WCA Global Climate Change Forum
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Latest developments in cement industry technology
水泥工业技术最新进展

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1. 水泥工业技术发展的目标

The goal of cement industry technology development

2. 最新技术进展 Latest technological progress

- 提高能源使用效率、降低运营成本

Improve energy efficiency and reduce operating costs

- 降低环境负荷、促进可持续发展

Reduce environmental impact

1. 水泥工业技术发展的目标

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技术指标路线图 Technical indicators roadmap

	2014	RTS Low-variability case 2030	RTS Low-variability case 2040	RTS Low-variability case 2050	Roadmap vision (2DS) Low-variability case 2030	Roadmap vision (2DS) Low-variability case 2040	Roadmap vision (2DS) Low-variability case 2050	
Cement production (Mt/yr)	4 171	4 250	4 429	4 682	4 250	4 429	4 682	+12%
Clinker to cement ratio	0.65	0.66	0.67	0.66	0.64	0.63	0.60	-9%
Thermal energy intensity of clinker (GJ/t clinker)	3.5	3.4	3.3	3.2	3.3	3.2	3.1	-10%
Electricity intensity of cement (kWh/t cement)	91	89	86	82	87	83	79	-13%

Key indicators for the global cement industry in the RTS and the roadmap vision (2DS)

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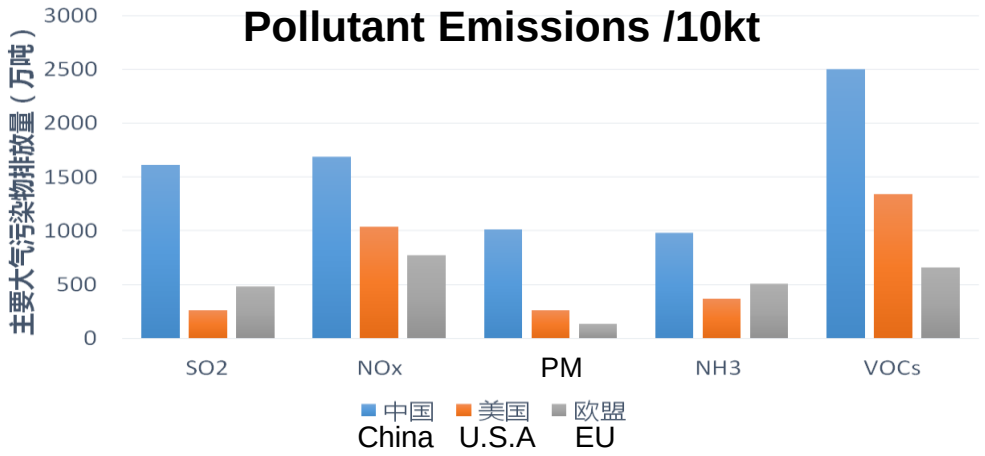
The goal of cement industry technology development

中国大气污染已成为全球关注的焦点！



1. 水泥工业技术发展的目标

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提高生产效率

Improve energy efficiency & reduce operating cost

- **节能技术** Thermal energy efficiency
- **降低运行成本的技术** Reducing OPEX
- **燃料替代** Alterative Fuel
- **降低熟料系数** Reduction of clinker to cement ratio

降低环境负荷

Reduce environmental impact

- **碳减排技术** Carbon Capture，Utilization & Storage
- **低排放技术 (粉尘、NOx, SOx排放)** Emission Reduction (Dust, NOx, SOx)
- **水泥工厂亮化工程** Cement factory beautification project

1. 水泥工业技术发展的目标
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2. 最新技术进展 Latest technological progress

- **提高能源使用效率、降低运营成本**
  Improve energy efficiency and reduce operating costs
- 降低环境负荷、促进可持续发展
- Reduce environmental impact

2. 最新技术进展 Latest technological progress

2.1 提高能源使用效率、降低运营成本

Improve energy efficiency and reduce operating costs

- 节能技术 Thermal energy efficiency
- 降低运行成本的技术 Reducing OPEX
- 燃料替代 Alterative Fuel
- 降低熟料系数 Reduction of clinker to cement ratio

