

The Combustion of Syngas

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Syngas

- **Syngas** (from *synthesis gas*) is the name given to fuel gasses of varying composition that are generated in coal gasification and some types of waste-to-energy facilities. (Webster)
- The gas mixture contains varying amounts of CO and H₂ and other organic compounds generated by the gasification of a carbonaceous material.

Syngas

- Syngas is nothing new
- Known as “Manufactured Gas” in the early 1800’s it was first used for lighting
- Coal and coke were the main feed stocks
- Manufactured Gas plants were a prominent fixture in US cities in the late nineteenth and early twentieth centuries
- The electric light and government financing of fuel pipelines after WW II led to the demise of manufactured gas industry

Syngas

- “Manufactured Gas” is made by blowing air and/or steam through an incandescent fuel bed
- The resulting gases have low BTU value with respect to natural gas
- Producer Gas - 180 BTU/Ft³
- Blue Water Gas - 300 BTU/Ft³
- Carbureted Gas - 536 BTU/Ft³

Syngas Comparison

Fuel Gas	Ft ³ /MM BTU	Air Req'd (Ft ³ /Ft ³ Fuel Gas)	Air Ft ³ / MM BTU	Flame Temperature (°F)
Natural Gas	998	9.38	9,361	3,800
Blue Water Gas	3,846	2.09	8,038	3,710
Carbureted Gas	1,866	5.03	9,386	3,700
Coke Oven Gas	1,757	5.42	9,523	3,155
Producer Gas	5,465	1.45	7,924	3,010

How do we burn this stuff?



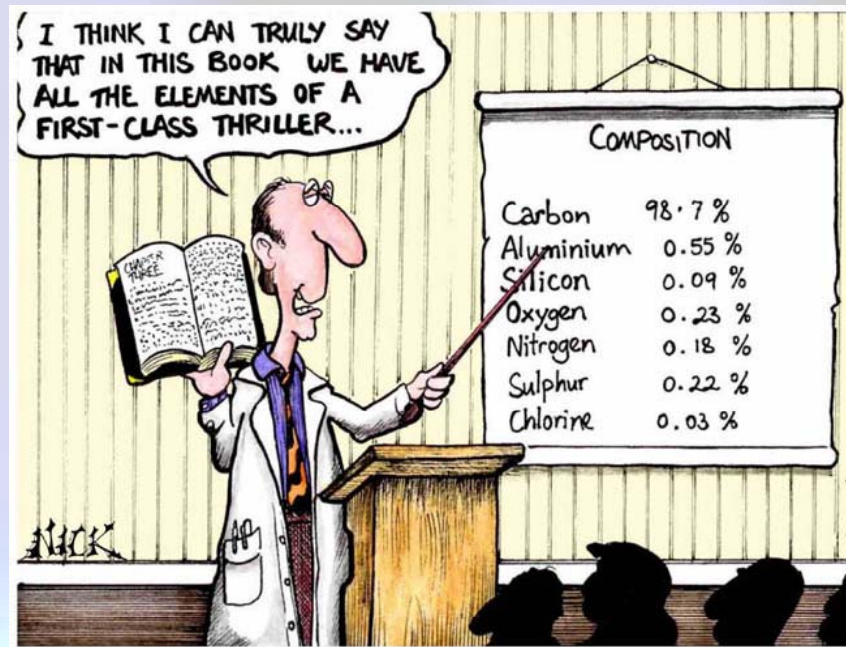
Combustion Basics

- Combustion or burning is a complex sequence of exothermic chemical reactions between a fuel and an oxidant accompanied by the production of heat or both heat and light in the form of either a glow or flames.

Syngas Combustion

Primary issues when burning a fuel

- What is the stoichiometry?
- What is the flame temperature?
- What is the flame speed?



