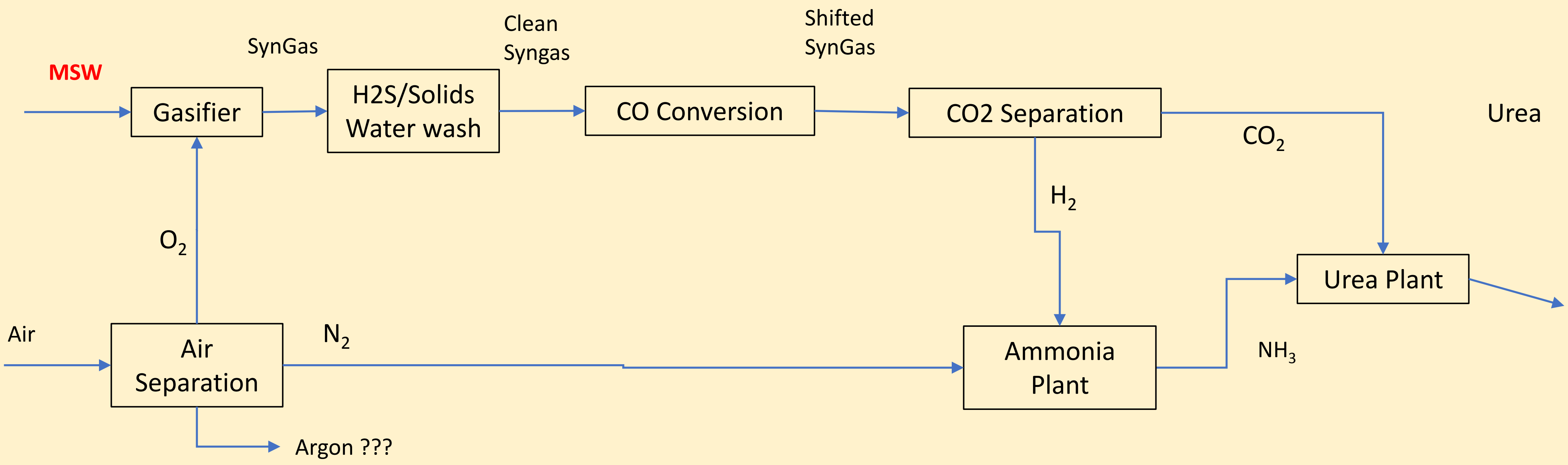
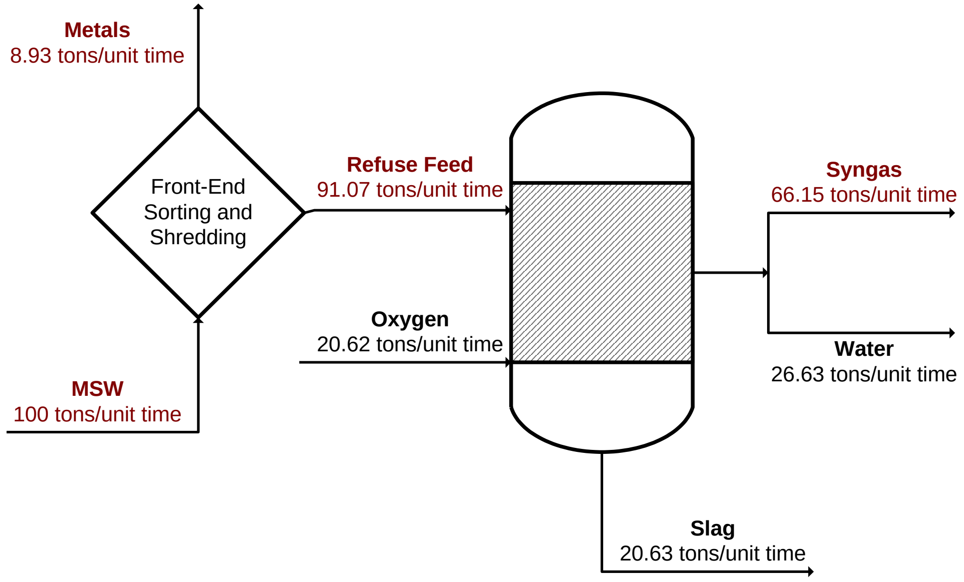
MSW Processing- Gasifier Section

