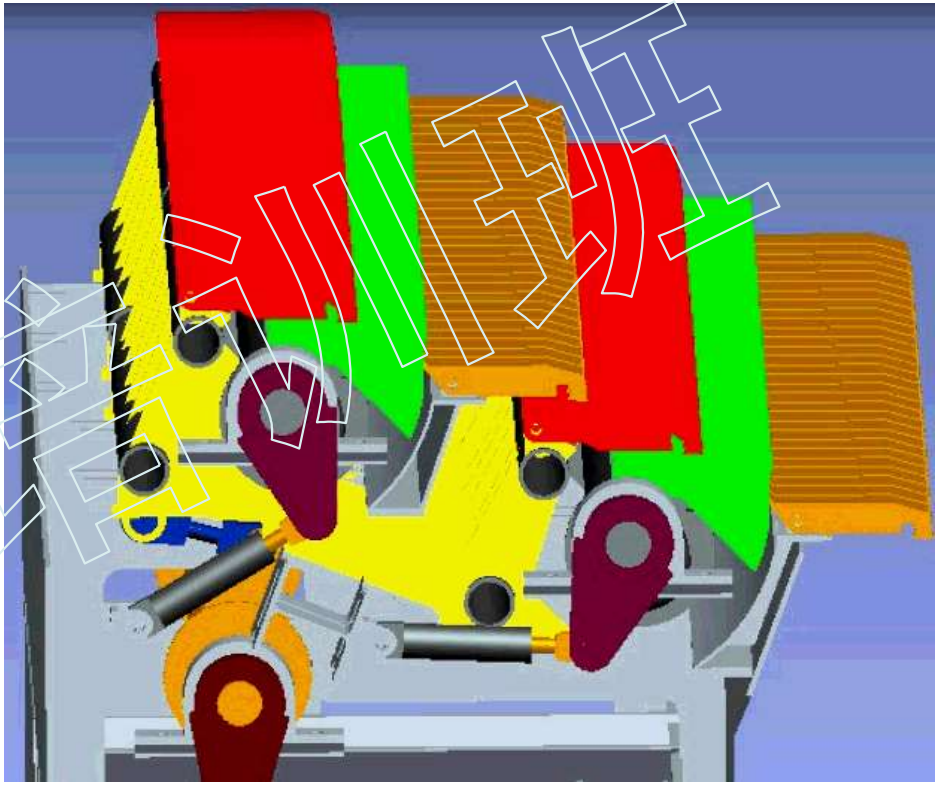
The waste and grate movement is in the reverse direction, like martin grate

滚筒型炉排：

The drum type grate

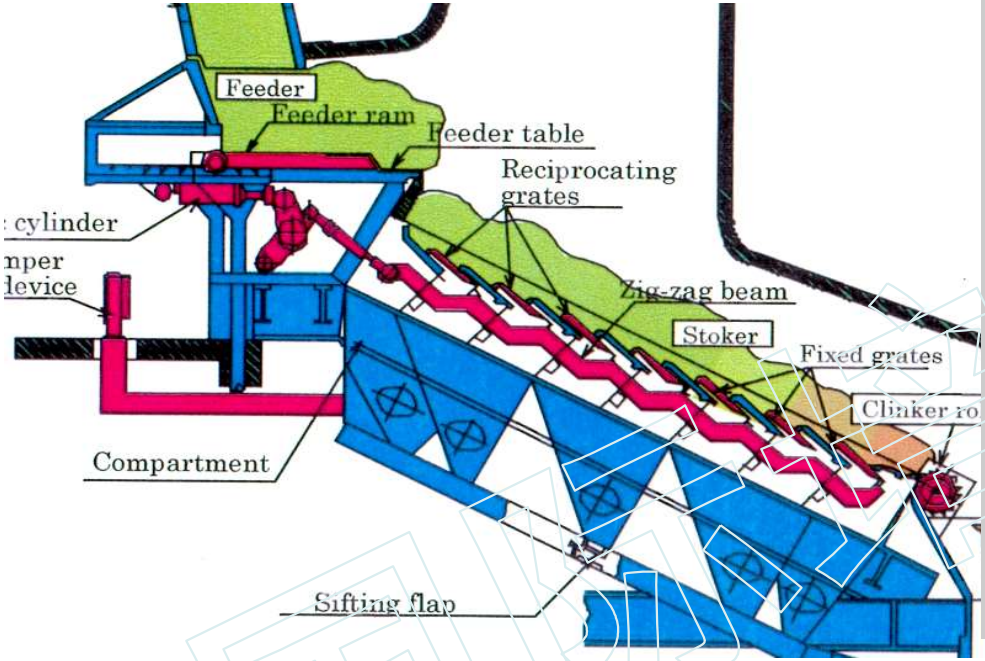
（1）机械炉排炉 Mechanical Grate

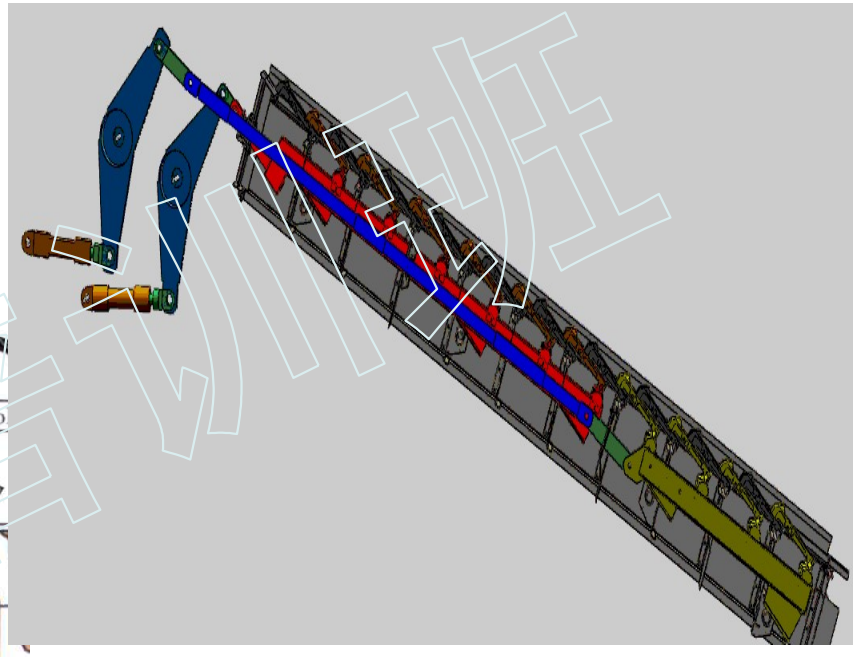




顺推往复炉排炉Forward pushing grate

（1）机械炉排炉Mechanical Grate





马丁逆推往复焚烧炉
Martin Reverse-acting grate

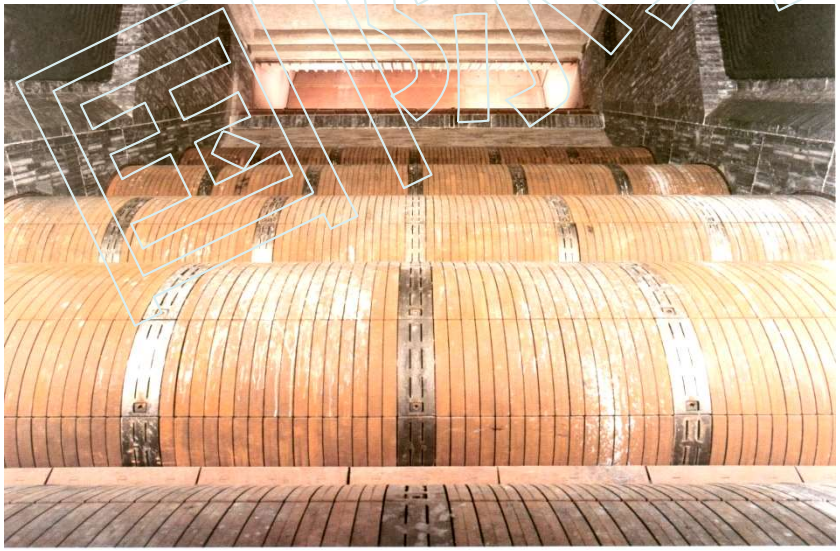
滚动炉排 The drum type grate

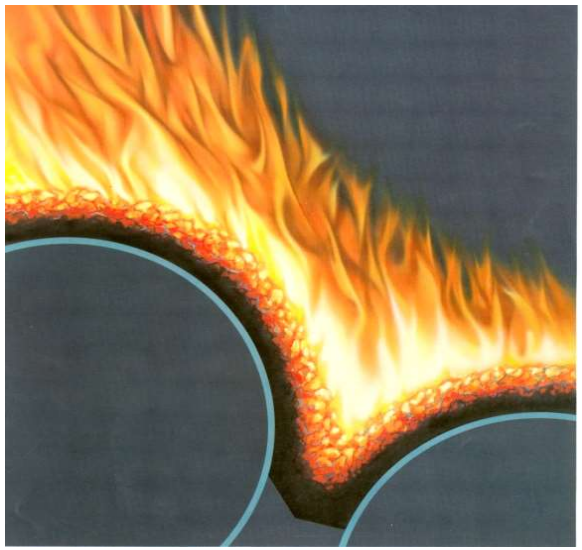
- 滚动炉排也是一种前推式炉排，一般由倾斜布置的一组空心圆滚筒组成，滚筒呈20°倾斜，自上而下排列。 **Rolling grate is also a kind of pushing grate, generally by the arrangement of a set of hollow circular cylinder, Roller is 20 ° inclined and arranged from top to bottom.**
- 滚筒在液压装置的作用下做旋转运动，使得滚筒上的垃圾在燃烧过程中形成波浪式的运动，垃圾从而得到充分的搅拌，拨火作用强，燃烧充分。

Rotation of the roller is under the action of hydraulic equipment, waste makes the roller shape in the combustion process into the wave movement, the waste get fully mixing

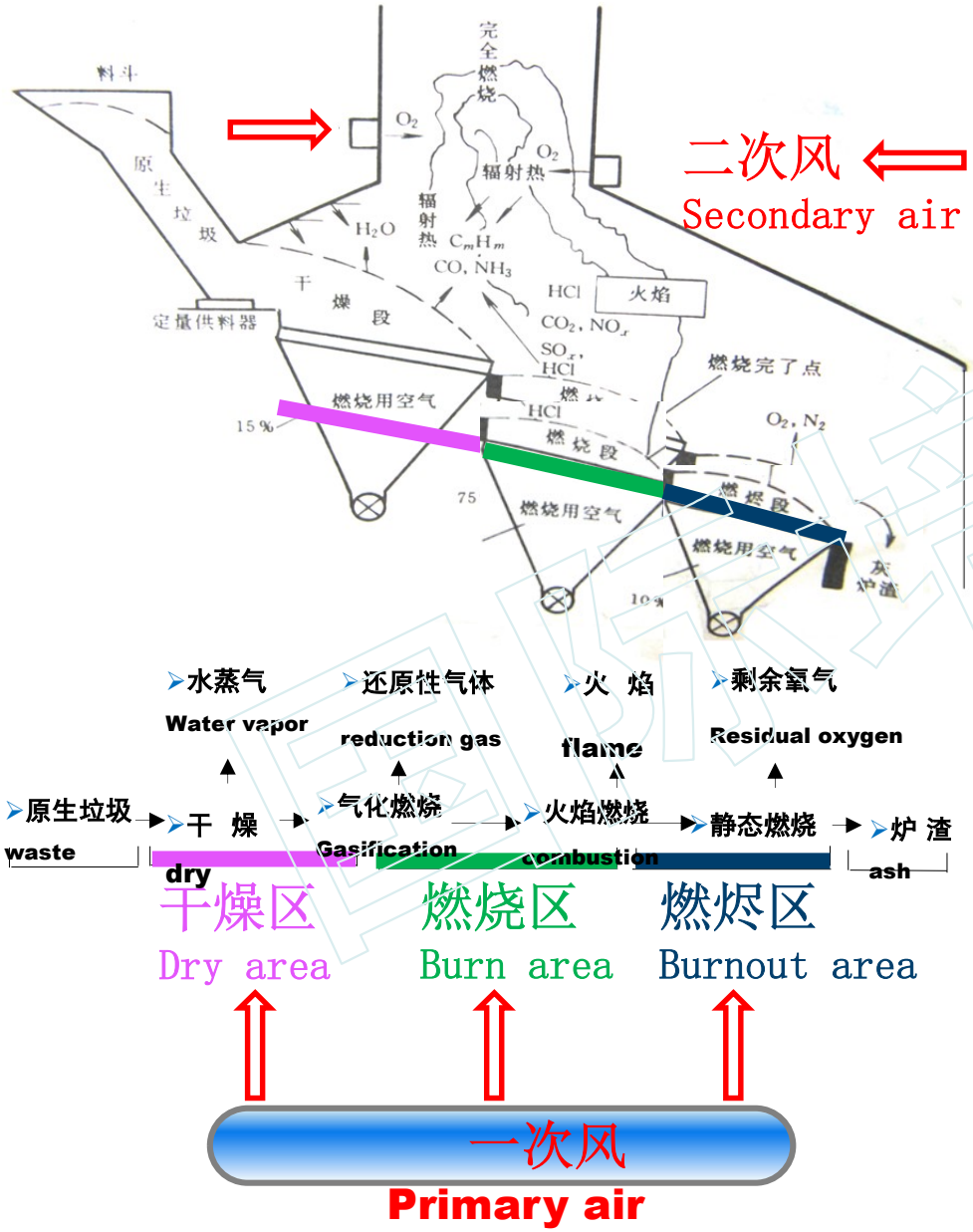
- 该炉排的典型代表是BABCOCK滚筒式机械炉排焚烧炉。

The grate is the typical representative of BABCOCK rotary mechanical grate incinerator.





4、垃圾焚烧炉原理 Principle of waste incinerator



- 生活垃圾在焚烧炉内的燃烧过程分为两种模式： 堆积层固定碳在炉排上焚烧
  挥发分在空间的气相自由燃烧

Waste in the incinerator combustion process is divided into two kindsPattern:
The accumulation of fixed carbon burned in the grate
Free gas phase combustion of volatile in space

- 垃圾进入焚烧炉，固体燃料依次进行:

Waste into the incinerator, solid fuel, in turn, are:

  - 加热升温 temperature heating
  - 水分蒸发 water evaporation
  - 挥发分析出 Volatile comeout
  - 焦炭燃烧 The coke combustion
  - 燃尽灰渣排出 Burnout ash discharge

- 一次风从炉排下部通入，使固定碳在充足的氧气下完全燃烧。 PA from the lower part into grate, make the fixed carbon in full Complete combustion under oxygen.
- 二次风从炉膛喉口处通入，扰动可燃气体CO、CH_4等充分燃烧。Secondary air to pass into the from the furnace throat, turbulence combustible gas CO, CH4 and fully burning
- 燃烧的最终产物为H_2O、CO_2，燃烧后热灼减率和CO的多少标志着充分燃烧的程度。The degree of how much combustion is the full combustion of CO.

5、空气过量系数 Excess air coefficient

■ 为实现稳定运行，完全焚烧和控制环境污染，需要有一定的空气过量系数。

To achieve stable operation, fully burning and control of environmental pollution, need to have excess air coefficient.

$$\alpha = \frac{v}{v_0} = \frac{21}{21 - o_2}$$

其中：V：实际供空气量； The actual air volume

V_0：理论燃烧的空气量； Theoretical combustion air volume

O_2：余热锅炉出口烟气含氧量； Waste heat boiler flue gas oxygen content for export

在传统燃烧技术的基础上，实现底空气比燃烧，减少烟气产生量和污染物的排放；也可减少热量损失而提高余热回收利用率。

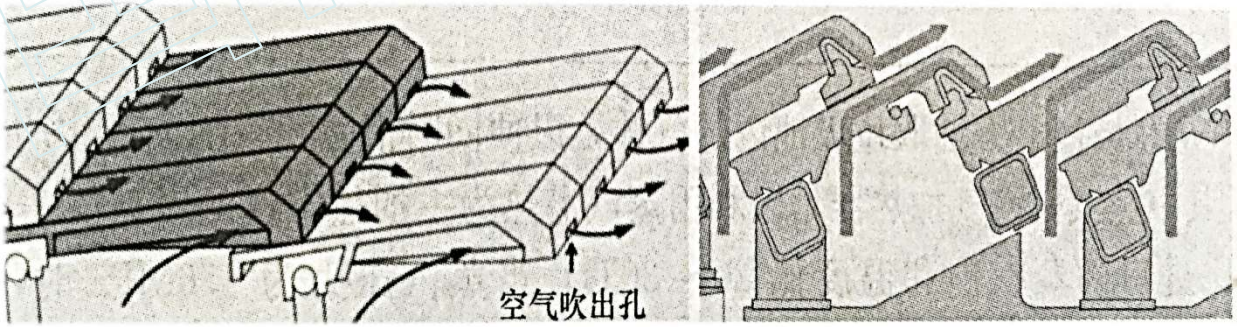
The basis of the traditional combustion technology, the realization of the bottom than the combustion air, reduced discharge flue gas and emissions of pollutants; To reduce heat loss and improve the utilization rate of waste heat recovery.

■ 单位垃圾的理论燃烧空气量：Unit of waste theoretical combustion air volume:

V_0=0.0889C+0.2647H+0.0333S+0.0301Cl-0.0333O（Nm^3/kg）

6、助燃空气系统包括：Combustion air including：

- 助燃空气一次风、二次风和炉墙冷却风Primary air and secondary air and furnace wallcooling air
- 1）一次风 Primary air
- 提供垃圾干燥的风量和风温，为垃圾着火准备条件； Provide waste dry air and the temperature, for waste fire conditions
- 提供垃圾充分燃烧和燃尽的空气量；Provide waste fully burning and burning air volume;
- 冷却炉排，避免炉排过热变形；Cooling grate, avoid overheating grate deformation;
- 为维护垃圾在负压运行，一次风从垃圾处吸取； To maintain waste bunker in negative pressure operation, Primary air is absorbed from the waste bunker
- 为保证入炉垃圾的干燥，一次风需加热，一次风温由水份热值的大小确定。
  In order to ensure the garbage into the dry, PA shall be heated, the temperature is determined by the content of the water.



低空气燃烧技术的一次空气典型分配示意图

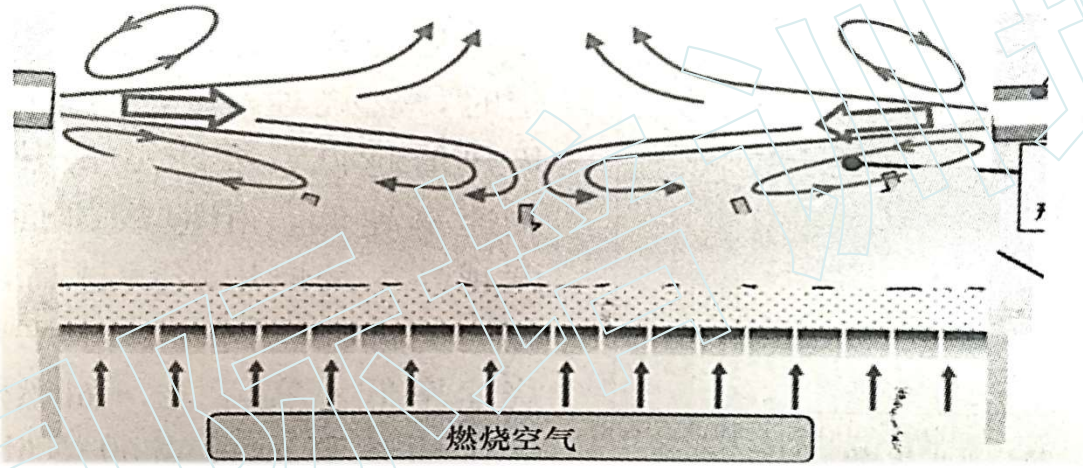
Low air combustion technology in a typical distribution diagram

7、助燃空气系统包括： Combustion air including:

2）二次风：Secondary air

作用：促使炉膛内烟气充分搅动，使炉膛出口CO充分燃烧。

Allowing the furnace flue gas stirring fully, make CO full burnout in chamber



喷嘴出口的二次空气流线示意图

Secondary air nozzle export flow diagram

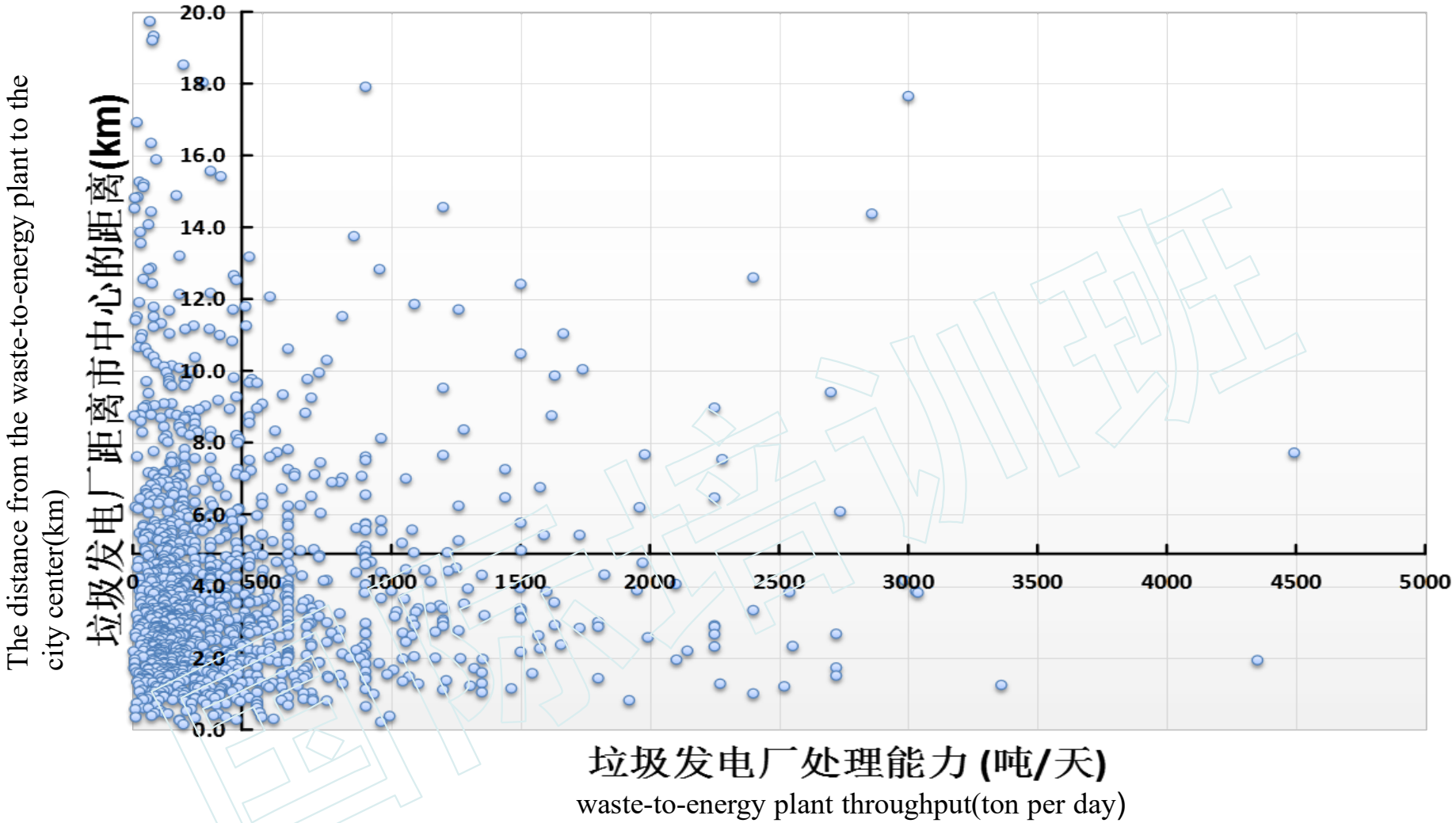
3）炉墙冷却风 Furnace wall cooling air

提供炉墙冷却风，以防炉渣在炉膛上结焦。

Provide cooling air furnace wall, to prevent slag coking on furnace wall.

