



OPTIMISING THE CONVERSION OF WASTE PLASTIC INTO ELECTRICITY USING A ZETA CONVERTER

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Abstract

Two of the major issues in the world - Increasing amount of waste plastic and the ever increasing pollution, These two issues are encountered by our Single Integrated System that generates electricity from waste plastics. The waste plastic is converted to oil through pyrolysis and thereby using that oil to generate electricity. The oil produced burns with 80% reduced co2 emission thereby increasing the efficiency of the electricity generated. The output generated is optimized by zeta converter to obtain a boosted output voltage.

Key Words: Plastic Waste, Pyrolysis, Steam Energy, Zeta Converter

1 INTRODUCTION

The invention of plastic in the year 1907, is considered as one of the most important breakthroughs of the 20th century. Over the years, a number of different plastics have been synthesized for a variety of purposes. However, as the volume of plastic started increasing substantially, due to the increase in population, so did the amount of plastic waste. Today, a century later, it is a major pollutant, that is creating havoc on earth.

As the population in India stands at 1.3 billion individuals, the amount of plastic waste generated in India is a serious concern to environmentalists. Studies have revealed that about 15,000 tons of plastic waste is generated in India, on a daily basis, of which around 6,000 tons are left untreated as pollutants.

India also has a large population of people who have no access to electricity. Approximately, 300 million people only dream of electricity. This is due to poor infrastructure and improper planning. Our project aims to tackle both these issues with a single solution. By subjecting plastic to a process called pyrolysis, it is converted into plastic oil on condensing the vapor. The waste plastic which is found everywhere, scattered all over our country, is actually a hidden form of black gold in its solid state. Black gold refers to oil in its most basic form after extraction from under the earth's surface. This wealth of waste is turned into useful oil through pyrolysis. The oil is used to generate steam which is converted to useful electricity with 80% reduced CO₂ emissions. This can not only reduce the plastic waste, but also provide electricity to rural India. To boost the efficiency of the electricity generated, we optimize our system with a zeta converter which is a DC-DC converter of the fourth order.

2 PROPOSED MODEL

Our Proposed model is the single integration system of three parts put together namely the process of pyrolysis, conversion of steam to electricity and boosting the obtained voltage by Zeta Converter. The Explanation of our Proposed model is as follows,

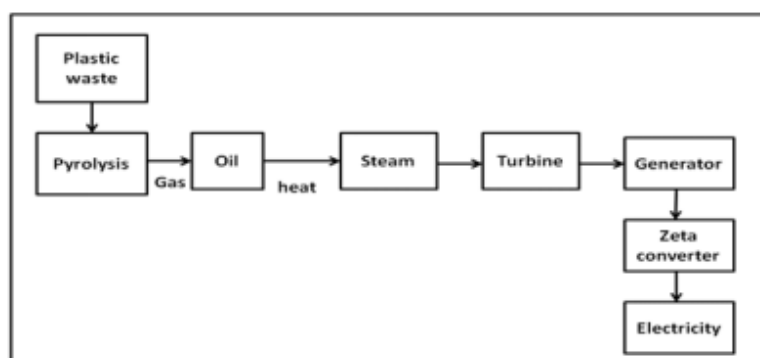


Figure 1 Block Diagram of our Proposed System

A. Plastic Waste to Pyrolysis

The Plastic waste content in municipal solid waste is average 1.5 Kg/per person. About 60% of plastics waste is collected for recycling and remaining 40% is not collected and left on the site as a litter.[1] So therefore this issue is addressed by the process of Pyrolysis. Pyrolysis is the decomposition brought about by high temperature. In our system, it's the Thermal degradation of waste in an inert atmosphere that gives An alternative fuel, namely pyrolysis oil. [2] This thermal pyrolysis of plastic waste leads to the production of pyrolysis oil, valuable resource recovery and reduction of waste problem.[3]

B. Steam Energy

In most parts of the world, turbine is steam driven. The thermal energy contributes to 70% of energy produced. The fossil fuel mostly, coal, dominates here as it provides the source of production of steam when burnt. But the cost of the fuel and the pollution created by it is increasing exponentially. Due to the heavy population increase, the requirement of electricity becomes important but simultaneously the depletion of coal is at its high rate too. The direct cost of electric energy produced by thermal power station is the result of cost of fuel, reason being which its becomes a hurdle to many parts of India that electricity- an essential need, becomes

just a dream for many.

