Economic and Environmental Benefits Adoption of pyrolysis process of Scrap Tires in Palestine

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Pyrolysis

- What is pyrolysis ?

Pyrolysis process is the thermal decomposition of materials at elevated temperatures in an inert atmosphere

- What are waste tire pyrolysis products ?

Figure 1. Tire pyrolysis products

- Where was the study taken ?

The study was done in West bank – Palestine

- What was the aim of the study ?

To study the potential of tire pyrolysis oil in Palestine economically and environmentally

- Where was the data collected from ?

➢ Studies done in different countries published on google scholar and science direct

➢ Palestinian Central Bureau of Statistics

Tire pyrolysis products

1. Finding the total weight of tires
   - Palestinian Central Bureau of Statistics
   - Average weight of tires

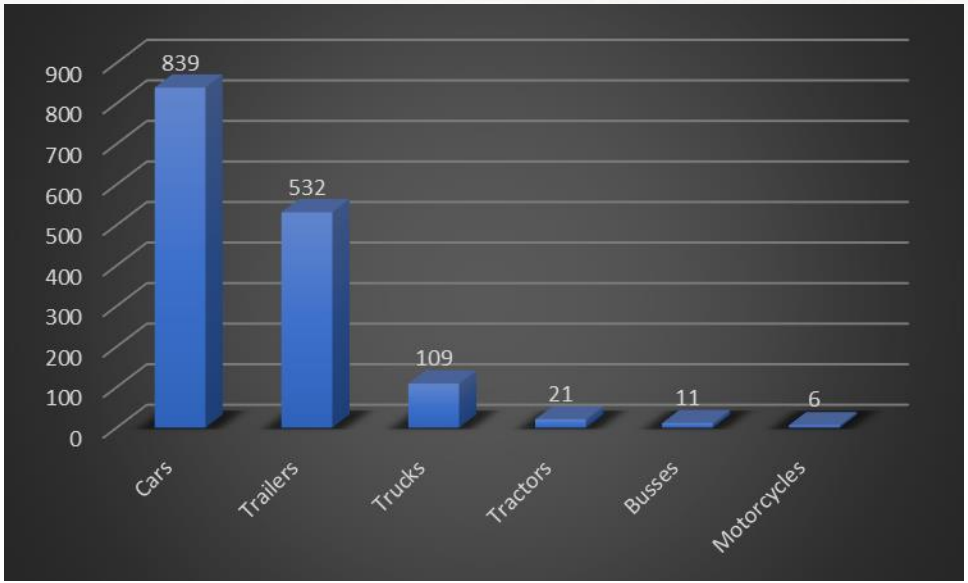


Figure 2. Total weight of tires from each type of vehicle

Tire pyrolysis products

2. Finding the yield percentages