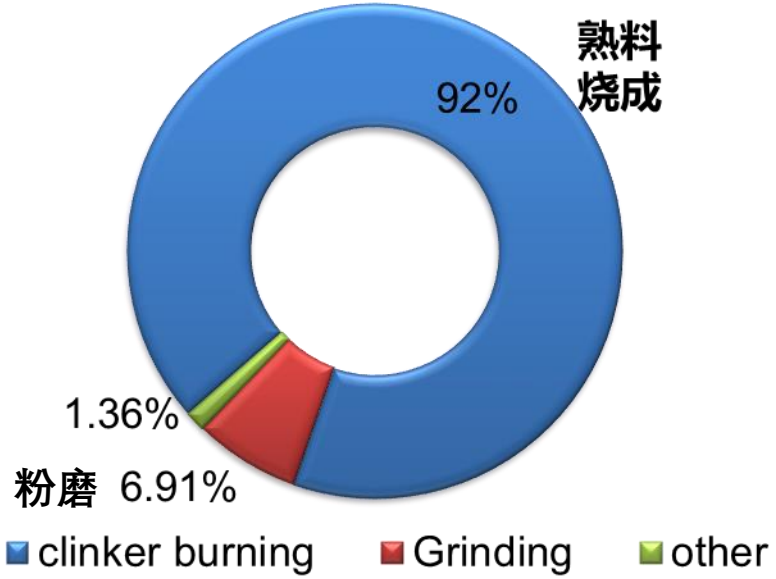
2.1 提高能源使用效率、降低运营成本

Improve energy efficiency and reduce operating costs

➢ 节能技术 **Thermal energy efficiency**

烧成系统节能
Clinker production

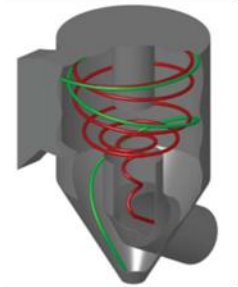
粉磨节能
Grinding energy saving

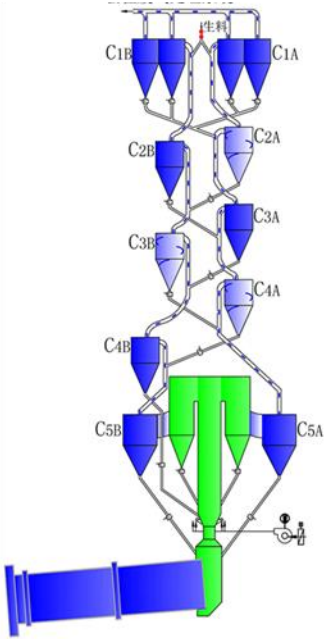


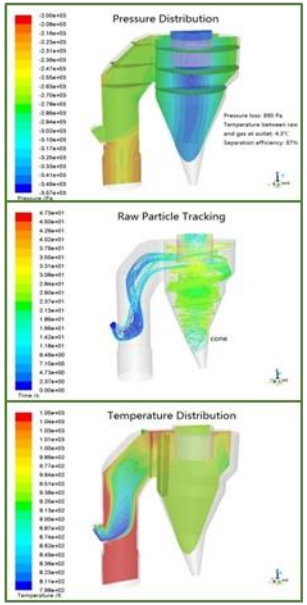
➢ 节能技术 Thermal energy efficiency

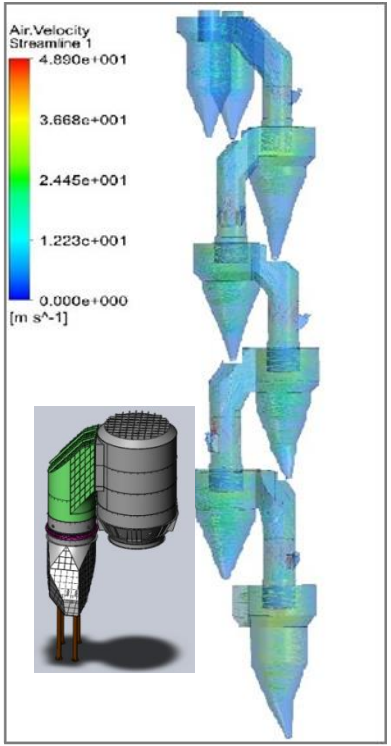
烧成系统节能 Clinker production

- 改进旋风预热器，进一步降低阻力，提高换热效率
- Improve cyclone preheater to further reduce drag and improve heat transfer efficiency







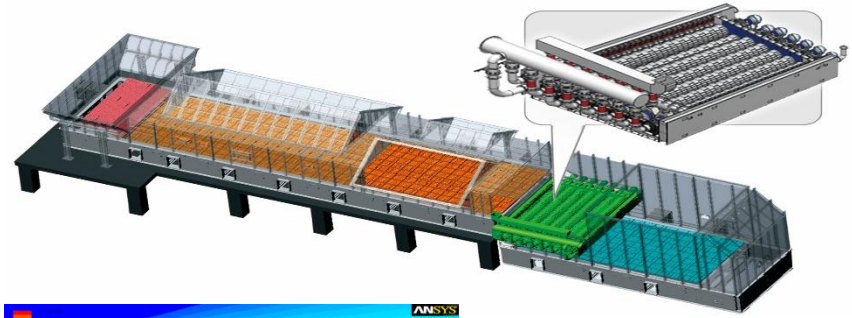


➢ 节能技术 Thermal energy efficiency

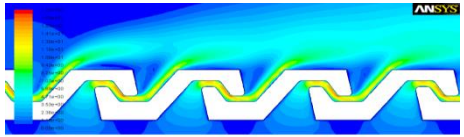
烧成系统节能 Clinker production

- 冷却机，提高热回收率，提高运转率

Heat recovery rate 75%
Power consumption4.5-5.5kWh/t



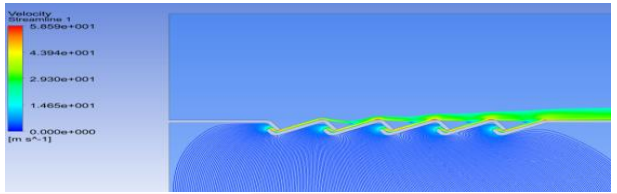
➢固定或步进篦床输送
Horizontal grate transmission



➢模块化设计 Modular design

➢篦床无漏料设计 No leakage

➢自动流量控制 Automatic air flow control regulation



➢ 节能技术 Thermal energy efficiency

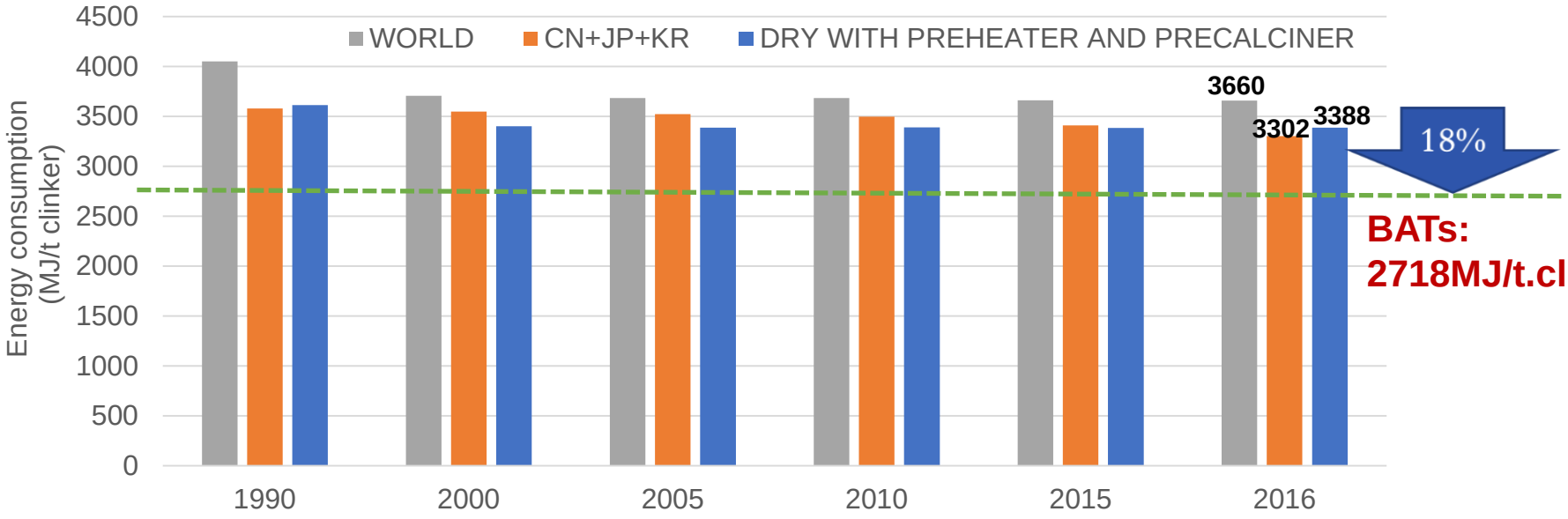
烧成系统节能 Clinker production

烧成系统最佳节能技术
BATs on Clinker burning

Capacity： 5500t/d；
Heat consumption： 2718 MJ/t.cl（650kCal/kgcl）
Power consumption： 17~18 kWh/t.cl
Power of WHR ： 25kWh/t.cl
C1 outlet pressure：≤4200Pa（5sp）
≤ 4800Pa（6sp）
Separation efficiency: >95%
Dust of C1 outlet on site: <45g/Nm3