Combustion Basics

- Combustion of Methane and Air



- 9.52 standard cubic feet of air per standard cubic foot of methane
- 17.2 pounds of air per pound of methane

Syngas

Analysis of Manufactured Gases (% Volume)

GAS	CH₄	C₂H₆	C₄H₁₀	CO	H₂	CO₂	O₂	N₂
Natural Gas	90.0	5	-	-	-	-	-	5
Carbureted Gas	10.9	2.5	6.1	21.9	49.6	3.6	0.4	5.0
Producer Gas	5.0	-	-	16.0	25.0	14.0	-	40.0
Coke Oven Gas	32.3	-	3.2	5.5	51.9	2.0	0.3	4.8
Blue Water Gas	4.6	-	0.7	28.2	32.5	5.5	0.9	27.6

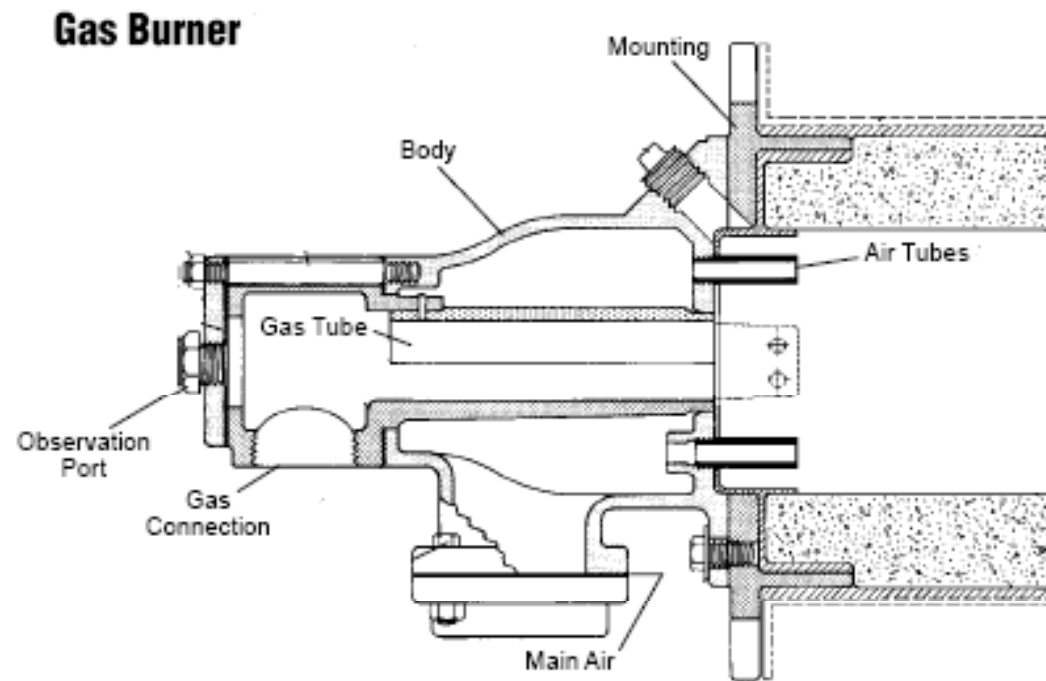
Syngas

FUEL	FLAME VELOCITY(ft/sec)
Acetylene	8.75
Carbon Monoxide	1.7
Carbureted Water Gas	2.15
Coke Oven Gas	2.3
Hydrogen	9.3
Natural Gas	1.0
Propane	2.78

Mechanical Impacts

- Burner Design
- Pipe Sizes
- Controls

Burner Design



Pipe Sizing

Firing Rate Required 5 MM BTU/HR		
	Natural Gas	Producers Gas
Volume of Gas Required (ft ³ /hr)	4,990	27,325
Specific Gravity	0.6	0.8
Line Size (1 psi Δ P)	2.5"	6"

Syngas Combustion Options

- Equipment designed to run on Syngas only
- Dual Fuel Systems
 - Separate burners and valve trains
 - Single burner – two valve trains

Process Implications

- Flame luminosity effects radiant heat transfer
- Flames generated by fuels with high carbon content are more luminous than flames with high hydrogen content
- Syn-Gas luminosity may require de-rating of equipment