三、焚烧发电厂系统

Incineration power plant systems

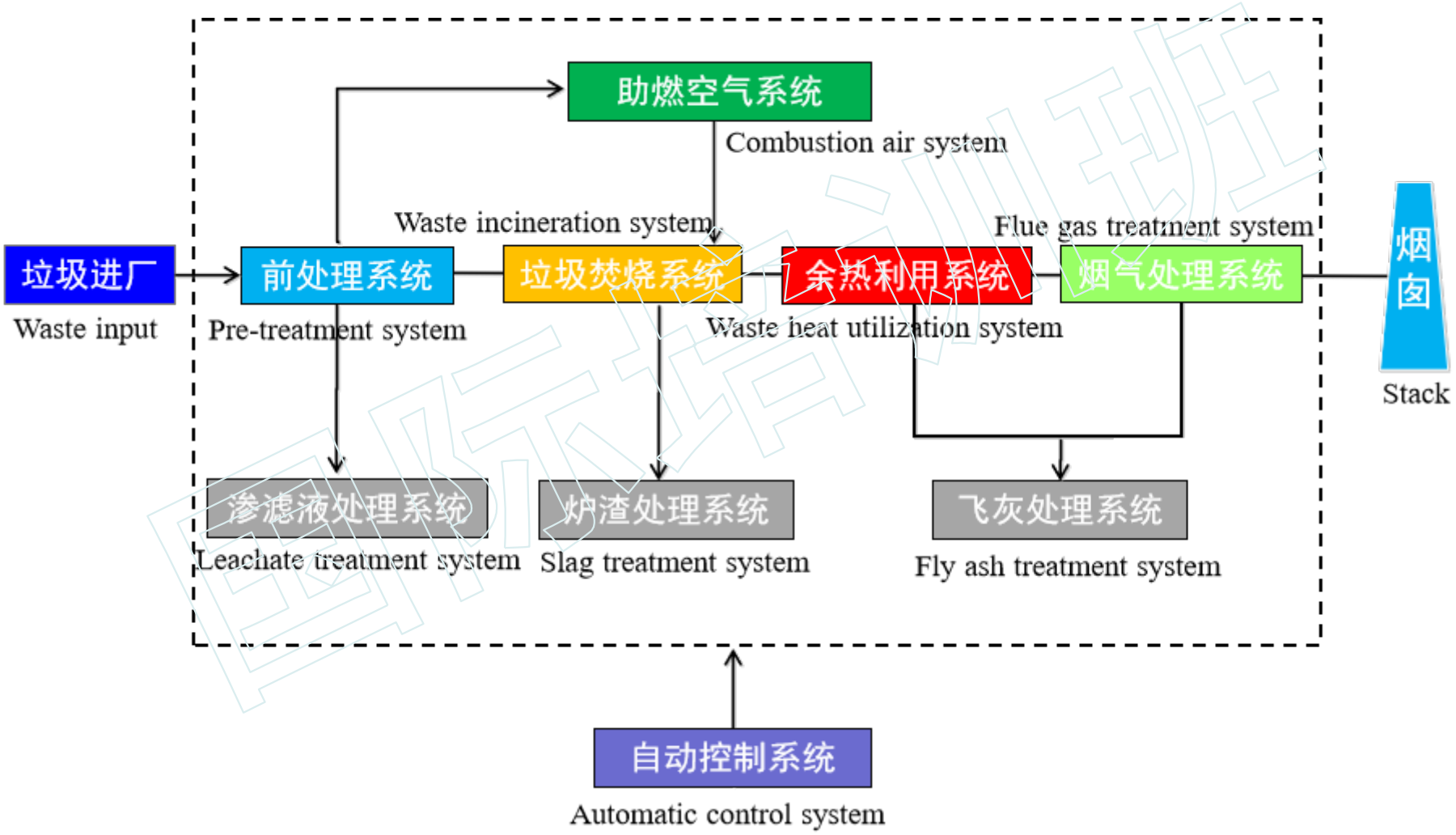


当前哥伦比亚大学GWC协会的研究: 全球垃圾发电厂与城市中心的距离(Bourtsalas, 2016)

Current research of the GWC Association in Columbia University: the distance from the waste-to-energy plant to the city center (Bourtsalas, 2016)

1、焚烧工艺流程方框图

Incineration process block diagram



2、生活垃圾焚烧发电工艺流程图

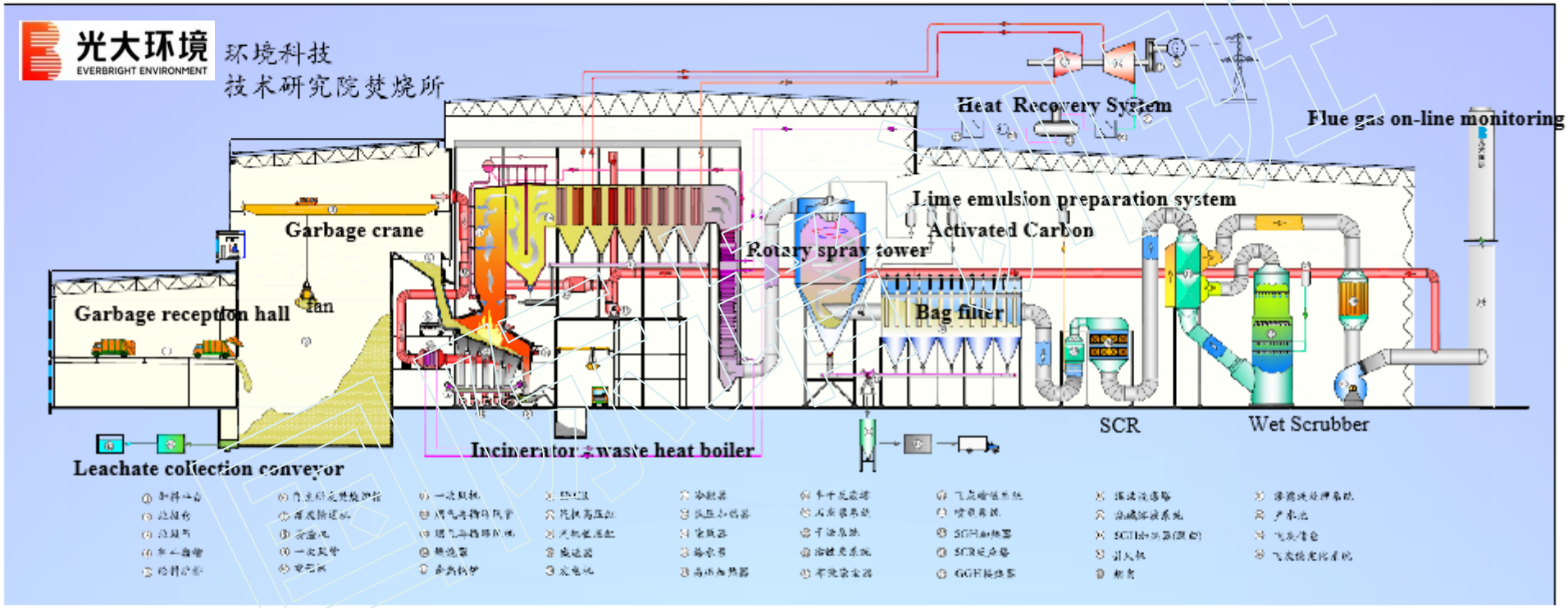
Waste incineration process flow diagram

前处理系统 Pre-treatment system

垃圾焚烧系统 Waste incineration system

余热利用系统 Waste heat utilization system

烟气处理系统 Flue gas treatment system



垃圾焚烧工艺流程示意（苏州四期为例）

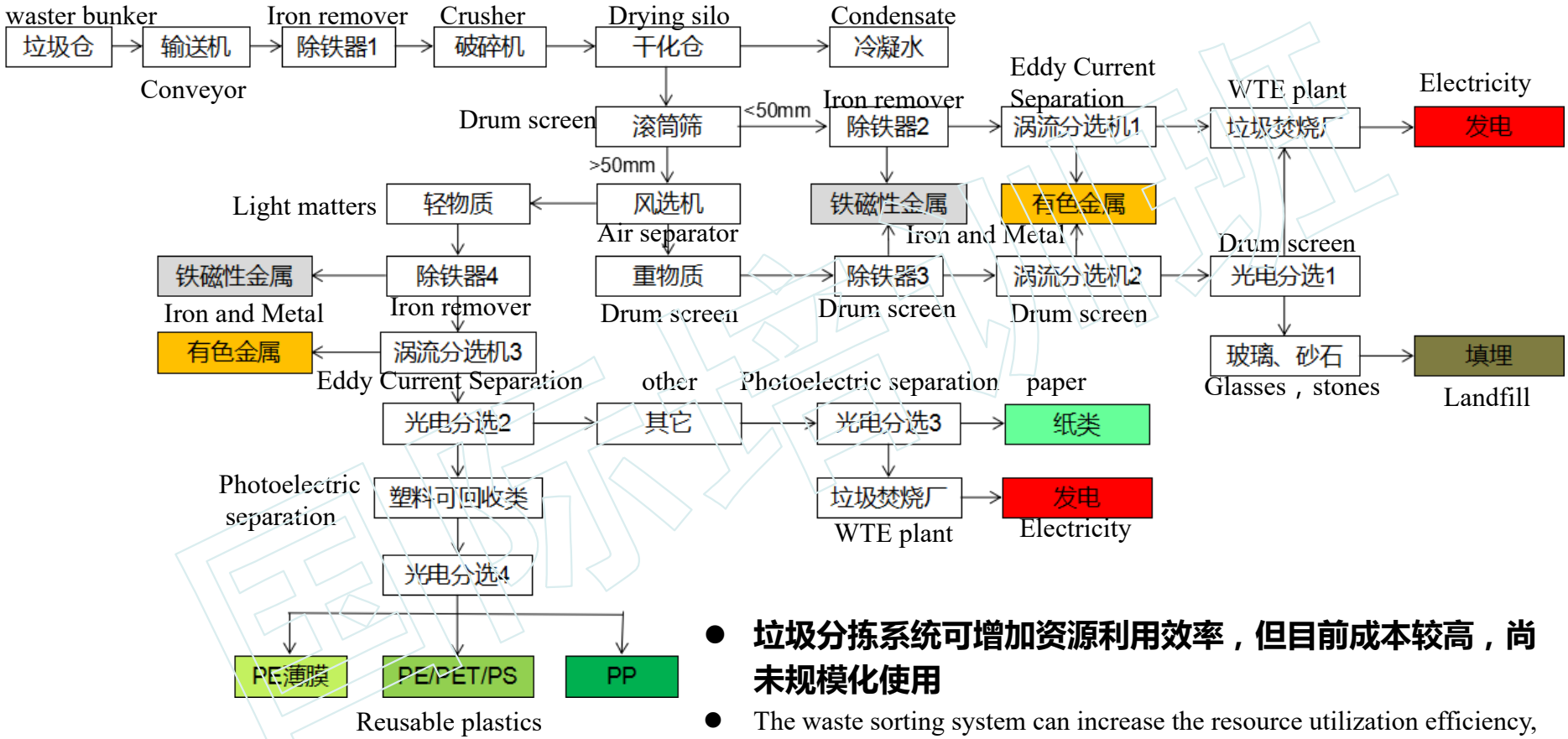
Incineration process diagram （Suzhou 4 phase）

安全生产 Safe Production

完全燃烧 Complete combustion

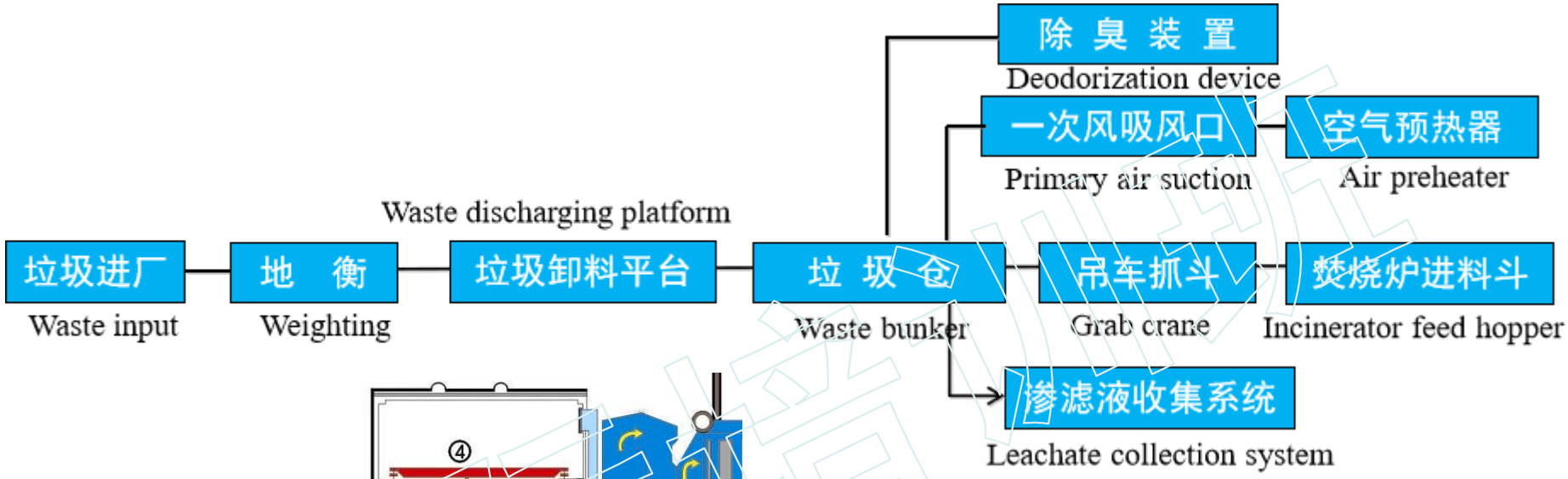
达标排放 Emissions standard

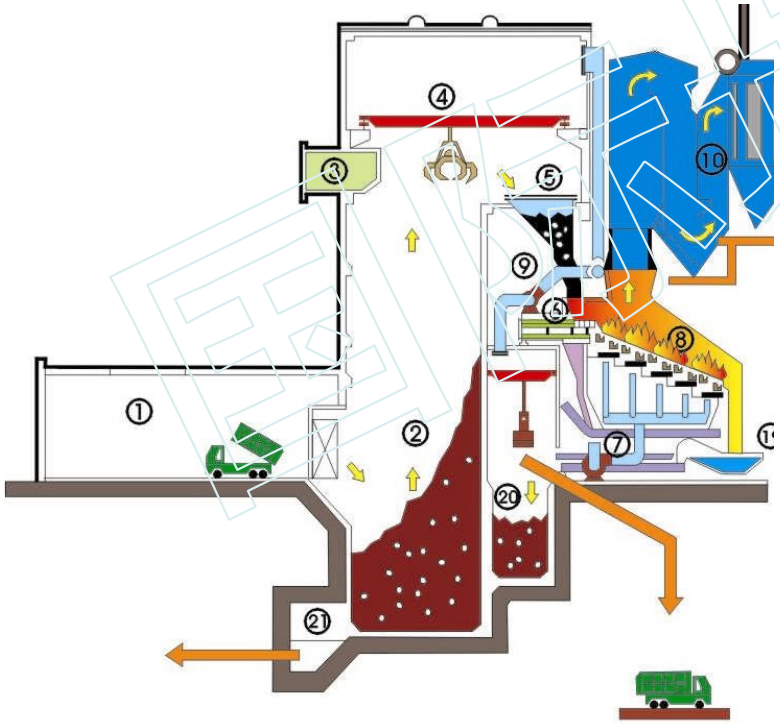
（1）垃圾分选系统
Waste sorting system



- **垃圾分拣系统可增加资源利用效率，但目前成本较高，尚未规模化使用**
- The waste sorting system can increase the resource utilization efficiency, but the current cost is high and has not been used in a large-scale way
- **经破碎、干化、机械粗分选后，进行智能光电分选，提升产品纯度；**
- After crushing, drying and mechanical rough sorting, intelligent photoelectric sorting is carried out to improve product purity;

（2）前处理系统
Pre-treatment system

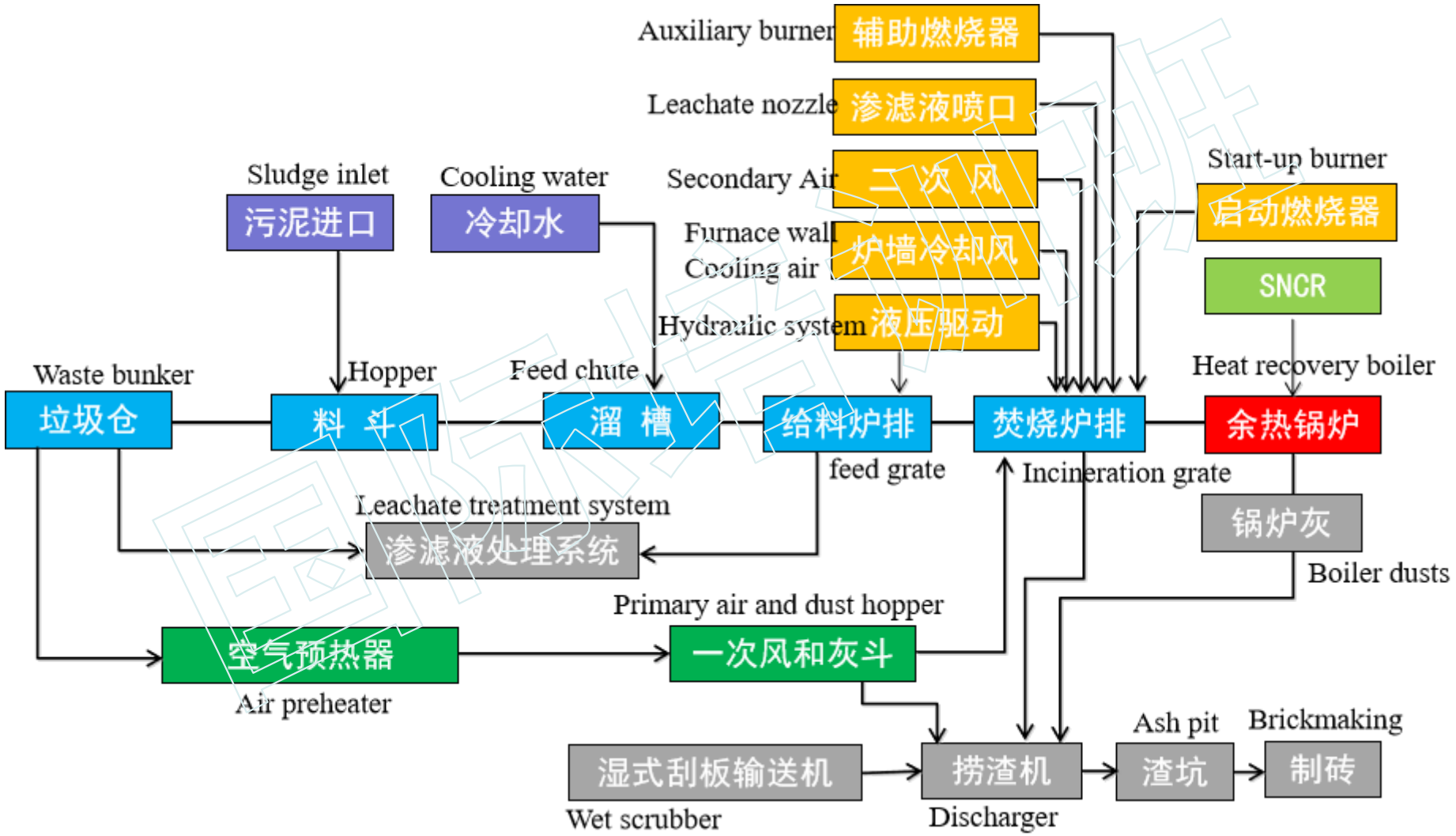




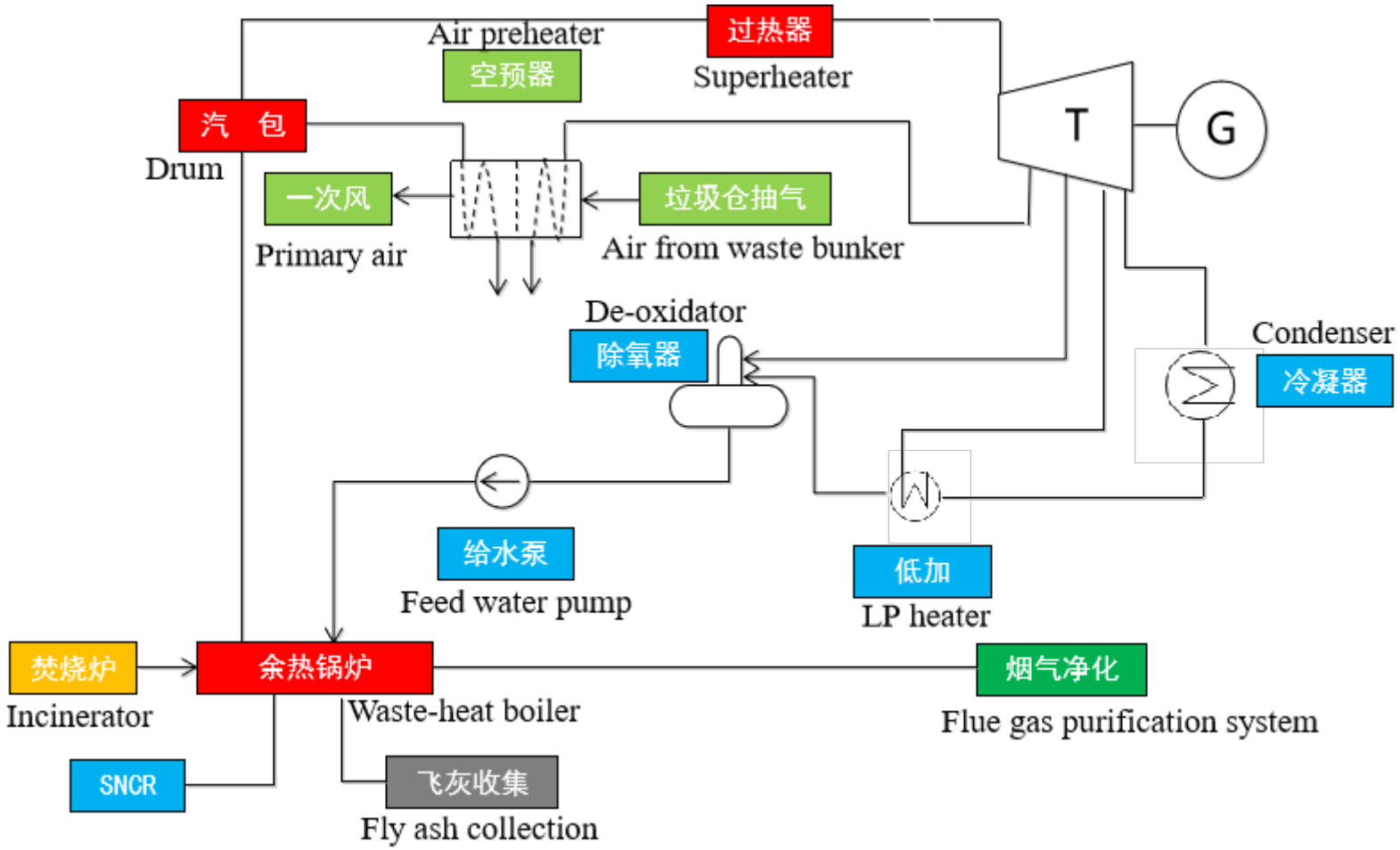
垃圾仓 Waste bin

- **容积5-7天** Volume 5-7 days
- **密封** Sealing
- **负压运行** Negative pressure operation
- **渗滤液收集** Leachate collection
- **除臭装置** Deodorization device
- **消防装置** Fire Service Installations