➢ 节能技术 Thermal energy efficiency

烧成系统节能 Clinker production



➢ 节能技术 Thermal energy efficiency

粉磨节能 Grinding energy saving

生料粉磨 Raw meal grinding

系统选型：

1、原料的理化性能

Physical and chemical properties of raw materials

2、原料最大水份

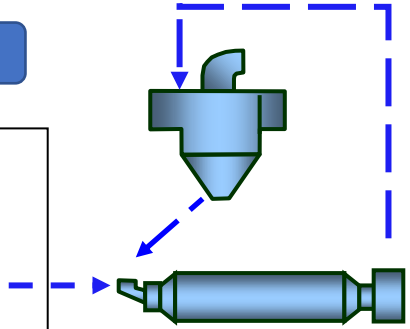
Maximum moisture content of raw materials

3、装备的可靠性运行保障，大型化要求

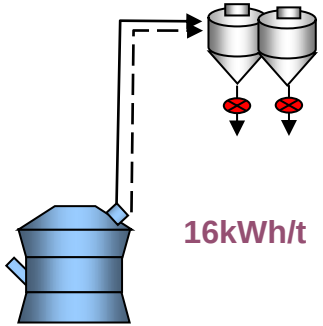
Equipment reliability operation guarantee

4、成本对能耗的敏感性以及人力成本

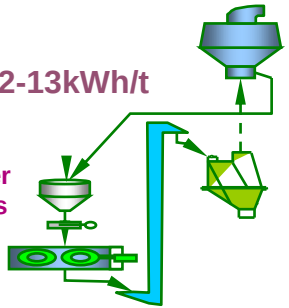
Cost sensitivity to energy consumption and labor costs

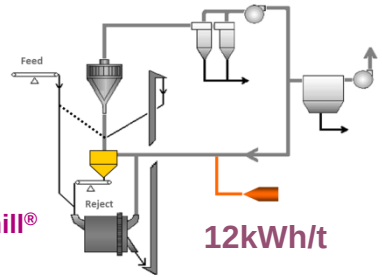


22kWh/t



16kWh/t





Horomill®

12kWh/t

➢ 节能技术 Thermal energy efficiency

粉磨节能 Grinding energy saving

生料辊压机终粉磨 Raw material roll press final grinding

- 系统电耗 12.5kWh/t

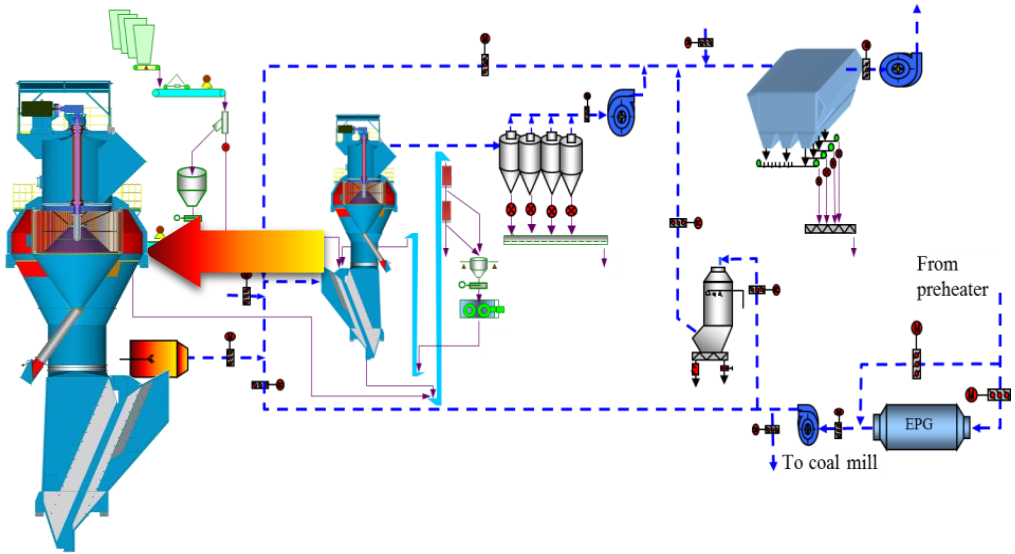
System power consumption

- 组合式选粉机

Combined powder separator

- 烘干能力满足要求

Drying capacity meets requirements



➢ 节能技术 Thermal energy efficiency

粉磨节能 Grinding energy saving

水泥粉磨 Cement grinding

系统选型：

1、水泥的品种及能力要求

Cement variety and capacity requirements

2、混合材的理化性能

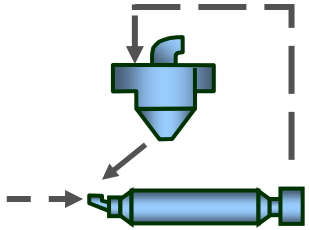
Physical and chemical properties of mixed materials

3、装备的可靠性运行保障

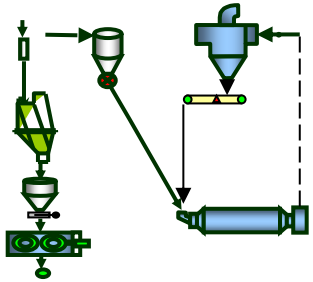
Equipment reliability operation guarantee

4、成本对能耗的敏感性以及人力成本

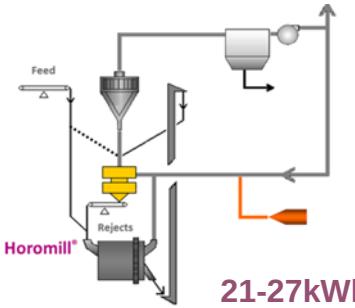
Cost sensitivity to energy consumption and labor costs



