Continuous Pyrolysis System

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***Abstract*—This system defines how to extract furnace oil from Waste tires / Plastic in the continuous method. This system will help to reduce the waste tire and plastic into useful energy with no effluent and harm to the environment.**

CONTINOUS PYROLYSIS PLANT

1. INTRODUCTION

Pyrolysis-Oil production by continuous pyrolysis is an option for biomass pre-treatment prior to its final energetic utilization in other processes such as combustion, gasification etc. Solid biomass is converted by rapid heating in an oxygen free environment into a hot gaseous mixture of recoverable condensable in vapor and aerosol form, permanent gases, while a small fraction remains as a solid residue (char). Subsequent quenching, cooling and condensing processes allow the recovery of the liquid product known as Pyrolysis-Oil. Main product for this Production is either Grated rubber (mostly from waste tyres, waste rubber industries) or Grated Plastic.

2. DESCRIPTION OF THE TEST PLANT

1000kg/hr Continuous pyrolysis process plant is designed to produce continuous pyrolysis-oil. Depending on the Raw material grades the production of the pyrolysis-oil is around 50% to 70% of the production.

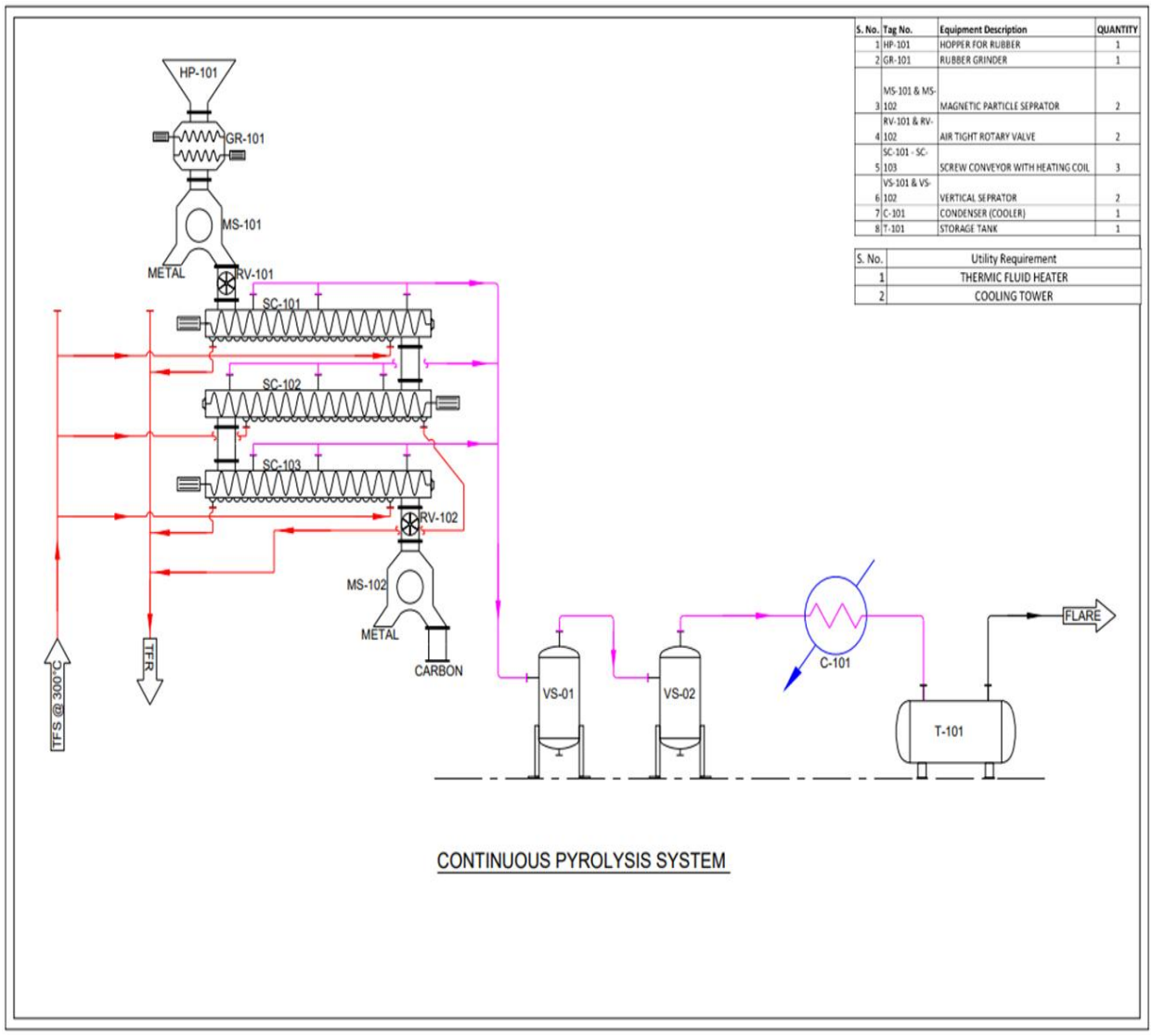
The process contains following of the equipment:

- Hopper for Holding Waste Tyres or Waste rubber of big size – HP-101
- Rubber Grinder to produce small pieces of 2mm to 5mm in size – GR-101
- Magnetic particle Separators to separate metal from the Rubber and from the Carbon – MS-101 & MS-102
- Airtight Rotary Valve, to avoid oxygen intake into the process for proper Pyrolysis process – RV-101 & RV-102
- Screw Conveyor with Heating coils from continuous pyrolysis process – SC-101 to SC-103 (Quantity may vary depending upon the gear box speed and length of the screw conveyor)
- Vertical Separators to remove heavy oil and wax from the process – VS-101 & VS-102
- Condenser to condense Pyrolysis-Oil from the process – C-101
- Pyrolysis-oil storage tank – T-101

Required Utilities for the Process are as follows:

- Thermic Fluid Heater with oil Temperature of 300ºC
- Cooling Tower

3. PROCESS FLOW DIAGRAM:



S. No.	Tag No.	Equipment Description	QUANTITY
1	HP-101	HOPPER FOR RUBBER	1
2	GR-101	RUBBER GRINDER	1
3	MS-101 & MS-102	MAGNETIC PARTICLE SEPRATOR	2
4	RV-101 & RV-102	AIR TIGHT ROTARY VALVE	2
5	SC-101 - SC-103	SCREW CONVEYOR WITH HEATING COIL	3
6	VS-101 & VS-102	VERTICAL SEPRATOR	2
7	C-101	CONDENSER (COOLER)	1
8	T-101	STORAGE TANK	1

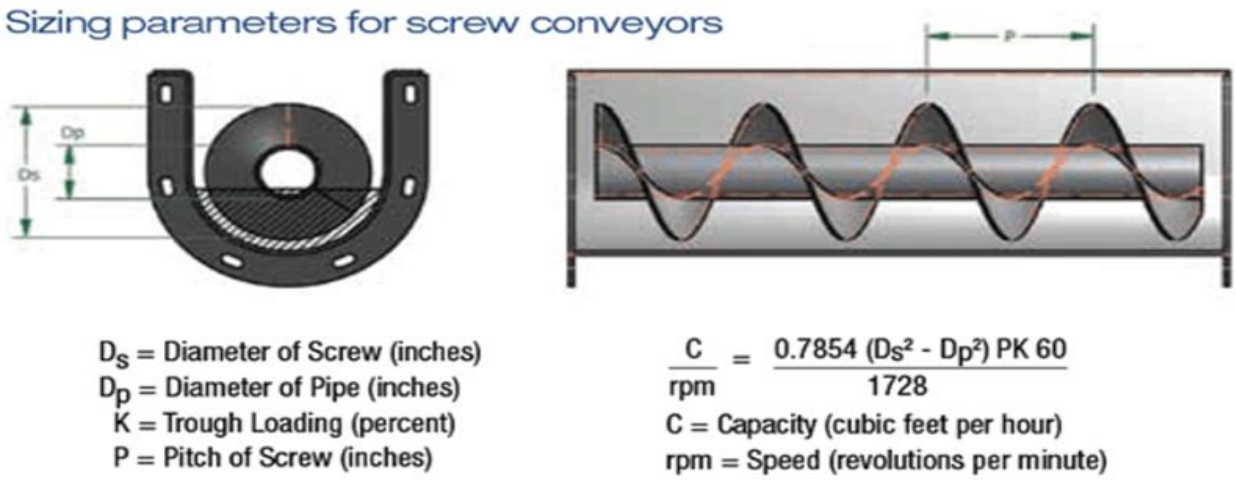
S. No.	Utility Requirement
1	THERMIC FLUID HEATER
2	COOLING TOWER

