Twin Fluidbed Coal Gasifier-
Innovated Technology

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Twin Fluidbed Coal Gasifier-
Innovated Technology

- ***Results into moderate high calorific value, Clean Producer/Syn gas***
- ***Sub-bituminous low ash Coal or Lignite fines is handled***
- ***Envisages separate Gasification and Combustion process in Twin fluidbed reactors for gas production, which is purified for clean gas***
- ***Atmospheric pressure coal gasification by fluidisation of < 6mm fine size coal, without pure Oxygen/enriched oxygenated Air as gasifying agent.***
- ***Steam is gasifying agent, for syn gas;and self-supporting; while Air is also used to support the combustion process to meet heat requirements***

Gasifier commissioned, rated 2nos. x 12000 nm^3/hr gas output, in 2015 at Shanxi Xinhua/China. Gas calorific value 1800-2200 kcal/nm^3.

Twin Fluidbed Coal gasification- Innovated technology

Salient features:

Gasification of < 6 mm uniform size coal fines, as compared with lump coal required as feedstock in fixed-bed gasifier. So,lower gas production cost

Atmospheric pressure operation, without pure oxygen/enriched oxygenated air as gasifying agent; full recovery and utilization of waste heat

Stable and easy operation ; Ash is only side product

No phenol water disposal, Much reduced tar disposal,

Sulphur recovery feasible , after gas desulphurisation

Efficient and productive use of Coal fines resources

Leftover Ash- carbon content < 5%, higher thermal efficiency

Fluidbed Gasification System Categories

a. Bubbling fluidised bed

-- Low fluidising velocities

--Avoids discharge of bed material

--Energy provided by partial combustion of fuel

b. Circulating fluidized bed.

-Higher gas velocities, and smaller bed material particles

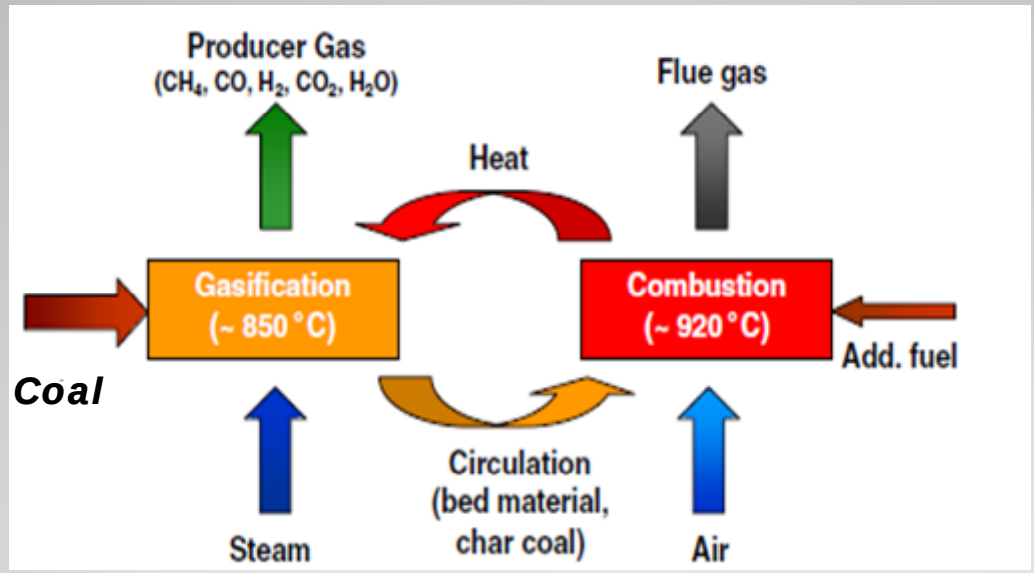
-Entrained material is recycled back to the fluid bed to improve the carbon conversion efficiency

Twin Fluidbed Gasifier is Circulating fluidised bed type

Fluidised bed gasifiers fundamentals

- *Excellent mixing characteristics and high reaction rates of gas–solid contacting.*
- *Typically operated at temperatures between 800 and 850°C*
- *Conversion can be divided into four steps ; drying, pyrolysis, and gasification while combustion as the other step*
- *Reactions occur in a statistically distributed fashion over the whole reaction zone*

Concept Of Twin Fluidbed Gasification - 1



Concept Of Twin Fluidbed Gasification - 2

-Gasification of Coal in turbulent fluidised condition with steam.