   - Categorize tires by size

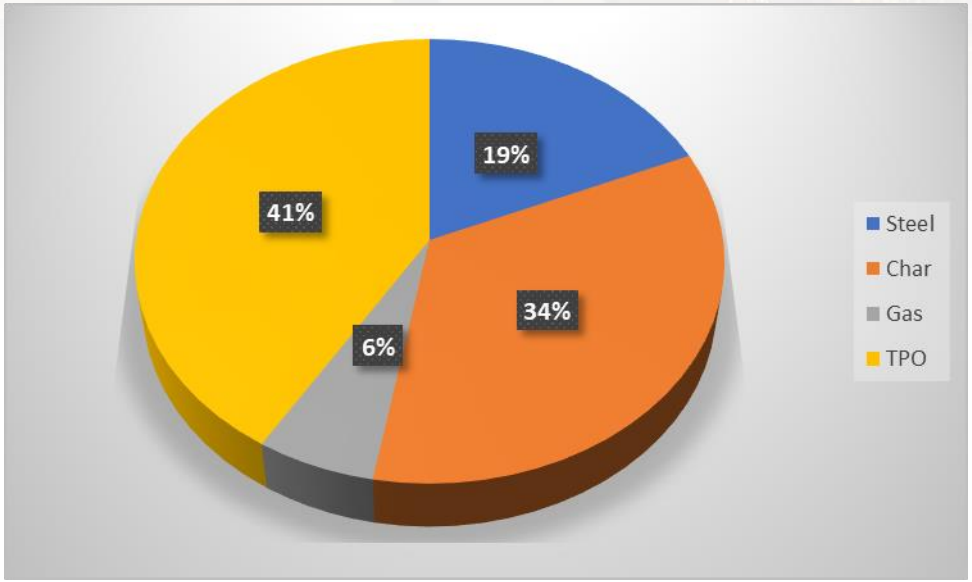


Figure 3. Tire pyrolysis products yield percentages

Tire pyrolysis products

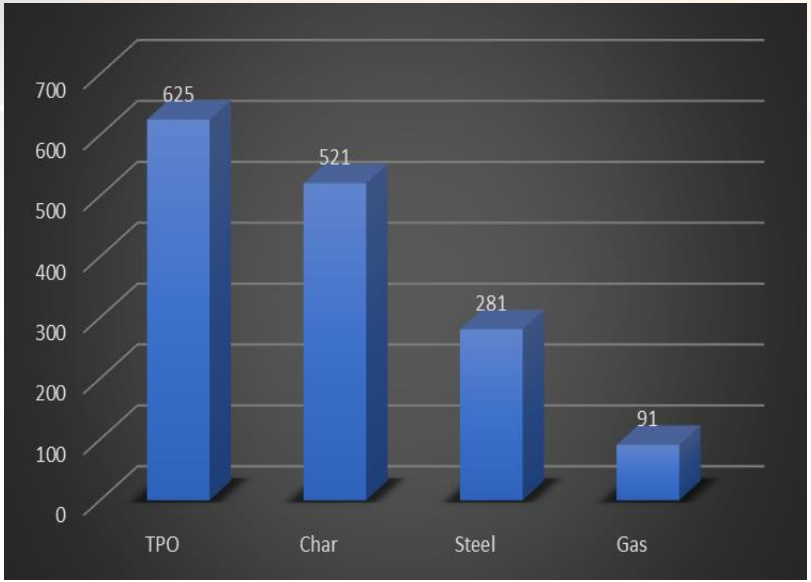


Figure 4. Tire pyrolysis final products

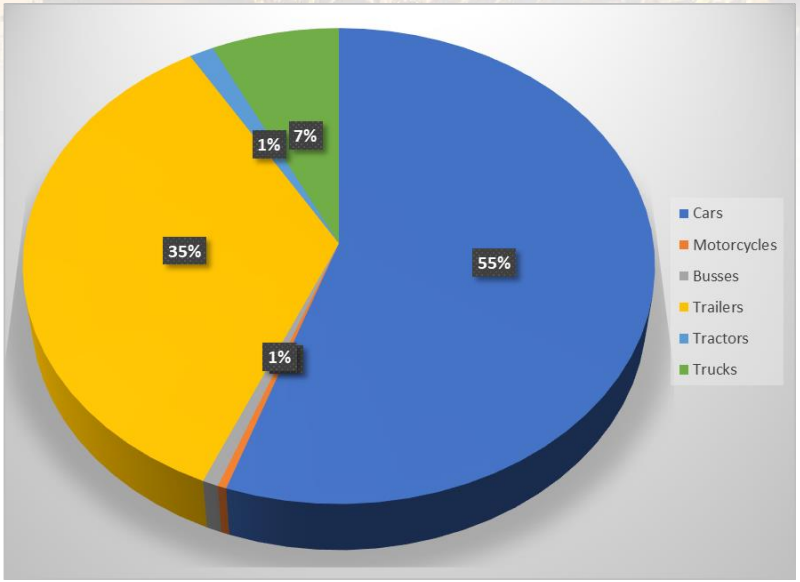


Figure 5. TPO percentages based on the type of vehicle

Tire pyrolysis products

3. Fractional distillation
    - Determining the maximum distillation yield

Table 1. distillation percentages from different researxhes

Year	Temperature of pyrolysis	Total %
2017	450° C	68.15%
2017	450° C	71.25 %

- Average yield % is 69.7%
- Distilled TPO is 435 tons

Emissions Analysis:

- Emissions produced by burning fossil fuels such as; NOx, Sox, CO are among the most important motives for looking for new alternatives.

- According to EPA, NOx and Sox content should be less than **740** (mg/m^3) and **1%** (w/w) respectively to keep AQI within the acceptable ranges .

- Distilled TPO (DTPO) blends can reduces HC, NOx and CO emissions .