4. OPERATION METHODOLOGY

- Steel wires from the Waste Tires are removed before it is processed for Pyrolysis.
- Waste tyres are then passed through Grinder where it is cut into pieces of 2mm to 4mm for further action.
- Magnetic particle separator removes any metal contains from the grinded rubber and through airtight rotary valve it is send to the Screw conveyor.
- Screw conveyors have provision of heating and temperature inside the screw conveyor is set at 300ºC.
- Allocated time of travel for Rubber inside the Heated Screw conveyor is around 4hours to extract complete Pyrolysis oil. (This is an experimental value, and this time may increase based on the actual experiment)
- Through all the Screw conveyor pyrolysis oil vapour generated is passed through Vertical Separator where heavy oil or wax is collected.
- Further vapour is cooled in Condenser and liquid Pyrolysis oil is stored in the storage tank.

- There is also Gas generated in the process and the Gas can be utilized again in the Thermic fluid heater to generate energy thereby reducing the fuel consumption in the Thermic fluid heater or it can be sent to atmosphere via flare stack.
- Processed rubber is converted into Carbon, and it is passed to Magnetic particle separator through air tight rotary valve where the carbon is collected from the metal present inside.

5. SCREW CONVEYOR SIZING



Diameter of Screw	Ds:	12	inch
Diameter of Pipe (Center Shaft)	Dp:	4	inch
Trough Loading	K:	0.3	30% considered
Pitch of Screw	P:	12	inch
Capacity of Screw conveyor	C1:	12.57	Cubic. ft/hr.rpm
Required Capacity of Conveyor	C	0.50	tons/hr
Required Capacity of Conveyor	C:	1100.00	lb/hr
Bulk density of the fuel	W:	500	kg/cub.mtr
Bulk density of the fuel	W:	31.21	lb/cubic.ft
Required Capacity of Conveyor	C:	35.24	cubic.ft/hr
Design Factor	CF0:	115%	
Nominal Capacity	C:	40.527	cubic.ft/hr
Conveyor Pitch factor	CF1	1	
Type of flight factor	CF2	1.37	
Required Speed of Conveyor	N:	4.42	rpm
Equivalent length	L	6	mtr
	L:	19.69	ft
Screw Diameter factor	Fd:	18	
Hanger Bearing factor	Fb:	4.4	Max. taken
Flight factor	Ff:	1	
Material factor	Fm:	2.5	
Paddle factor	Fp:	1	
	HPf:	0.00	HP
	HPm:	0.06	
Motor power rating:	HP	0.08	HP
Motor power rating:		0.06	KW

6. HEAT DUTY CALCULATION

Specific heat of Rubber:	Cp:	2.01	KJ/kgK
Inlet Temperature:	T1	30	ºC
Outlet Temperature:	T2	285	ºC
Mass of Rubber:	m	1000	kg/hr
Heat	Q	512550	kJ/hr
	Q	122502.53	kcal/hr

(This is just the rough value of Thermic fluid heater plant.)