（3）焚烧系统
Waste incineration system

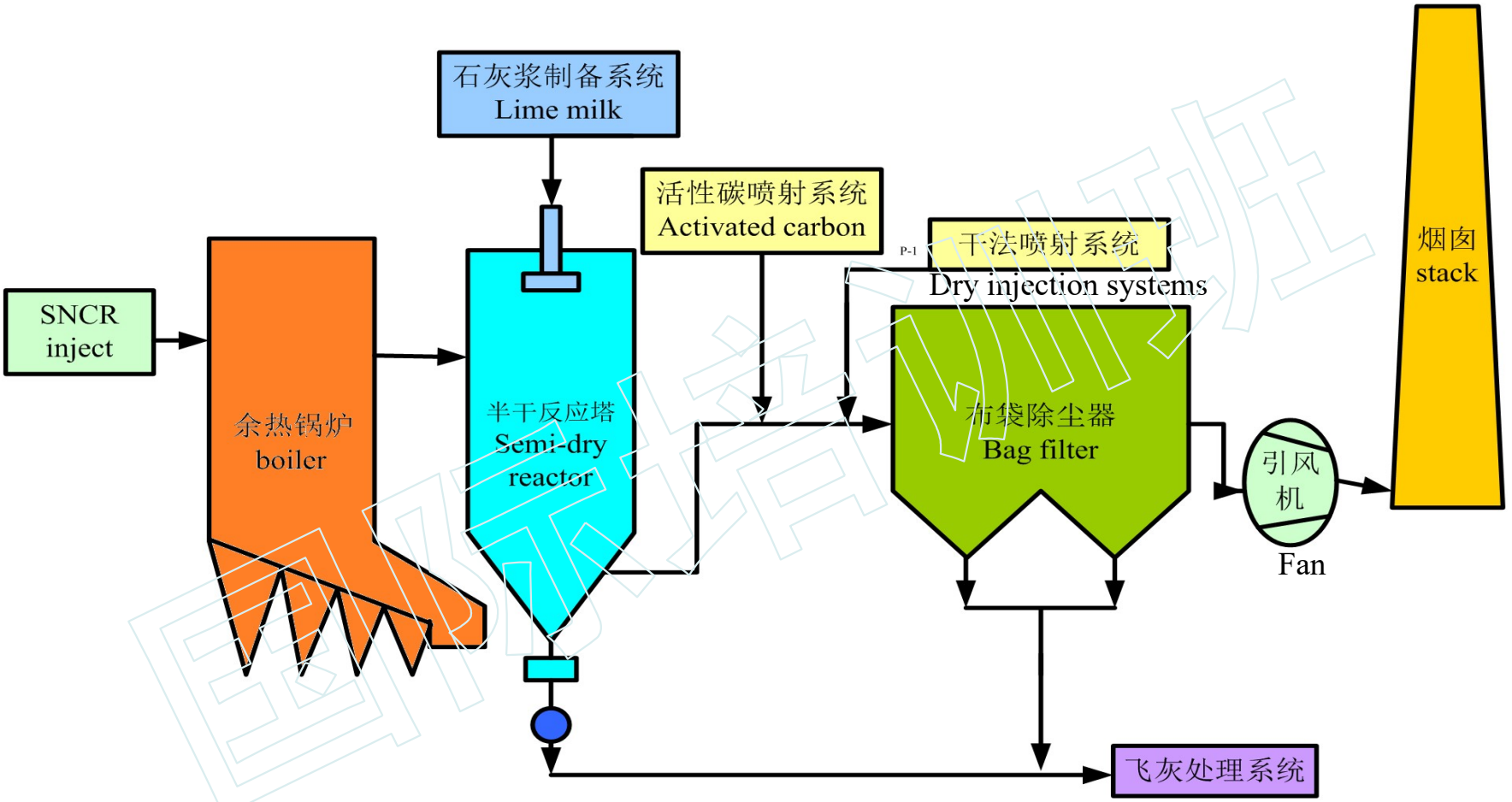


（4）余热利用
Waste heat utilization



- **余热利用给垃圾电厂提供2/3的总效益** Waste heat is used to provide the total benefit of 2/3 to the waste power plant.
- **余热利用方式：供电、供热和热电联供等**
  Waste heat utilization : power supply, heating and cogeneration etc.

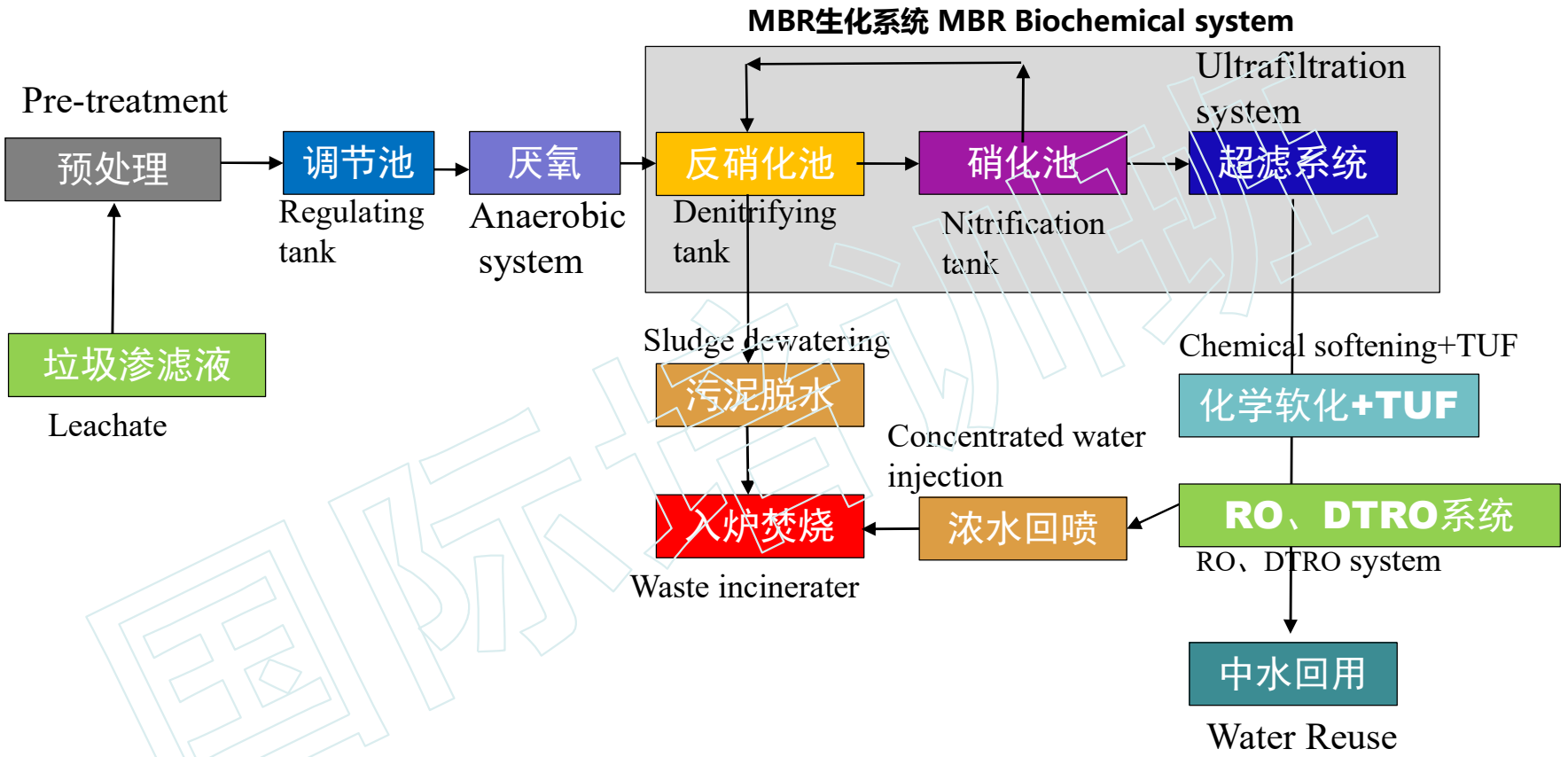
（5）烟气净化系统
Flue gas purification system



欧盟2010标准工艺流程：SNCR+半干法+干法+活性炭+布袋除尘器

EU 2010 standard process: SNCR+ semi-dry + dry + activated carbon + bag filter

（6）渗滤液处置系统
Leachate processing system



工艺流程：预处理+调节池+厌氧+MBR生化系统+化学软化+TUF+RO+DTRO

Standard process: Pre-treatment+ Regulating tank+ Anaerobic system+ MBR Biochemical system + Chemical softening+TUF +RO+DTRO

四、光大自主研发垃圾焚烧炉

Everbright self-developed waste incinerator

1、光大自主研发生活垃圾焚烧炉已形成标准化、系列化产品：

Everbright Self-developed waste incineration system has become standardized, serialized products:

300、350、400、500、600、750、850、1000tpd

目前已投产、在建的自主研发生活垃圾焚烧炉超300台。

Currently nearly 300 self-developed waste incinerators have been put into operation and construction.

750t/d ：供货量超75台，填补了国内大容量焚烧炉空白。

750t/d：over 75units manufactured

850t/d ：宜兴项目2台投运

850t/d: Yixing 2 phase 2 units inoperation.

1000t/d ：吴江二期项目在建3台，将成为世界单台炉处理量最大的焚烧炉

1000t/d :Wujiang 2 phase is building 3 units Which would become world's biggest waste incinerator

- **光大发展使用光大自主研发技术，成熟后再推向市场。**

Everbright develop and use independent research technology, when it become mature and then be put into the market.

- **光大集市场、科研、产品设计、工程设计、设备制造、工程建设、运行维护、售后服务于一体。在工程建设、运行维护中发生问题及时反馈，形成闭环，进一步优化、完善设计。**

Everbright consists of market, research, product design, engineering design, equipment manufacturing, construction, operation and maintenance, after-sales service. Problems occurred and timely feedback in the construction, operation and maintenance to form a closed loop, and further optimization and improvement.

自主研发500t/d垃圾焚烧炉排

500 t/d self-developed waste incineration grate

自主研发750t/d垃圾焚烧炉排

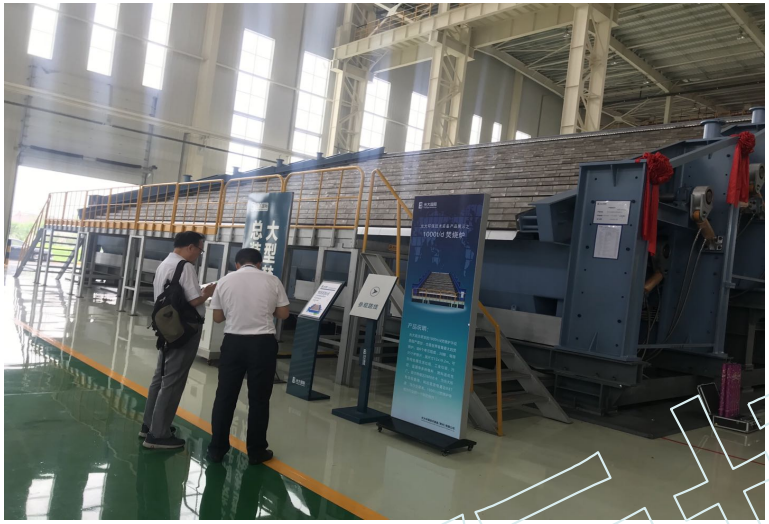
750 t/d self-developed waste incineration grate

850t/d焚烧炉排标准单元

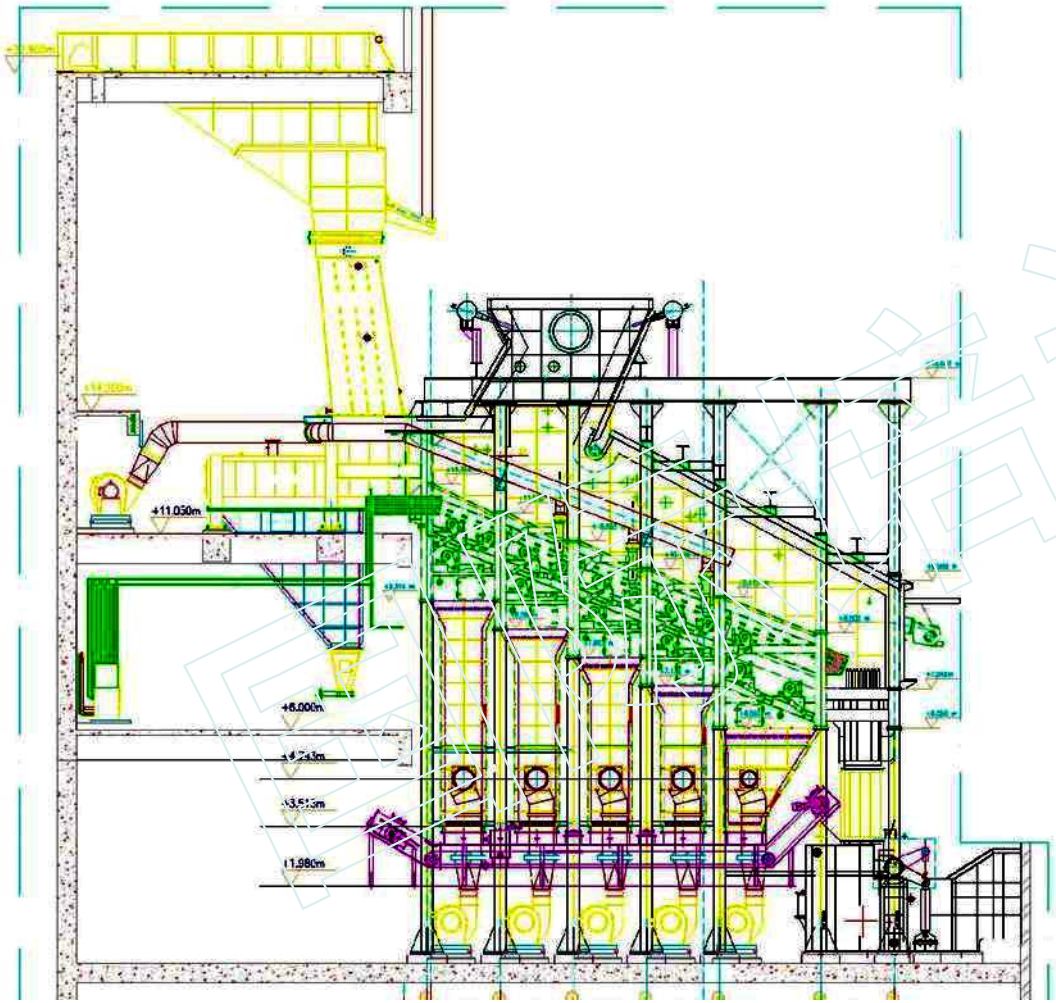
850 t/d incineration grate standard unit

1000t/d焚烧炉排

1000 t/d incineration grate

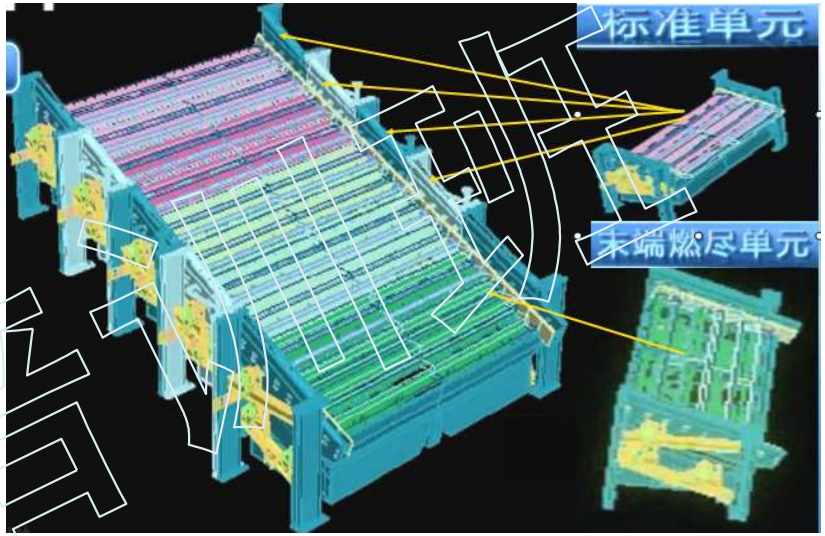


设备组成
Incineration grate components



01、料　斗　Hopper
02、溜　槽　Feed chute
03、给料炉排　Feeding grate
04、焚烧炉排　Incineration grate
05、钢结构　Steel.structure
06、焚烧炉　Incinerator
07、灰　斗　Ash hopper
08、渗滤液斗　Leachate hopper
09、漏灰渣输送机　Leakage ash conveyor
10、捞渣机　Discharger
11、一次风机　Primary air fan
12、二次风机　Secondary air fan
13、液压站、阀站
Hydraulic station, valve station
14、边墙冷却风机　Side wall cooling fan
15、启动燃烧器　Start-up burner
16、辅助燃烧器　Auxiliary burner

焚烧炉排
Incineration grate



- **纵向分为五个单元，包括四个标准单元和一个加长的末端单元**
  The longitudinal is divided into five units, including four standard units and last extended end unit.

  干燥段：第一、第二标准单元组成
  Drying section: the first and second standard unit

  燃烧段：第三、第四标准单元组成
  Combustion section: the third and fourth standard unit

  燃尽段：加长的末端单元
  Burnout section: an extended end unit

- **各单元都可以独立调节**
  Each section can be adjusted independently.

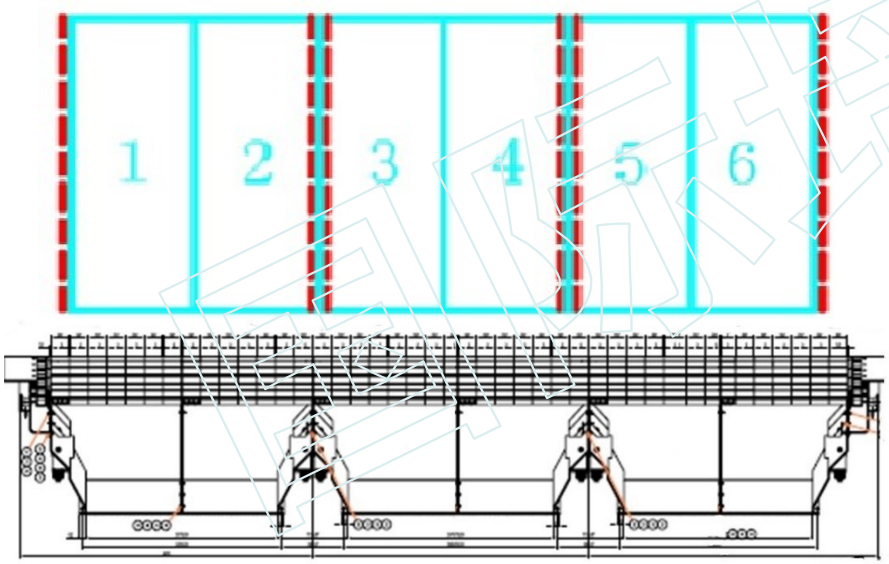
2、模块化设计
Modular design

- **国外500t/d以上的大型焚烧炉为纵向布置，随容量增大，纵向模块数量也增加。**

The large-scale incineration furnace above 500t/d in foreign countries is in the vertical direction, with the increase of the capacity, the number of longitudinal modules is also increased.

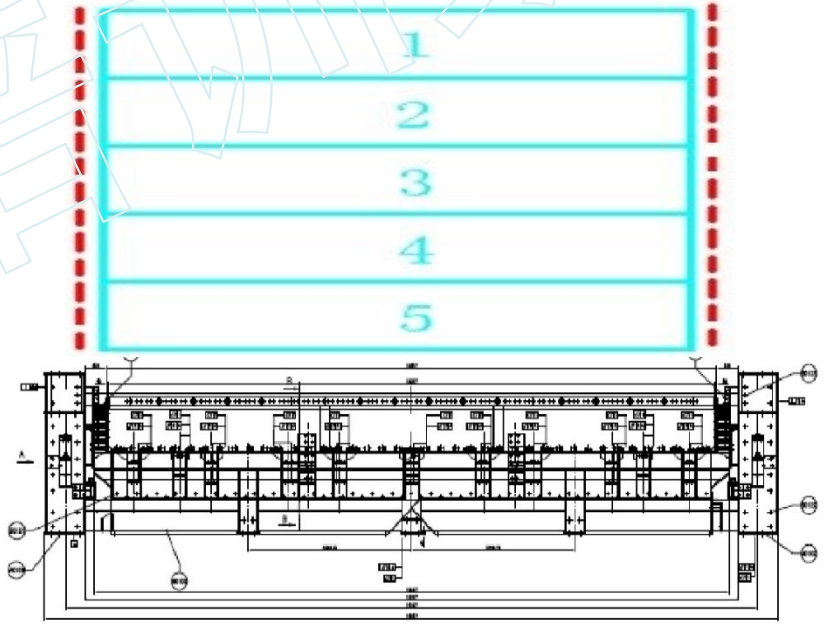
- **光大自主研发的焚烧炉只有五大模块组成，为横向布置。**

Everbright self-developed waste incinerator only consists of five modules with the horizontal direction.