To resolve this issue, our system uses the oil obtained from the process of pyrolysis and is used as an alternative source instead coal and other depleting fossil fuels. The CO₂ emission generated by the pyrolysis oil is reduced to 80% contributing to a more green environment as Reduction of CO₂ can be obtained by choosing A best alternative fuel and good technical development.[4]

C. Zeta converter

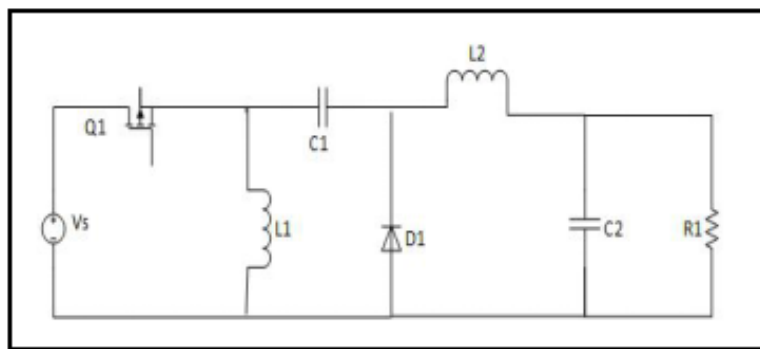


Figure 2 Topology of the Zeta Converter

The Zeta converter is in essence a DC-DC converter. It uses electronic circuits to boost voltage from a lower level to a higher level or vice versa. It has a wide operating range from a few volts to many thousand volts. The converter offers a high level of controllability over the voltage levels, as the duty cycle of the charging voltage can be easily varied to suit the application. This coupled with the high efficiency of the converter make it perfect for this application. The Zeta converter showed itself as very attractive because it operates as step up as well as step down voltage, beside the fact of being a naturally isolated structure and processing power at one single stage[5]. Therefore the overall system gives us efficient output voltage, reduces the cost of electricity, reduces the environmental hazard created by plastics and also produces a more green energy as the emission of co₂ is reduced by 80%.

3 DESIGN CALCULATION

The following tabular column are the design parameters for the simulation model of our whole system. for Our Model we have considered the parameters of our synchronous generator where the Power = 187MW, Voltage = 13.8KV, Frequency = 60 Hz. We have designed our Rectifier as follows where duty cycle as 70% and Frequency = 10KHz and the other design calculations are as follows :

Sl no	STEAM TURBINE AND GOVERNER	EXCITATION SYSTEM	ZETA CONVERTER
1.	Nominal Speed = 3600 RPM	$S_{base} = 8.1 \text{ KVA}$	Input Voltage $V_{in} = 78 \text{ V}$
2.	Regulator Gain $K_p = 1$	$V_{base} = 400 \text{ V}$	Output Voltage $V_{out} = 150 \text{ V}$
3.	Full Load = 2880 RPM No Load = 3000 RPM	Frequency = 10Hz	Frequency = 100KHz
4.	Speed Reference = 1pu Speed Relay Time Constant = 0.001 Servo Motor Time Constant = 0.1	Speed = 1200 RPM	Duty Cycle Consider value of V_{in} to be 10% of that of V_{out} . $D = \left(\frac{V_{out}}{V_{in} + V_{out}} \right)$ = 65%
5.	Nominal Power = 187 MW	$I_{base} = \frac{S_{base}}{V_{base}} = 20 \text{ A}$	Inductor L_1 Considering the ΔL_1 value As 0.01 $L_1 = \left(\frac{\frac{1}{2} \cdot V_{in} \cdot D}{0.01 \cdot F_s} \right)$ = 25mH
6.	Reference Power = 140 MW	$I_{pu} = \frac{I_{actual}}{I_{base}} = 1 \text{ pu}$	Inductor L_2 $L_2 = 25 \text{ mH}$
7.	Power Reference = $(Pref) = \frac{\text{Reference power}}{\text{Nominal power}} = 0.75 \text{ pu}$	$V_{pu} = 1.102 \text{ pu}$	Input Capacitor C_{in} $C_{in} = \frac{D}{0.01 \cdot V_{in} \cdot F_s}$ = 8.3 μF
8.	Permanent Droop $\text{Droop \%} = \frac{\text{no load speed} - \text{full load speed}}{\text{no load speed}} = 0.04$	$Z_{pu} = \left(\frac{V_{base}}{I_{base}} \right) \cdot \left(\frac{S_{base}}{V_{base}^2} \right) = 1.102 \text{ pu}$	Output Capacitor C_{out} $C_{out} = \frac{D}{8 \cdot V_o \cdot F_s}$ = 10 μF