Crude TPO:

- Crude TPO has higher Sulphur content compared with ordinary DF. So, more emissions produced as shown in **figure. 6**

- **Figure. 6** shows comparison between crude **TPO** (10%, 30%, and 50%) blends and **DF** for a single cylinder direct injection diesel engine at 1500 rpm

Figure. 6 :

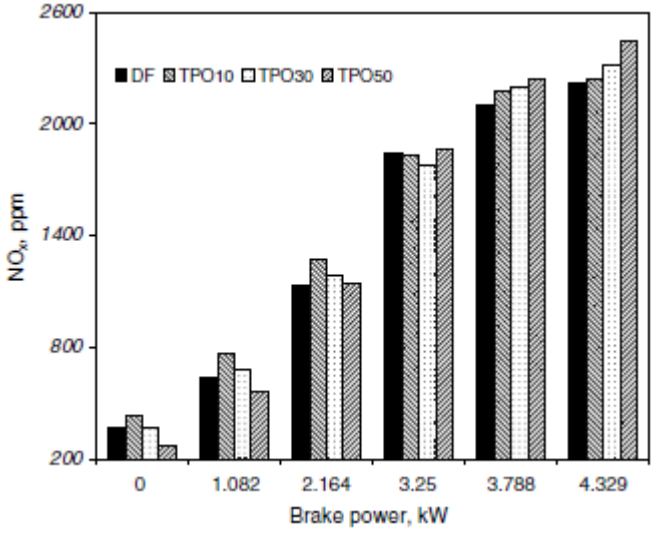


Figure 6.1 Variation of NOx with brake power .

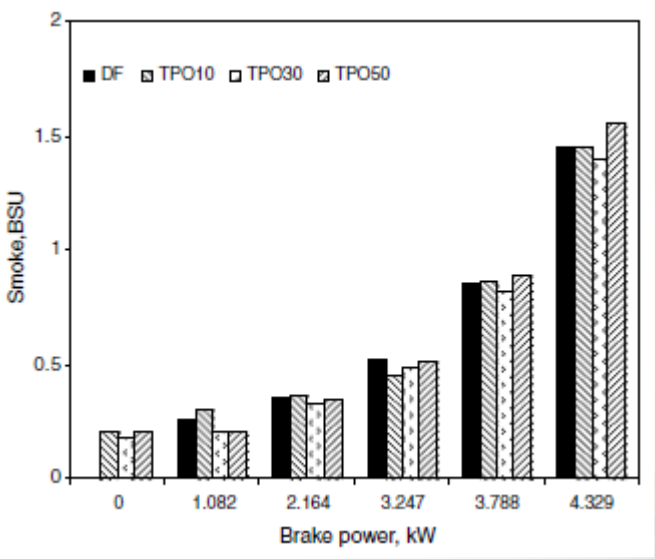


Figure 6.2 Variation of smoke with brake power .

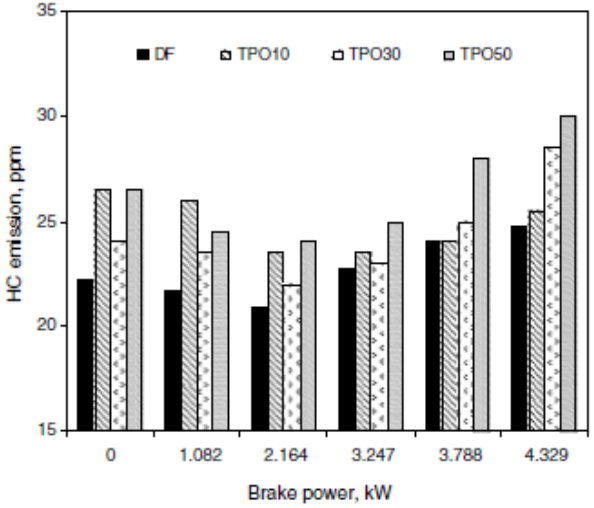


Figure 6.3 Variation of HC with brake power .