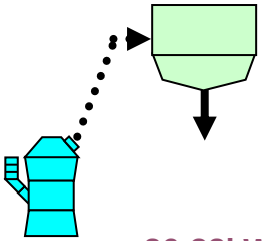
38-40kWh/t



23-32kWh/t



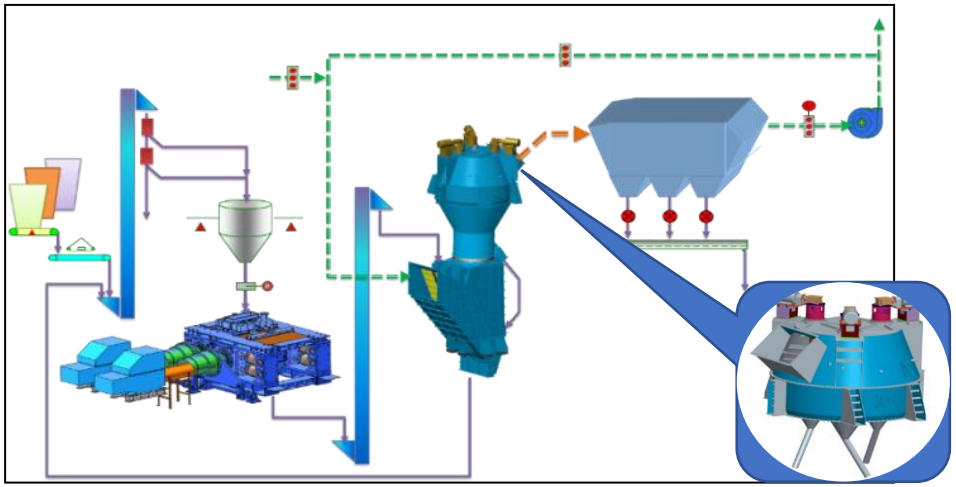
21-27kWh/t



26-32kWh/t

➢ 节能技术 Thermal energy efficiency

辊压机终粉磨系统 Roller final grinding



电耗（power consumption）：23~26kwh/t

2.1 提高能源使用效率、降低运营成本

Improve energy efficiency and reduce operating costs

➢ 降低运行成本的技术 Reducing OPEX

- 智能化控制 Intelligent control

——单机设备检测与控制模块
Equipment detection and control module

——过程检测与子系统智能控制
Subsystem intelligent control module

——生产控制+管理控制
Production and management intelligent control

✓ 降低生产成本
reduce cost

✓ 提高生产质量
Improve quality

✓ 规范并简化流程
Standardize processes

✓ 高效运维管理
Efficient management

✓ 提高劳动生产力
Increase labor productivity

- 智能化控制 Intelligent control

—单机设备检测与控制模块 Equipment detection & control module

——单机设备运行状态诊断模块

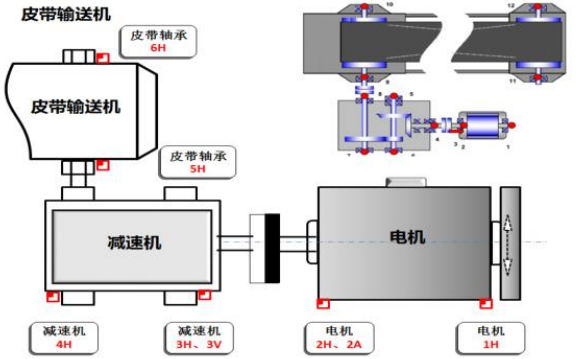
Device status diagnostic module

——过程检测与子系统智能控制

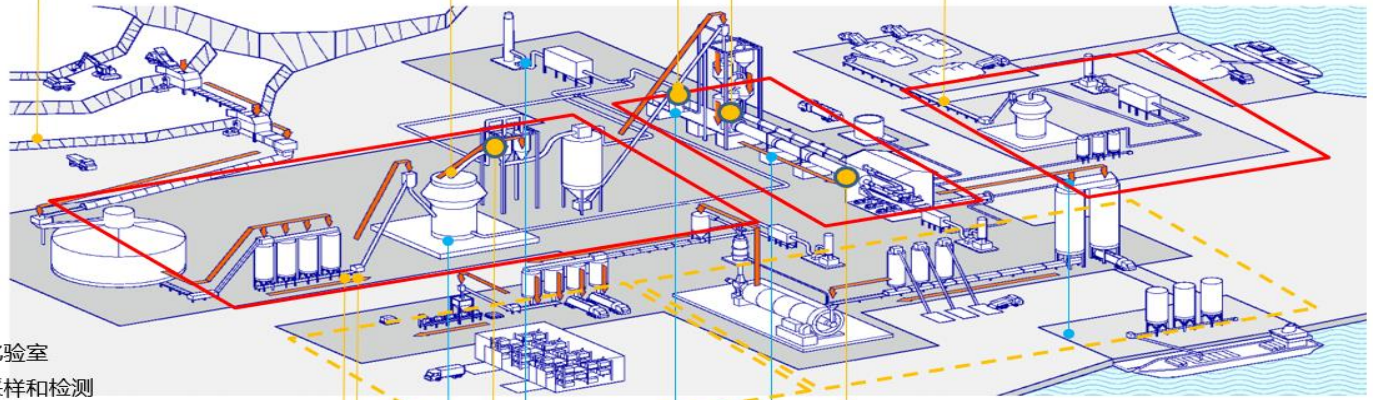
Subsystem intelligent control module

——生产控制+管理控制

Production and management intelligent control



• 智能化控制 Intelligent control



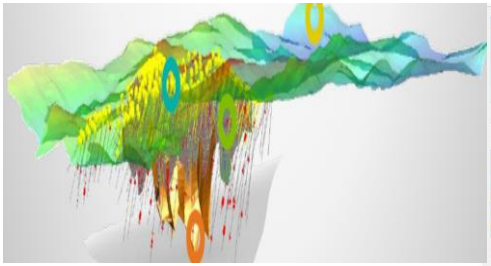
智能化生产控制系统

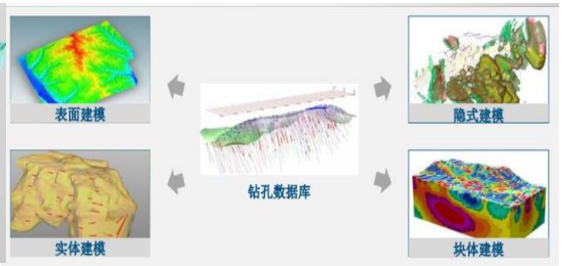
Intelligent production control system

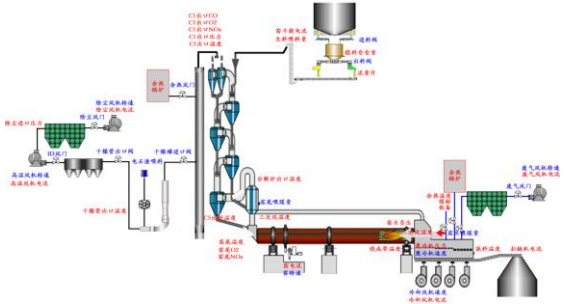
- **智能化控制 Intelligent control**

—过程检测与子系统智能控制

Subsystem intelligent control module







智能优化控制 Kiln optimization control

- 提高系统稳定性，减少故障率

Improve stability, Reduce failure rate

- 提高最优参数最小偏差运行率

Increase minimum deviation operating rate with optimal parameter >30%

- 提高系统设备运转率20%

Improve equipment operation rate >20%

- 降低质量波动10%~20%

Reduce quality fluctuations10%~20%

- 降低生产成本2-3%

Reduce cost 2-3%

- 无人干预运行率提高到98%

Operating rate of unmanned intervention ~ 98%

• 工厂智能化改造 Intelligent of Plant

智能制造
Intelligent Manufacturing

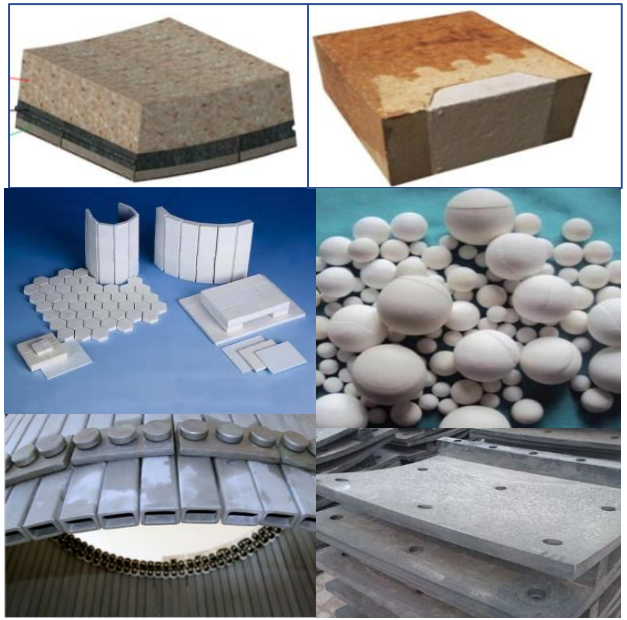
敏捷感知 Perception
实时分析 Analysis
自主决策 Decision
精准执行 Execution
学习提升 learning

2.1 提高能源使用效率、降低运营成本

Improve energy efficiency and reduce operating costs

- ➢ 降低运行成本的技术 **Reducing OPEX**
- • 新材料应用 **New material application**

新型耐火材料 **New refractory**
新型耐磨材料 **New wear resistant material**
新型耐热材料 **New heat resistant material**

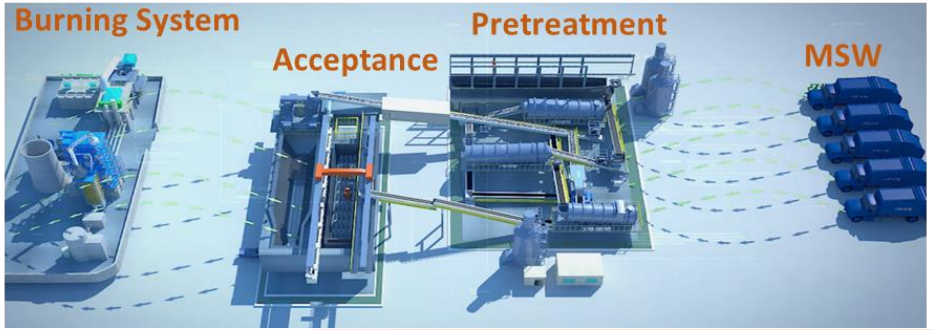