Figure 3 : Block Diagram of the Whole System

The Simulation result for the above design is as follows, We obtained an output voltage of 149.9 Volts from our System as per our designed Calculation .The simulation Model and the Graphs Obtained are as follows, graphs Obtained are as follows,

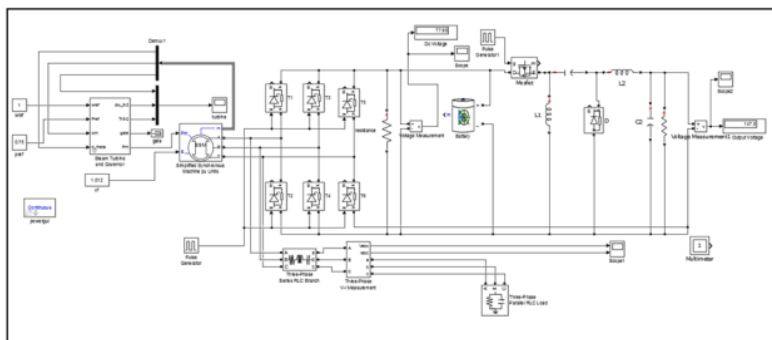


Figure 4 Block Diagram of the Whole System

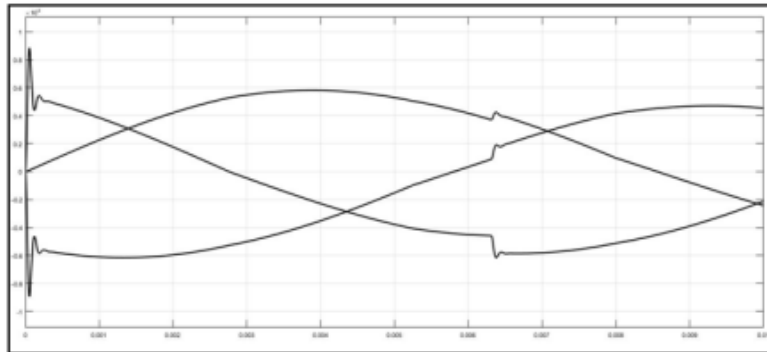


Figure 5 Three phase output waveform from Synchronous Generator

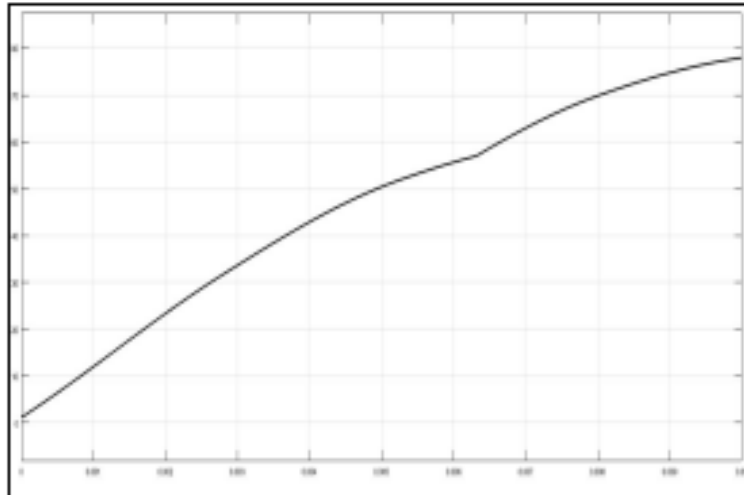


Figure 6 Output Voltage waveform from Rectifier

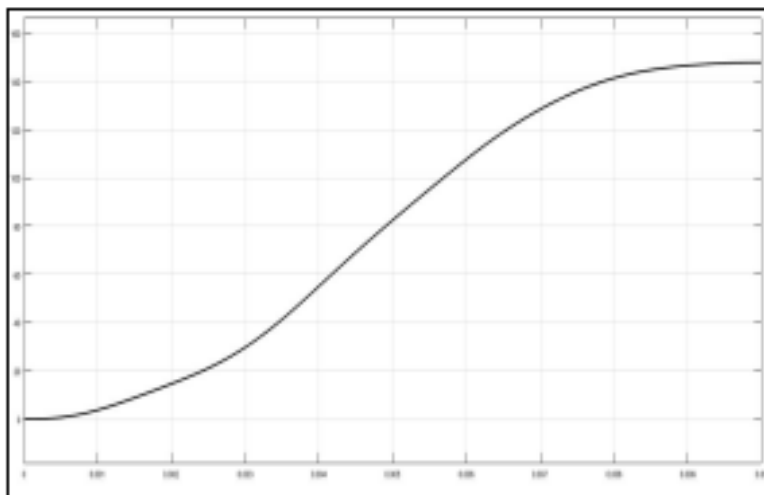


Figure 7 Output voltage Waveform Obtained by Zeta Converter

4 HARDWARE DESIGN AND RESULT

A. Hardware Methodology

The methodology of our Proposed model is as follows,

1. The pressure vessel containing is subjected to 400 deg Celsius which is produced by liquefied petroleum gas.
2. The plastic melts that results in vapour formation that flows through the copper tube to the collection vessel.
3. The collection vessel is surrounded by cool water that condenses the hot vapour in the collection vessel.
4. For 400g of plastic that was burned we obtained 20ml of pyrolysis oil.
5. The condensed vapour gives us the pyrolysis oil.

The pyrolysis oil obtained by pyrolysis becomes the source of fuel that is used to heat the water in the pressure vessel to produce steam.

The methodology of converting the steam to electricity is as follows :

1. The water in the pressure vessel is converted to steam.
2. The pressure in the vessel builds and releases through the valve which is kept open.