-Steam reforming of evolved Volatiles and Char gasification results in syn gas.

-Heat of reaction (endothermic), and bed material heat up is provided by combustion of residual char+ add-up coal(as reqd.), in fast fluidised mode with preheated air.

-Steam co-generation by waste heat recovery from both flue gas and Producer gas

Chemical Reactions Summary

- ***I Steam gasification of Coal***

  as per stoichiometric conversion

  $C_x H_y O_z + (x - z)H_2O \rightarrow xCO + (y/2 + x - z)H_2$

- *plus CO_2, CH_4 and light hydro carbons (C_2H_4, C_2H_6,C_3H_8)*

- ***II Reforming of Hydrocarbons***

  - is expressed as

- *(i) $C_nH_m + nH_2O \rightarrow nCO + (n + m/2) H_2$*
- *(ii) $C_nH_m + nCO_2 \rightarrow 2nCO + m/2 H_2$*

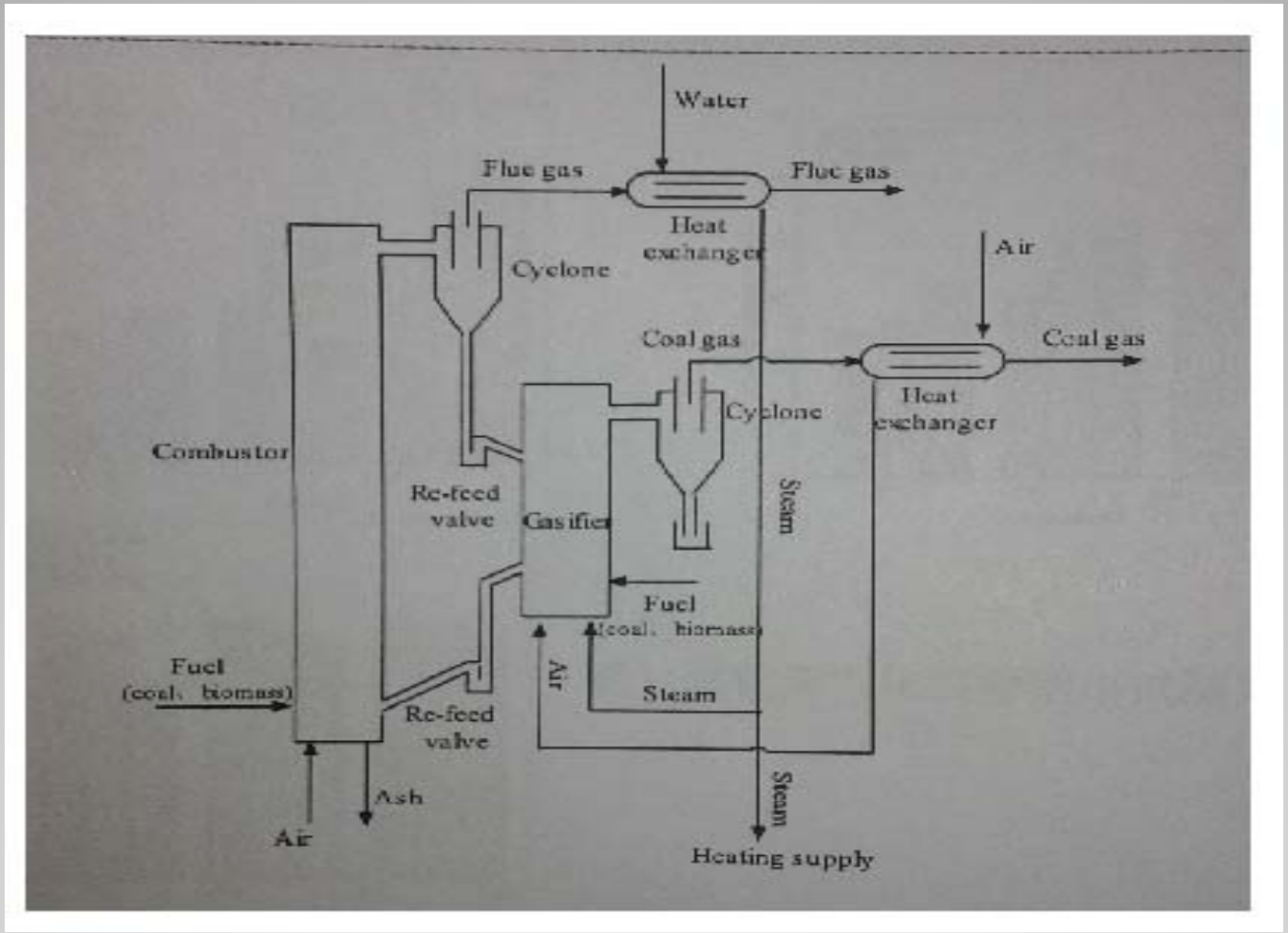
- ***III Furthermore, syn gas composition***