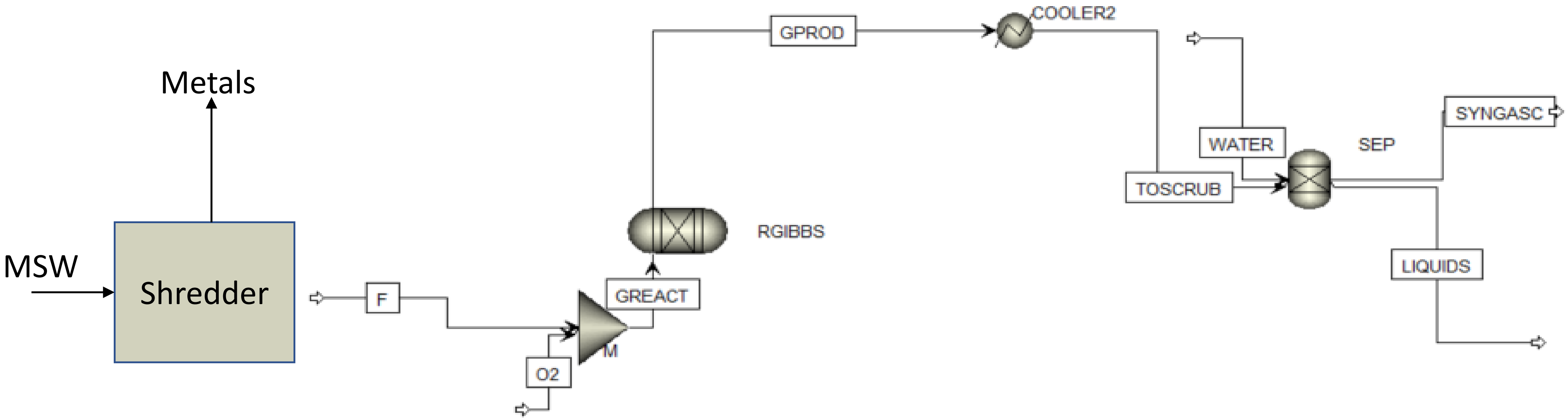
Chosen Flowsheet



MSW Plant

SHREDDER AND GASIFIER

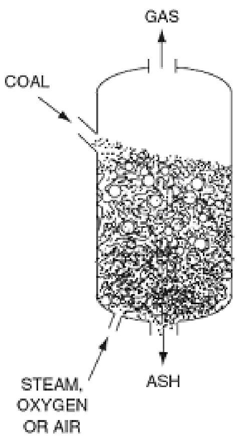


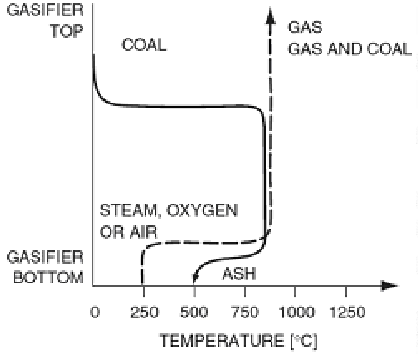


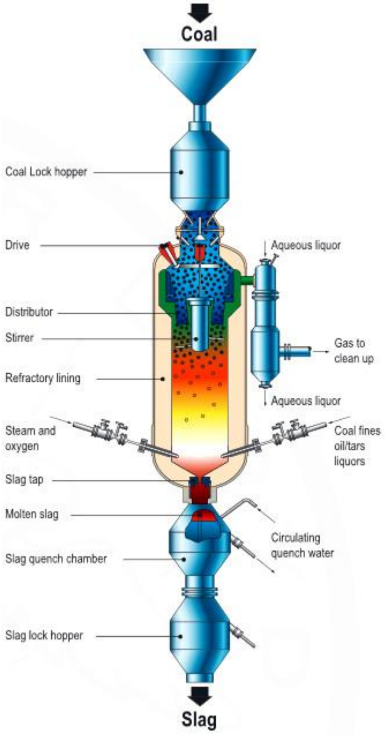
MSW Plant

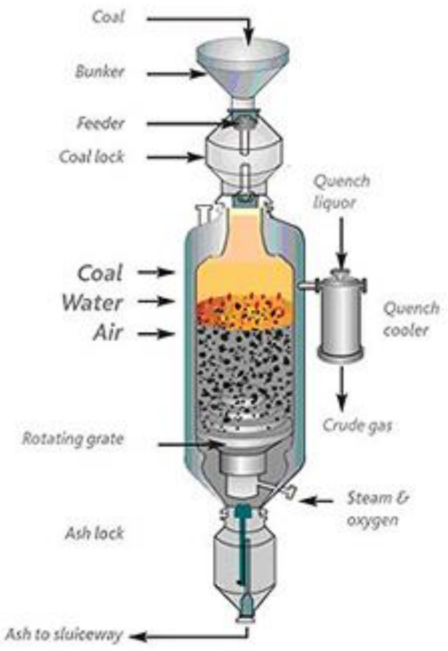
GASIFIER

MOVING BED GASIFIER: Calculate diameter assuming 4 mm diameter pellets with 30% void fraction and 0.5 cm/sec downward velocity of the moving bed.









Reference point for diameter: 720 tpd of coal → 12’ diameter. L/D=3-4

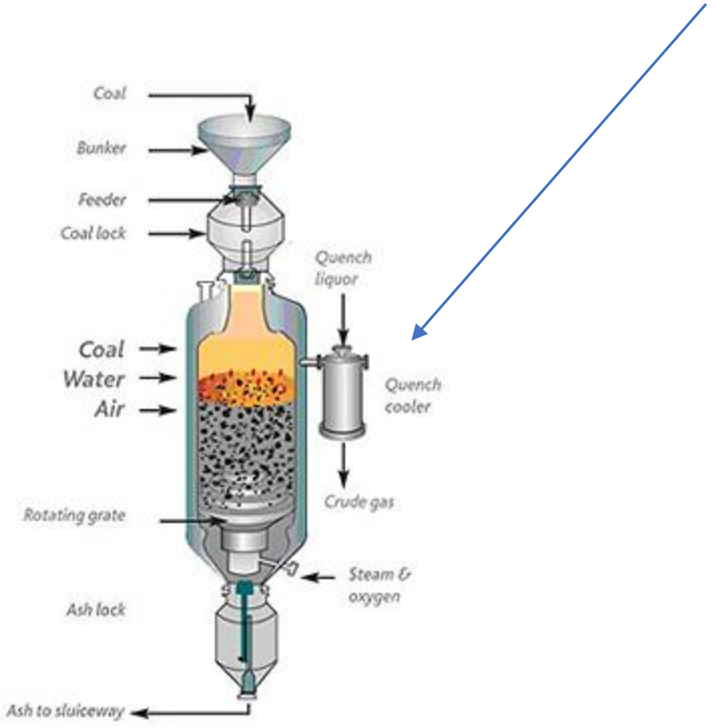
https://www.netl.doe.gov/research/coal/energy-systems/gasification/gasifipedia/fmb

https://www.enggcyclopedia.com/2011/12/gasification-process-types/

https://biomasspower.gov.in/document/download-lef-tside/Biomass%20gasification.pdf

Assumptions:

- Gasifier produces gases in equilibrium
- Pressure is close to atmospheric.
- Temperature can be regulated by small & quick quenching
- Final quenching to room temperature is needed.
  Why? How?
- For simplicity, we will assume 8% ash (metal carbonates) and tar in the form of elemental C



Problems:

- Simulators do not have gasifiers
- Simulators like Aspen do not use non chemical components, like paper, cellulose, plastics, etc.