3. The steam generated ,runs the blades that in turn is connected to a 3v DC motor .
4. The DC motor is connected to a LED that lights indicating electricity is generated.
5. The output obtained is 3 volts for our Prototype.



Figure 8 Image of the Pressure Vessel and the Copper Tube for pyrolysis



Figure 9 Image of the Pressure Vessel and the Copper Tube for steam generation

In our Prototype ,the 3volts is indicated by a 3 volt battery that is connected to the zeta converter,

1. The biasing is provided by IN5408 diode as we are dealing with high voltages.
2. The switching pulse for our circuit is provided by a n-channel MOSFET whose PWM signal is given by Arduino UNO. The Arduino gets the input from the potentiometer through its analog port and gives the output in its digital port. The program for Arduino to give switching pulse to MOSFET is as follows

```

int ledPin = 9; // LED connected to digital pin 9
int analogPin = 3; // potentiometer connected to analog pin 3
int val = 0; // variable to store the read value
void setup()
{
  pinMode(ledPin, OUTPUT); // sets the pin as output
}
void loop()
{
  val = analogRead(analogPin); // read the input pin
  analogWrite(ledPin, val / 4); // analogRead values go from 0 to 1023
  analogWrite values from 0 to 255
}

```

The design parameters for boosting the 3v, obtained from the steam turbine generator, to 30v by zeta converter is as follows,

SL NO	PARAMETERS	VALUES
1.	INPUT VALUE	3V
2.	OUTPUT VALUE	30V
3.	INDUCTOR VALUE ($L_1=L_2$)	2.2mH
4.	INPUT CAPACITOR C_{IN}	47 μ f
5.	OUTPUT CAPACITOR C_{OUT}	220 μ f
6.	DUTY CYCLE	65%
7.	FREQUENCY	1024Hz

