

# The 2018 International Pittsburgh Coal Conference

## “三高” 煤气化技术研究进展

“Three - High” Coal Gasification Technology Research Progress

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阳泉煤业（集团）有限责任公司

Yangquan Coal Industry (Group) Co., Ltd.

2018年10月  
October, 2018



# 报告提纲

## Report Outline

- 煤气化技术发展历程  
**Part 1 : Development of Coal Gasification Technology**
- R-GAS煤气化技术  
**Part 2 : R-GAS Coal Gasification Technology Research**
- 晋华炉煤气化技术  
**Part 3 : JinHua Gasifier Coal Gasification Technology Research**
- 结束语  
**Concluding**



## Part 1

### 新型煤气化技术——煤炭清洁利用之本

### New coal gasification technology —— Clean coal utilization

- 中国煤炭占能源消费比例约70%
- Coal accounts for about 70% of energy consumption in China
- 主要用于直接燃烧，能量利用率不高，碳排量高
- Direct combustion, energy utilization is not high, carbon emissions are large
- 现代煤化工主要采用新型煤气化技术，是煤炭高效清洁转化利用的重要方向
- Modern coal chemical industry adopts new coal gasification technology, an important direction for efficient and clean coal conversion



阳煤太化新材料园区

Yangmei Taiyuan Chemical Industry New Material Company



# Part 1

## 煤气化技术的发展历程

### Development trend of coal gasification technology

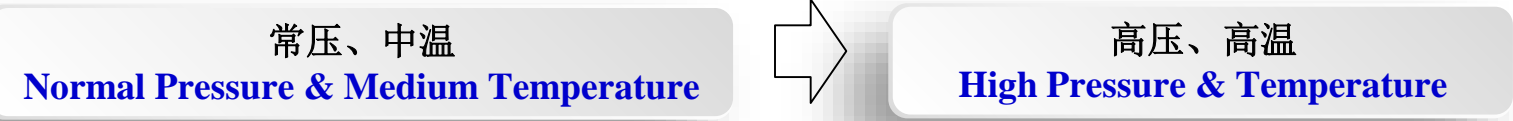
- 1 气化炉  
Raw coal (coal type, ash fusion temperature, ash content, etc)



- 2 原料煤（煤种、灰熔点、灰分等）  
Raw coal (coal type, ash fusion temperature, ash content, etc)



- 3 操作条件（温度、压力）  
Operational condition (temperature, pressure)





# Part 1

## 煤气化技术的发展历程

### Development trend of coal gasification technology

#### 4 技术可靠性 Engineering reliability

短周期运行  
Short-term running



长期稳定  
Long-term stability

#### 5 环保化 Environmental protection

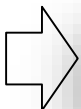
高污染、高能耗  
High Pollution & energy consumption