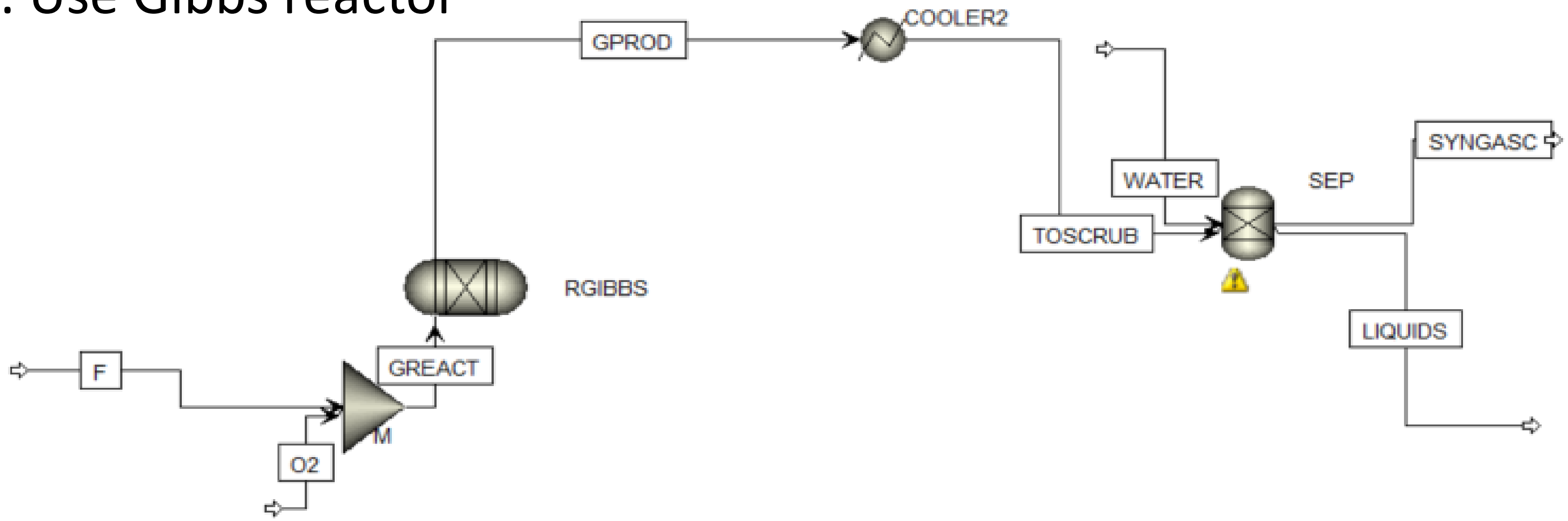
Typical formulas for materials exist:

- Dry Paper: $C_6H_{9.6}O_{4.6}N_{0.036}\ S_{0.01}$
- Mixed Plastics: $C_6H_{8.6}O_{1.7}$
- Mixed organic wastes: $C_6H_{10}O_4$.

- These are examples. Make sure they are correct

How to handle the simulation?

- Just obtain a stoichiometrically sound equilibrium composition. Use Gibbs reactor



What is the feed to the Gibbs reactor:

- An arbitrary mix of gases that mirrors the atom-mol composition of the MSW.
- Example (Ash has been already removed). Original mass (100 Kg)→ 92 Kg left→ Reduced further by metals and glass.

MSW wt% Content	wt%	Atom-Moles
Carbon	56.3	4.688
Hydrogen	3	2.976
Nitrogen	1.2	0.086
Sulphur	3.5	0.109
Oxygen	36	2.249
Total	100	10.107

Moles

Extra O2	Extra H2O
1.5	1

CO
CO2
CH4
H2S
SO2
NO
NO2
H2O
H2
C(Tar)

What is the composition of the mixture of gases that represents the atom-mole amounts?

CO
CO2
CH4
H2S
SO2
NO
NO2
H2O
H2
C(Tar)

What is the composition of the mixture of gases that represents the atom-mole amounts?