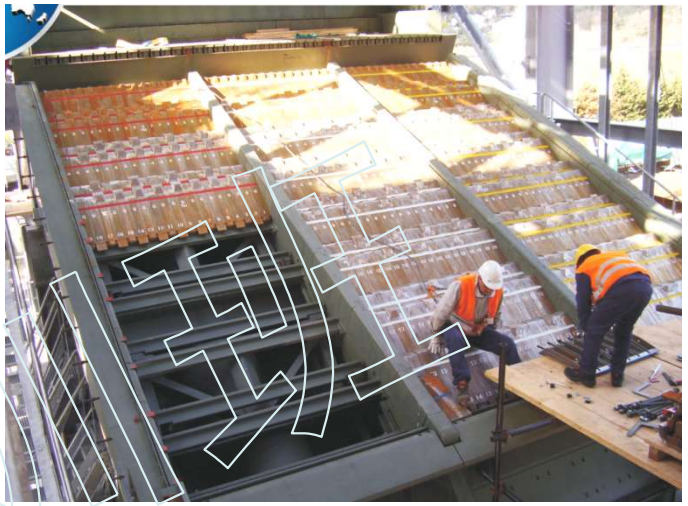
进口炉排纵向布置

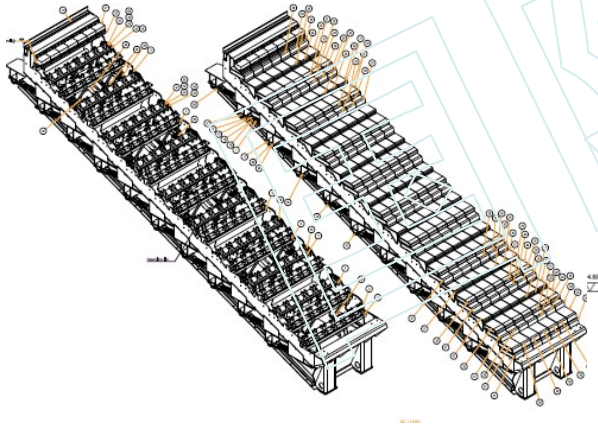
Imported grate is arranged in a vertical direction

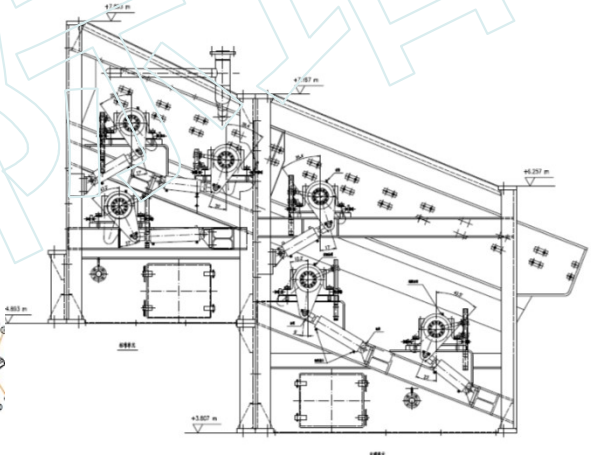


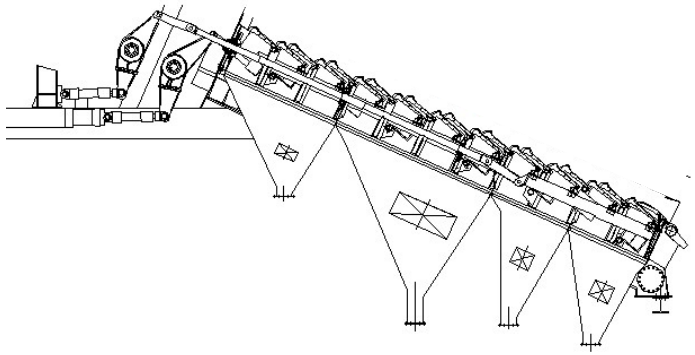
自主研发炉排横向布置

Grate of independent research is arranged in a horizontal direction









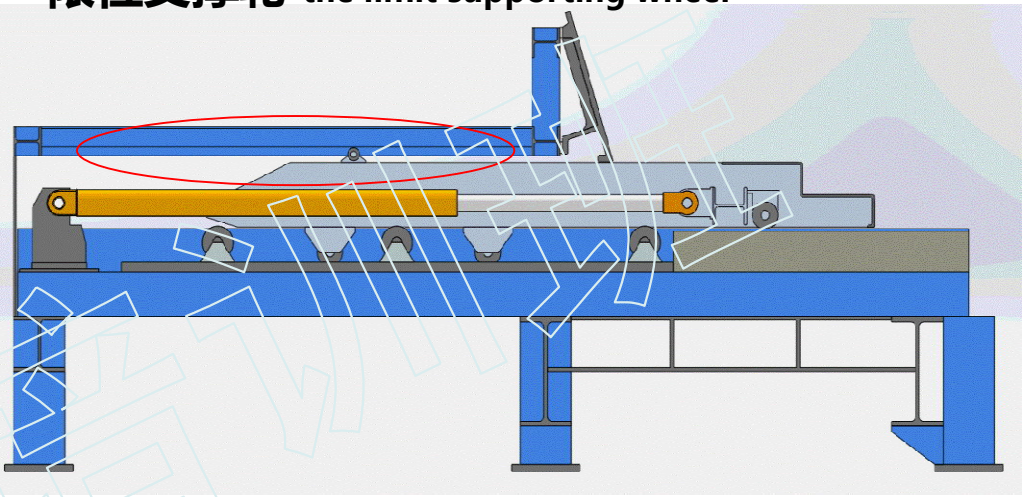
进口500t/d炉排
Imported 500t/d grate

自主研发500t/d炉排
Self-developed 500t/d grate

马丁500t/d炉排
Martin500t/d grate

3、给料炉排 The Feeding Gate

限位支撑轮 the limit supporting wheel

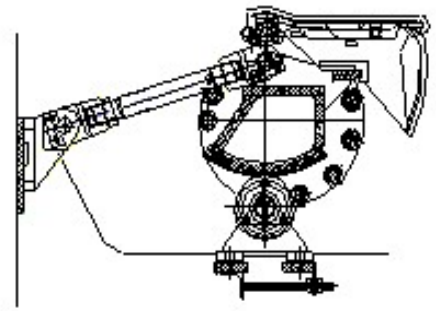


- 特别设计的限位支撑轮防止给料小车卡死 Special design of the limit supporting wheel prevents the Feeding trolley from being stuck
- 给料炉排宽度与焚烧炉排宽度相同 The width of the feeding gate is the same as the width of The combustion grate
- 给料炉排的行程、速度和频率都可以调节 The travel ，the velocity and the frequency of the feeding Gate can be adjusted

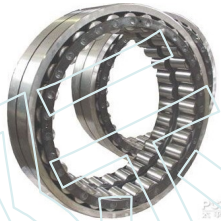
4、关键部件优化提升 Optimization key components

进口炉排 Imported grate

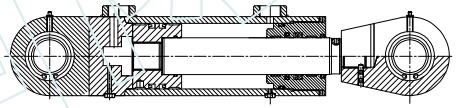
单滚轮支撑
Single roller support



需加润滑油
Needs lubricating oil

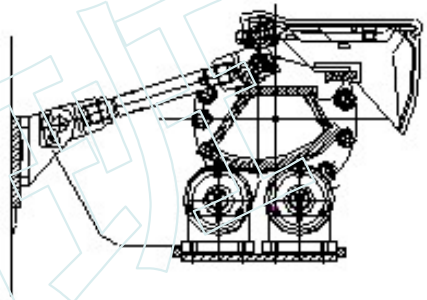


无缓冲液压缸
No Buffer hydraulic cylinder



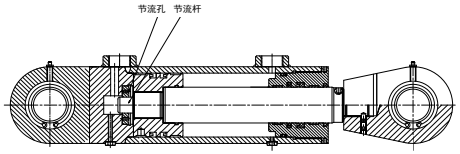
自主研发炉排 Self-developed grate

双滚轮支撑
Double rollers support

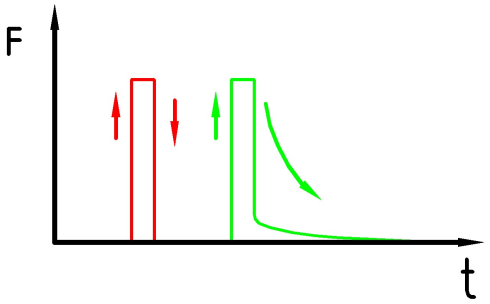


自润滑轴承
Self lubricating bearing

带缓冲液压缸
Buffer hydraulic cylinder

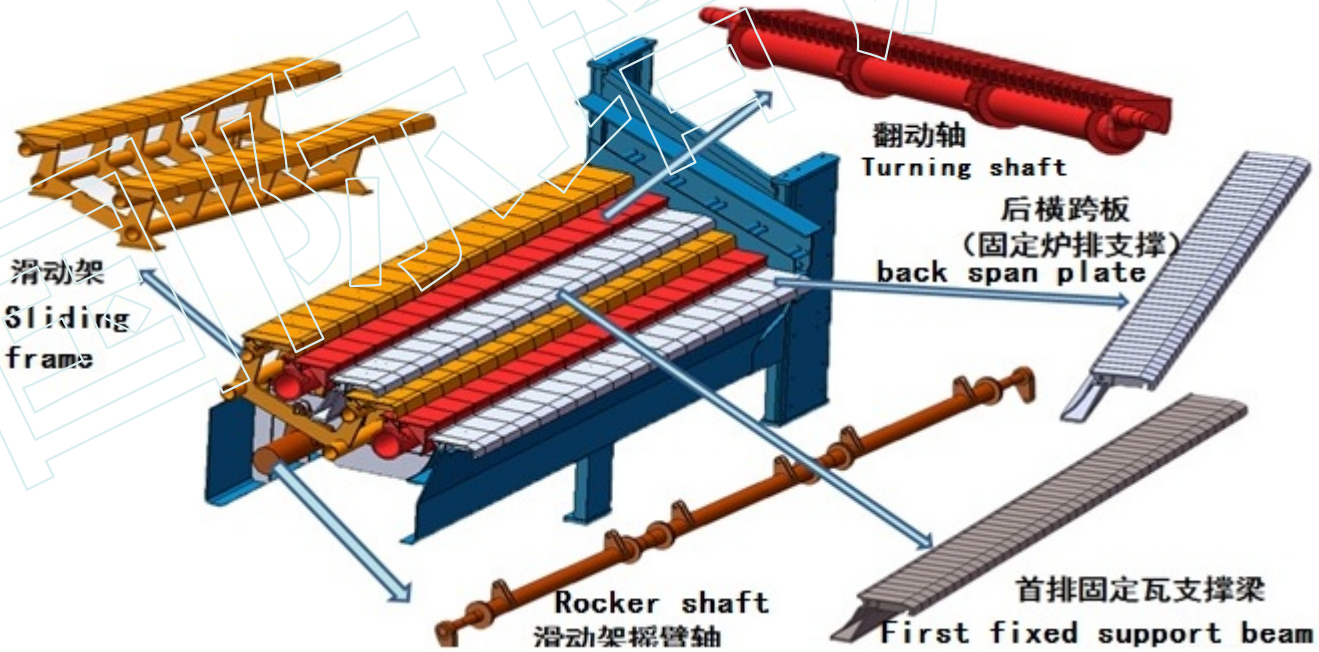


- **减少对支撑轮轴承的冲击载荷**
  Reduce the impact load on supporting roller bearing
- **延长翻动轴及翻动支撑轮使用寿命**
  Extend service life of the turning axis and the supporting wheel



5、关键部件校核计算 Key components verify calculation

- **垃圾焚烧炉为热机，设计时必须充分考虑部件的热应力、热变形、热膨胀。炉内构件在10倍载荷和300℃高温下校核强度、刚度和挠度，保证焚烧炉安全、可靠运行。** The Waste incineration furnace is heat engine, The thermal stress, thermal deformation and thermal expansion of the components must be considered in the design. The strength, rigidity and deflection are checked at 10 times of load and 300 ℃ to ensure the furnace safe and reliable.



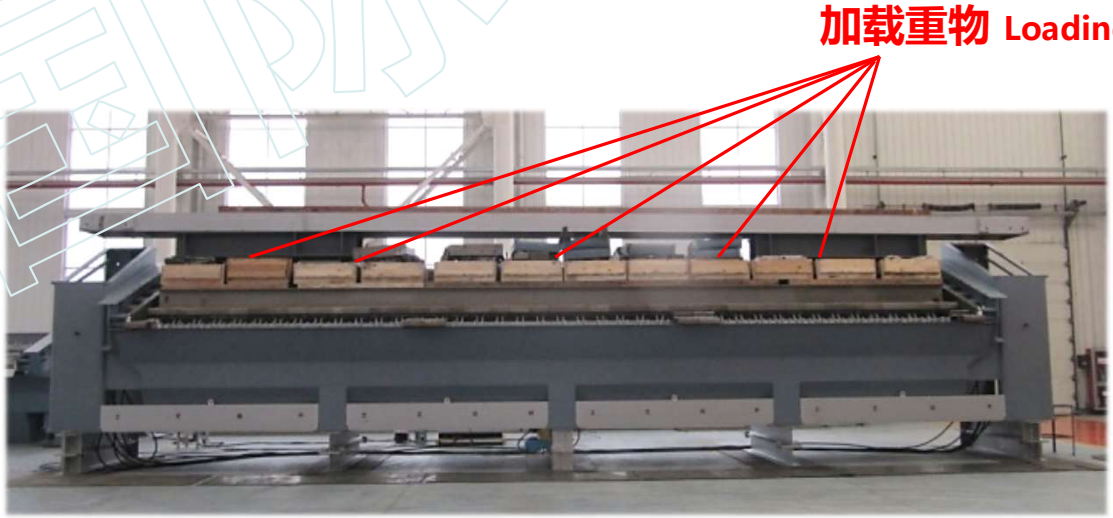
6、样机加载试验 Prototype loading test

- 用钢丝绳固定重物对滑动架加载至21t，连续运行2小时。三个滑动架同步进退、平稳、无异响、无跑偏、无跳跃现象，表明滑动架加载后，驱动轴平稳传递扭矩，支撑驱动轴的滑动轴承负荷、液压缸推力等满足设计要求。

  The sliding frame was loaded weight fixed by wire rope to 21t， working continuously for two hours. The three sliding frame was synchronized, working smoothly. there were no abnormal noise, no deviation, and no jump. it showed that the driving shaft transfer torque smoothly, Sliding bearing load and hydraulic cylinder thrust meet the design requirements

- 对翻动轴加载至5t，连续运行1小时，传动和承载部件的试验结果符合设计要求。

  The turning shaft was loaded weight to 5t， working continuously for one hours，the result meet the design requirements



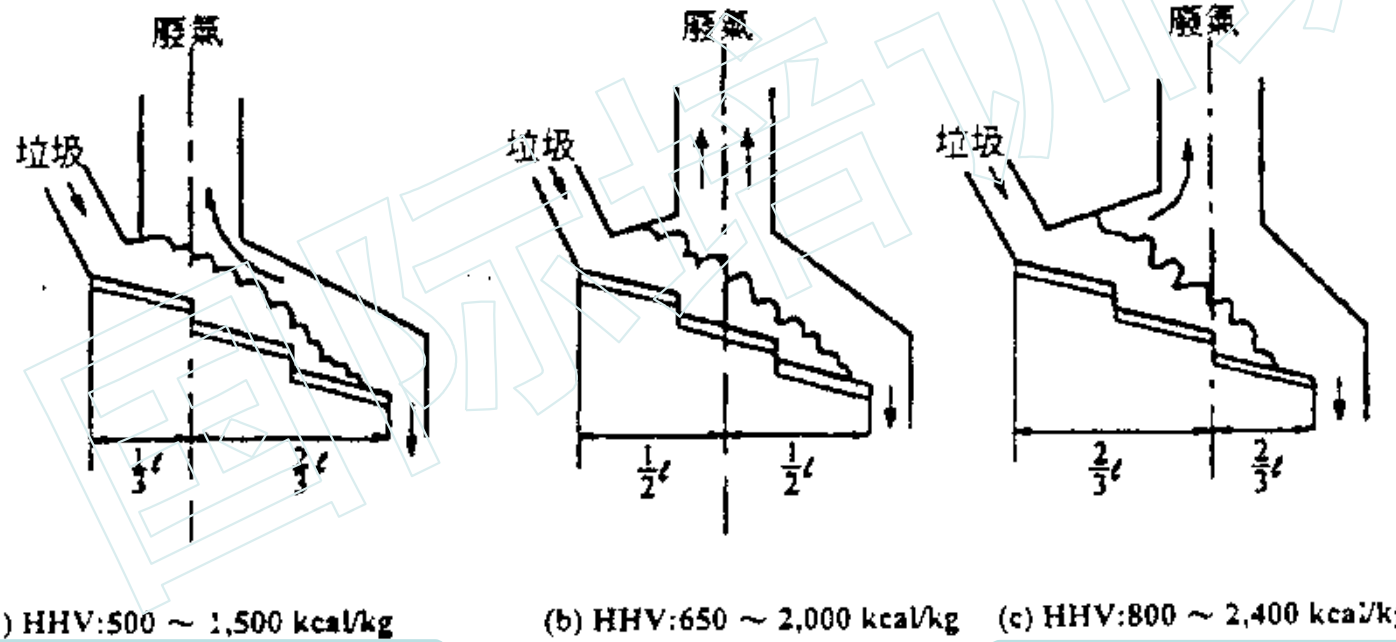
11、炉膛结构研究

furnace research

- **炉型用CFD（数值模拟计算流体动力学）模拟**

Every incinerator furnace is CFD simulated(Computational Fluid Dynamic)

炉型的种类/furnace tpyes



(a) HHV:500 ~ 1,500 kcal/kg

逆流式、高水分、低热值
Counter current, high moisture, low heat value

(b) HHV:650 ~ 2,000 kcal/kg

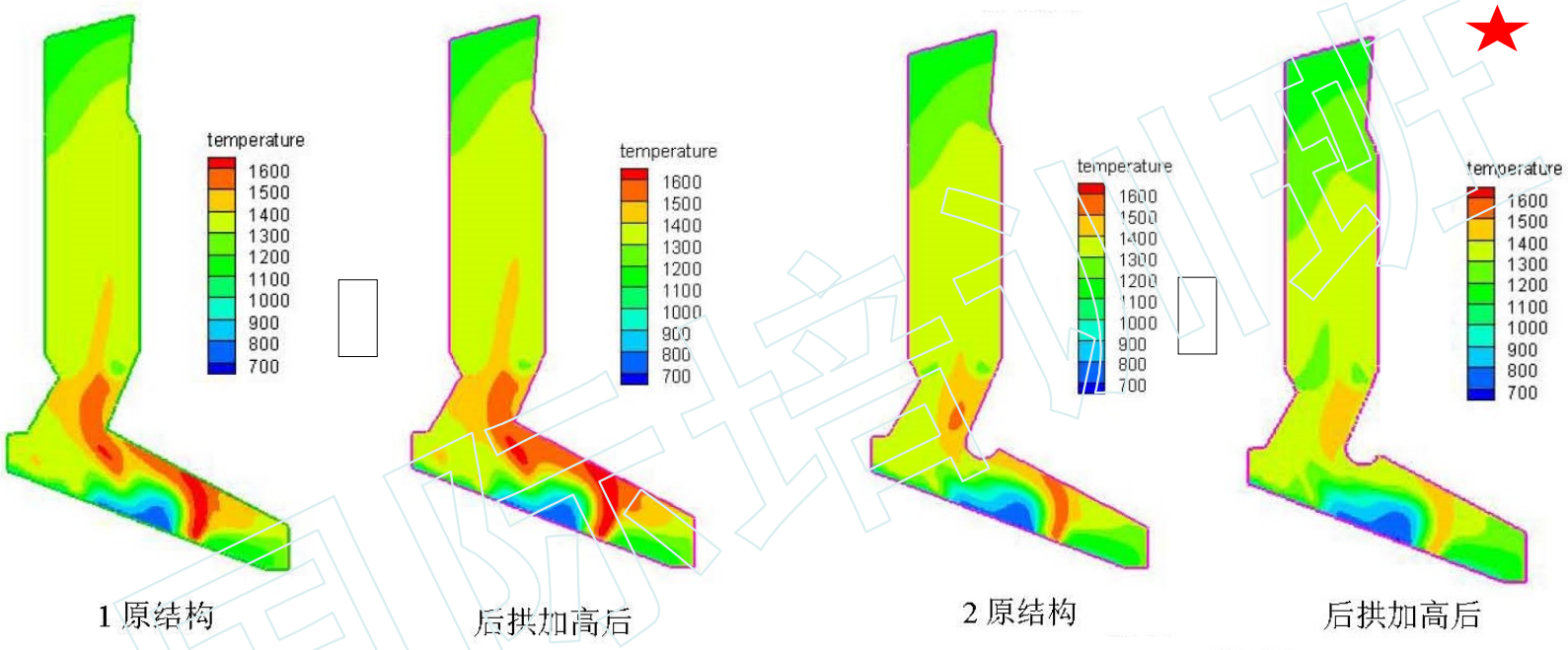
交流式、两者之间
Mixcurrent, in middle

(c) HHV:800 ~ 2,400 kcal/kg

顺流式、低水分、高热值
Cocurrent, low moisture, high heat value

用CFD模拟温度场，减缓结焦时间

CFD is used to simulate the temperature field, be suing to alleviate coking



优化炉膛结构用于苏州三期3x500t/d，宁波2x500t/d和南京4x500t/d，吴江2X750t/d焚烧炉，使结焦状况有所改善，使炉膛清焦时间长达8个月以上。

The optimized furnace is applied in Suzhou III phase 3x500t/d, Ningbo 2x500t/d and Nanjing 4x500t/d, the furnace coking is alleviated, interval time of cleaning coke is extended to 8 months or longer