低污染、低能耗  
Low Pollution & energy consumption

#### 6 大型化 Enlargement

<100吨/天  
<100TPD



750~1500吨/天  
750~1500TPD



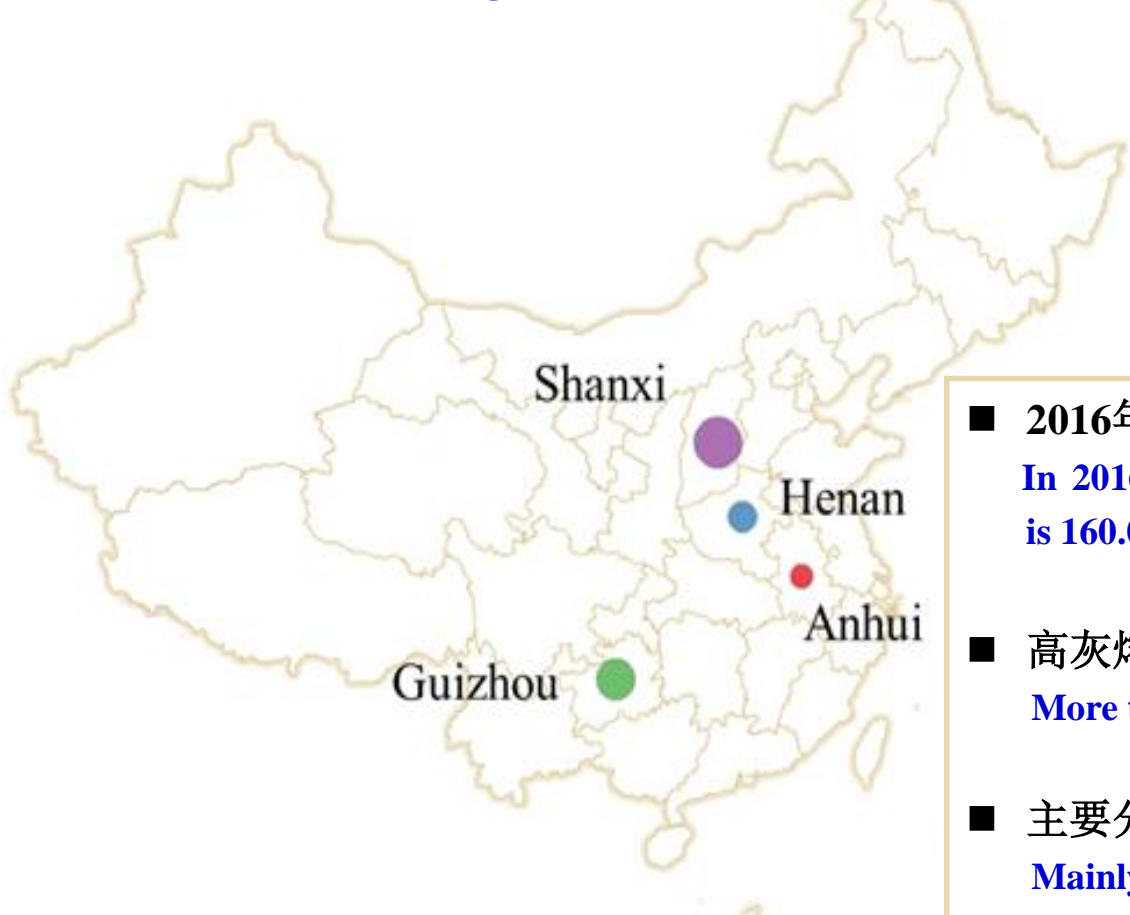
3000吨/天  
3000TPD



## Part 2

### 中国高灰熔点煤分布

### Distribution of High AFT Coal in China



■ 2016年我国煤炭探明储量1.60万亿吨  
In 2016, the detected coal reserve quantity is 160.0 billion tons in china.

■ 高灰熔点煤占全国探明储量40%以上  
More than 40% are high AFT coals

■ 主要分布于山西、河南、安徽、贵州  
Mainly in Shanxi, Henan, Anhui and Guizhou

中国高灰熔点煤分布情况

The distribution of high AFT coal in China



## Part 2

### 山西煤种特点

#### Characteristics of Shanxi Coal

- 2016年煤炭探明储量2674亿吨，“三高”劣质煤占30%以上

Of the 267.4 billion tons of detected coal reserve in 2016, more than 30% were “Three- High” poor-quality coals.