MSW wt% Content	wt%	Atom-Moles
Carbon	56.3	4.6878
Hydrogen	3	2.9762
Nitrogen	1.2	0.0857
Sulphur	3.5	0.1091
Oxygen	36	4.6878
Total	100	2.9762

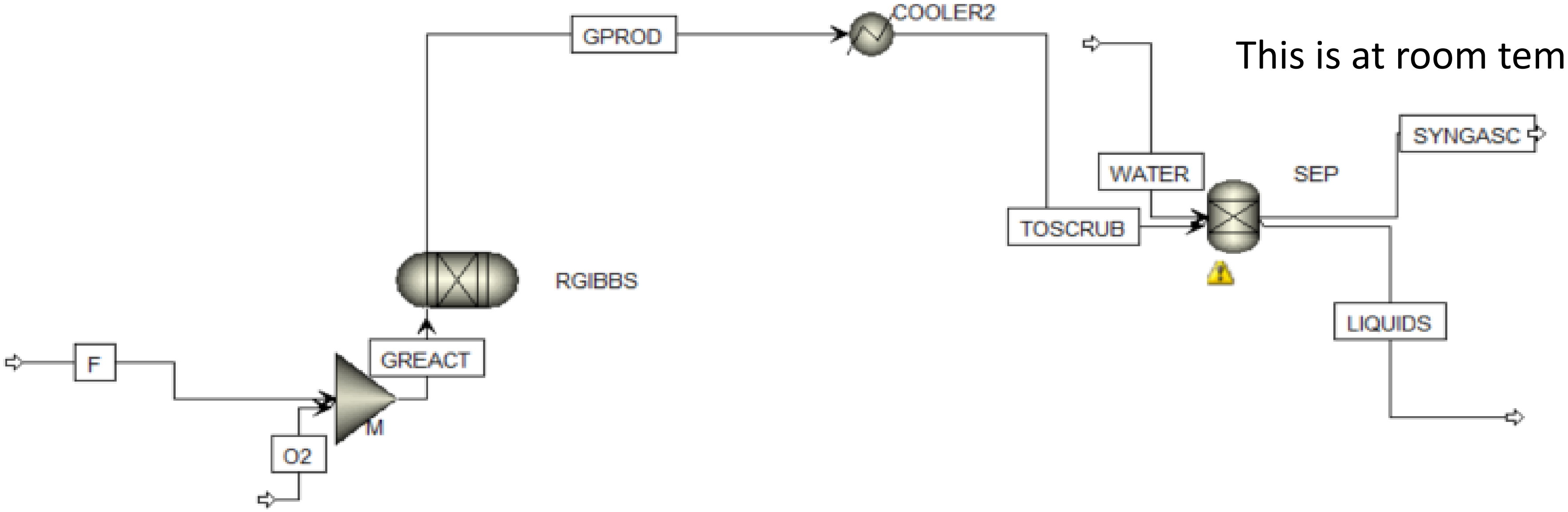
Moles

Extra O2	Extra H2O
1.5	1

CO	4.6876	Calc C balance
CO2	0.0001	chosen
CH4	0.0001	chosen
H2S	0.1090	Calc S balance
SO2	0.0001	chosen
NO	0.0856	Calc N balance
NO2	0.0001	chosen
H2O	1.4749	Calc O balance
H2	0.9040	Calc N balance
C(Tar)	0.0000	chosen

CO=4.6878 moles-Moles of CO_2 and CH_4 chosen.
H_2S= atom moles of sulfur
NO= Atom moles of N – moles of NO_2 chosen
…………….
H_2O needs to take into account

Simulation Results



This is at room temperature, right?