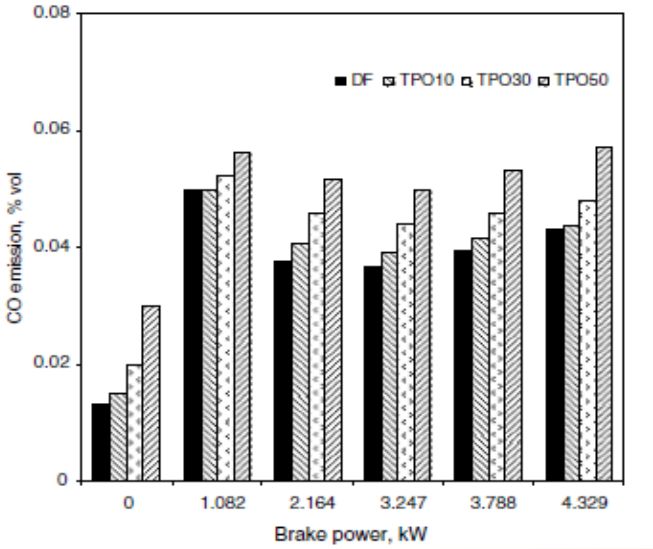


Figure 6.4 Variation of CO with brake power .

Distillation and Mitigation :

- Experimental researchers found that crude TPO contain about (1.4 - 0.95)% Sulphur which is relatively high according to EPA.
- To use this TPO safely, Distillation is required.

Distillation Analysis:

The modification of the crude TPO involves three stages:

I. Removal of moisture.
II. Desulphurization (FGD).
III. Vacuum distillation.

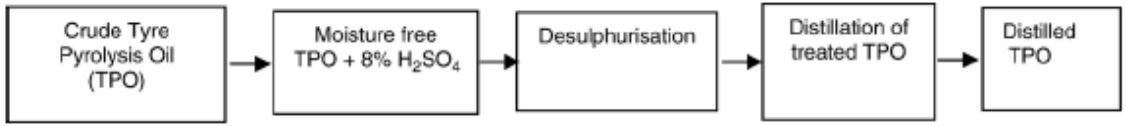


Figure 7 : Distillation of Tire pyrolysis oil process.

DTPO Emissions Analysis:

- **DTPO** has strong citrusy smell, that's due to the sulfur content, which is always higher than ordinary **DF** as shown in **Table. 2**.

Table 2: Comparison between crude TPO, DTPO and its blends with Diesel

Property		Diesel	Crude TPO	DTPO	DTPO80	DTPO90
Density @ 15 °C kg/m^3		830	935	871	860	865
Kinematic Viscosity, cst @ 40 °C		2	3.2	1.7	1.76	1.73
Gross Calorific Value MJ/kg		46.5	42.83	45.78	45.9	45.8
Flash Point, °C		50	43	36	39	37
Fire Point, °C		56	50	48	49	48
Sulphur Content, %		0.045	0.95	0.26	0.21	0.23
Ash Content, %		0.01	0.31	—	—	—
Carbon Residue, %		0.35	2.14	0.02	—	—
Aromatic content, %		26	64	—	—	—
Distillation temperature,°C	Boiling Point	198.5	70			
	10%	240.5	114.5			
	50%	278.5	296.1	—	—	—
	90%	330.5	386.4	—	—	—
	EP	344	388.7	—	—	—

DTPO Emissions Analysis:

- **Figure. 8** shows comparison between DTPO (80%, and 90%) blends and ordinary (DF), using NOx, CO, HC emissions and smoke for a single cylinder direct injection diesel engine at 1500 rpm.

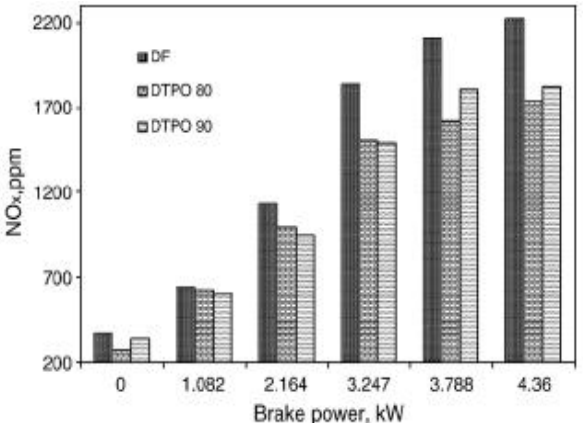


Figure 8.1 Variation of NOx with brake power .