  - is mainly influenced by

- *(i) $C + H_2O \rightarrow CO + H_2$*
- *(ii) $CO + CO_2 \rightarrow 2CO$*

- ***IV and the CO- water, shift reaction***
- *$CO + H_2O \rightarrow CO_2 + H_2$*

Principle of Twin Fluidbed Coal Gasifier - 1



Principle of Twin Fluidbed Coal Gasifier - 2

COAL FINES ENTERS GASIFICATION REACTOR, BED TEMPERATURE 850-900 C

DRYING, PYROLYSIS OF COAL FINES

VOLATILES REFORMING AND CHAR GASIFICATION WITH STEAM

RESIDUE CHAR LEAVES TO COMBUSTION REACTOR TOGETHER WITH BED MATERIAL THROUGH INCLINED STEAM FLUIDISED CHUTE

FINES SEPARATED FROM GAS ALSO TAKEN AND SUPPLEMENTS ADDITIONAL COAL AS REQD. IN COMBUSTION REACTOR

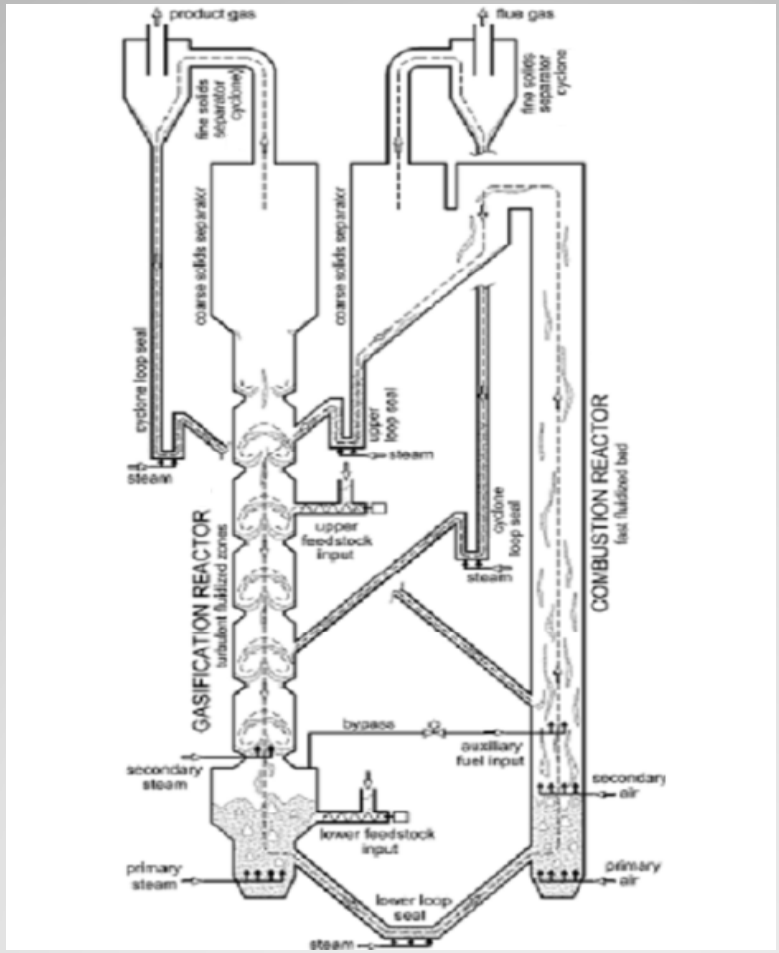
COMBUSTION REACTOR IS FAST FLUIDISED BED. AIR IS USED AS FLUIDISATION AGENT

BED MATERIAL ALSO HEATED UP THERE

PARTICLE SEPARATION FROM FLUE GAS AND ALSO IN CYCLONE, AND SO HOT BED MATERIAL FLOWS BACK INTO GASIFICATION REACTOR VIA LOOP SEAL(COARSE AND FINES STREAMS SEPARATELY)