- 灰熔点1500℃以上

Ash fusion temperature (AFT) above 1,500 °C

- 灰分含量 20%以上

Ash content higher than 20%

- 硫含量 2%以上

Sulfur content higher than 2%

### 阳煤集团煤种特点

#### Characteristics of YangMei Coal

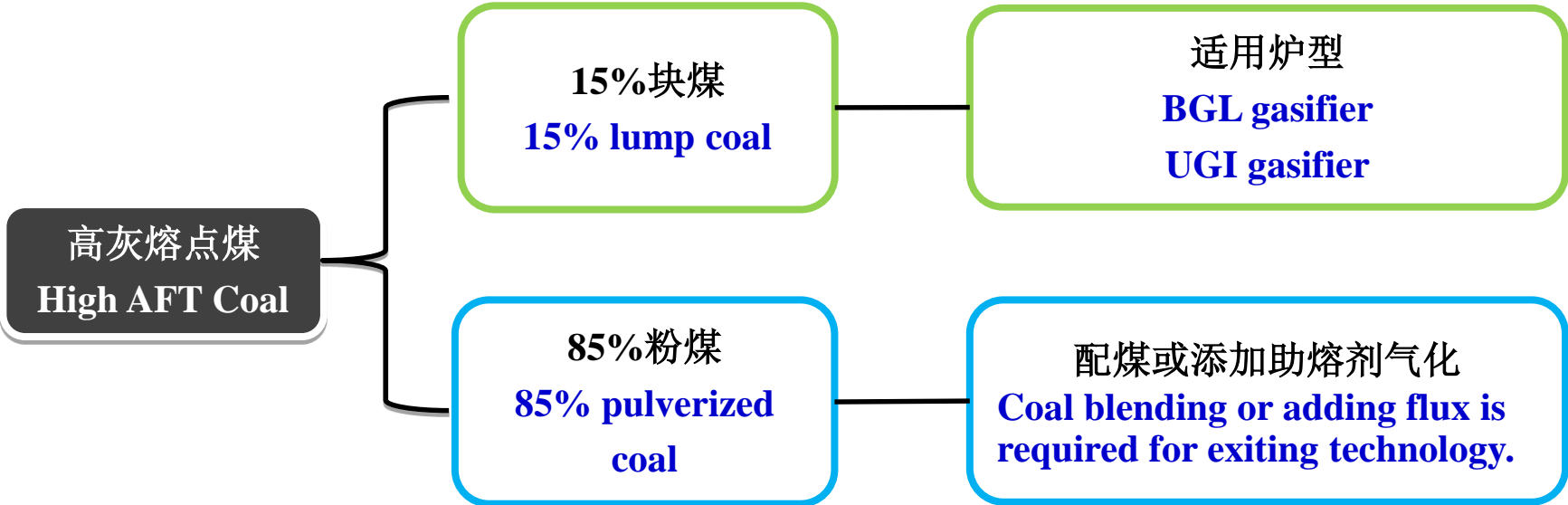
- 煤炭总储量200亿吨以上，70%以上属于高灰熔点煤

Total coal reserves more than 20 billion tons, more than 70% of which are high-AFT coal.



# Part 2

## 高灰熔点煤气化难题 Challenge of High AFT Coal



**煤化工行业国际性难题：**  
**不配煤、不添加助熔剂，实现灰熔点1500℃以上粉煤的低成本气化**  
**An international challenge of coal-to-chemicals industry:**  
**To efficiently gasify coal of high AFT over 1500℃ without adding fluxant or using blending coal.**





## Part 2

### R-GAS煤气化技术

### R-GAS™ Gasification Technology

- 针对高灰熔点粉煤气化难题，阳煤集团2014年启动R-GAS™煤气化项目开发  
**Targeting the challenges of high-AFT coal gasification, YangMei initiated R-GAS™ demonstration project in 2014**
- 项目与美国GTI公司合作开发，并列入山西省2014年煤基重点科技攻关项目  
**The project is co-developed with GTI. In 2014, this project was listed as a Key Project of Shanxi Coal-based Scientific And Technological Projects**
- 阳煤集团运输290吨三高煤至GTI进行中试试烧  
**YangMei shipped 290 tons “Three- high” coal to GTI, accomplish pilot test**
- 目前项目进入800吨/天工业示范装置建设阶段  
**YangMei started the 800 MTPD R-GAS™ industrial demonstration project**



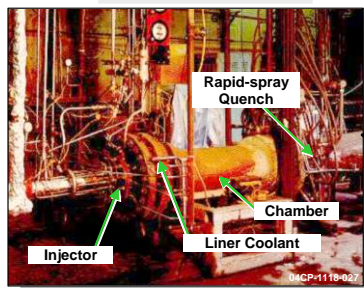
# Part 2

## R-GAS煤气化技术研发历程

### R&D Process of R-GAS Gasification Technology

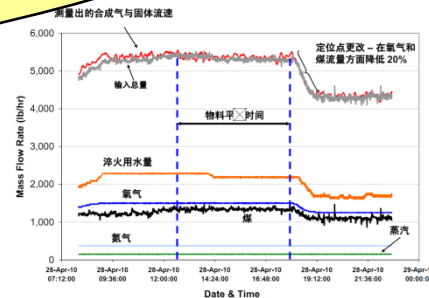
800吨/天示范工厂(2017年启动)  
800TPD demonstration plant(2017)

