

OBJECTIVE Design a process that maximizes the economic utility of the C6 F2F's biochar off-gas stream through product evaluation, heat integration, and water recycle.

BACKGROUND

Biochar off-gas is a complex unknown mixture.

Laboratory and literature results yield the following composition breakdowns.

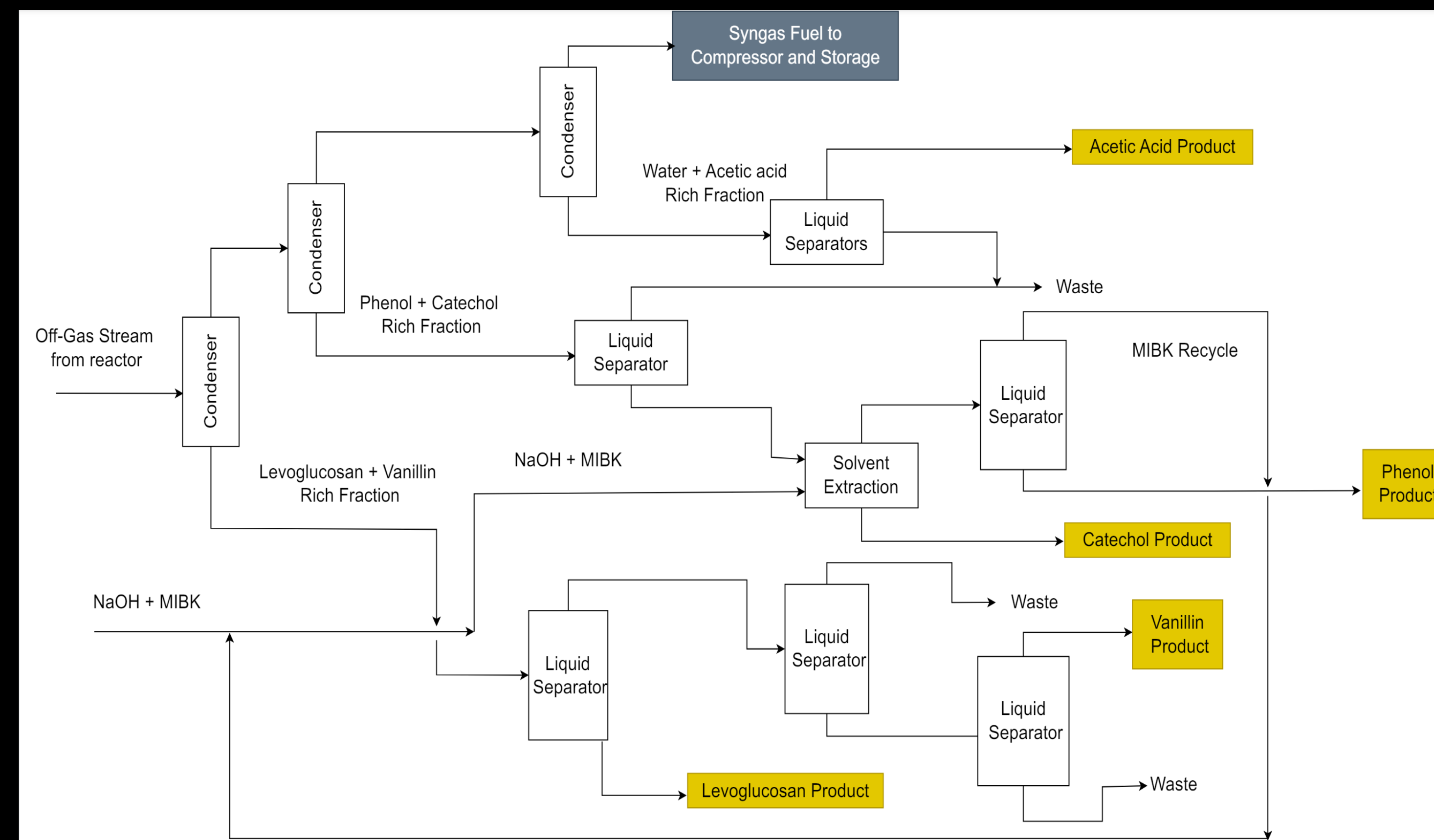
Pine Bio-Oil Components		
Component	Average weight percent (wt%)	
phenols	20.4	
levoglucosan	5.71	
acetic acid	5.69	
hydroxyacetaldehyde	3.43	
1-hydroxy-2-propanone	3.15	
1,2-cyclopentanedione	3.32	
isoeugenols	9.04	
vanillin	2.94	
unknown/other chemicals <2%	46.3	
total	100	

Pyroligneous Acid Components		
Component	Average weight percent (%)	
acetic acid	35.43	
phenols	9.5	
catechol	6.91	
2,6-dimethoxy-phenol	3.5	
propanoic acid	2.81	
4-methyl-1,2-benzenediol	1.60	
isobutyric acid	1.18	
1-hydroxy-2-propanone	1.07	
trace chemicals soluble in water	38	
total	100	

Syngas Components		
Component	Normalized weight percent (%)	
hydrogen H ₂	1.32	
methane CH ₄	9.19	
carbon dioxide CO ₂	38.2	
carbon monoxide CO	45.9	
ethane C ₂ H ₆	1.54	
ethylene C ₂ H ₄	3.88	
total	100	