BOTH CONNECTIONS , THE LOOP SEAL AND THE CHUTE ARE FLUIDISED WITH STEAM THIS EFFECTIVELY PREVENTS GAS LEAKAGE BETWEEN GASIFICATION AND COMBUSTION ZONES

Twin Fluidbed Gasifier Reactors- Process Flow - 1



Twin Fluidbed Gasifier Reactors- Process Flow - 2

Steam gasification of Coal fines, uniform size important

Intensive Gas-Solid contact is key parameter

Countercurrent flow in the fuel result in high conversion rates

Improved gas quality with much reduced amount of tar

Combustion Reactor is fast fluidised bed, and Gasification reactor is turbulent fluidised bed

Design Concept of Twin Fluidbed Coal Gasifier (1)

- *Two reactor units interconnected with circulating solids*
- *The solids loop starts in the combustion reactor where solids are entrained.*
- *Coarse and fine bed material are separated from the flue gas stream and then sent to the gasification reactor via steam fluidized loop seals (upper loop seal and cyclone loop seal).*
- *The gasification reactor is divided into a sequence of sections by constrictions whereas solids density is high above these constrictions.*

Design Concept of Twin Fluidbed Coal Gasifier (2)

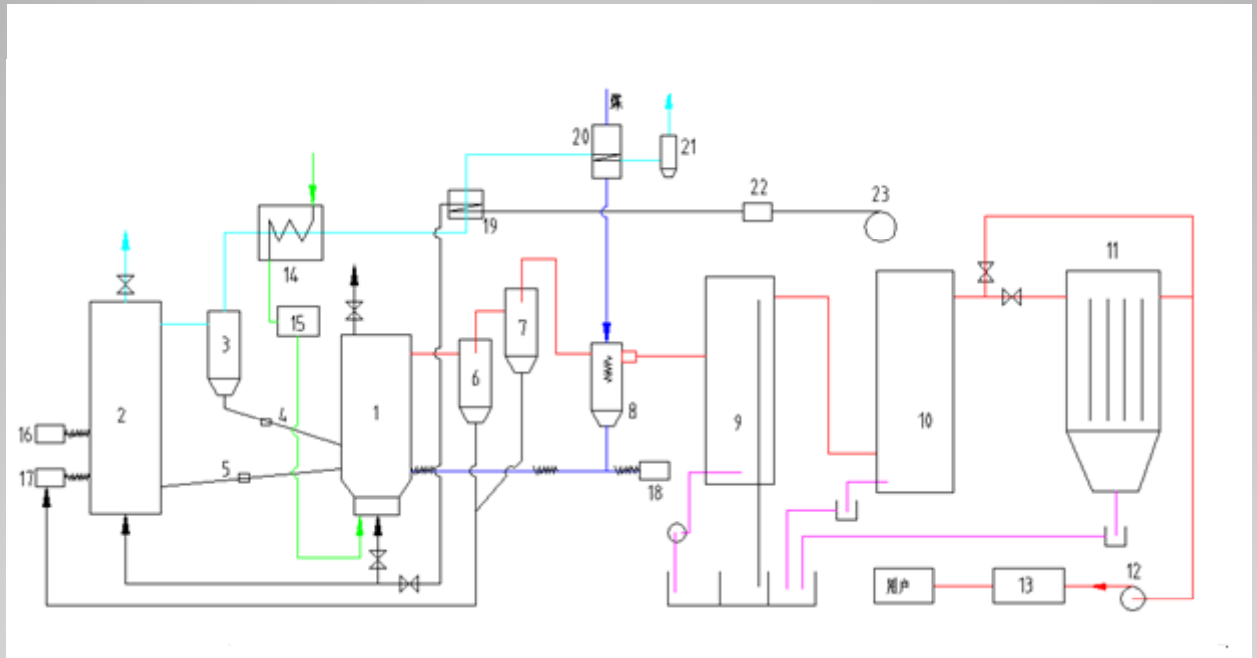
The fluid dynamics of the bed material in the gasification reactor is equivalent to a column of stirred vessels.

Optimal residence time distributions are possible depending on the location of feedstock input; coarse with low volatiles at higher region ,fines/high volatiles at bottom

From the gasification reactor, the solids mainly flow back into the combustion reactor via a second loop seal connecting the bottom regions of the two reactors (lower loop seal).

Fine solids entrained and separated from the gasification reactor product gas stream are also directed back into the system.