GTI 18吨/天中试装置(2009 年启动)  
GTI 18 TPD pilot plant(2009)



阳煤煤种测试  
(2014-2016年)  
YangMei coal testing  
(2014-2016)

伊利诺斯州#6、油砂石油焦、艾尔伯达次烟煤测试(2009-2013年)  
Illinois #6 coal, the oil sand petroleum coke, Elberda sub-bituminous coal testing (2009-2013)



概念验证与测试(1975-2009年)  
Concept verification and testing  
(1975-2009)



## Part 2

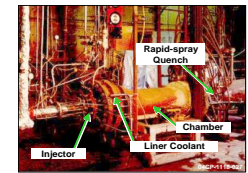
### R-GAS煤气化技术特点

### Technical Features of R-GAS Gasification Technology

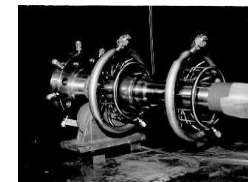
- 气化中心温度 $2500^{\circ}\text{C}$ 以上，不配煤、不添加助熔剂，完全气化高灰熔点煤
- Gasification center temperature reach over  $2500^{\circ}\text{C}$ , Coal blending or adding flux are not required for complete gasification.
- 快速混合烧嘴搭配平推流反应器，体积减少90%
- Rapidly mix injector and entrain flow reactor, volume reduced by 90%.
- 模型预测：R-GAS气化炉气流床技术中效率最高、费用最低的气化技术
- Model prediction: the highest efficiency and the lowest cost one in the entrained flow bed technology.



快速混合烧嘴  
Rapid Mix Injector



水冷壁  
Cooled Membrane Wall



快速喷雾激冷  
Rapid Spray Quench

## 试烧煤样

## YangMei Coal Samples

### 煤样分析 Coal Analysis

煤种 Coal	灰熔点 FT °C	硫含量 S %, dry basis	灰含量 Ash %, dry basis	灰成分 Ash Composition Analysis	
				SiO <sub>2</sub> %	Al <sub>2</sub> O <sub>3</sub> %
新景煤 Xinjing	>1500	1.6~1.7	23.4~28.1	48.5~53.9	34.3~39.8
新元煤 Xinyuan	>1500	1.12	24.50	57.39	31.03
15号煤 15#	>1500	1.9~2.1	21.8~23.2	50.8~53.7	28.0~28.8