Figure 10 Design for Zeta Converter

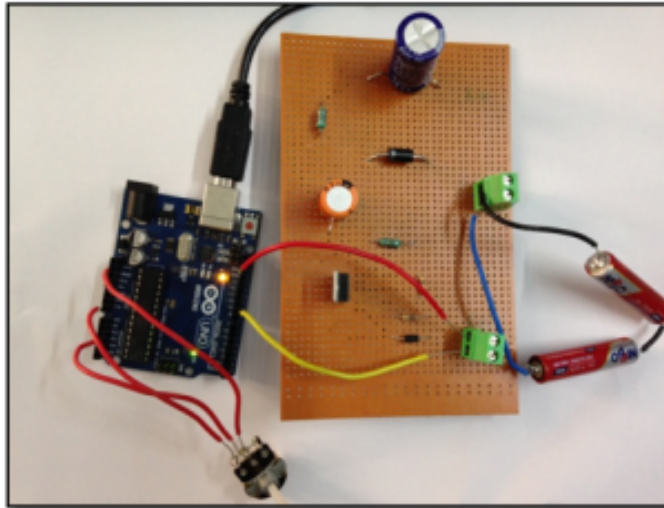


Figure 11 Image of Zeta Converter

B. Hardware Results

The pyrolysis oil obtained was 20ml for 400g of plastic Waste. The following is the Image of the pyrolysis oil obtained by the the process of pyrolysis.



Figure 13 Image of Pyrolysis Oil

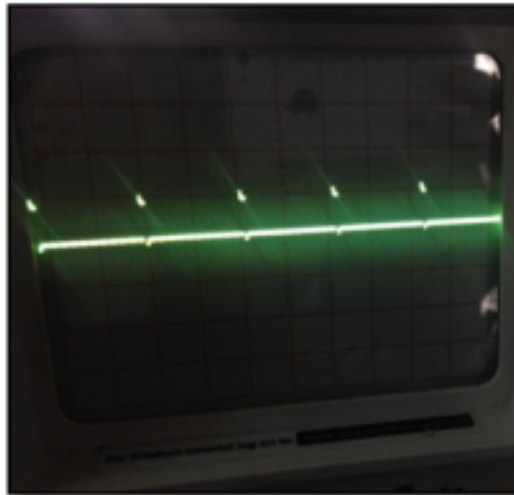


Figure 14 Pulse When Frequency Is 1024Hz

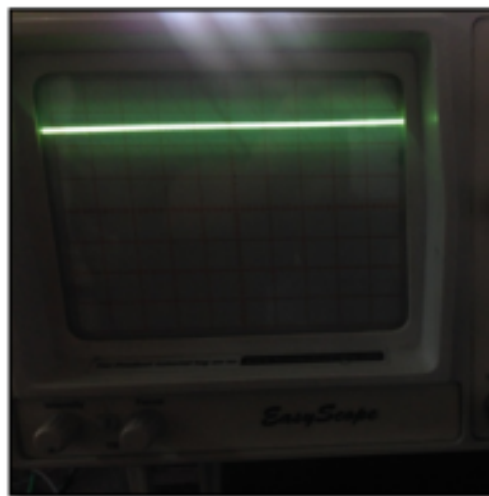


Figure 15 The output voltage Waveform (30 volts)

5 CONCLUSION

Thus, our project aims to solve two major issues faced by the world, with a single feasible solution. The plastic wastes, which were earlier dumped into landfills and oceans, can be converted into useful oil. This will greatly reduce pollution of both land and sea resources. The oil obtained can be used for generating electricity via a steam turbine. The oil can also be subjected to fractional distillation to get different grades of fuel including petrol, diesel and kerosene. This will not only reduce our dependence on fossil fuels, drilled out of the earth, but also create a self-sustainable society. The Pyrolysis oil produces 80% reduced CO₂ emission when burnt contributing to a green energy solution. The output obtained is further optimised by converting the obtained voltage to a boosted voltage by the zeta converter. The output waveform is ripple free and a stable boosted voltage.

References

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