Fluidbed Gasification and Gas purification process



1.Gasifier 2.Heating Furnace 3 Cyclone/Whirlwind 4 & 5.Material sealing valve 6&7 Cyclone
8.Flash tank 9 Inter cooler 10 Electric oil remover 11 Bag Dust collector 12& 23 Draft Fan
13 Gas mist separator 14 & 19 Heat Exchanger 15 Steam Regulator cylinder
18 &16 &17 Feeding machine 20 Coal dewatering device 22 Scrubber

Gasifier process design features

Gasification strength

Semi-Bituminous Coal 250 ~ 350kg / m 2 .h

Lignite 300 ~ 400kg / m_2.h

(Max Hearth Blast pressure 12 kPa)

Dry coal gasification rate

Semi-Bitumnous Coal 1. 7 ~ 2.2 m_3 / kg

Lignite 1. 5 ~ 2.0 m_3 / kg

LHV

Semi-Bituminous Coal 9000 ~ 11000 kJ / Nm_3

Lignite 8500 ~ 10500 kJ / Nm_3

Steam consumption rate 0. 5 ~ 0. 75 kg / kg coal

Air consumption rate 2.0 ~ 2.5 Nm_3 / kg coal

Cinder carbon <5% Gas (boosted) pressure <4.5 /(22)kPa

Coal Grade desirable

Coal Ash_{ad} <18%, Ash fusion point >1150 C, S_{ad} <1%, Net Q >21MJ/kg

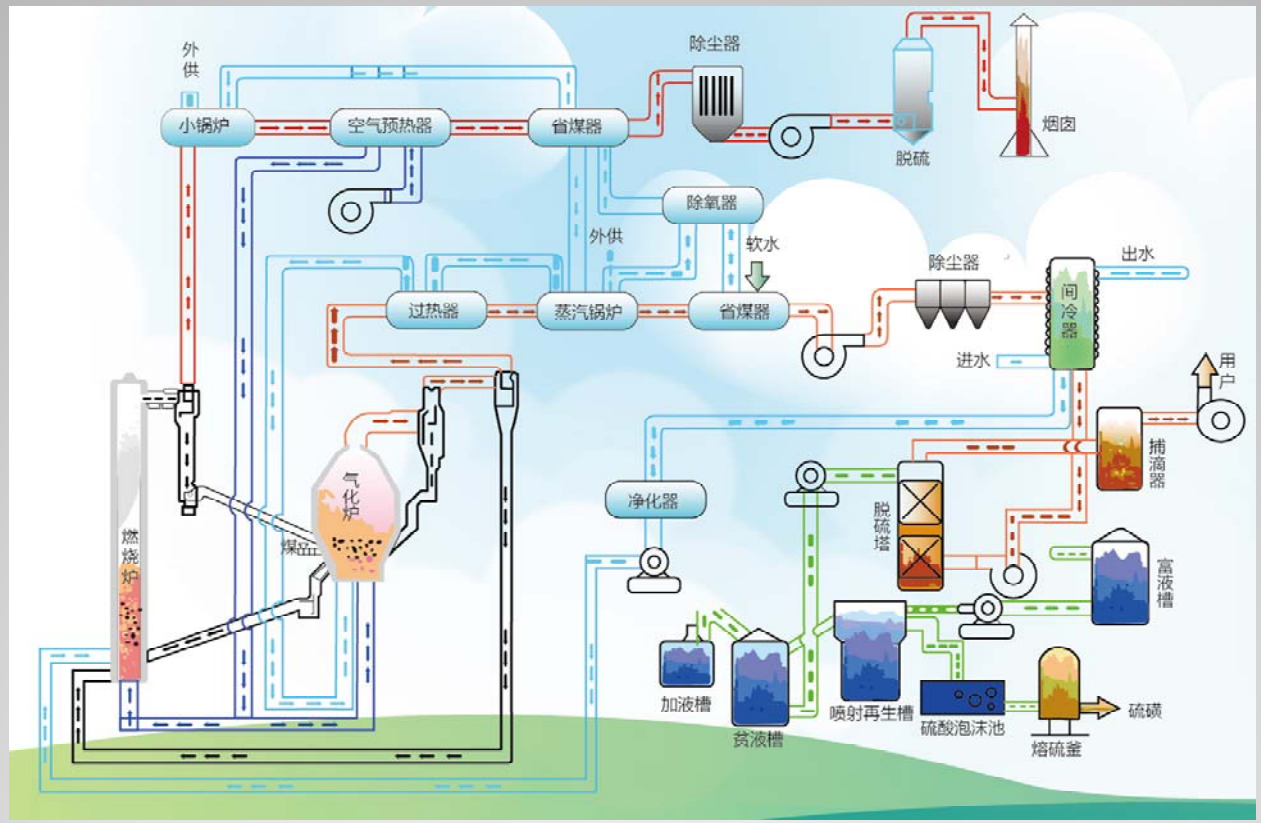
Gas components (with qualified coal)