## 试烧效果

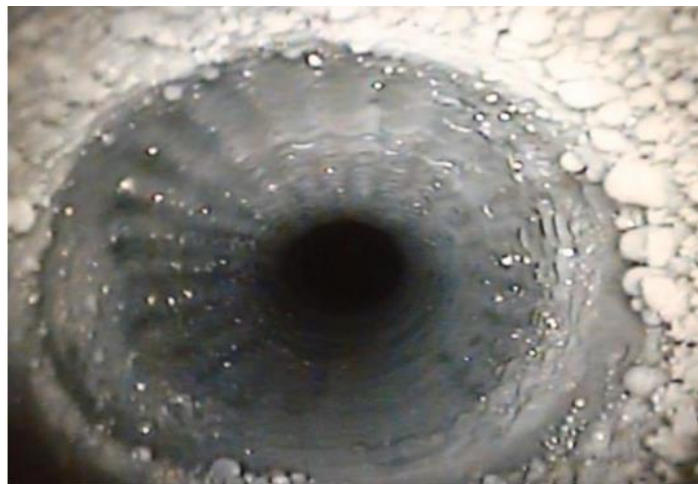
### Test Results

### 试烧数据

#### Test Data

煤种 Coal	煤 Coal Kg/hr	氧气 O <sub>2</sub> Kg/hr	蒸汽 Stream Kg/hr	氮气 N <sub>2</sub> Kg/hr	有效气 CO+H <sub>2</sub> (dry)%	碳转换率 Carbon Conv. %	碳平衡 Carbon Balance %	质量平衡 Mass Balance %	能量平衡 Enthalpy Balance %
新景煤 Xinjing	472.6	454	90.8	227.9	75.9	87.5	99.0	97.0	97.0
新元煤 Xinyuan	471.7	508.5	90.8	77.1	69.3	97.0	99.0	101.3	96.7
15号煤 15#	427.2	522.1	90.8	181.1	64.7	98.4	96.5	97.5	95.4

### 挂渣情况 Slag Coverage



气化炉内壁上部挂渣情况  
Slag coverage around top of the liner

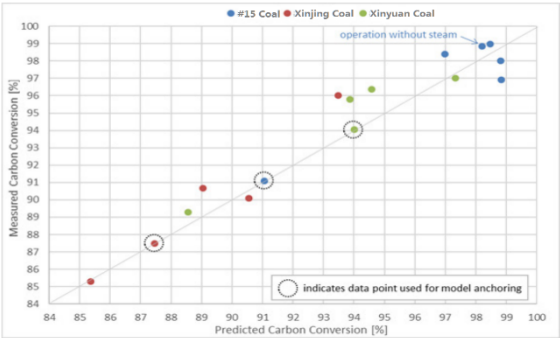


气化炉内壁中段挂渣情况  
Slag coverage around center of the liner

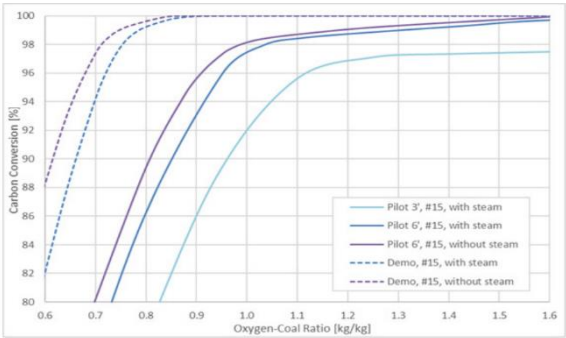


# Part 2

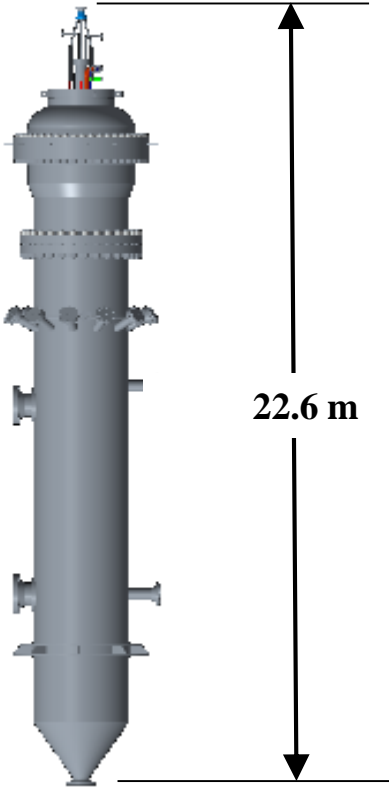
## R-GAS气化炉性能预测 Performance Prediction



碳转换率一维模型  
1-D Model Carbon Conversion



碳转化率对氧煤比预测模型  
Mass oxygen per mass coal predicted mode



18 吨/天中试炉  
18TPD Pilot Gasifier

模型放大及性能预测  
Model Scale-up & Performance prediction

800 吨/天工业示范炉  
800 MTPD Demo Plant Gasifier

## 不同炉型性能对比

### Performance Comparison

参数/Parameter	GE炉	Shell炉	航天炉	R-GAS炉*
碳转换率/ Carbon Conversion, %	99	99	99	99~99.5
冷煤气效率/ Cold Gas Efficiency, %	72~76	80~83	80~83	76.2~78.8
有效气 CO+H <sub>2</sub> (%,dry)	78~82	88~92	88~92	85.1~90.3
比氧耗 Nm <sup>3</sup> O <sub>2</sub> /kNm <sup>3</sup> (CO+H <sub>2</sub> )	350~420	330~360	330~360	324~364
比煤耗 kg Coal/kNm <sup>3</sup> (CO+H <sub>2</sub> )	550-620	550~600	550~600	468~484