2.1 提高能源使用效率、降低运营成本

Improve energy efficiency and reduce operating costs

➢ 燃料替代 Alterative Fuel

替代物处置方式 disposal method
1、直接焚烧替代燃料（AFR）或垃圾衍生燃料（RDF）20-80%
Incineration as alternative fuels directly or refuse derived fuel
2、预处置+水泥厂内 20-60%
Predisposal & Incineration as alternative fuels
3、厂内处置+焚烧 <50%
Disposal in-plant & Incineration



2.1 提高能源使用效率、降低运营成本

Improve energy efficiency and reduce operating costs

➢ 燃料替代 Alterative Fuel

- 根据替代物种类与形态，采取不同的预处理方式对进行调配。 According to the type and form of the substitute, different pretreatment methods are used to match.
- 根据既有的窑实际运行情况，针对不同的处理种类，选择合理的处置量。According to the actual operation of the existing kiln, select a reasonable amount of disposal for different types of treatment.
- 使用替代燃料会增加系统热耗。The alternative fuel ratio is inversely proportional to the system heat consumption, and excessive alternative fuels increase system heat consumption.

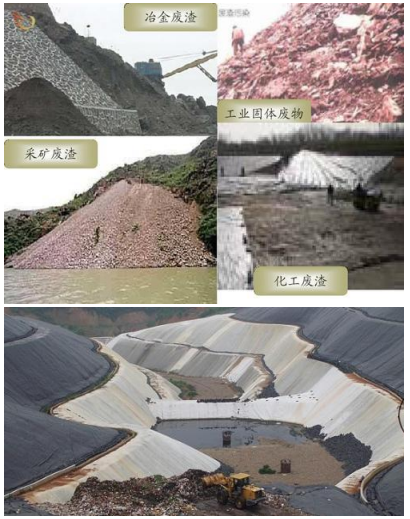
2.1 提高能源使用效率、降低运营成本

Improve energy efficiency and reduce operating costs

➢ **降低熟料系数 Reduction of clinker ratio in cement**

现有产品品种的优化改进—增加混合材掺量
Optimization of existing standard products—Increase the amount of mixed materials

- 改进工艺系统 Improved process system…
- 化学激发剂 Chemical activator…
- 工业固废资源化利用 Industrial solid waste resource utilization…



2.1 提高能源使用效率、降低运营成本

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➢ 降低熟料系数 Reduction of clinker to cement ratio

新型水泥基材料开发 New cementitious material

Features of low-carbon cement (vs PC) 低碳水泥特性（对比硅酸盐水泥）

Production process 生产工艺

- Low burning temperature 低燃烧温度 1300-1350℃
- Energy-saving up to 节能可达 20%
- Reduction in CO_2 emission over 10% 二氧化碳减排超过 25%
- Applicable for Industrial fly ash, sulfuric acid slag 可利用工业废渣

1. 水泥工业技术发展的目标
The goal of cement industry technology development

2. 最新技术进展 Latest technological progress

- 提高能源使用效率、降低运营成本
  Improve energy efficiency and reduce operating costs
- **降低环境负荷、促进可持续发展**
  Reduce environmental impact

3. 技术展望 Technology Perspectives

2. 最新技术进展 Latest technological progress

2.2 降低环境负荷、促进可持续发展

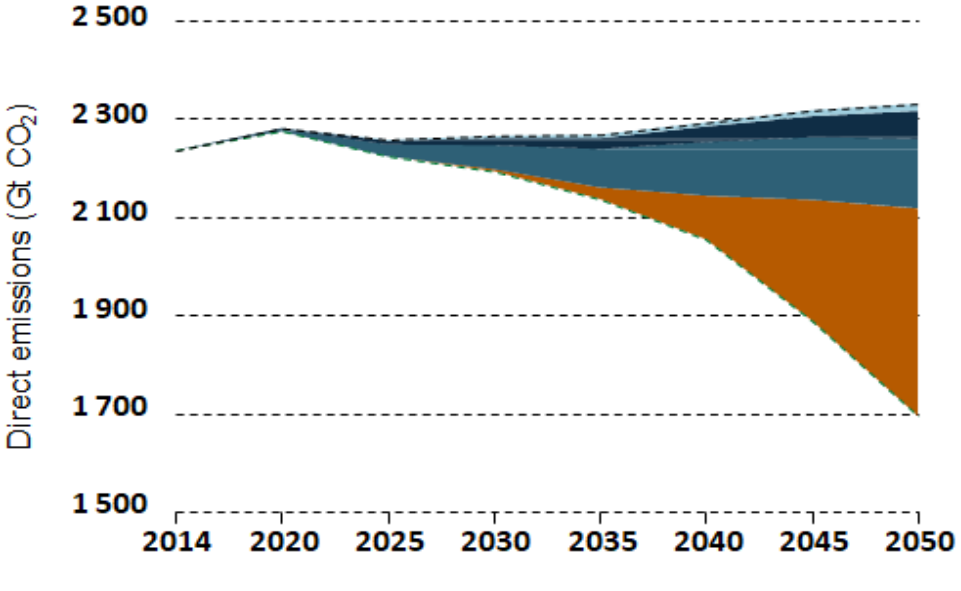
Reduce environmental impact and promote sustainable development