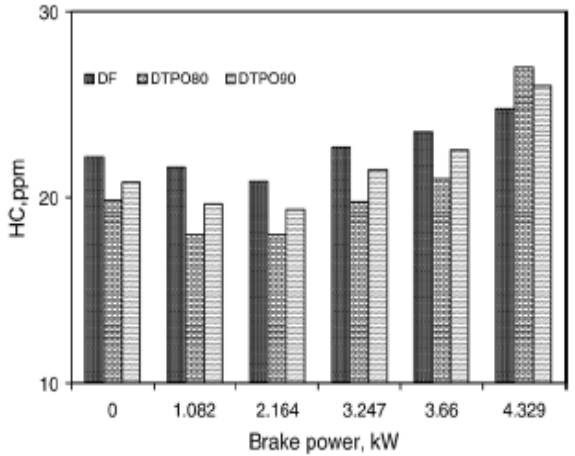


Figure 8.2 Variation of HC with brake power .

DTPO Emissions Analysis:

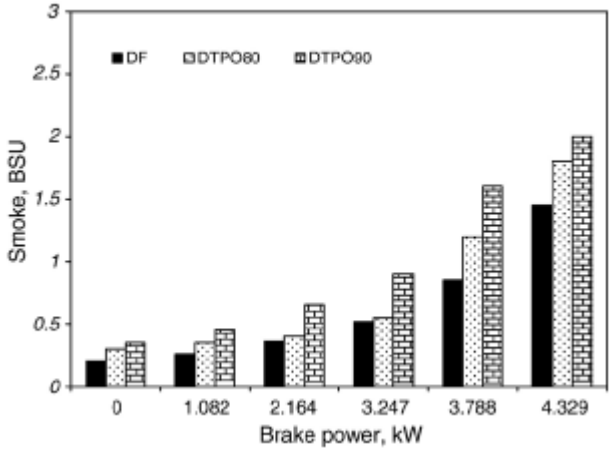


Figure 8.3. Variation of smoke with brake power.

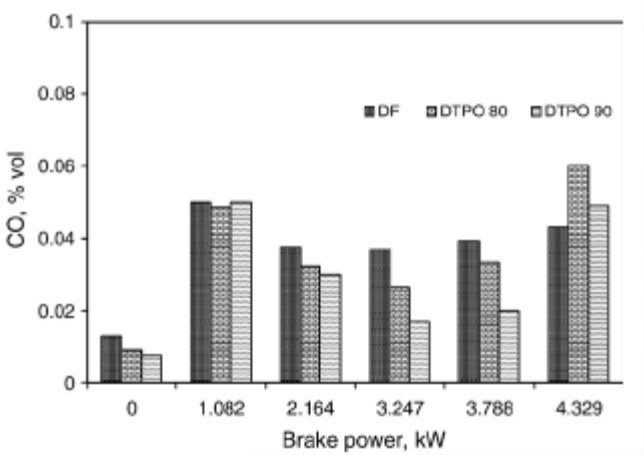


Figure 8.4. Variation of smoke with brake power.

Results

- Effect of increasing DTPO in fuel mixture on performance, emission and combustion on DI diesel engine

Performance	BSFC increased BTE decreased
Emission	**NOx** decreased **HC** decreased **CO** decreased **Sox** increased **H** and **C** relatively the same
Combustion	Longer ignition delay
Noise and vibrations	Increased