Liquid Detail	Details	Value	Units
Pyrolysis Oil	Cp	2.48	KJ/KgK
Pyrolysis Oil	Latent Heat (ᴨ)	500	KJ/Kg
Pyrolysis Oil	Flow rate	0.58	m3/hr
Pyrolysis Oil	Density	1206	kg/m3
Pyrolysis Oil	Mass flow rate (m_c)	700	kg/hr
Pyrolysis Oil	Inlet Temperature	275	ºC
Pyrolysis Oil	Outlet Temperature	40	ºC
	Heat required to condensate Vapour	350000	KJ/hr
	Heat required to cool Pyrolysis Oil	407960	KJ/hr
	Total Heat to cool down	757960	KJ/hr
COOLING WATER CALCULATION			
Water	Total Heat to be transferred	757960	KJ/hr
Water	Specific Heat, Cp	4.187	KJ/KgK
Water	Inlet Temperature	34	ºC
Water	Outlet Temperature	40	ºC
Water	Flow rate required	30171.165	Kg/hr
	Required Cooling tower size	59.87	TR

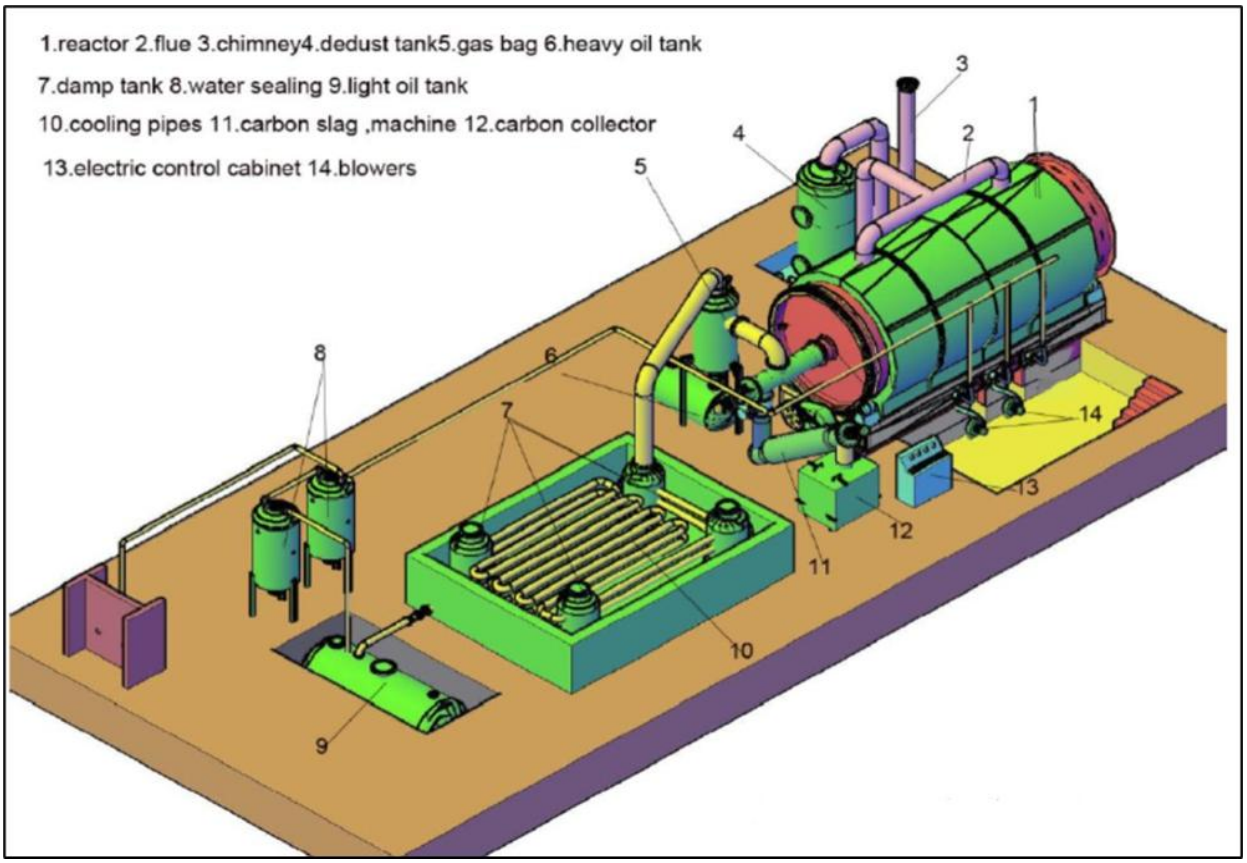
7. BATCH TYPE OR OLD METHOD

In Batch type pyrolysis reaction is a non-continuous process where reactor is filled with Raw material manually and Furnace oil is extracted, once the extraction is done then Carbon is taken out manually but to take carbon manually, rector needs to cool down which consumes lots of time.

8. PROBLEMS IN BATCH TYPE PYROLYSIS

In the old method Reactor is directly prone to heating in atmosphere which has impact on the reactor life and prone to leakage which has cause many safety incidents. Most of the states in India has banned this process due to safety and environmental norms.

Batch type operation are 8hours production and 8hours for loading and unloading the Raw material and Carbon from the reactor. Another 4 to 6 hours of cooling of reactor.



In Batch type pyrolysis loading and unloading of the Raw material and Carbon is a challenge which needs manual intervention of the Person. There are also health hazards during unloading of the Carbon.

9. BENEFITS OF CONTINUOUS PYROLYSIS:

In continuous pyrolysis process production is not hindered and product is collected 24hours continuously. Compare to 5tons Batch plant output in per day basis is 3 times less compare to 1tons continuous process.

No effluent like ash because no direct heating is involved. No environmental hazard.

No health hazard to the workers as carbon can directly packed with minimum person intervention.

10. OUTPUT FROM THE CONTINUOUS PYROLYSIS PLANT (1TONS/HOUR)

Considering continuous operation of 20hours per day:

S No.	Item Description	Production Quantity	Selling Price Unit Rate (Approx).	Daily Earnings (INR)
1.	Pyrolysis Oil	10 Tons/Day	40,000 Rs. /Tons	Rs. 4,00,000
2.	Carbon	6 Tons/Day	500 Rs. /Tons	Rs. 3,000
3.	Steel Wire from Tire	3.2 Tons/Day	13,000 Rs. /Tons	Rs. 41,600
4.	Heavy Oil, Wax, etc.	0.8 Tons/Day	1,000 Rs. /Tons	Rs. 800
Total Daily Earnings				Rs. 4,45,400
Amount in words: Four Lakhs Forty-Five Thousand and Four Hundred only.				

11. COMPARISON OF CONTINUOUS AND BATCH TYPE PYROLYSIS

Comparison between 1tons/hour Continuous and 5 tons Batch Pyrolysis plant:

	1Tons/hour Continuous Plant	5Tons/Day Batch Plant
Raw Material Processing per Day	20 Tons (Assuming 20hours operation)	5Tons
Pyrolysis Oil production (Considering 50% output)	10 Tons/Day	2.5 tons/Day
Environmental	No Effluent or Ash collection and Gas generated can be used back in Thermic fluid heater	Ash is generated due to direct heating of the reactor
Safety	Screw conveyor is not directly prone to heating. Proper material and design will have long life	The reactor is directly prone to heating which can cause damage to the reactor and can also cause safety incidents.
Manpower	50% to 70% less manpower compared to Batch Type reactor	5 to 10 persons per shift
Revenue Generation	3 times more Revenue compared to Batch type of 5Tons pyrolysis.	1/3rd Revenue compared to Continuous plant.

If Furnace oil is further processed, Bio-Diesel can be generated by Distillation.