Gas composition

CO	15 to 20%
CO_2	15 to 20%
H_2	38 to 43%
CH_4	8 to 13%
O_2	<0.2%
N_2	12 to 17%

Gas Station Process Flowsheet (with gas desulphurisation)

Gas output 11000-13000 nm3/hr



Coal feed 6.5 – 7.5 Ton/hr ; Power connected load : 1075 kW

Gas Desulphurisation Principle

- *1 Absorption:*
- *- feed gas is in countercurrent contact with base solution to absorb H 2 S ;*
- *H 2 S + Na 2 CO 3 = NaHS + NaHCO 3*
- *2 Sulphur precipitation via high valence metal ion, based on vanadium pentaoxide,*
- *NaHS + NaHCO 3 + 2NaVO 3 =*
- *S ↓ + Na 2 V 2 O 5 + Na 2 CO 3 + H 2 O*
- *3. Resulting low-valence metal ions is oxidized by quinone back to high metal ion;*
- *Na 2 V 2 O 5 + 2Q (quinine)+H2O +Na 2 CO3 →*
- *2 NaVO 3+ 2 HQ (phenol)*
- *4. Regeneration of Quinone:*
- *By air injection ,HQ is oxidized to quinones state;*
- *2HQ + 1 / 2O 2 = 2Q + H 2 O*

Wet Tannin Latex desulphurisation system

- *Raw gas enters desulphurisation tower from bottom and meets base solution from top.*
- *Base solution contains wet tannin latex alongwith vanadium oxide*
- *Tower is packed with packing rings*
- *H2S gets absorbed, and gas is transported to user end after mist separation*
- *Base solution with absorbed H2S is taken to desulphurising tunnel, where S is separated*
- *Present tannin (quinone) oxidises low valence metal ion back to high metal ion (V2O5 based), and goes along with base solution*
- *Remaining liquid is sent to Spray regenerating tunnel, where oxidation by air enables regeneration of wet tannin latex*
- *H2S in final gas < 50 mg/nm3*

Further Dry desulphurisation : adsorption over iron oxide /charcoal lowers H2S < 20 mg/nm3

Gas Station 12000 nm3 /hr – gas yield, analysis and calorific value

Sub-bituminous coal as feedstock, coal gas composition:

CO	CO_2	H_2	CH_4	N_2
~ 23%	~ 14%	~ 35%	~ 6%	~ 22%

Coal gas yield: > 1.8 $Nm^3 \cdot kg^{-1}$; Coal gas heating value: > 2000 kcal · Nm^{-3}; Ash carbon content:< 5%

Lignite as feedstock, coal gas composition:

CO	CO_2	H_2	CH_4	N_2
~ 21%	23%	27%	~ 8%	~ 21%

Coal gas yield: > 1.3 $Nm^3 \cdot kg^{-1}$, Coal gas heating value: > 2000 kcal · Nm^{-3}; Ash carbon content: < 5%.

Gas Station reported performance

Coal analysis:

Moisture 10, After air drying	1.7 %
Ash db	7.01 %
Volatile matter db	32.5 %
Fixed carbon db	59.39 %
Sulphur db	0.33 %
CV	6433 kcal/kg

Gas analysis:

CO : 23 %
CO2: 13%
H2 : 35 %
CH4 : 7 %
N2 : 22 %
CV : 2000 kcal/nm3

Application:

- *-Produced fuel gas, is of moderate high calorific value; enables high flame temperature in Kiln/Furnace (suited for Iron ore pellet induration , Calcined Bauxite kiln)*
- *- Produced gas could find application in DRI Rotary Kiln substituting Injection Coal therein , with better efficiency*
- *- High moderate CV syn gas with co-generation of steam in addition for outlets*
- *It enables efficient utilization of low cost fine size coal: Sub-Bituminous low ash Coal/Lignite can be gasified with high efficiency , who are having high reactivity.*

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St. Xavier's College, Calcutta 1965
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Thank You
For Attention!