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Process Equipment (PFD #): R1							
Section: Pyrolysis							
Item	**Study Node**	**Process Parameters**	**Deviations**	**Possible Causes**	**Possible Consequences**	**Action Required**	**Assigned to:**
1	Gas Outlet	Temperature	None	1. Chamber heat source not working.	*No heat for heat exchanger.	1. Check heat source	Operator
			High	1. Heat source providing too much heat. Exothermic reaction in chamber.	*Heat exchanger hot stream will be too hot, make CO_2 inlet stream too hot.	1. Check heat source	Engineer
			Less	1. Heat source providing too little heat. Endothermic reaction in chamber.	*Heat exchanger hot stream will not be hot enough to heat CO_2 stream.	1. Check heat source	Engineer
		Pressure	High	1. CO_2 flow rate too high. Gas reaction runway, too much gas production. Outlet blocked or hindered.	*Different Syngas product ratios	1. Decrease CO_2 flow rate.	Engineer
		Flow	None	1. CO_2 not flowing, outlet blocked.	*Chamber may rupture, no syngas production, no heat source for heat exchanger.	1. Check outlet and CO_2 flow rate	Engineer
			High	1. CO_2 flow rate too high.	*Too much heat for heat exchanger. CO_2 inlet too hot.	1. Decrease CO_2 flow rate	Operator
			Low	1. Low CO_2 flow rate.	*Not enough heat for heat exchanger. CO_2 inlet not hot enough.	1. Increase CO_2 flow rate	Operator
	Char Outlet	Temperature	None	1. No heat in chamber.	*No char for activated carbon	1. Check chamber heat source	Operator
			High	1.Chamber too hot	*Burnt char, affect quality of bio-oil	1. Check chamber heat source	Operator
			Low	1. Chamber not hot enough	*Poor char quality for bio-oil	1. Check chamber heat source	Operator

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2	Feed Stream (inlet)	Flow of N_2	No	1. Closed outlet valve on FBR 2. No reaction/material in FBR 3. Vapor steam condensing in previous heat exchanger.	* No water condensed or recycled,steam shortage in subsequent reactions. * Excess heat retained in, equipment damage.	1. Consider a valve that fails open 2. Install alarm/sensor	Engineer Engineer
			Less	1.Valve on FBR partly closed 2. Some vapor condensing in previous heat exchanger.	* Not enough water recycled; steam shortage. * Previous HX damaged by condensation.	1. Consider a valve that fails open. 2. Install a flow meter	Engineer Engineer
			More	1. More raw material in FBR than expected; more gases evolved as byproducts. 2. Higher temperatures lead to volume expansion of gases.	* More water condensed and recycled than needed; extra energy must be supplied. * Condenser experiences a higher pressure.	1. Install a flow regulator and flow splitter. 2. Design condenser using stronger materials.	Engineer Engineer
		Temperature	High	1. Not enough cooling water for previous heat exchanger. 2. Gas products leaving FBR hotter than expected.	* Less water will be condensed, causing a steam shortage. * More water vapor entrained in CO2 stream leaving condenser, which can affect the yield of the pyrolyzer.	1. Consider valves that fail open and more powerful pumps. 2. Install flow meter. 3. Install O_2 flowmeter and regulate T, P.	Engineer Engineer Engineer
			Low	1. Too much cooling water in previous heat exchanger. 2. High heat loss rates in piping between HX and condenser.	* More water condensed and recycled than needed; extra steam results in higher pressures in pipes. * Condensed water leaves condenser at lower temperatures than expected; need more energy to revaporize water to form steam.	1. Insulate pipe between previous heat exchanger and condenser. 2. Install flow regulator. 3. Design larger steam pipes	Engineer Engineer Engineer

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3	Reactor Vessel	Flow of effluent and fluidizing medium	None	1. Valve on FBR inlet closed. 2. Tripped circuit breaker.	* Loss of function for most major equipment. *Loss of control and automation	1. Install GFCI outlets 2. Install automated valve for vessel	Electrician Engineer
			Low	1. Valve on FBR partly closed. 2. Clog in reactor valve from activated carbon pieces.	* Unsuccessful batch run, needs to be restarted	1. Install mesh screens to cover vessel inlet and outlet	Contractor
			High	1. Surge of Steam	* Explosion	1. Outfit reactor vessel to withstand high pressures and install emergency relief valve.	Contractor
		Temperature Pressure	Low or High	1. The heater and pressure controller malfunctioned.	*Pressure and Temperature too high will cause explosion. *Temperature and Pressure deviating from operational conditions results in different percentage of products obtained (Hence it will affect the amount of Bio-Oil obtained in our case).	1.Check the pressure and temperature regularly.	Engineer

References

Hung, J. J. (2012, May). *The Production of Activated Carbon from Coconut Shells Using Pyrolysis and Fluidized Bed Reactors*. Retrieved August 1, 2015, from http://arizona.openrepository.com/arizona/bitstream/10150/243968/1/azu_etd_mr_2012_0079_sip1_m.pdf