\*以15号煤为原料，模型预测数据

\*Model Predicted Data Based on 15# Coal



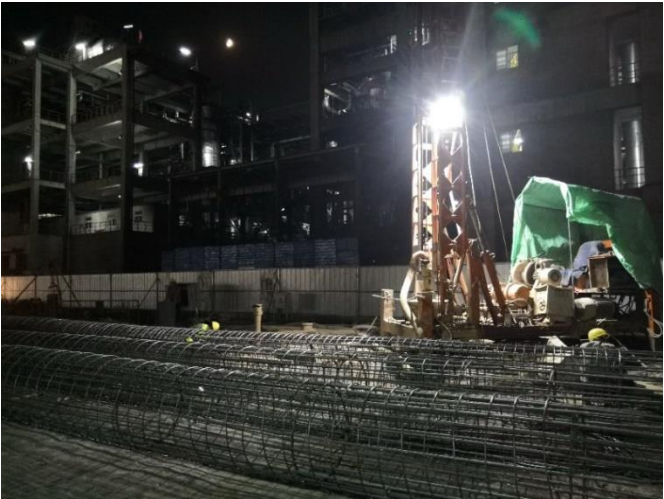


## Part 2

### 800吨/天R-GAS示范项目规划

### 800 MTPD R-GAS Demonstration Project Planning

- 压力：4MPa;
- **Pressure: 4MPa**
- 温度：气化炉出口温度1905℃;
- **Temperature: Gasifier outlet temperature 1905 °C**
- 尺寸：高22.8m，外径1.6m（气化段）/2.8m（激冷段）
- **Size: height 22.8m, outer diameter 1600mm / 2800mm**



800吨/天R-GAS示范装置建设现场  
800 MTPD Demonstration Project Site



800吨气化炉施工

### 800吨/天R-GAS示范项目规划

### 800 MTPD R-GAS Demonstration Project Planning





## Part 3

### 水煤浆水冷壁废锅气化炉（晋华炉）

### **Slurry Feed Membrane Wall Gasifier with Radiant Syngas Cooler (JinHua Gasifier)**

- 阳煤集团与清华大学合作研发的新型气化技术
- **New gasification technology from YangMei and Tsinghua University**
- 合成气显热回收利用副产高温、高压蒸汽
- **Syngas sensible heat recovery by-product high temperature, high pressure steam**