12、用CFD模拟一次风

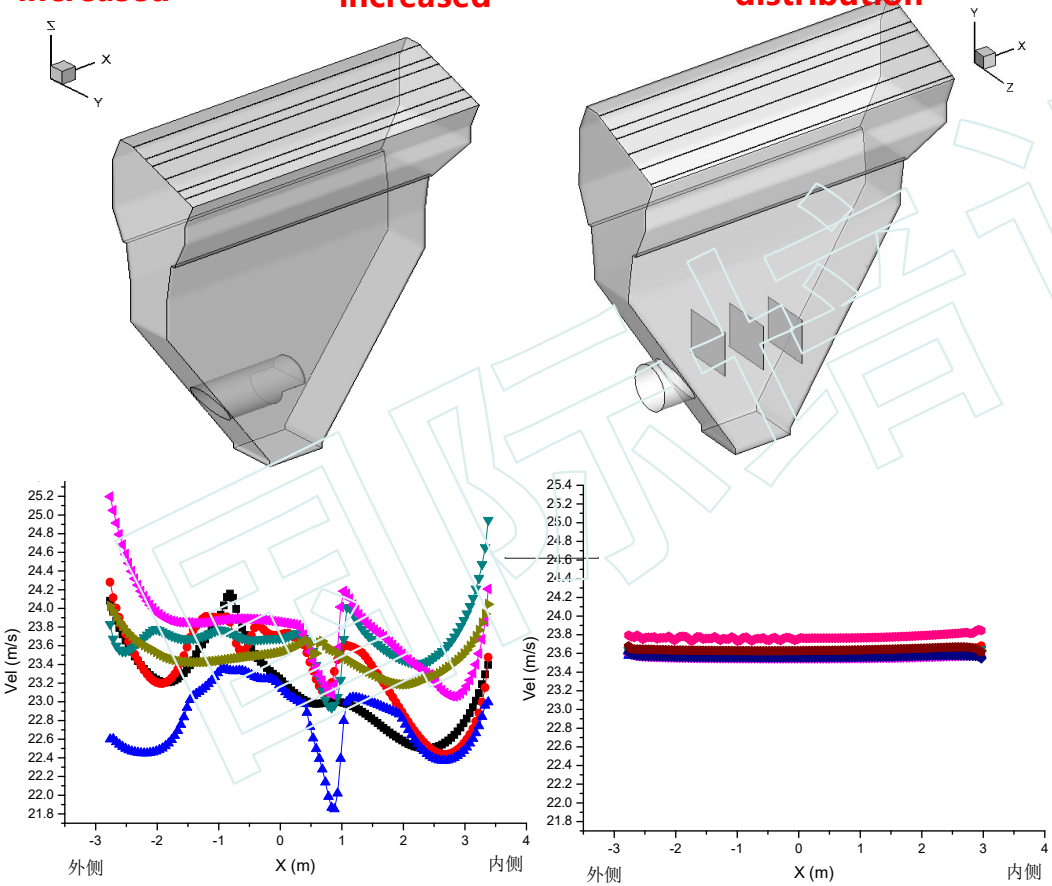
Primary air CFD simulation

处理量增大 → 炉膛宽度增加 → 易使炉膛燃烧不均匀，产生偏烧

Throughput increased → boiler width increased → Combustion uneven distribution

给料均匀
Evenly distribution feeding

一次风布风均匀
Primary air distribution



优化前
Before optimization

优化后
After optimization

- 用空气动力学数字模拟CFD优化
  一次风进风口的位置和形式
  Primary air inlet position and shape is CFD simulated
- 增加导流板 Adding guide plate
- 一次风布风均匀性±0.6%
  Uniformity of primary air distribution is ±0.6%

13、用CFD模拟二次风

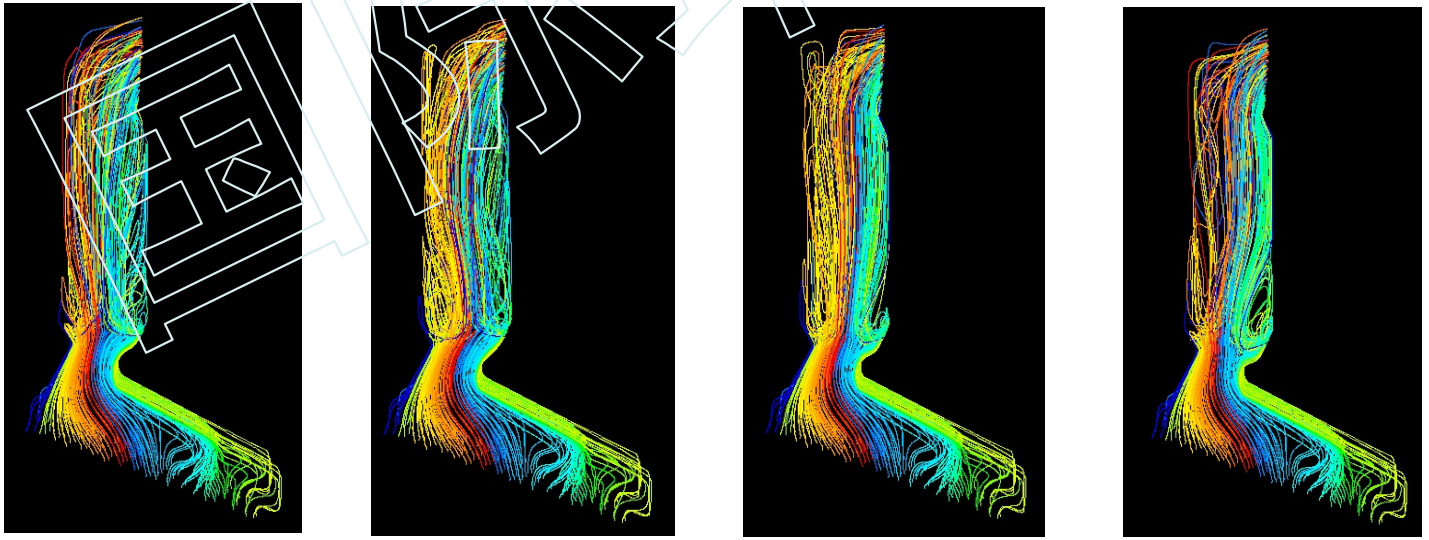
Secondary air CFD simulation

- 二次风配风方式对颗粒物在炉膛的停留时间、对余热锅炉的充满度及炉膛出口NO_x浓度有较大影响。

  The distribution of secondary air could affect particle residence time, boiler flue gas fullness degree and Nox generation

- 用CFD对二次风喷嘴的不同安装角度、不同流速用40种配比方案得出最佳值，使焚烧炉效率高， NO_x浓度低。

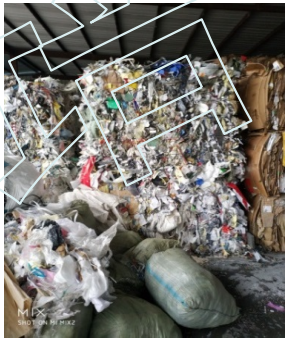
  Angle, velocity of secondary air are CFD studied, 40 schemes are designed and compared each other, to make the optimized boiler have high effciency, low Nox



15、多种固废协同焚烧
(Co-incineration of various solid wastes)

- 利用垃圾焚烧设备，协同处置多种固废，如工业垃圾、市政污泥、湖中的蓝藻等，提高垃圾焚烧设备利用率，降低政府固废处置成本，一举多得
- 如，疫情阶段，光大垃圾焚烧厂积极响应国家号召，发挥行业优势，利用垃圾焚烧厂无害化处置医疗废弃物和医疗口罩，大大减轻了防疫压力
- 协同处置的关键在于热值以及污染物排放






工况一	蓝藻(预设)	生活垃圾	工业垃圾	市政污泥	综合
	50t/d	1500t/d	1200t/d	300t/d	3X1000t/d
热值：	175Kca/kg	1400Kcal/kg	4506Kcal/kg	288Kcal/kg	2600Kcal/kg

16、光大自主研发焚烧炉性能测试

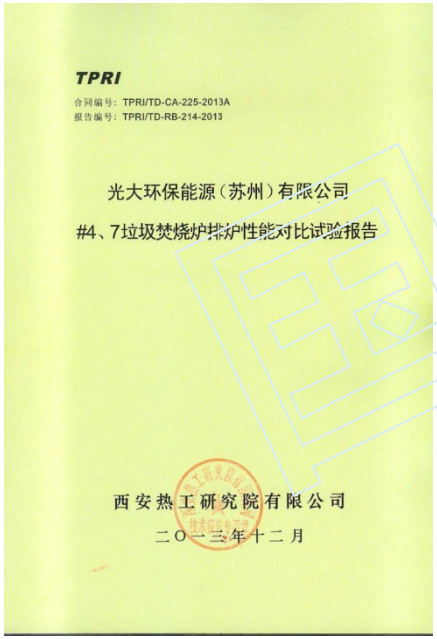
Third party Performance test

■ **苏州垃圾焚烧发电项目二期进口2x500t/d和三期自主研发3x500t/d炉排炉，在同一地点、用同一种垃圾、在同一个工厂、同等容量、不同制造商。请西安热工院对两种炉排进行热力测试。结果表明：**

In Suzhou MSW incineration project, two phase 2x500t/d incinerators are imported and three phase 3x500t/d incinerators are independent R&D products, they are in the same place, burning the same waste, have the same capacity and different manufacturer. Xi'an Thermal Engineering Institute are invited to do the performance test, results are:

自主研发炉排炉的各项运行性能指标明显优于进口设备

Many operation performance indexs of EB R&D products are obviously superior than import products


TPRI

合同编号：TPRI/TD-CA-225-2013A

报告编号：TPRI/TD-RB-214-2013

光大环保能源（苏州）有限公司

#4、7垃圾焚烧炉排炉性能对比试验报告

西安热工研究院有限公司

二〇一三年十二月

项　目	蒸汽参数（℃/MPa）	发电量★（kWh/t）	耗电量★（kWh/t）	热灼减率★（110%负荷）	热效率（η）
引进设备	394/3.8	421.19	75.95	>3%	77.823%
自主研发	398/3.95	450.6	57.34	1.94	79.966%
差　值		+29.41	-18.61		
单台炉年差值		+490万kWh	-310万kWh		+2.14%
单台炉年效益		+318.5万元	-201.4万元		

☆

项　目	石灰耗量★（kg/h）	活性炭（kg/t）	氨 水★（L/t）	NO_x浓度★（mg/Nm³）	备注
引进设备	207.5	0.356	2.39	181	上网电价：0.65元/kWh 生石灰：600元/t 活性碳：5,000元/t 氨水(20%)：600元/t 氨水（20%）密度：0.92g/ml
自主研发	135.58	0.383	1.90	134	
差值	-71.92	+0.027	-0.49	-47	
单台炉年差值	-1.2万t	+4.5 t	-8,159 L/a		
单台炉年效益	-720万元	+2.25万元	-0.45万元		

全年同比增加效益：1,600 万元。

Annual profits increased: 16 million RMB

二恶英检测结果（清华大学环境质量检测中心2015年7月）

Dioxin testing results (Environmental quality testing center of Tsinghua University, July 2015)

计量认证及编号：

清华大学环境质量检测中心

Center for Environmental Quality Test, Tsinghua University

持久性有机污染物

Persistent Organic Pollutants

检 测 报 告

DETECTING AND ANALYZING REPORT

报告编号

SERIES NUMBER CEQT-BG(P)-20150081

委托单位

ENTRUSTING UNIT 光大环保能源（寿光）有限公司

报告时间

REPORTING DATE 2015年7月9日

检测单位（公章）

DETECTING AND ANALYZING UNIT 清华大学环境质量检测中心

地址：清华大学环境节能楼502

ADDRESS: 502 Environment and Energy Building, Tsinghua University

邮编：100084 电话：010-62795315

POSTCODE TELEPHONE

采样日期	点位描述	样品编号	二噁英类毒性当量(TEQ)质量浓度 (ngTEQ/Nm³)	
2015年6月15日	光大环保-寿光-1#炉-布袋除尘器-风机后距地面24米采样平台	20150623-01-13(P)	0.0028	
		20150623-01-14(P)	0.0028	
		20150623-01-15(P)	0.0017	
		平均	**0.0024**	(SD= 0.0006)
2015年6月16日	光大环保-寿光-1#炉-布袋除尘器-风机后距地面24米采样平台	20150623-01-18(P)	0.0017	
		20150623-01-19(P)	0.0014	
		20150623-01-20(P)	0.0014	
		平均	**0.0015**	(SD= 0.0002)
2015年6月17日	光大环保-寿光-2#炉-布袋除尘器-风机后距地面24米采样平台	20150623-01-22(	0.0033	
		20150623-01-23(P)	0.0033	
		20150623-01-24(P)	0.0039	
		平均	0.0035	(SD= 0.0003)
2015年6月18日	光大环保-寿光-2#炉-布袋除尘器-风机后距地面24米采样平台	20150623-01-25(P)	0.0022	
		20150623-01-27(P)	0.0014	
		20150623-01-28(P)	0.0022	
		平均	**0.0019**	(SD= 0.00

2015年6月16日	光大环保-寿光-1#炉-布袋除尘器-风机后距地面24米采样平台 Everbright-Shouguang project-1#-bag filter-after ID fan	20150623-01-18(P)	0.0017	
		20150623-01-19(P)	0.0014	
		20150623-01-20(P)	0.0014	
		平均 Average	**0.0015**	(SD= 0.0002)

■ 苏三期500t/d焚烧炉污染物实测值

Pollutants measured value of Suzhou three phase 500t/d incinerator

污染物名称 Pollutant name (mg/Nm^3)	锅炉出口 Boiler outlet	反应塔与布袋之间 Between reactor and bag filter	烟囱入口 Stack inlet	欧盟2010排放标准 EU 2000 standard	新国标* New national standard GB18485-2014
颗粒物Particle	2410	5214	6	10	20
HCl	538	41.9	6	10	50
SOx	195	25.6	1.3	50	80
NOx	130	128	126	200	250
CO	11.65	6.4	5.8	50	80
二噁英Dioxin（$ngTEQ/Nm^3$）	0.6	-	< 0.03	0.1	0.1

* 新建生活垃圾焚烧炉，24小时均值。

*Newly build MSW incinerator, 24 hours average

■ **苏州三期3 台500t/d炉排炉自2013年1月14日至2014年1月14日投运**

一年以来，单台炉：

From the day put into operation, 14 January 2013, to 14 January 2014, Suzhou three phase 3×500t/d grate incinerator have the performance:

- **年运行 8,390小时**

–Annual operation time 8,390 hours

- **年焚烧垃圾约18万吨**

–Annual MSW processed 180,000 tons

- **吨垃圾发电量达 450kWh/t**

–Electricity generation 450kWh/t

- **平均机械负荷率 102%**

–Average mechanical loading 102%

- **平均热负荷率 101%**

–Average thermal loading 101%

- **炉渣热灼减率达小于 3%**

–Ash heat reduction rate less than 3%

上海市环境工程设计科学研究院有限公司

检 测 报 告

三期 1#		三期 2#		三期 3#	
G14-01-95		G14-01-96		G14-01-97	
1.74	1.70	1.65	1.68	1.62	1.67
1.67		1.63		1.72	
1.73		1.75		1.60	
1.76		1.67		1.79	
1.73		1.78		1.73	
1.64		1.67		1.70	
1.79		1.69		1.57	
1.73		1.72		1.69	
1.64		1.61		1.70	
1.60		1.65		1.58	

17、光大自主研发焚烧炉技术优势

Technology advantages of self-developed incineration system

- 特别适合处理中国 “高水分、高灰分、低热值” 的生活垃圾。
  Especially suitable to incinerate “high moisture, high ash, low heat value” MSW in China
- 模块化设计，便于运输，安装周期短，仅需7天，保证现场安装质量。
  Modular design, easy to transport, short installation period, just need 7 days, installation quality onsite can be guaranteed
- 配备先进的自动燃烧控制系统，保证最高的燃烧效率。
  Together with advanced automatic combustion system, to achieve higher combustion efficiency
- 炉排片采用高含量Cr、Ni合金，耐高温、耐磨损、耐腐蚀、抗冲击，炉排片年更换率≤3%。
  The grate step made of high Ni, Cr alloy, with high temperature resistance, wear resistance, corrosion resistance and impact resistance, annual replacement rate ≤3%
- 独特的翻动炉排设计，燃烧效果好，燃尽率高，炉渣热灼减率≤3%。
  Unique grate flipping design, with excellent combustion effect, high burnout rate, ash heat reduction rate ≤3%
- 同区域吨垃圾发电量最高。Have the highest electricity generation per ton in the same region
- 超负荷能力强。Have the strong ability of overload
- 设备运行可靠、稳定，年运行时间≥8,000h。Facility is highly reliable and stable, yearly operation ≥8,000h
- 产品标准化和系列化，满足不同规模城市建厂要求：150、200、 250、300、350、400 、500、600、750t/d与850t/d
  Products are standardized modularized, can meet various need: 150、200、 250、300、350、400 、500、600 and 750t/d;
- 可掺烧污泥，已在多个电厂有运行业绩。
  Have the ability of co-combustion with sludge, experiences are obtained in several plants
- 垃圾发电厂提高经济效益：吨垃圾发电量高（提高蒸汽参数）、 年运行时间长、超负荷能力强、高速汽轮发电机组。To increase plant economic performance: more electricity generated per ton(to increase steam parameter), longer yearly operation time, ability of overload, high speed turbine。

18、光大自主研发焚烧炉成果鉴定

Achievement identification

2012年4月27日，在中国环境科学学会组织的成果鉴定会上，专家组一致认为

27th April 2012, expert group on the achievement identification meeting organized by China Environment Science Society consensus that:

1）光大国际所研发的新型炉排炉技术适合国内生活垃圾的特点；

The grate incinerator newly developed by EB suitable for domestic MSW

2）实现了我国生活垃圾焚烧炉排炉技术的国产化；

Realized the localization of MSW incinerator technology;

3）达到了同类技术的国际先进水平。

Have reached advanced world level among similar technology.

并建议进一步加快成果的推广应用。

And recommended to further speed up the application of the achievement.

五、光大自主研发烟气净化技术

Self-developed flue gas system of Everbright

生活垃圾焚烧发电工艺流程图

Waste to energy plant process flow chart

一 进：生活垃圾 1 in MSW

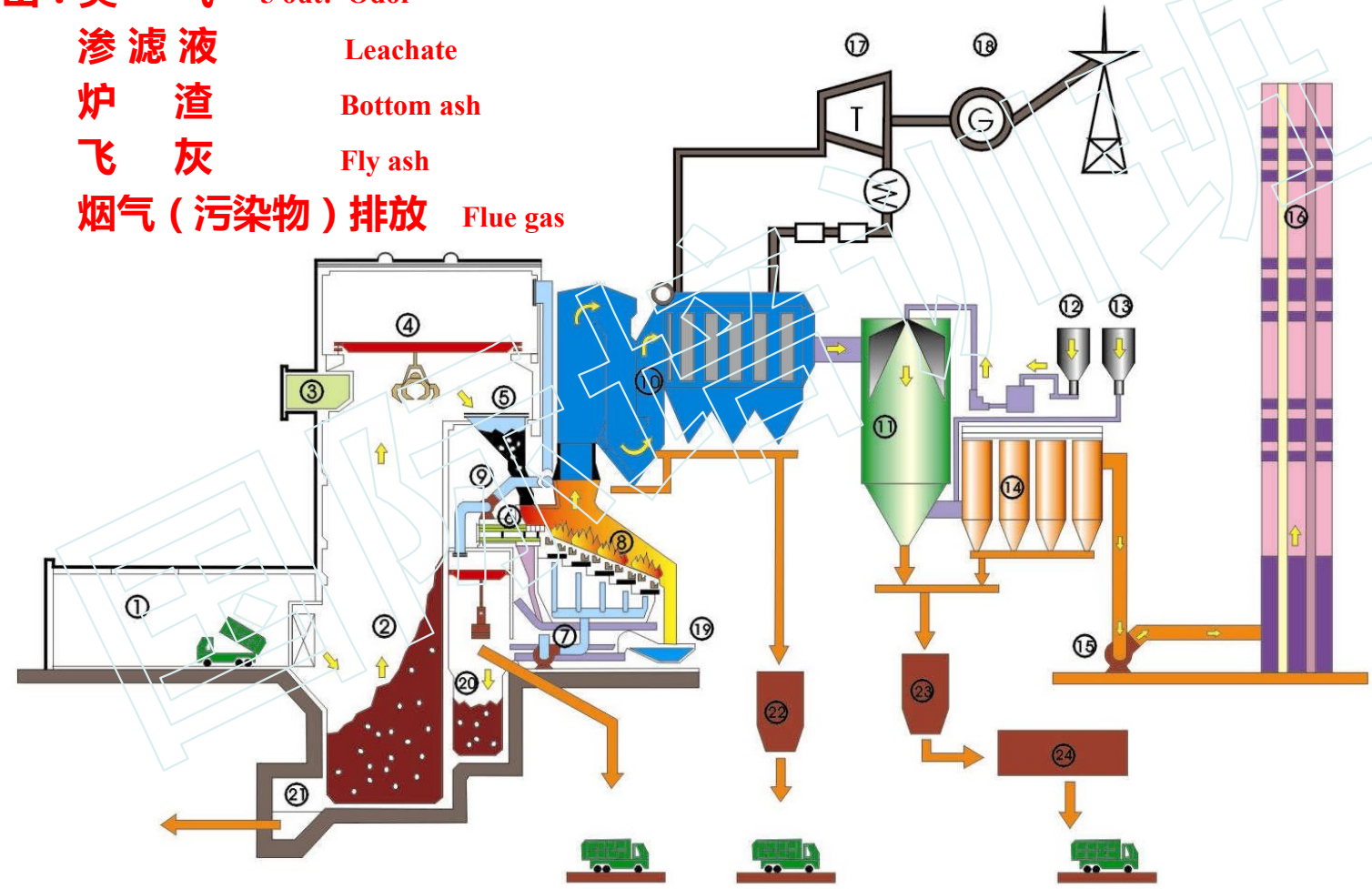
五 出：臭　　气 5 out: Odor

渗 滤 液 Leachate

炉　　渣 Bottom ash

飞　　灰 Fly ash

烟气（污染物）排放 Flue gas



1、烟气排放控制标准

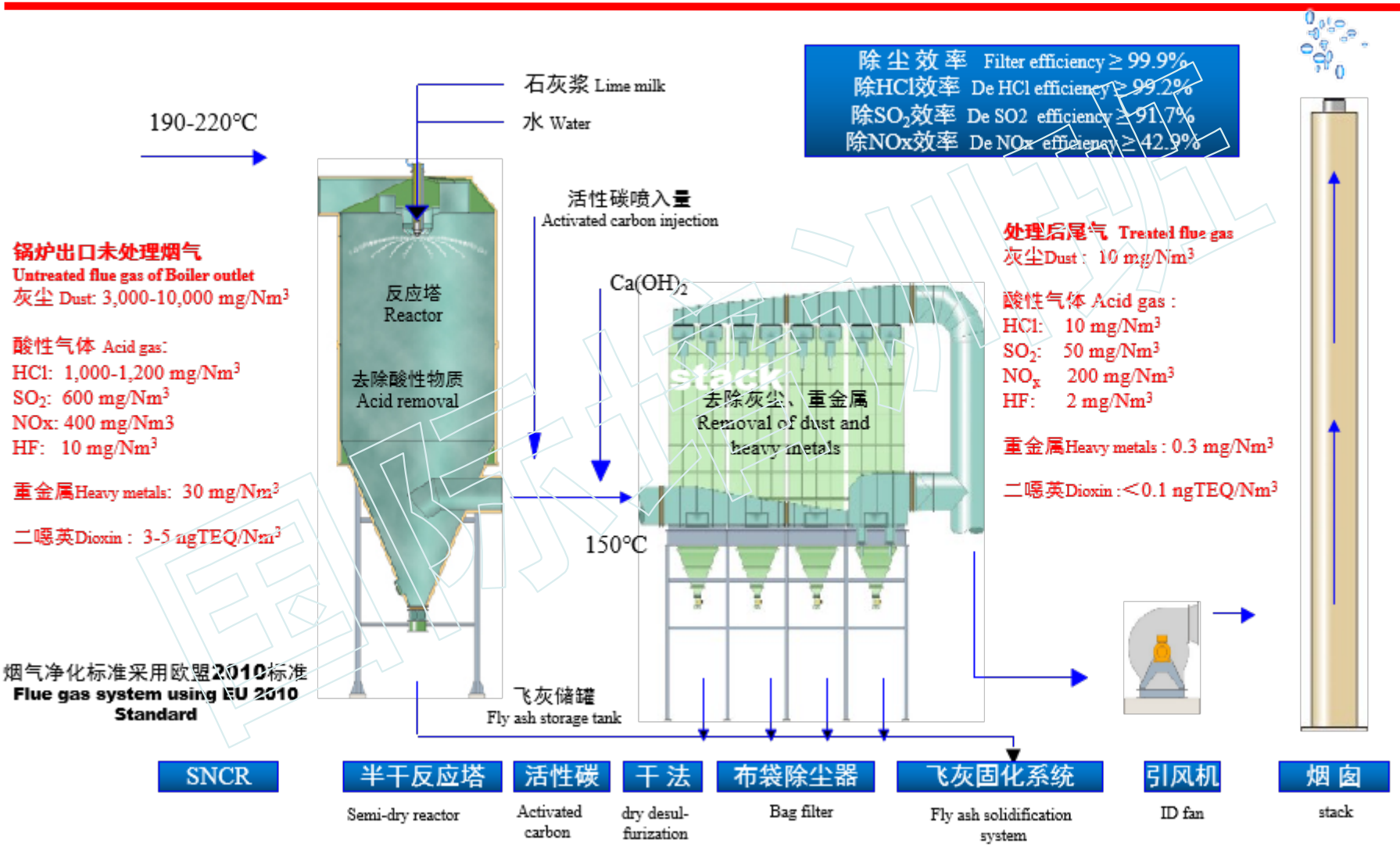
Flue gas emission standard

污染物	国标 GB18485-2014	欧盟2010	海南DB46-484	河北 DB13/5325-2021	天津DB12	天津（引领性指标）	欧盟 BAT2019（new plants）	杭州项目设计标准
单位	mg/Nm3（@11%O2，dry）							
颗粒物	20	10	8	8	8	8	2-5	5
HCl	50	10	8	10	10	5	2-6	5
HF	-	1	1	-			<1	
SO_x	80	50	20	20	20	10	5-30	10
NO_x	250	200	120	120	80	60	50-120	50
CO	80	50	30	80	50			
TOC			10					
Hg及其化合物	0.05	0.05	0.02	0.02	0.02			
Cd及其化合物	0.1	0.05	0.03	0.03	0.03			
锑、砷、铅、铬、钴、铜、锰、镍及其化合物	1.0	0.5	0.3	0.3	0.3			
二噁英类	0.1	0.1	0.05	0.1	0.1	0.05		0.01
NH3				8	8	3.8	2-10	