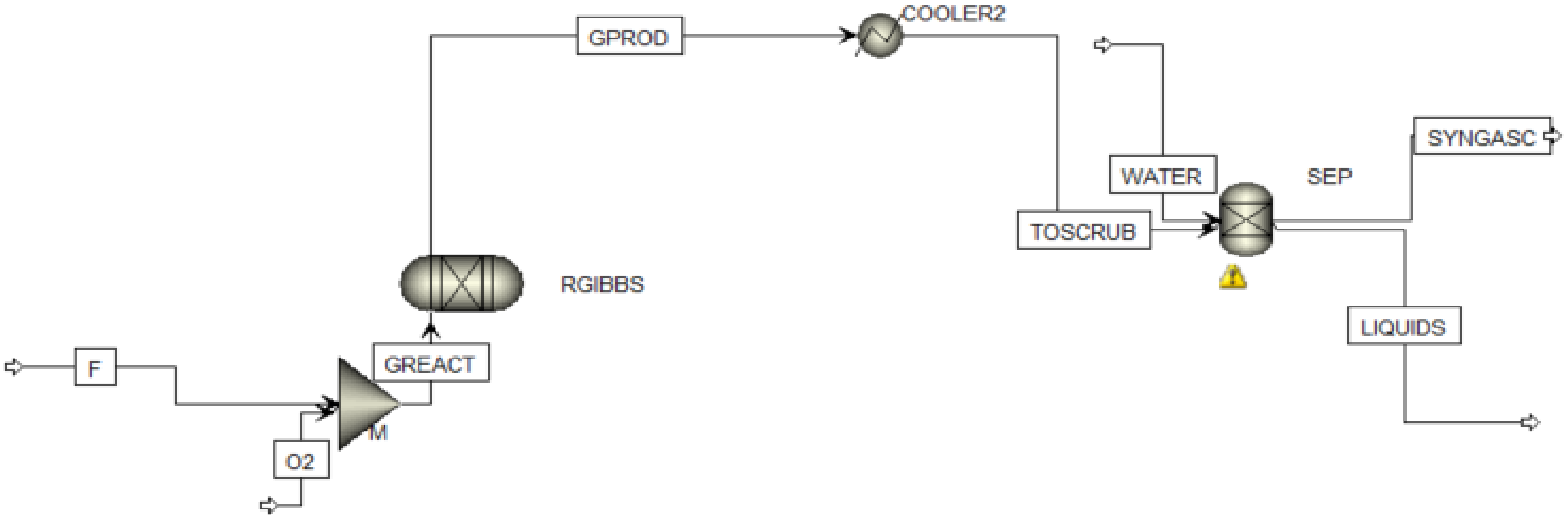
Feed Comp	Moles
CO	4.6876
CO2	0.0001
CH4	0.0001
H2S	0.1090
SO2	0.0001
NO	0.0856
NO2	0.0001
H2O	1.4749
H2	0.9040
C(Tar)	0.0000

	x inlet	T=600 Equilibrium
CO	0.64554	0.144
CO2	0.00001	0.302
CH4	0.00001	0.017
H2S	0.01502	0.016
SO2	0.00001	0
NO	0.01178	0.012
NO2	0.00001	0
H2O	0.20311	0.13
H2	0.12449	0.174
C(Tar)	0.00000	0.205

Now you can vary the amount of Oxygen
And water added.
Also, you can vary the temperature.

Temperature? This part is not part of the project.

This is at room temperature, right?



- From the simulation at a given temperature (600, 700, 800?), one can get the enthalpy of the products.
- The gasifier is adiabatic, so the first law says that $H_{prod}(T)+H_{ash}(T)=H_{MSW}(25)+H_{O2}(25)+H_{H2O}(T=??)$. Looks like the heat of reaction!!!
- If we know $H_{MSW}(25)$, then we can vary the temperature of the Gibbs reactor until you get the equality to hold.
- What is $H_{MSW}(25)$? It is the heat of formation of MSW. Is it available? Maybe.
- If the heat of formation is not available, the heating values (HHV and/or LHV) is available. These are related to the heat of combustion MSW+ $O_2 \rightarrow CO_2+H_2O$+ nitrogen and sulfur compounds +ash. If the heat of combustion is known and the adiabatic flame temperature is known then the $H_{MSW}(25)$ can be obtained.