- 碳减排技术 Carbon Capture，Utilization & Storage
- 低排放技术 (粉尘、氮氧化物、硫化物排放)

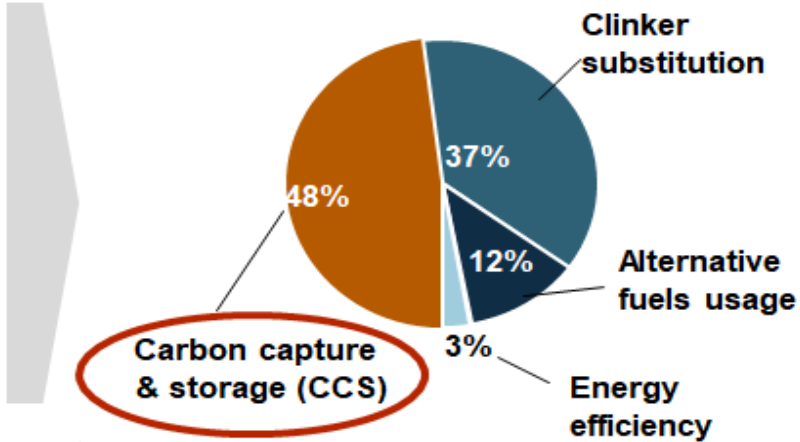
  Emission Reduction (Dust, NOx, SOx)
- 水泥工厂亮化工程 Cement factory beautification project

➢ 碳减排技术 CCUS

Direct CO_2 emissions from global cement production



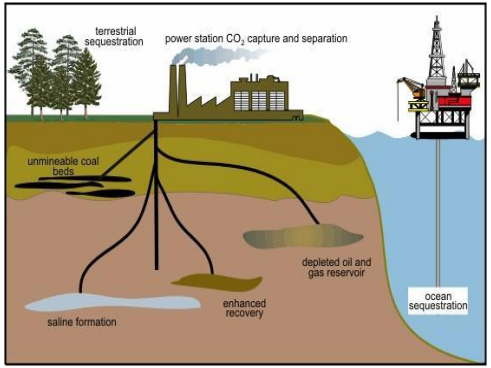
Key levers for CO2 reduction



➢ 碳减排技术 CCUS

碳捕集 CCS

- 石灰石间接加热 Limestone indirect heating
- 富氧燃烧 Oxygen-rich combustion
- 胺法吸收 Amine absorption
- 钙循环 Calcium cycle
- 吸附蒸馏 Adsorption distillation