超低排放、因地制宜，是垃圾焚烧烟污染物控制的发展趋势

2、光大烟气净化技术

Flue gas purification system



常规烟气净化技术

3、光大自主研发烟气净化技术创新点

The technical innovation of Everbright Self-developed flue gas system

- **光大环保自主研发烟气系统排放采用欧盟2010标准，工艺流程：** Everbright Self-developed flue gas system using EU 2010 Standard, process flow as follows:

SNCR+半干法+活性炭+干法+布袋除尘器

SNCR + Semi-dry + Activated carbon + dry desulfurization + Bag filter

- **烟气排放优于欧盟2010标准，其NO_x排放为80mg/Nm³，二噁英0.05ngTEQ/Nm³，工艺流程：** Flue gas emission standard of Nanjing project is better than EU 2010, its NOx emission is 80mg/Nm³, Dioxin is 0.05ngTEQ/Nm³, process flow as follows:

SNCR+半干法+活性炭+干法+布袋除尘器+低温SCR

SNCR + Semi-dry + Activated carbon + dry desulfurization + Bag filter+ Low temperature SCR

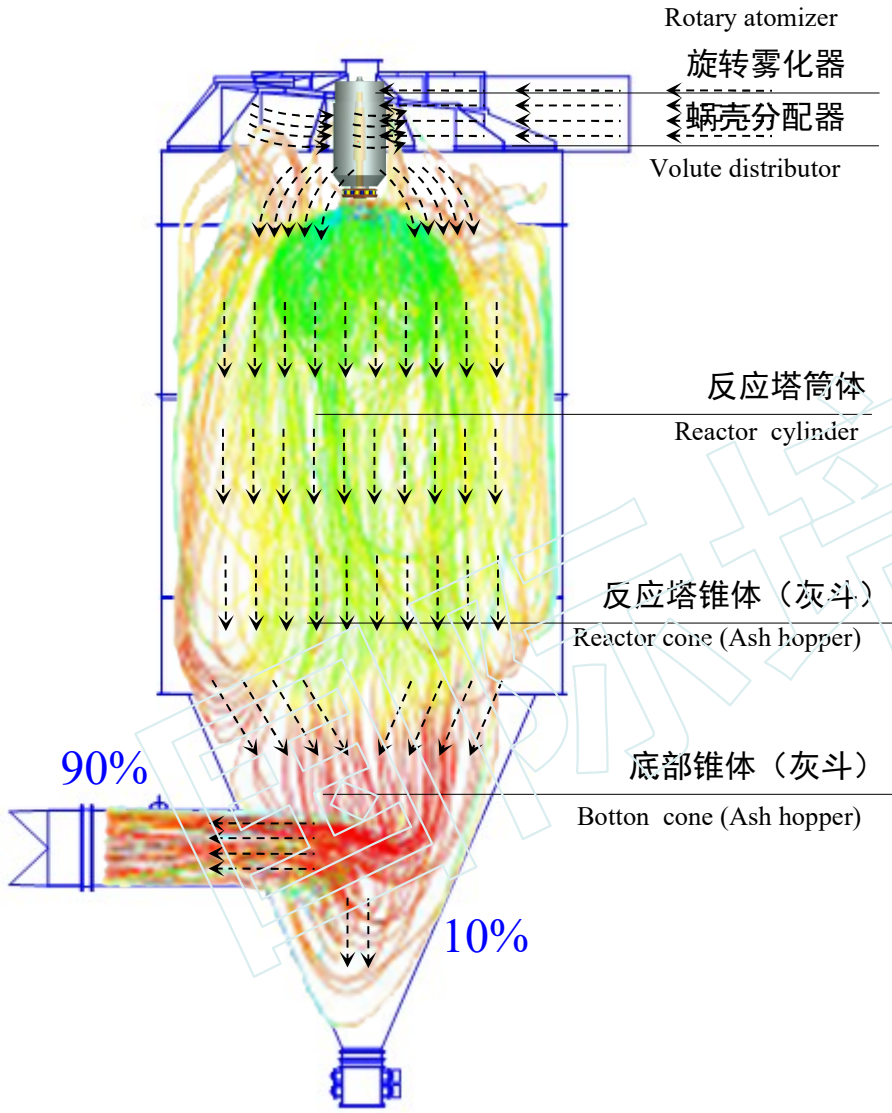
- **杭州九峰、苏州四期烟气为超低排放，其中NO_x为50mg/Nm³，二噁英为0.01ngTEQ/Nm³，工艺流程：** Flue gas emission standard of Hangzhou project and Suzhou IV project is Ultra low emission, NOx emission is 50mg/Nm³, Dioxin is 0.01ngTEQ/Nm³, process flow as follows:

SNCR+半干法+活性炭+干法+布袋除尘器+低温SCR+SGH+GGH+湿法+脱白

SNCR + Semi-dry + Activated carbon + Dry desulfurization + Bag filter+ Low temperature SCR+SGH+GGH+ Wet process + Removal of white smoke

序号 No.	名 称Name	欧盟2000 EU 2000	杭 州Hangzhou	苏州Suzhou	南京Nanjing
1	颗粒物 Particles	10	5	5	10
2	HCl（mg/Nm³）	10	5	5	10
3	SO_2（mg/Nm³）	50	10	10	50
4	HF（mg/Nm³）	1	1	1	1
5	NOx（mg/Nm³）	200	50	50	80
6	二噁英Dioxin （ngTEQ/Nm³）	0.1	0.01	0.01	0.05

(1) 半干式反应塔系统 Semi-dry reactor system



- **烟气进入蜗壳分配器，经导流板后，烟气向四周均匀分布，并作下旋运动，紊流状态烟气与旋转方向相反的石灰浆液充分接触反应。**

  The flue gas enters the volute distributor through the guide plate, being distributed evenly to all around, and downward movement, turbulent gas fully contact and react with lime slurry rotating in the opposite direction.

- **脱酸反应过程是酸性气体和碱性石灰浆液雾滴之间的气液反应,即离子反应。**

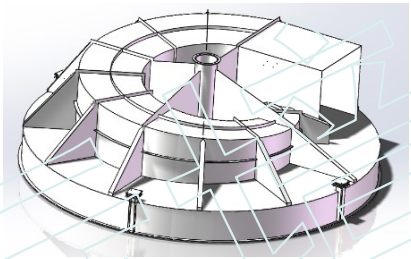
  De acid reaction process is a gas-liquid reaction between acid gas and alkaline lime slurry droplet, belonging to Ionic reaction.

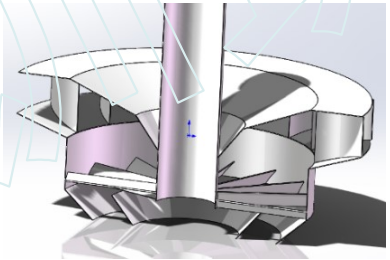
- **经过大约18 - 20s，石灰浆液滴蒸发，形成固态反应产物，较大颗粒落入底部锥体排口，占5-15%。其它随烟气进入布袋除尘器。**

  Lime slurry droplet will evaporate after 18-20s,to form solid reaction products, larger particles fall into the bottom outlet of the cone , with 5-15%. Others enter into the bag filter with the flue gas.

（1）反应塔烟气分配器 Flue gas distributor of Reactor

- **反应塔蜗壳采用等压螺旋式进风道。** The reactor adopts isobaric spiral inlet volute.
- **两组导流叶片采用CFD进行优化设计，使烟气均匀分布、产生紊流，与石灰浆均匀混合。** The two groups of guide blades are optimized by CFD, to ensure the flue gas equidistribution, produce the turbulence and well mixsure with the lime slurry.
- **提高耐磨性，延长使用寿命。** Improve wear resistance and prolong service life.





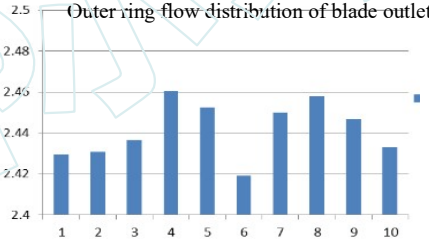
叶片出口外环流量分布

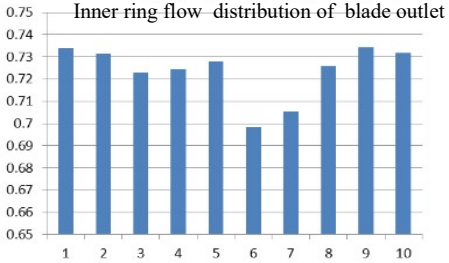
Outer ring flow distribution of blade outlet

叶片出口内环流量分布

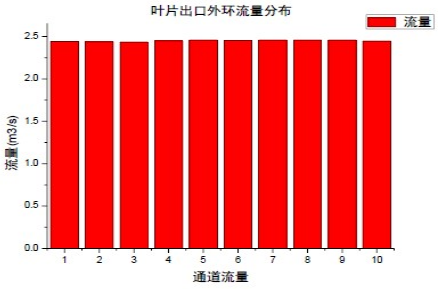
Inner ring flow distribution of blade outlet

优化前
Before optimization





优化后
After optimization



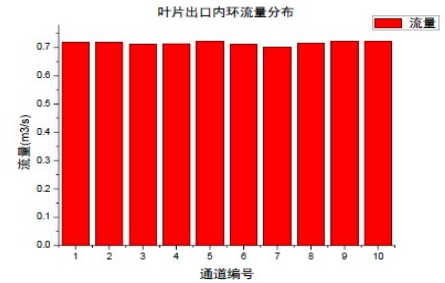
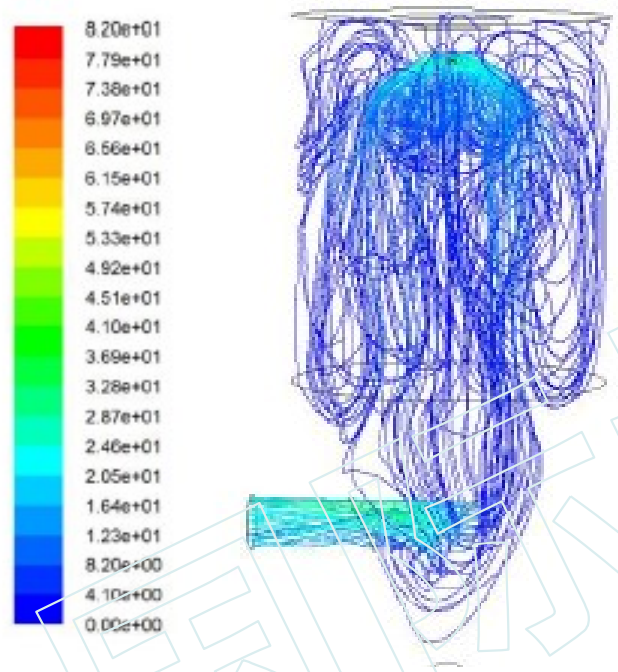


图 6-8 叶片出口外环流量分布

图 6-7 叶片出口内环流量分布

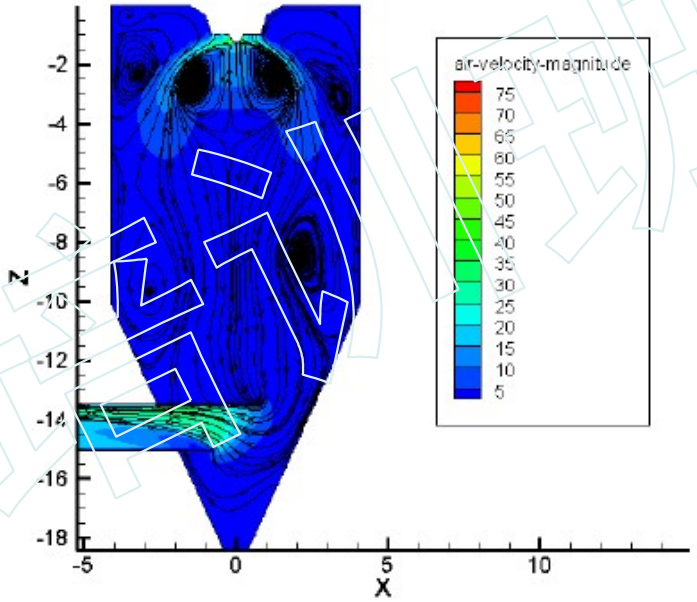
（2）半干式反应塔设计模拟

Simulation of semi-dry reactor design



塔内烟气流线分布

The flue gas flow line distribution in the reactor



石灰浆速度场

Velocity field of Lime slurry

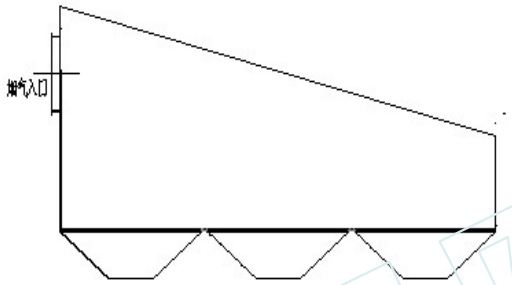
- **通过CFD优化，实现烟气、石灰浆和降温水的均匀分布、混合和良好反应。**

Through the CFD optimization, to achieve flue gas、lime slurry and cooling water equidistribution，well mixing and fine reaction。

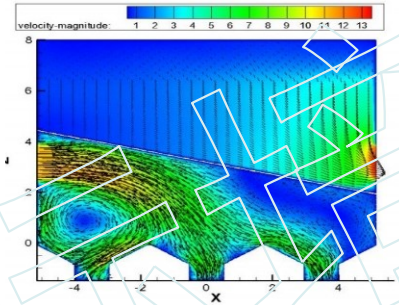
（3）除尘器进风口烟气流场的优化

Optimization of flue gas flow field in bag filter air inlet

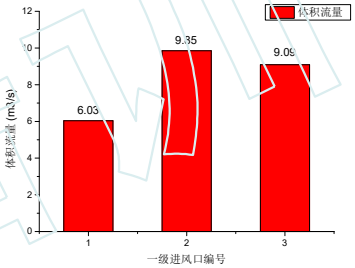
- **除尘器进风口烟气流场经CFD优化后，增加导流板均匀分配风量，提高布袋除尘效率。** **After flue gas flow field in bag filter air inlet is optimized by CFD, it increases guide plate to distribute flue gas uniformly, improve the efficiency.**
- **同行业所有厂家均未考虑进风口问题，此为我司除尘器一大特色。** **All the other bag filter manufacturers have not considered the issue of air inlet, this is a major feature of EB bag filter design.**



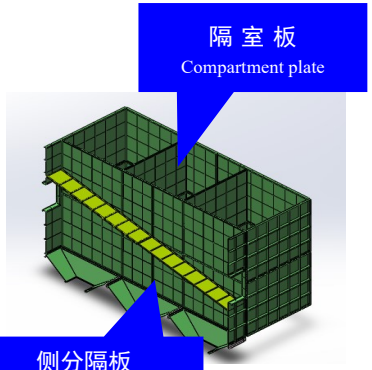
一级进风口优化前方案
One-level air inlet program before optimization

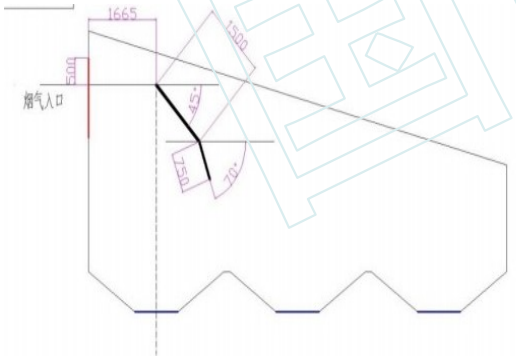


未优化前箱体示意图
Diagrammatic sketch of box before optimization

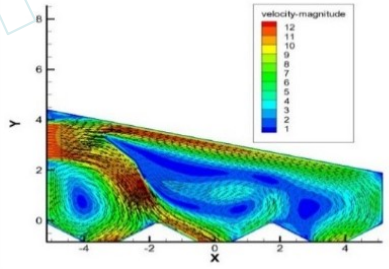


一级进风口烟气体积流量图（优化前）
Flue gas volume flow diagram of one-level air inlet (before optimization)

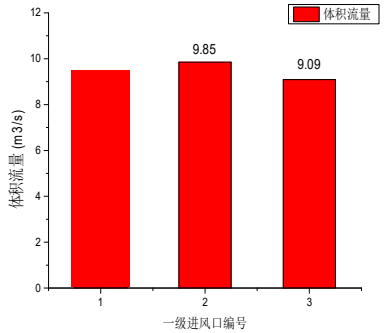




一级进风口优化后方案
One-level air inlet program after optimization



优化后箱体示意图
Diagrammatic sketch of box after optimization

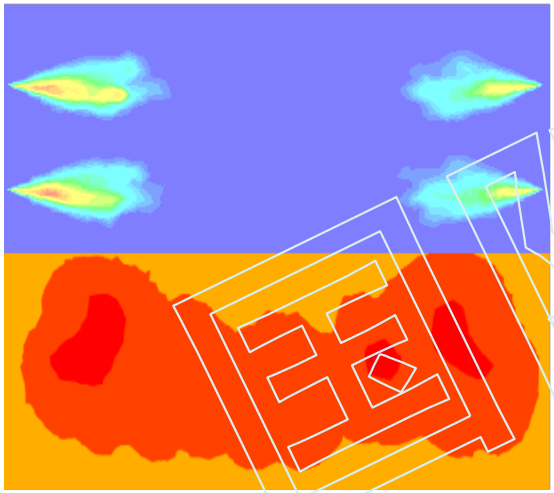


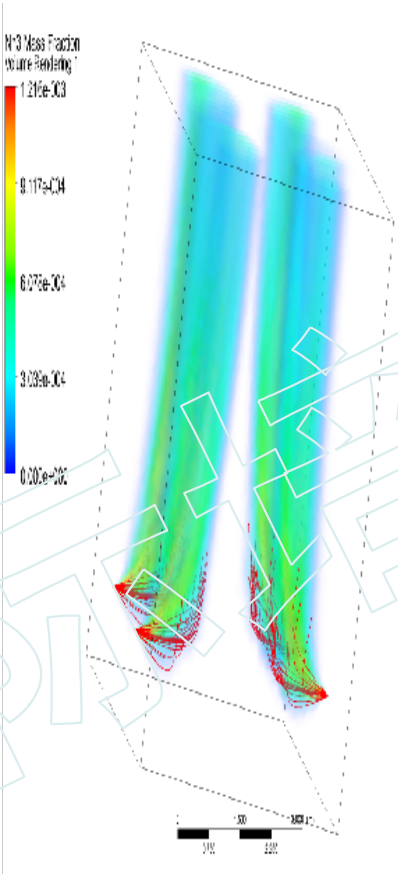
一级进风口烟气体积流量图（优化后）
Flue gas volume flow diagram of one-level air inlet (after optimization)

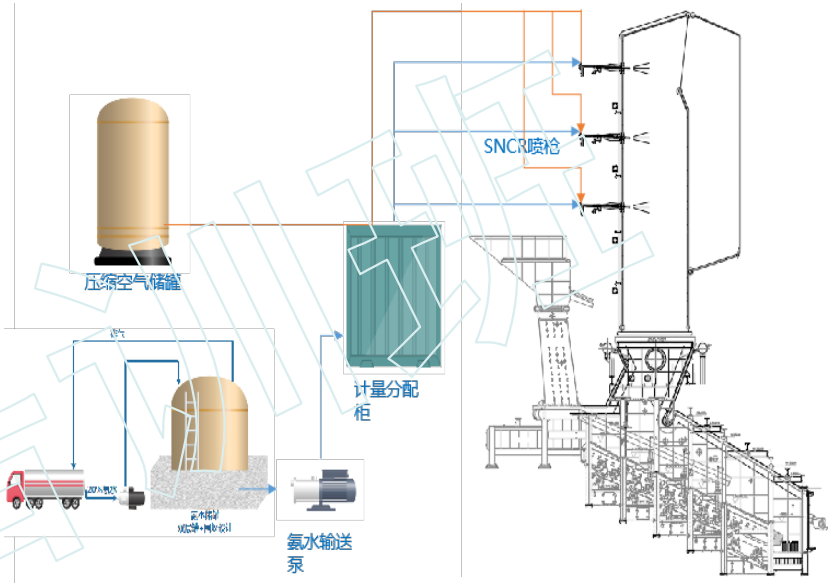
everbright developed wet scrubber reaching ultra_low emission levels, better than imported technology