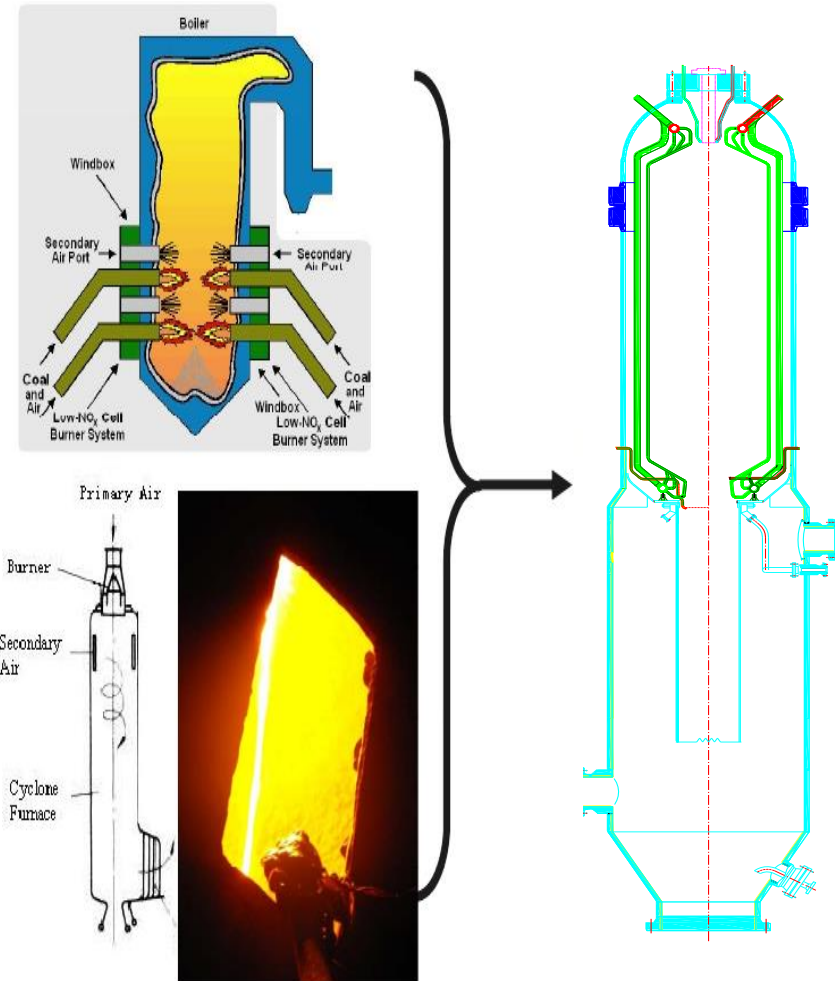


## Part 3

### 晋华炉技术特点

#### Technical Features of JinHua Gasifier

- 气化炉气化室、辐射废锅、激冷室采用直连的方式，共用一个整体外壳，结构简单
- **The gasification chamber, the radiation waste heat boiler and the quench chamber are directly connected, sharing a shell.**
- 气化室采用水冷壁结构，可以使用高灰熔点、高灰份、高硫、高碱金属、低挥发份煤以及半焦、石油焦作为气化原料
- **Membrane wall structure, it can gasify “three- high”, high alkali metal, low volatile coal, semi-coke, petroleum coke**
- 采用辐射废锅回收热量，提高了煤的能量利用率
- **Recovering heat from a radiation waste heat boiler, improving energy utilization of coal**





## Part 3

### 1500吨/天晋华炉技术参数

### Technical Parameter of 1500 MTPD Gasifier

- 操作压力: 6.5MPa
- **Pressure: 6.5MPa**
- 操作温度 (炉膛) >1500度, 炉体350度
- **Temperature ( Center ) >1500 °C, (Shell) 350 °C**
- 直径3200/4200mm, 总高~30m
- **Diameter: 3200 / 4200mm, height ~30m**
- 有效气 (CO+H<sub>2</sub>) 105000Nm<sup>3</sup>/h
- **CO+H<sub>2</sub> : 105000 Nm<sup>3</sup>/h**
- 每千方合成气可副产高压蒸汽0.6-0.8吨
- **High pressure steam: 0.6-0.8 t / 1000 Nm<sup>3</sup> syngas**





## 结束语 Concluding Remarks

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### 煤气化技术发展方向

### Development Direction of Coal Gasification Technology

- 加强基础理论研究和试验
- **Strengthen basic theoretical research and experimentation**
- 大型化和高压化发展和应用
- **The development and application of large-scale and high-pressure**
- 特殊原料气化技术研究和应用
- **The development and application of special raw coal gasification technology**
- 煤气化环保技术研究和开发
- **The research and development of coal gasification and environmental protection technology**

阳煤一直致力于研究新型煤气化技术，R-GAS气化技术和晋华炉技术，都是为实现“三高”煤的低成本气化，这两项技术若能成功研发，将极大地促进煤化工产业的发展，对全国乃至全球“三高”煤的高效清洁利用具有重要意义。

**YangMei has been working on new gasification technology, R-GAS gasification technology and Jinhua gasifier technology, all of which are aimed at realizing the low cost gasification of “three- high” coal. If these two technologies are successfully applied, they will greatly promote the development of the coal chemical industry. It is of great significance to the efficient and clean utilization of the “three- high” coal in China and the world.**



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**欢迎各位专家到阳煤集团  
指导工作！**

**Welcome to YangMei Group for  
Guiding the work!**