水泥工业碳减排

Cement CCUS

Carbon **C**apture, **Utilization** and **S**torage

降低燃烧热耗 Reduce energy consumption

提高CO2浓度，降低捕集成本 Increase CO2 concentration and reduce capture integration

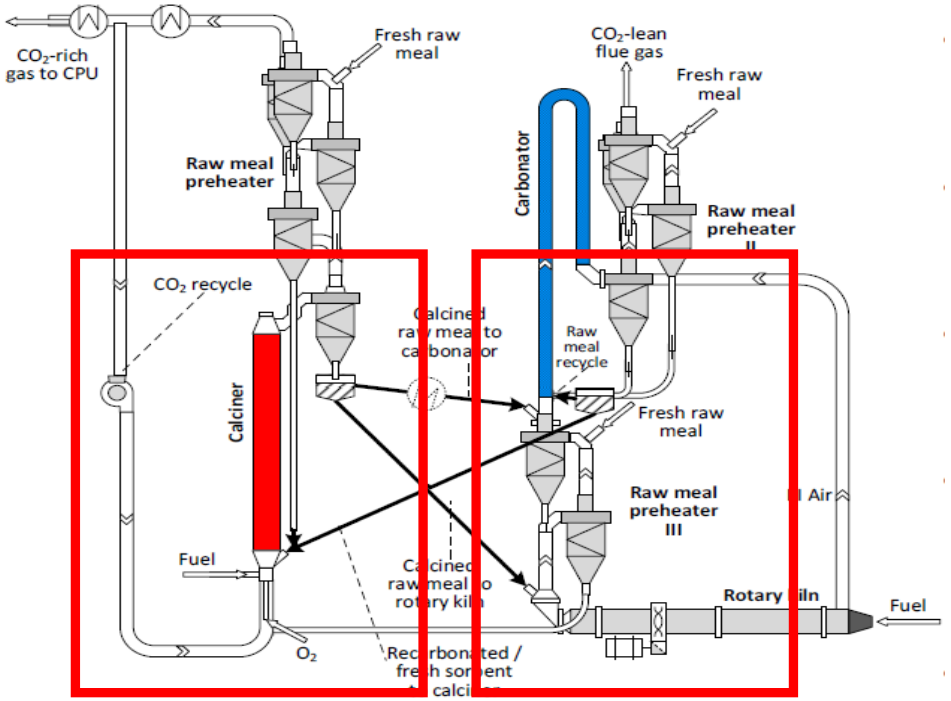
燃烧后捕集 Post-combustion capture

➢ 碳减排技术 CCUS

- $CaCO_3$独立分解技术

Independent decomposition

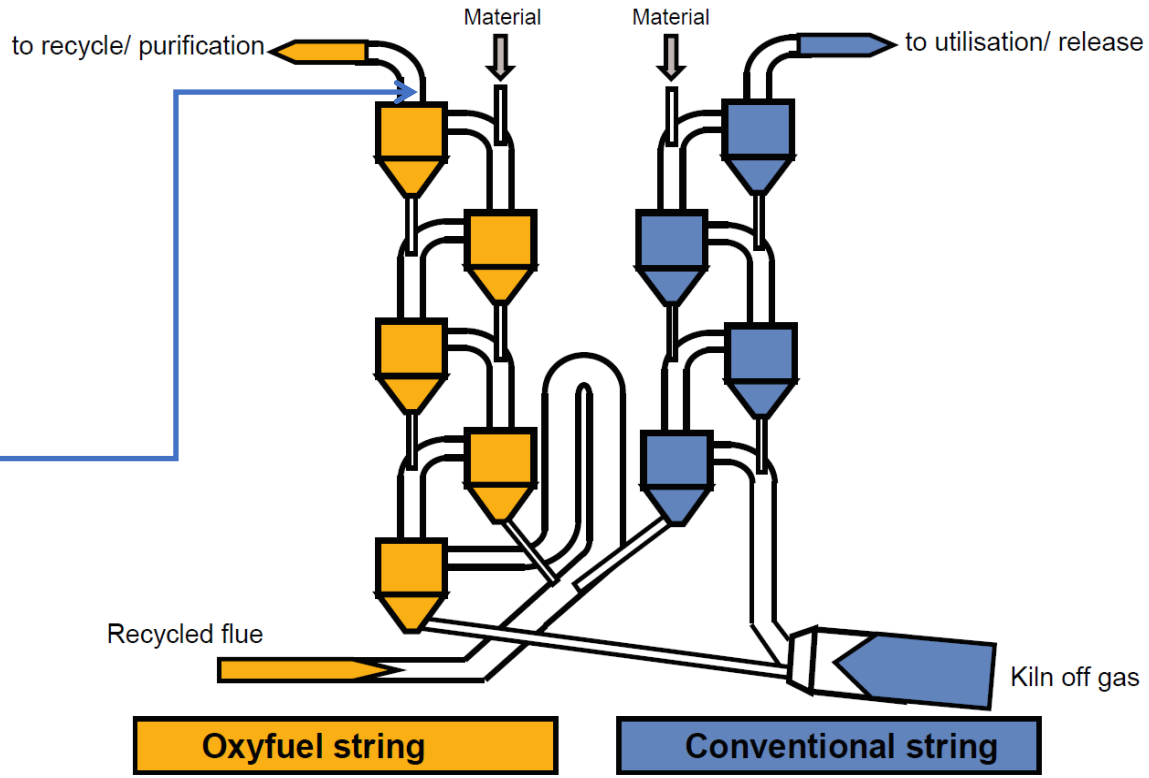
- （CO_2>90%）



➢ 碳减排技术 CCUS

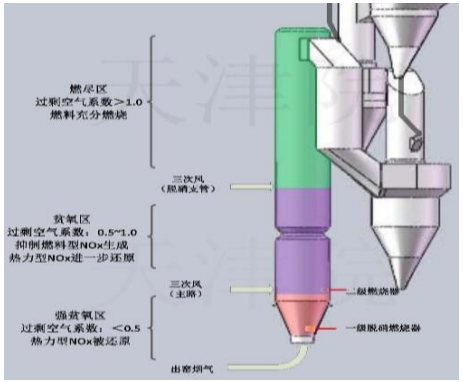
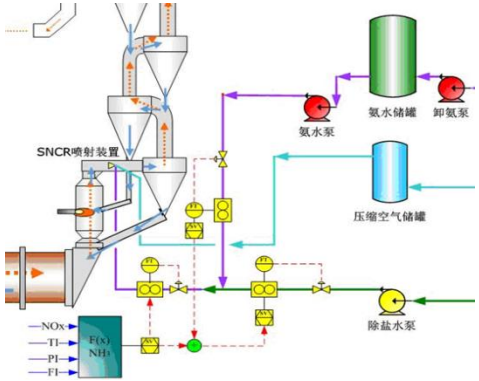
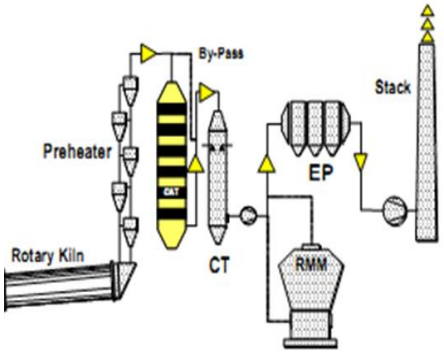
分解炉全氧燃烧技术
Full –oxy-fuel

CO_2	76.9%
O_2	3.2%
N_2	7.3%
H_2O	12.6%



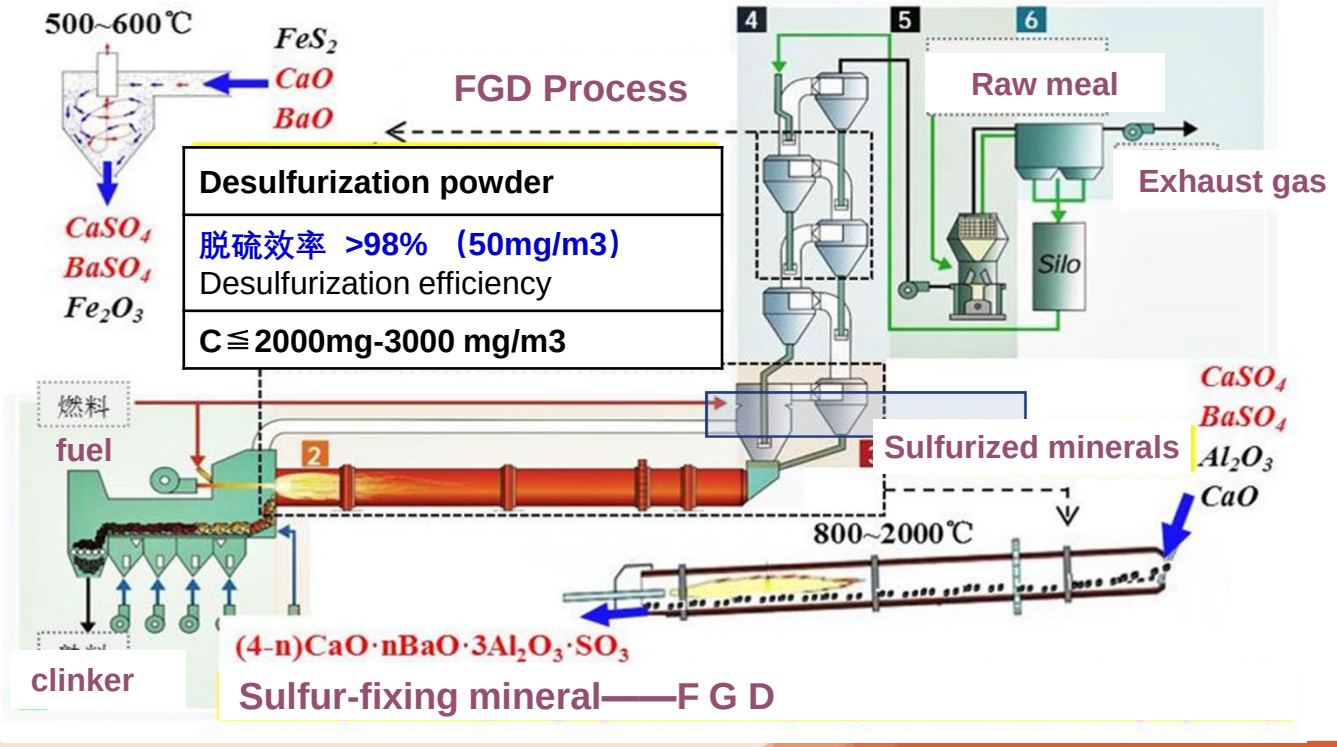
➢ 低排放技术 Emission Reduction (Dust, NOx, SOx)