序号	项　目	单位	GB18485-2014	欧盟2010/75/EC	EB technology	imported technology
1	颗粒物	mg/Nm³	20	10	<4.53	
2	HCl	mg/Nm³	50	10	<0.71	~1-1.5
3	HF	mg/Nm³	-	1	<0.95	
4	SO2	mg/Nm³	80	50	ND	~5-9
5	NOx	mg/Nm³	250	200		
6	CO	mg/Nm³	80	50		
7	汞及其化合物	mg/Nm³	0.05	0.05	<0.026	
8	镉、铊及其化合物	mg/Nm³	0.1	0.05	<0.0011	
9	锑、砷、铅、铬、钴、铜、锰、镍及其化合物	mg/Nm³	1	0.5	<0.000244	
10	二噁英	ng-TEQng/Nm³	0.1	0.1	0.0072	
11	自由液滴	mg/Nm³			<12	

（9）SNCR脱硝系统







$4\ NH_3 + 4NO + O_2 \rightarrow 4N_2 + 6H_2O$

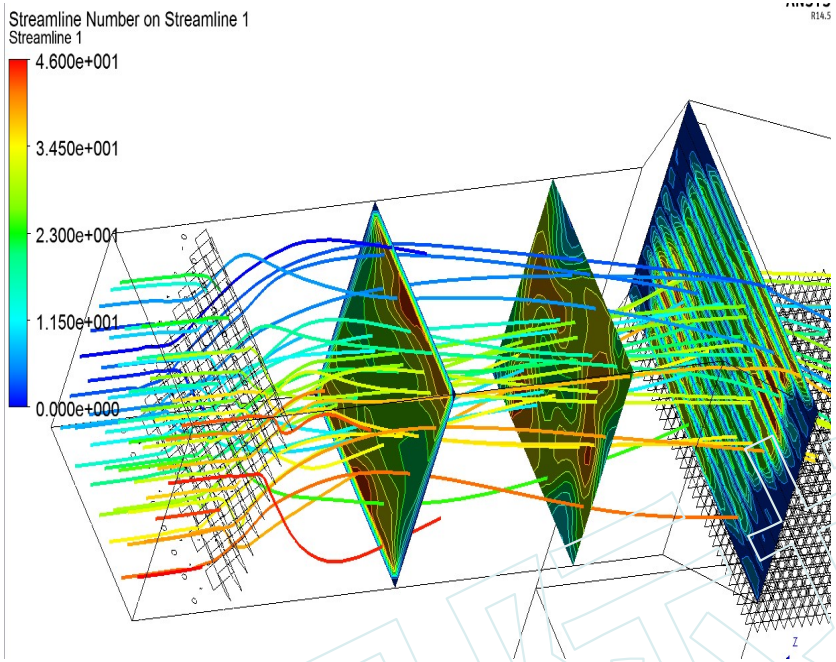
$NO + CO(NH_2)_2 + 1/2O_2 \rightarrow 2N_2 + CO_2 + H_2O$

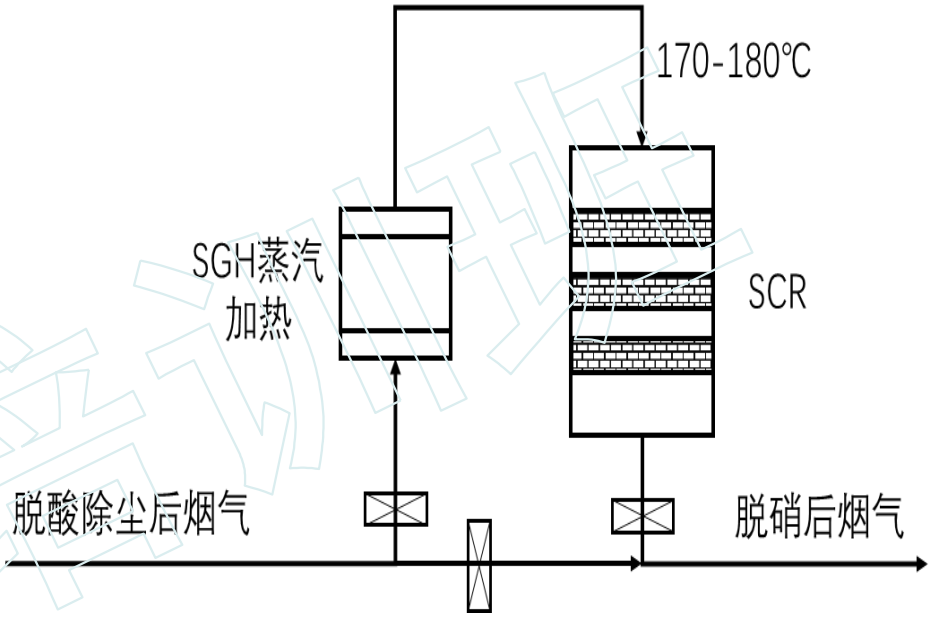
$4NH_3 + 5O_2 \rightarrow 4NO + 6\ H_2O$

引进吸收**SNCR**脱硝技术，并结合**CFD**模拟以及实验，提高混合效果，提高脱硝效率

increase efficiency with the use of CFD and experiments

（10）SCR脱硝系统





利用**CFD**模拟，提高**SCR**系统流场的均匀性

CFD simulation is used to improve the uniformity of flow field in SCR system

结合垃圾焚烧特点，采用低温低尘低硫布置

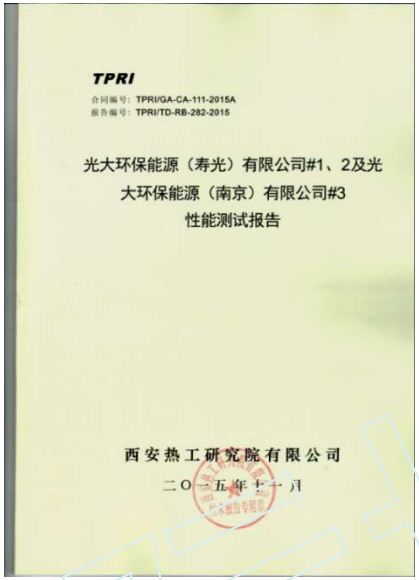
SCR condition: low temperature, low dust, low SO2

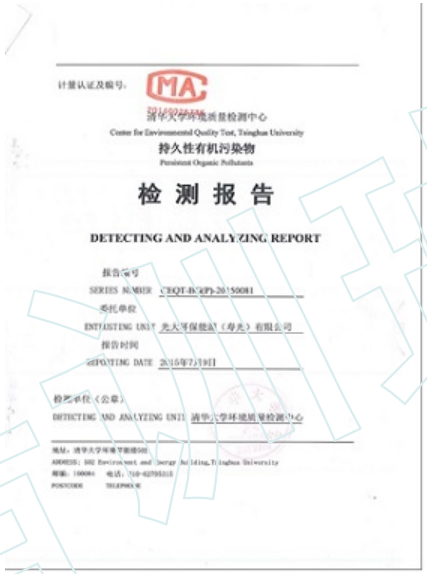
（11）脱白（demist）

有脱白的项目与无脱白的对比
different projects with/without demisting

4、光大自主研发烟气净化技术成果鉴定

Technology identification of Everbright self-developed flue gas system





- **委托西安热工研究院有限公司对光大环保能源（寿光）有限公司#1、2焚烧炉、余热锅炉、烟气净化系统的整体运行性能、汽轮机性能、全厂物料消耗量等进行全面测试。Xi'an Thermal Power Research Institute is commissioned by Everbright to do a comprehensive test on the operation performance of No.1-2 incinerator、HRSG 、flue gas system and turbine, the whole plant material consumption for Everbright Environmental Energy Company Limited (Shouguang).**

- **委托清华大学环境质量检测中心对光大环保能源（寿光）有限公司#1、2烟气净化系统的二噁英类（PCDD/Fs）污染物排放进行全面检测。Environmental quality testing center of Tsinghua University is commissioned by Everbright to do a comprehensive test on dioxin (PCDD/Fs) emissions of flue gas system in Everbright Environmental Energy Company Limited (Shouguang).**

■ 烟气净化系统性能检测结果 Test results of the performance in flue gas system

项 目 Item	单 位 Unit	1#号焚烧线 No.1 boilor				2#号焚烧线 No2. boilor			
		反应塔入口 Reactor inlet	反应塔出口 Reactor outlet	烟 囱 Stack	烟气净化系统脱除效率 Removal efficiency /(%)	反应塔入口 Reactor inlet	反应塔出口 Reactor outlet	烟 囱 Stack	烟气净化系统脱除效率 Removal efficiency /(%)
HCl	mg/Nm³, 11%O_2	478.6	92.2	6.9	98.6	570.7	96.6	5.3	99.1
HF	mg/Nm³, 11%O_2	9.9	1.6	0.313	96.8	4.6	0.6	0.144	96.9
SO_2	mg/Nm³, 11%O_2	272.54	49.51	9.32	96.6	191.01	31.85	1.7	99.1
NOx	mg/Nm³, 11%O_2	109.65	86.96	106.67	/	83.71	88.81	73.93	/
TOC	mg/Nm³, 11%O_2	0.44	0.22	0.19	/	0.32	0.24	0.18	/
总重金属 Total heavy metal	mg/Nm³, 11%O_2	14.66	2.51	0.21	98.6	18.85	0.37	0.39	97.9
二噁英类 Dioxin (PCDD/Fs)	ngTEQ/Nm³	3.95	/	0.00195	99.95	2.85	/	0.0015	99.9
烟气黑度 Blackness	林格曼级 Ringelmann Black Degree	<1	<1	<1	/	<1	<1	<1	/

#以上数据均折算为11%氧量及标况状态 All data above are converted to 11% oxygen and the standard state

5、光大自主研发烟气净化系统成果鉴定

Technology identification of Everbright self-developed flue gas system

2015年12月18日，在中国环境科学学会组织的成果鉴定会上，专家组一致认为光大环保研发的高效烟气净化技术工艺，经多个项目成功应用，排放指标达到或优于欧盟2010排放标准的要求，达到国际先进水平。

In the achievement appraisal meeting organized by Chinese Society For Environmental Sciences in Dec.18,2015, expert concurred that emission of Everbright self-developed efficient flue gas system meeted or exceeded EU2010 standard, through successfully applied by multiple projects, it had reached the leading level in the world.

六、废弃物处置技术

Waste disposal technology

废弃物处置技术 Waste disposal technology

飞灰填埋处置　Fly ash is hazardous waste　，which should be landfilled
首先经过螯合处置达标后，进入填埋场 should be chelated before landfill
pollutants still remain in the ash

光大环保苏州危废填埋场

Everbright Suzhou hazardous waste landfill

光大自主研发等离子飞灰熔融技术，实现飞灰的彻底无害化、资源化
self develped Plasma furnace technology, make the fly ash into glass, totally harmless and can be reused

炉渣处理 Bottom ash treatment

- 垃圾焚烧产生的炉渣经检验合格后，进行资源化利用 ：石油沥青铺装路面的替代骨料；水泥、混凝土的替代骨料；炉渣制砖；路基、路堤等的建筑填料；

  The bottom ash produced by the waste incineration is checked before it is used as a substitute for aggregate in asphalt pavement, cement, concrete replacement aggregate, slag brick, subgrade, embankment, etc.;

- 灰渣中的重金属成分和影响混凝土质量的Cl-成分，应注意灰渣的预处理和重金属固化问题。

  Heavy metals and chlorine and in the bottom ash and fly ash should be carefully taken care of before it is treated and solidified.

- 光大已制定《生活垃圾焚烧炉渣出厂标准（试行）》

  Everbright has adopted a standard for the quality check of the bottom ash.

七、提高垃圾发电厂效益措施

Technologies used to improve the efficiency of waste to energy plants

提高垃圾发电厂效益措施

Thermal efficiency of waste to energy plants

1、提高循环热效率 Improve the thermal efficiency of waste to energy plants

提高锅炉初参数：4.0MPa/400℃ → 6.4MPa/450℃、13MPa/430℃

Improve the steam parameter

降低锅炉排烟温度：210-190℃ → 170℃

Reduce the flue gas temperature at the outlet of boiler

蒸汽中间再热：430℃

Use the steam reheating

汽机高转速：3000rpm → 6000rpm

Use high speed turbine

2、选择焚烧炉 select better incinerator

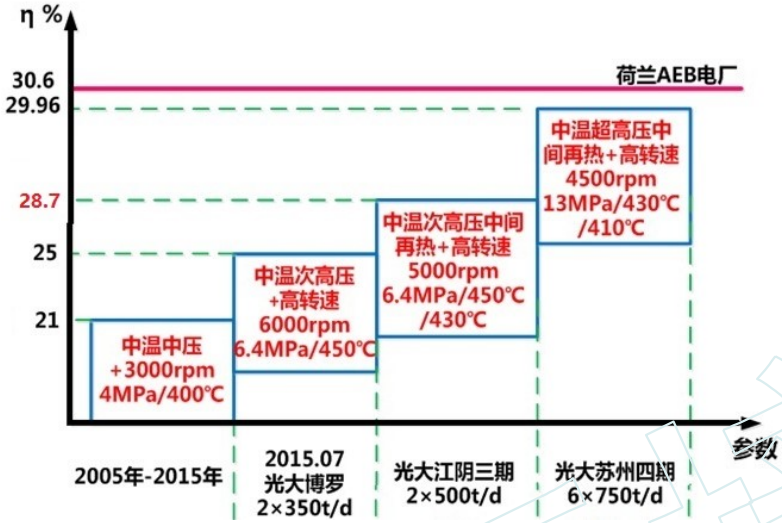
1）吨垃圾发电量高 With higher electricity production per ton waste

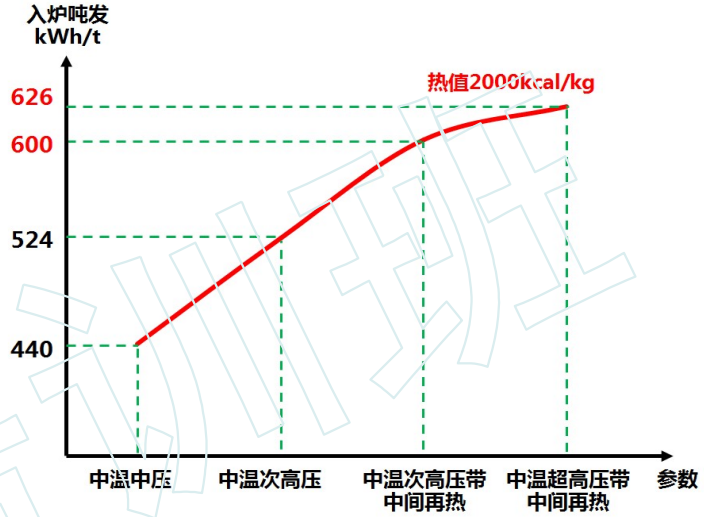
2）超负荷能力大 With higher capacity of overload

3）年运行＞8000小时 With operating time longer than 8000h per year

提高垃圾发电厂效益措施

Thermal efficiency of waste to energy plants





参数(parameters)	项目(projects)	全厂热效率 overall heat efficiency	入炉吨发 power generation per ton waste into incinerator
中温中压4MPa/400℃	350-400t/d	21.8%	440kwh/t
中温次高压6.4MPa/450℃	博罗2×350t/d	25%	524kwh/t
中温次高压中间再热 6.4MPa/450℃/430℃	江阴三期2×500t/d	28.7%	600kwh/t
中温超高压中间再热 13MPa/430℃/410℃	苏州四期6x750t/d	30%	626kwh/t

Everbright incineration plants with high parameters and high efficiency

二噁英 Dioxins

二噁英（Ⅰ） Dioxins (Ⅰ)

- **二噁英是致癌物质之一**

  Dioxins are the kind of carcinogen

- **二噁英存在于空气、土壤、水和食物中，是一种普遍的化学现象，它是人类生产活动和一些自然灾害的辅助产物。**

  Dioxins exists in air 、soil、water and food. It's a general chemical compound, and it's auxiliary products caused by human production activities and natural activities.

1）如含铅汽油、农药生产过程 Leaded gasoline, pesticide production process
纸浆、氯气漂白过程 Pulp, chlorine bleaching process
含氯酚类化工生产过程 The chemicals containing chlorophenols production process
金属冶炼过程 Metal smelting process
不完全燃烧条件下的垃圾焚烧过程中都会产生二噁英。
Incineration process under incomplete combustion conditions

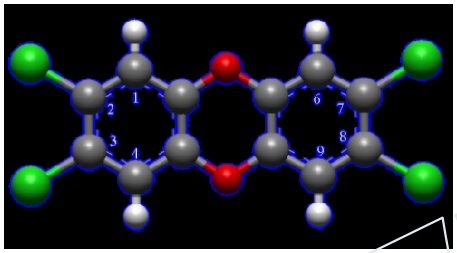
2）又如雷电引起森林火灾产生大量二噁英，如加拿大一次森林火灾产生了58.968Kg二噁英，相当于20世纪70-80年代的9万座日处理400吨生活垃圾规模的厂一年排放量。

lightning caused forest fires can produce a lot of dioxins. In Canada, a forest fire produced 58.968kg dioxins, equivalent to 90 thousand 400t/d waste-to-energy plant in 70-80s of twentieth Century.

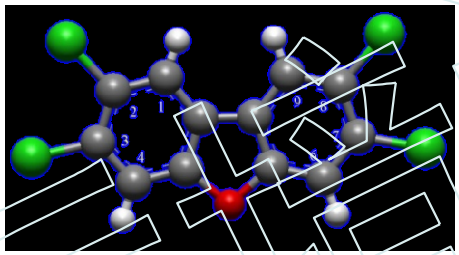
二噁英定义

二噁英是多氯二苯并-对-二噁英（polychlorinated dibenzo-p-dioxins，简称PCDDs）和多氯二苯并呋喃（polychlorinated dibenzofurans, 简称PCDFs）的总称，共包含210种异构体　简写为PCDD/Fs

Dioxin is the floorboard of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), which contains 210 isomers, abbreviated as PCDD/Fs



PCDDs
75 种异构体



PCDFs
135种异构体

重点关注对象：
十七种2,3,7,8-位氯取代的PCDD/Fs

- **二噁英，是POPs（persistent organic pollutants）的一种；**
- **二噁英常温下均为固体、熔点较高、难溶于水，脂溶性较高;**
- **随着氯化程度的增强，二噁英的溶解度和挥发性减小；**
- **化学稳定性强，在环境中能长时间存在。**

合成的二噁英，常温下为白色晶体

Dioxin is a kind of POPs (persistent organic pollutants).

Dioxins are solid at ordinary temperature, which have high melting point、high fat solubility and insoluble in water.

The solubility and volatility of dioxins decrease with the increase of chlorination degree.

Dioxin has good chemical stability and can exist in the environment for a long time .

环境中二噁英来源(Sources of dioxins in the environment)

如废物焚烧、金属冶炼过程、供热发电、化工生产、露天焚烧、交通运输、烧烤、吸烟过程中都会产生二噁英。

Dioxins are produced during waste incineration, metal smelting, heating and power generation, chemical production, open-air incineration, transportation, barbecue and smoking.








二噁英的危害Harm of dioxins to human body

■ **二噁英是致癌物质之一**

1）二噁英是毒性最强的化合物之一，它的毒性相当于氰化钾（KCN）的1,000倍，1盎司（28.35g)二噁英就能使100万人置于死地。

1） Dioxin is one of the most toxic compounds. Its toxicity is equivalent to 1000 times that of potassium cyanide (KCN). 1 ounces (28.35g) dioxins can expose 1 million person to mortal danger.

2）受害者身上得到毒性效应可能引起皮肤痤疮、头痛、失明、心力衰竭，严重时会导致致畸致癌，如乌克兰前总统尤先科受轻微二噁英中毒脸部痤疮，越战美军喷洒落叶剂后残留的二噁英致使当地出生的儿童多为畸形儿。）Toxic effects on victims can cause skin acne, headaches, blindness, and heart failure, and in severe cases, teratogenic cancer. For example, Ukraine's former president Yushchenko suffered minor dioxin poisoning from acne on the face, Vietnam War after the U. S. military sprayed defoliant residues of dioxins, resulting in the local birth of children are mostly deformities.

越战美军橙剂遗毒畸形儿

2004年7月

2004年12月

全球发生的二噁英污染事件主要是化工生产，有机氯农药使用，饲料加工过程和其他不可控的不完全燃烧导致。

Dioxins pollution events around the world are mainly caused by chemical production, the use of organochlorine pesticides, feed processing and other uncontrollable incomplete combustion.