MULTIPLE PRODUCT PROCESS DESIGN

Block Flow Diagram



ECONOMICS

Multiple Product Streams Design

Process	Total Bare Module Cost (\$)	Product Flow Rate (kg/yr)	Revenue low end estimate (\$/yr)	Payback Period (years)
three stage initial condensing of off-gas	753,700	N/A	N/A	N/A
condense + separate acetic acid	2,600,118	83,409	44,135	58.91
condense + separate phenol	2,839,163	167,179	112,966	25.13
condense + separate catechol	2,255,102	15,160	478,829	4.71
condense + separate vanillin	763,070	18,918	231,029	3.30
condense + separate levoglucosan	286,514	62,685	97,604	2.93

PA/Wood Vinegar Product Design

Process	Product Flow Rate (gal/yr)	Revenue low end estimate (\$/yr)	Total Bare Module Cost (\$)	COMd (\$/year)	Pay back Period (years)
Wood Vinegar	744,079.9	18,932,101.11	2,399,958	2,477,001	2.29

Literature Cited:

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ACKNOWLEDGEMENTS

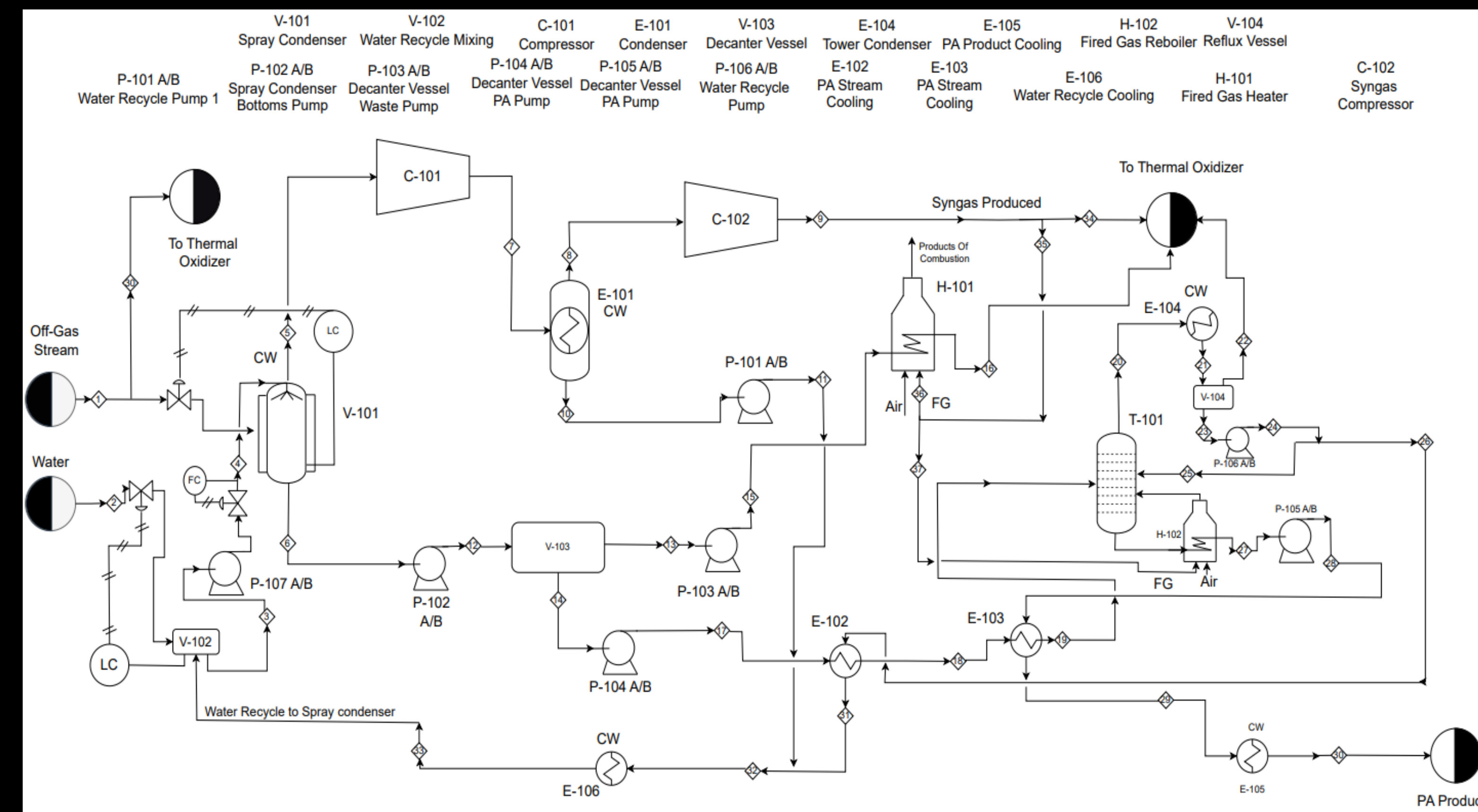
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Special thanks to the faculty of the Department of Chemical and Biological Engineering

PYROLIGNEOUS ACID PRODUCT DESIGN

Process Flow Diagram



CONCLUSIONS

- The syngas in the off-gas stream can be used as fuel for H-101, H-102, and the thermal oxidizer.
- The water removed from the PA stream will be recycled into the spray condenser (V-101).
- The multiple product stream design in pieces or as a whole is profitable, but not feasible until the market for micro-volumes is available locally and/or the reactor process is adjusted to increase the flow rates of each component.
- The best use of this off-gas stream is to produce a PA/Wood Vinegar product to be sold as an organic fertilizer and insecticide.



2024 Capstone Project