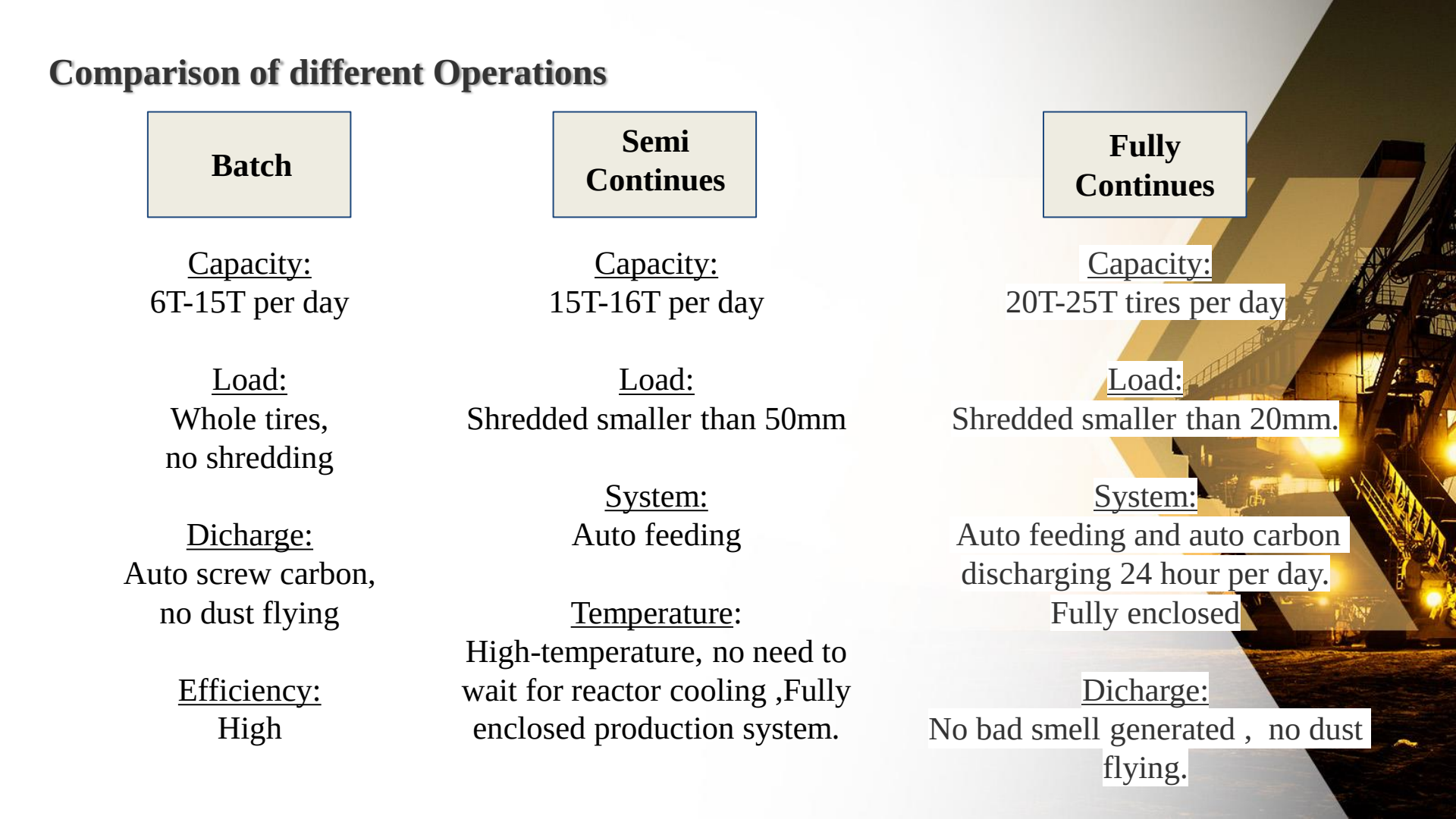
TIRE PYROLYSIS REVENUE ANALYTICS

Table 3. Technical parameters

Model	Capacity	Reactor Size	Operation
MJ-6	6T/D	2200*6000mm	Batch Type
Mj-10	10T/D	2600*6600mm	Batch Type
MJ-12	12T/D	2800*7100mm	Batch Type
MJ-15	15T/D	2800*8000mm	Batch Type
MJL-15	15T-16T/D	2800*7100mm	Semi-continuous Type
MLL-20	20T-25T/D	12500*2200*2500mm	Fully Continuous Type

Comparison of different Operations

Batch	Semi Continues	Fully Continues
Capacity: 6T-15T per day	Capacity: 15T-16T per day	Capacity: 20T-25T tires per day
Load: Whole tires, no shredding	Load: Shredded smaller than 50mm	Load: Shredded smaller than 20mm.
Dicharge: Auto screw carbon, no dust flying	System: Auto feeding	System: Auto feeding and auto carbon discharging 24 hour per day. Fully enclosed
Efficiency: High	Temperature: High-temperature, no need to wait for reactor cooling ,Fully enclosed production system.	Dicharge: No bad smell generated , no dust flying.