二噁英的危害Harm of dioxins to human body

- Harmful effects of dioxins emitted from waste incineration on human body

每吸入一盒香烟，二噁英吸入量是2.44pg TEQ，被动吸烟者达0.5pg TEQ，是焚烧烟囱300米处人吸二噁英量的2.8万倍；

二噁英达标排放并经扩散稀释后，它对人体的影响甚至远远小于一个人日常的被动吸烟摄入量。

全球没有一起二噁英污染事件来源于垃圾焚烧发电！

	The most stringent restrictions in the world and the normal content in the Beijing, Shanghai and Guangzhou	Proportion of incineration plant contribution from chimney 300m
The world's most stringent allowable value of dioxin in the air of Arizona, USA	0.023pg/m³	1/26000
Average content of dioxins in air of Beijing	0.268pg/m³	1/300000
Average content of dioxins in air of Shanghai	0.268pg/m³	1/300000
Average content of dioxins in air of Guangzhou	0.367pg/m³	1/420000

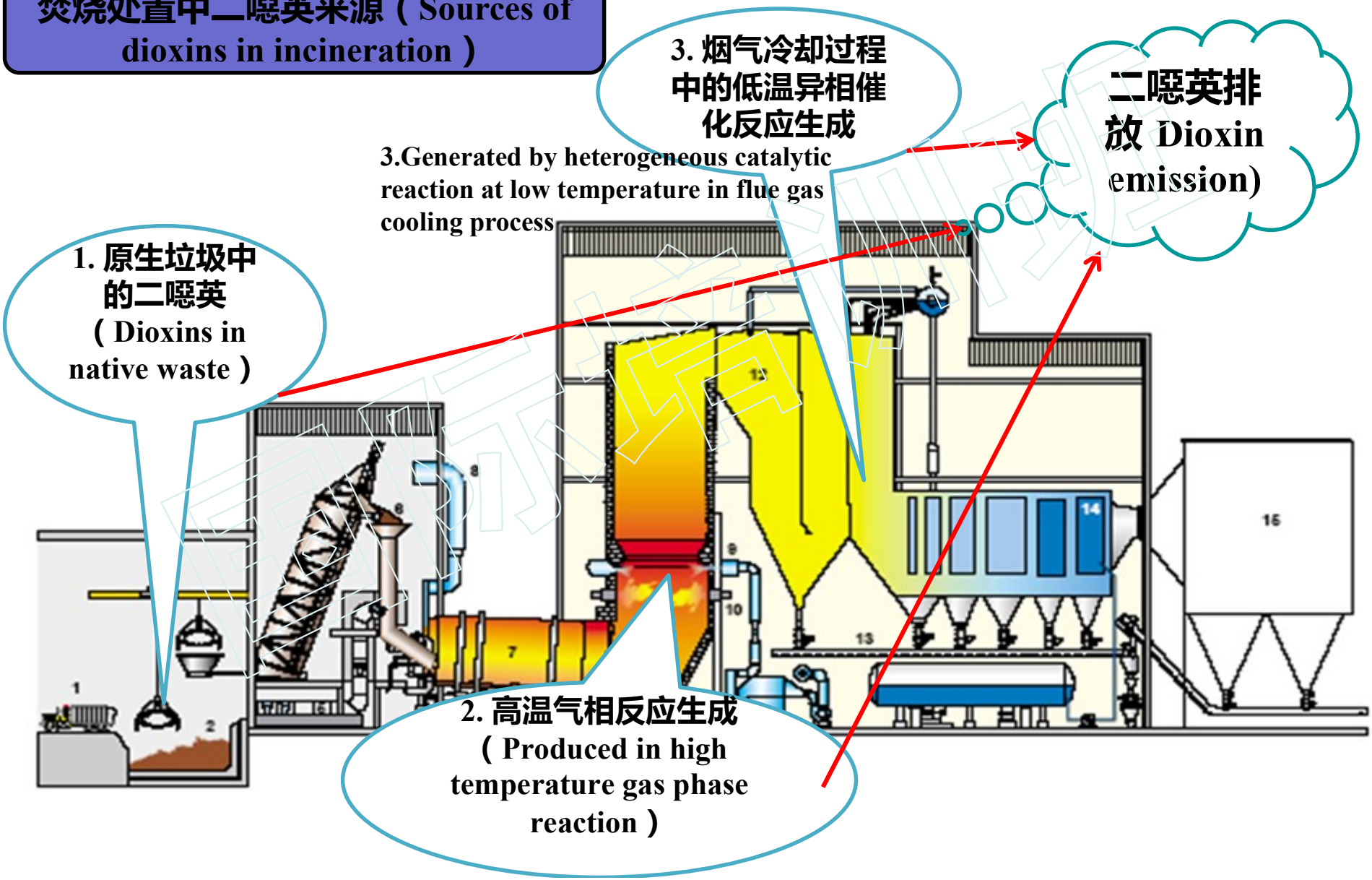
The dioxin intake per pack of cigarettes was 2.44 pgTEQ for passive smokers and 0.5 PG TEQ for passive smokers, which was 28,000 times the dioxin intake per person 300 meters from a burning chimney.

When dioxins reach the standard and are diluted by diffusion, their effects on the human body are far less than a person's daily intake of passive smoking.

There is no global dioxin pollution incident from waste incineration power generation!

焚烧处置过程中二噁英来源及生产途径
(Sources and production routes of dioxins in incineration process)

焚烧处置中二噁英来源（Sources of dioxins in incineration）



焚烧处置全过程二噁英控制

（Dioxin control in the whole process of incineration）

系统总体控制和协调，保证焚烧炉安全、有效、稳定运转，有效减少污染物排放

(The overall control and coordination of the system ensures the safe, effective and stable operation of the incinerator and effectively reduces pollutant emissions)

燃烧前控制技术

（预处理及配伍、进料系统）

Pre combustion control technology

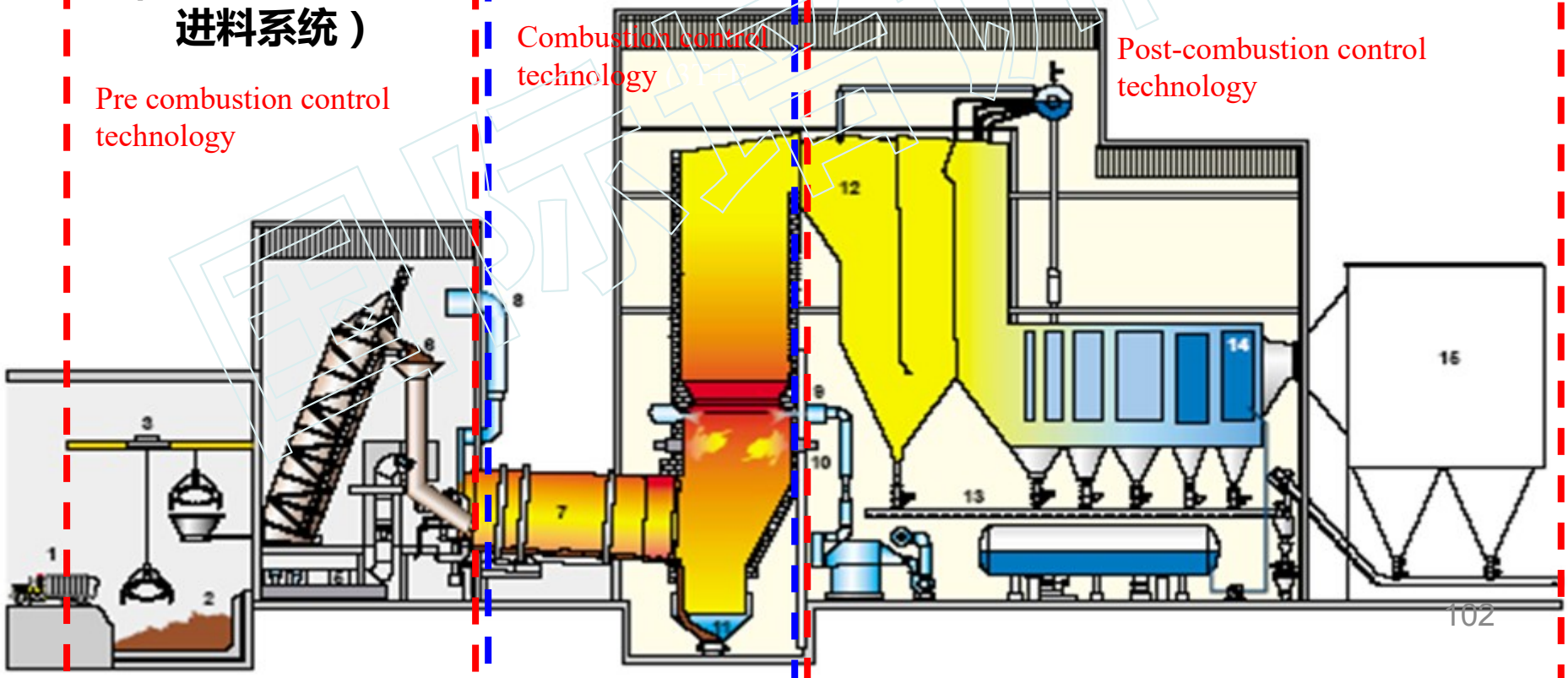
燃烧中控制技术（3T+E等）

Combustion control technology

燃烧后控制技术

（烟气净化）

Post-combustion control technology



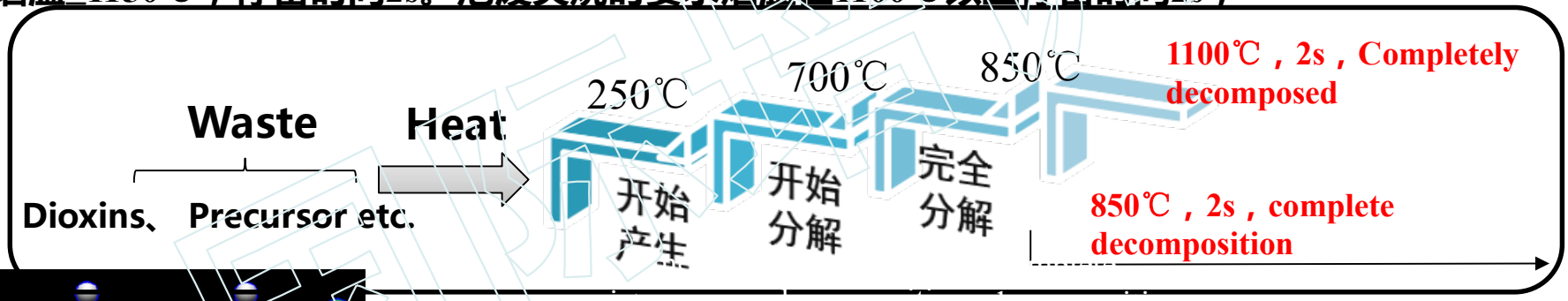
焚烧过程控制(Incineration process control)

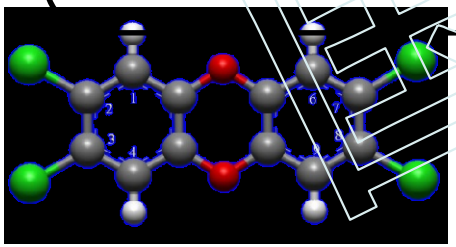
最佳焚烧条件——3T+E原则Optimum incineration conditions--3T+E principle

温度（Temperature）和停留时间（Time）：

●温度≥703℃，二噁英开始分解，实际垃圾焚烧要求烟气温度≥850°C，停留时间≥2s；

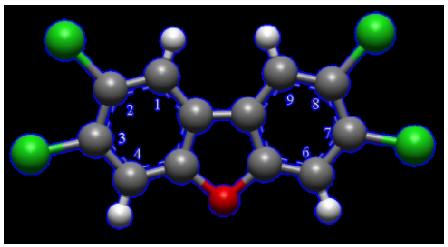
●Dioxins begin to decompose at temperatures above 703 ℃. Actual waste incineration requires flue gas temperature greater than 850 ℃, residence time greater than 2S ；多氯联苯类危险废物，完全降解所需烟温≥1150℃，停留时间2s。危废焚烧时要求烟温在1100℃以上停留时间2s；





Combustion

Breaks the intermediate oxygen bond and breaks it down into chlorobenzene and other substances, which then act as precursors to accelerate the formation of dioxins.



Completely decomposed and decomposed into small molecules such as CO2, H2O and HCl.

烟气净化过程控制(Flue gas purification process control)

Activated carbon and its adsorption effect

Coaly activated carbon

Coaly activated carbons consist mainly of micropores, with relatively few mesopores and macropores.

<

Wooden activated carbon

The pore structure of wooden activated carbon is mainly concentrated in 2-5nm

<

Cocoanut active charcoal

Cocoanut active charcoal has a considerable amount of mesopores in 2-20nm, which has the best adsorption effect on dioxins.

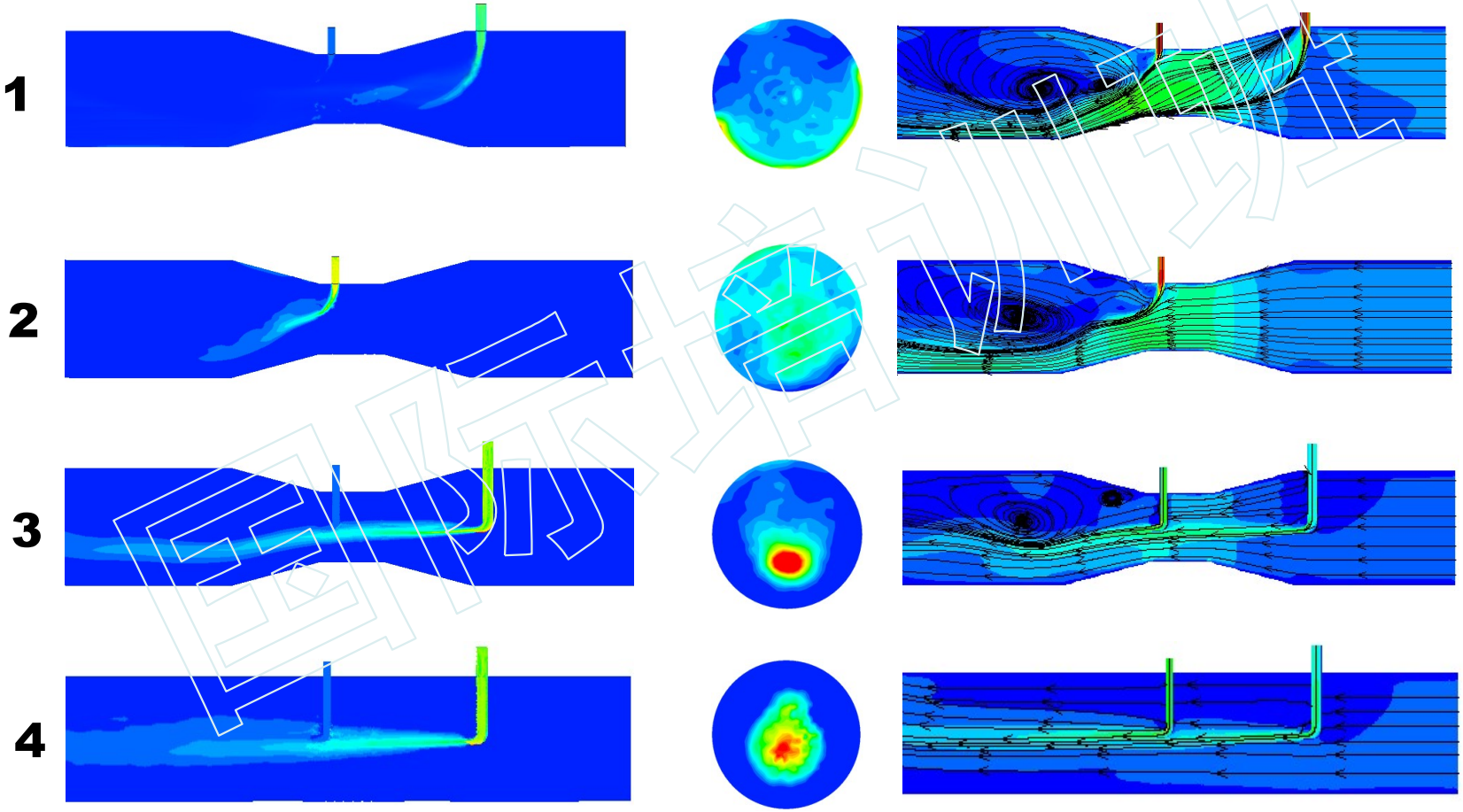
Project	Iodine value	Type	Activated carbon consumption kg/t
平度	900	Coaly	0.4-0.5
寿光	900	Coaly	0.4
潍坊	900	Coaly	0.4
济南	900	Coaly	0.4

常见废弃物焚烧厂活性炭选择依据: BET比表面积+碘吸附值，但是研究发现二者与二噁英的吸附效果之间无明显相关性；建议活性炭选购依据为：BET比表面积+亚甲基蓝值。

Selection basis of activated carbon in common waste incineration plant: BET specific area + Iodine sorption value . However, no significant correlation was found between the two and dioxin adsorption. It is suggested that the purchase of activated carbon is based on ：BET specific area + Methylthionine chloride value.

Flue gas purification process control

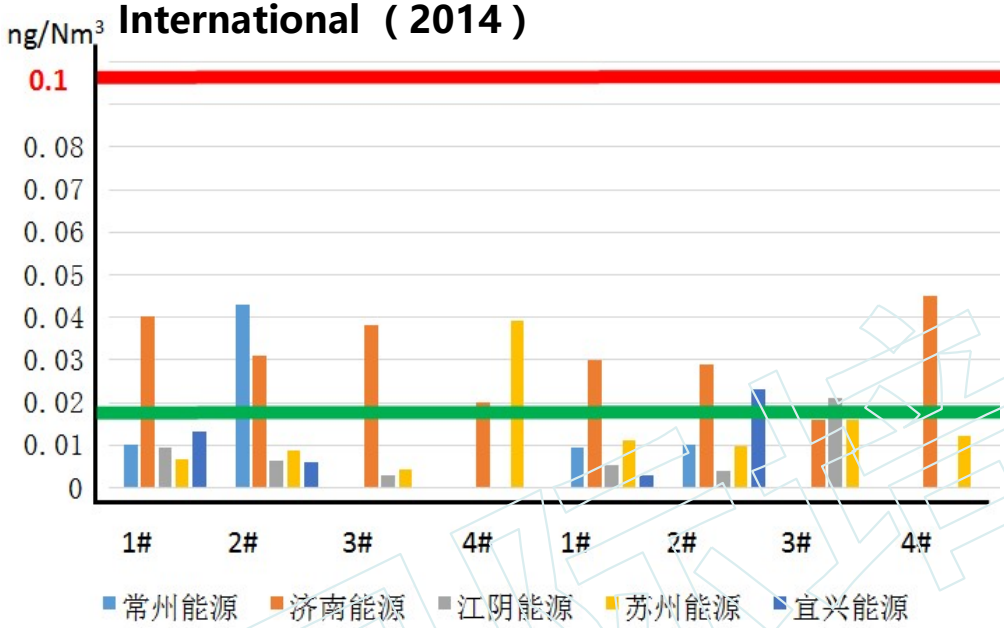
Optimization of activated carbon injection process——



The turbulence in Venturi enhances the contact area and mixing uniformity between activated carbon particles and flue gas, so that the adsorption effect of dioxins can be optimized.

Dioxin emission level in incineration treatment

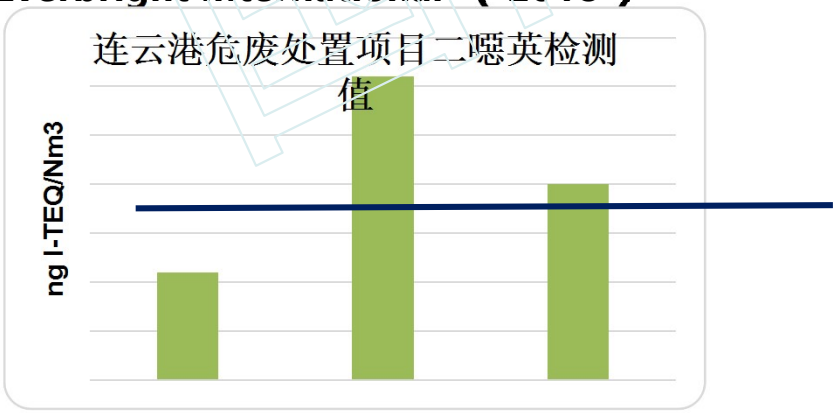
- **Actual emission data of dioxin pollutants from waste incineration in Everbright International（2014）**



均值0.019，远低于欧盟排放标准（0.1ng I-TEQ/Nm³）

The average value is 0.019, much lower than the European Union's emission standard (0.1ng I-TEQ/Nm3).

- **Actual emission test data of dioxin like pollutants from hazardous waste incineration in Everbright International（2018）**



均值0.021，远低于欧盟排放标准（0.1ng I-TEQ/Nm³）

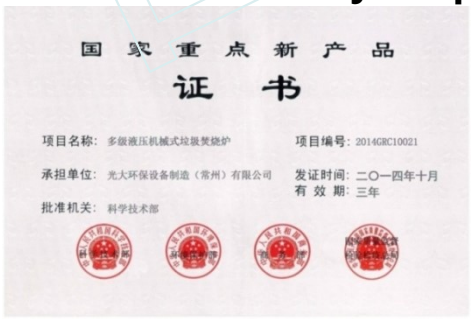
The average value is 0.021, much lower than the European Union's emission standard (0.1ng I-TEQ/Nm3).

结 语
Conclusions

光大自主研发焚烧炉荣誉证书

Everbright research and development of the certificate

- 获机中国械工业科学进步一等奖
  Won the First prize of the Mechanic Industry Science Progress
- 获环保部科学技术二等奖
  Won the Second prize of the Ministry of environmental protection
- 江苏省科学技术三等奖
  Won the third prize of Jiangsu province
- 江苏省科技转化专项资金1,000万元
  Won the 10 million RMB prize of utilization of technology of Jiangsu province
- 深圳市技术创新攻关项目400万元
  Won the 4 million RMB prize of program of technology of Shenzhen
- 常州市科技进步一等奖
  Won the first prize of improvement of technology of Changzhou
- 国家重点新产品
  National key new products
- 高新技术产品
  New and high-tech product
- 出口欧洲认证证书
  European certification of export
- 江苏省首台套重大装备及关键部件
  the first sets of major equipment and key parts of Jiangsu


国家重点新产品
证书
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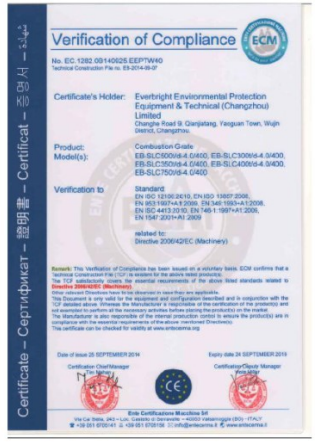
项目编号：2014GRC10021
承担单位：光大环保设备制造（常州）有限公司
发证时间：二〇一四年十月
有效期：三年
批准机关：科学技术部


高新技术产品认定证书
产品名称：多级液压机械式生活垃圾焚烧炉排炉
产品编号：130412G0363W
承担单位：光大环保设备制造（常州）有限公司
有效期伍年
二〇一三年九月


Verification of Compliance
ECM
Certificate's Holder:
Everbright Environmental Protection Equipment & Technical (Changzhou) Limited
Product:
Model(s):
Verification to
Standard
related to:
Directive 2006/42/EC (Machinery)
Certificate – Сертификат – 證明書 – Certificat – 증명서 – شهادة

垃圾焚烧发电全方位成果鉴定

Comprehensive achievements appraisal of waste incineration power generation

- 2012年4月27日，在中国环境科学学会组织的成果鉴定会上，光大自主研发的垃圾焚烧炉达到同类技术国际先进水平。

  On April 27th, China Environmental Science Society assessed that the China Everbright technology of waste incineration furnace reaches the international advanced level of similar technology

- 2015年12月18日，在中国环境科学学会组织的成果鉴定会上，光大自主研发的烟气净化达到国际先进水平。

  On December 18th,2015, China Environmental Science Society assessed that the China Everbright technology of Flue gas cleaning system reaches the international advanced level.

- 2015年12月29日，在中国环境科学学会组织的成果鉴定会上，光大国际垃圾焚烧发电全方位成果达到国际先进水平，在垃圾焚烧发电领域具有示范推广价值。

  On December 18th,2015, China Environmental Science Society assessed that The China Everbright technology of waste-to-energy reaches the international advanced level.

谢 谢!

Thank you!