脱硝 NOx emission reduction technology

工艺自脱硝Self-denitration in calciner（<400mg/m3）	选择性非催化还原（SNCR）（<320mg/m3）	选择性催化还原（SCR）（<150mg/m3）
		
50%	30%	20%

➢ 低排放技术 Emission Reduction (Dust, NOx, SOx)

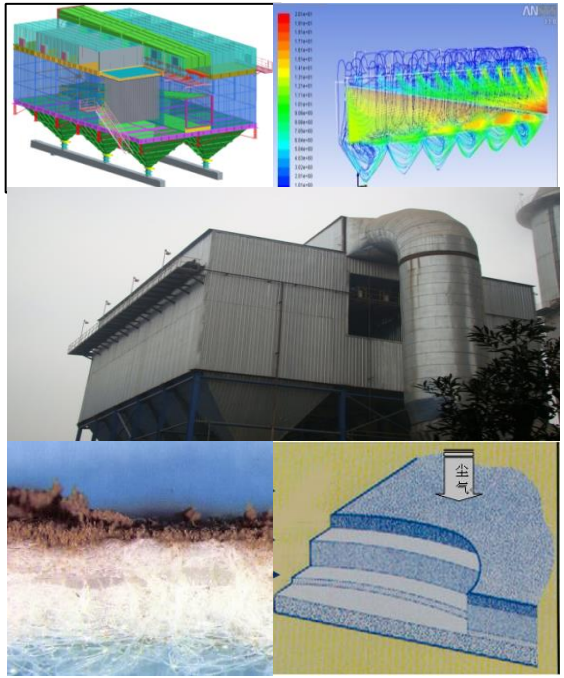
烟气脱硫
Flue Gas Desulfurization



➢ 低排放技术 Emission Reduction (Dust, NOx, SOx)

粉尘超净排放 dust emissions

- 排放浓度 Emission concentration：≤10mg/m3
- 阻力 Resistance loss：<600~800Pa
- 漏风率 Air leakage rate：<3.0%

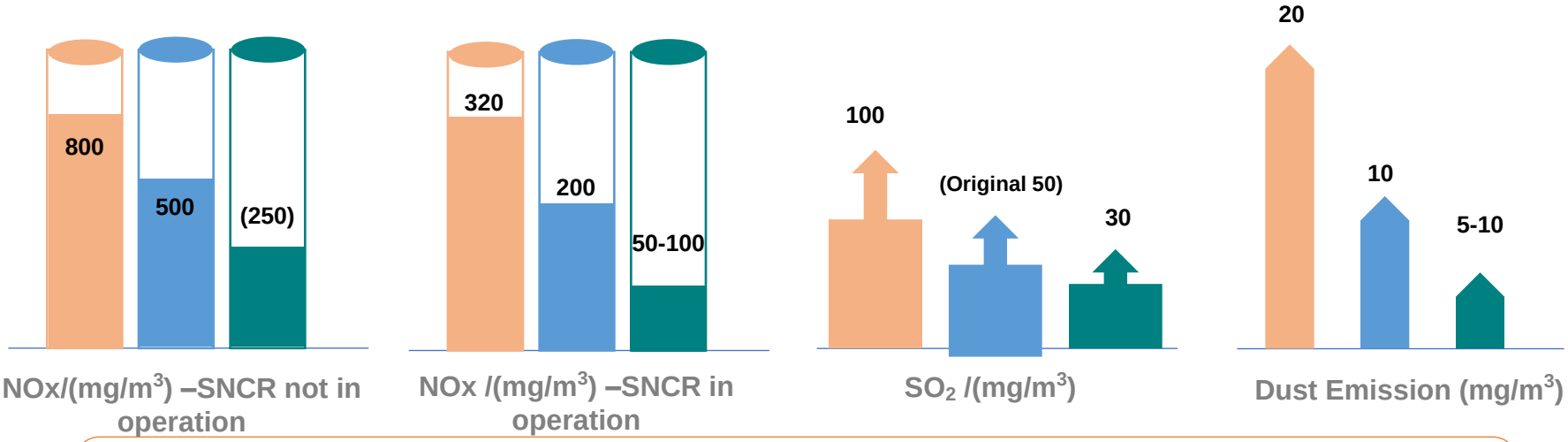


➢ 优化气体流场分布，改善结构设计采用新型滤料，强化滤袋寿命和性能

➢ Optimize air distribution, improve structural design, and adopt new filter materials

➢ 低排放技术 Emission Reduction (Dust, NOx, SOx)

低排放技术指标 Low emission technology roadmap



➢ 低排放技术 Emission Reduction (Dust, NOx, SOx)

国家标准要求 P.R.China National standard requirements

GB4915-2013…

GB16780-20XX

- $CO_2 \leq 0.9050$t/tCL.
- PM ≤30mg/Nm^3
- $SO_2 \leq 200$mg/Nm^3
- $NO_x \leq 400$mg/Nm^3

一般限值
General limit,

- $CO_2 \leq 0.8700$t/tCL.
- PM ≤20mg/Nm^3
- $SO_2 \leq 100$mg/Nm^3
- $NO_x \leq 320$mg/Nm^3

特别排放限值
special limit,

≤3094kJ/kgCL.

- $CO_2 \leq 8450$t/tCL.
- PM ≤10mg/Nm^3
- $SO_2 \leq 50$mg/Nm^3
- $NO_x \leq 100$mg/Nm^3

先进值
expected value

≤2760kJ/kgCL.

熟料热耗. GB16780
Clinker heat consumption

2.2 降低环境负荷、促进可持续发展

Reduce environmental impact and promote sustainable development

- 水泥工厂亮化工程 **Cement factory beautification project**

小结 Concluding Remarks

- 气候变化带来的环境和资源约束，要求水泥工业的向绿色制造可持续发展方向发展，低环境负荷技术成为未来研发与应用的热点
- **The environmental and resource constraints brought about by climate change require the cement industry to develop towards green manufacturing, and energy-saving and emission-reduction technologies become hot spots for future research and development.**

小结 Concluding Remarks

- 新一轮的信息技术革命驱动水泥工业向智能制造转型,工业互联网、大数据、云计算、5G、人工智能等新技术的应用对水泥工业流程再造可能会带来颠覆性影响。
- The information technology revolution has driven the transformation of the cement industry into intelligent manufacturing. The application of new technologies such as IoT, big data, cloud computing, 5G, artificial intelligence, etc. may have a disruptive impact on the process reengineering of the cement industry.

Collaboration & Mutual Success

合作及双赢

Thank you! 谢谢!

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