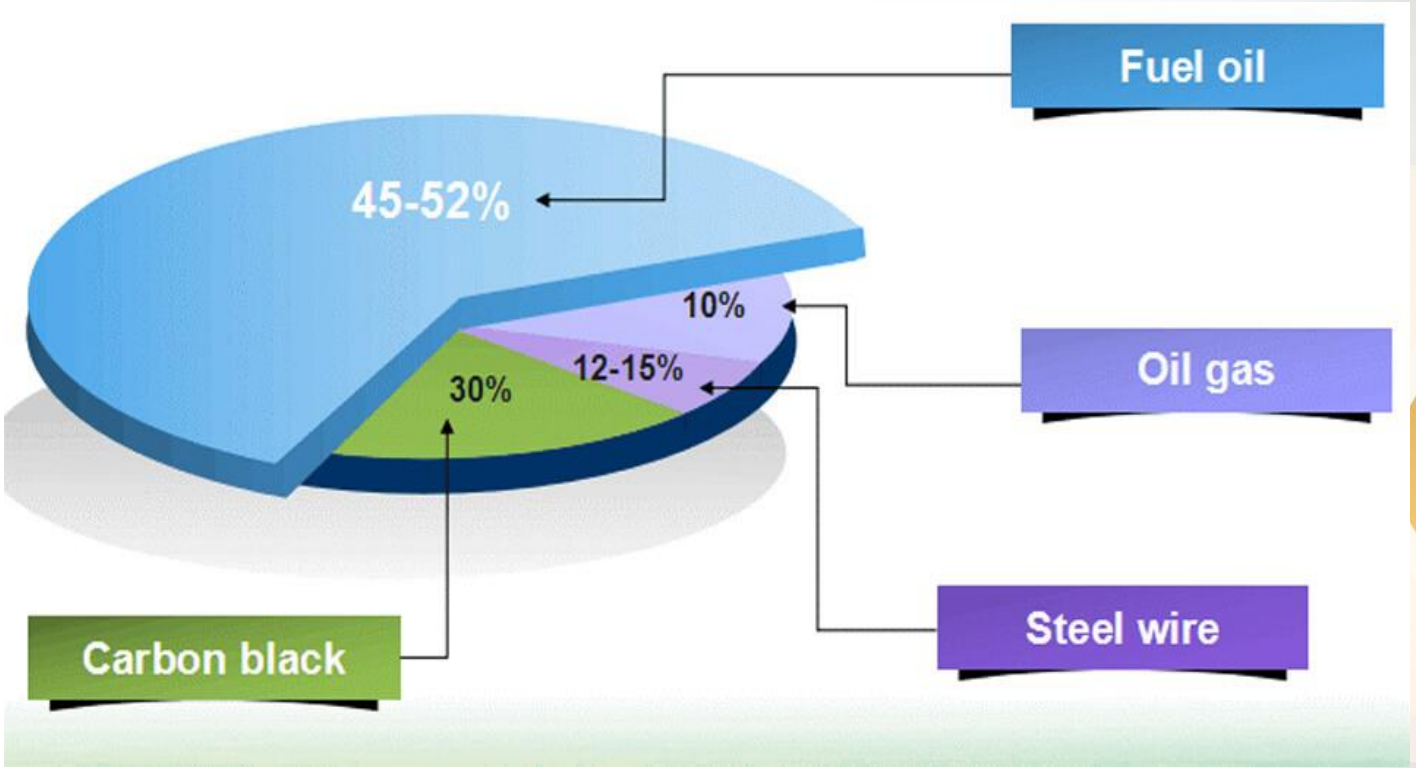


Figure 9. Typical output from tire pyrolysis process

Table 4. Profit analysis - case study [China] （10T/D）

Pyrolysis oil (45%)	4.5T, USD420/T	4.5T*USD 420/T=1890 USD
Steel wires (15%)	1.5T, 180USD/T	1.5T*USD 180/T=270 USD
Carbon black (30%)	3T, USD 50 /T	3T*USD 50/T=150 USD
Combustible gas (10%)	Recycled in the system	
Total		2310 USD

Table 5. Profit analysis - case study [Palestine] （10T/D）

Pyrolysis oil (41.2%)	4.12T, 521.2/T	4.12*521.2/T=2147 USD
Steel wires (34.3%)	3.43T, 1580/T	3.43*USD 1580/T =5419 USD
Carbon black (18.5%)	1.85T, USD 50 /T	1.85T*USD 50/T=93 USD
Combustible gas (10%)	Recycled in the system	
Total		7659 USD

Conclusion

- According to the positive outcomes, **TPO** has the potential to play a big role in the global energy market, notably in Palestine.
- DTPO can Contributes in decreeing pollution and greenhouses emissions such as NOx, HC, CO.
- It is suggested that various engine improvements be made in order to eliminate noise and lower the needed pressure in order to complete the procedure properly.
- Temperature plays the most important parameter in determining the amount of TPO. **550°C** is the optimum temperature.

Any questions ?