

**EXPERIMENTAL ANALYSIS OF THERMO CHEMICAL PROPERTIES FOR
DOMESTIC WASTE USING MICROWAVE INDUCED PLASMA
GASIFICATION**

Dissertation-II

Submitted in partial fulfillment of the requirement for the award of degree

Of

Master of Technology

IN

MECHANICAL ENGINEERING

By

Navinchandra Tripathi

(11204089)

Under the guidance of

Ketan Jawney (17970)



**DEPARTMENT OF MECHANICAL ENGINEERING
LOVELY PROFESSIONAL UNIVERSITY ,PUNJAB**

CERTIFICATE

I hereby certify that the work being presented in the dissertation entitled "**experimental analysis of thermo chemical properties for domestic waste using microwave induced plasma gasification**" in partial fulfillment of the requirement for the award of Degree of master of technology and submitted to the Department of Mechanical Engineering of Lovely Professional University, Phagwara, is an authentic record of my own work carried out under the supervision of (Ketan Jawney, Assistant Professor) Department of Mechanical Engineering, Lovely Professional University. The matter embodied in this dissertation has not been submitted in part or full to any other University or Institute for the award of any degree.

(Date- 23/06/2017)

Navinchandra Tripathi

11204089

This is to certify that the above statement made by the candidate is correct to the best of my Knowledge.

(Date-23/06/2017)

(Ketan Jawney)

(17970)

COD (ME)

The external viva-voce examination of the student was held on successfully _____

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DECLARATION

It is here by declared that the work presented in Dissertation 1 entitled **“experimental analysis of thermochemical properties for domestic waste using microwave induced plasma gasification”** as partial fulfillment of the requirements for the award of degree of M.Tech. (Thermal) in Mechanical Engineering, Department of Mechanical Engineering, Lovely Professional University, Phagwara, Punjab, has been carried out by me. Further, it has not been submitted in part or whole to any institution or university for the award of degree or diploma. If any material found copied, legal action may be taken against me.

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ABSTRACT

Presently a day's contamination is the significant issue on the planet. To overcome with this issue significant researchers are doing examination to secure the earth. For the most part individuals don't have the foggiest idea about the preferred standpoint and impediment of the residential waste material. Fundamentally residential waste material produces SYN gas after burning which we can use after the ignition. We are utilizing microwave as a wellspring of plasma energy having some specific vitality thickness and cutoff recurrence. Subsequently this paper can give the plan and value of Microwave stove for residential waste and its application.

The Municipal Solid Waste (MSW) gasification process is a promising contender for both MSW transfer and syngas creation. The MSW gasification process has been portrayed bottle - gravimetrically under different exploratory climates keeping in mind the end goal to comprehend syngas generation and scorch burnout. This preparatory information demonstrates that with any convergence of carbon dioxide in the environment the remaining roast is diminished around 20% of the first mass (in an inactive air) to around 5%, cross ponding to a lot of carbon monoxide creation

(0.7% of CO was delivered from a 20mg example of MSW with 100ml/min of clean gas at 825c

Two fundamental strides of warm corruption have been watched. The primary warm corruption step happens at temperatures in the vicinity of 280~350°C and comprises basically of the decay of the biomass part into light C1-3-hydrocarbons. The second warm corruption step happens in the vicinity of 380~450°C and is essentially ascribed to polymer parts, for example, plastics and elastic, in MSW. The polymer part in MSW emitted huge measure of benzene subordinators, for example, styrene. With a specific end goal to distinguish the ideal working administration for MSW gasification, a progression of tests covering a scope of temperatures (280~700°C), weights (30~45 Bar), and environments have been done and the outcomes are exhibited here.

This paper described the utilization of residential waste material through DMO (Domestic Microwave broiler) plasma energy. Presently a day's it is enormous issue of air contamination happen in our nation, so the primary target of our venture is to treat strong waste with the assistance of microwave gasification in nearness of plasma, so with the assistance of that we can again make a burnable gas which is either utilized for cooking nourishment or we can utilize it as a power hotspot for making power. So on one side we are diminishing strong waste without delivering any destructive gas which is one of the significant issue of our nation and on the opposite side we are creating flammable gas with the assistance of gasification within the sight of plasma which is again utilized for cooking sustenance or creating power. Any material, including low-level radioactive waste under specific conditions, can be decreased utilizing plasma gasification. Main objective of this experiment to find out the alternative ways to reduce the effect the domestic wastage which creates harmful environment to the surroundings. Degradation of any wastage produces the harmful gases like methane, ethane and other organic gases somewhat they are harmful for the environment.



Figure .1 (Municipal Solid Waste)

This venture is configuration to treat the strong waste with the assistance of microwave gasification so we can diminish it without making any contamination and on the opposite side we are delivering syngas which is an ignitable gas, which is additionally utilized as a power source. So that with the assistance of these venture on one side we are diminishing strong waste by treating it with the assistance of microwave gasification and on the opposite side we are delivering syngas which is a burnable gas. Syngas is essentially blend of carbon monoxide (CO), hydrogen and methane alongside the other segment. Plasma preparing of waste is natural clean. Because of the absence of oxygen the strong waste won't consume totally and it will keep the arrangement of numerous poisonous materials. The high temperature in a reactor likewise keeps the primary segments of the gas from framing dangerous compound, for example, furans, dioxins nitrogen oxides and sulfur dioxide. Plastic wastage are the real issue in the issue on the planet since it will decimate all the environment and environment will get dirtied.

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ABBREVIATIONS

MSW	Municipal solid wastage
CH ₄	Mthane
CuO	Copper Oxide
CO ₂	Carbon di Oxide
O	Oxygen
N	Nitrogen
C	Carbon
Gm	gram
Kwh	Kilowatt Hour
KJ	Kilojoule
Min	Minute
°C	Degree Celsius
K	kelvin(temperature scale)
Al	Aluminum

CHAPTER 1

INTRODUCTION

1.conventional ways of gasification:-

Gasification

Gasification forms include the response of carbonaceous feedstock with an oxygen-containing reagent, normally oxygen, air, steam or carbon dioxide, by and large at temperatures in overabundance of 800°C. It includes the halfway oxidation of a substance which suggests that oxygen is included however the sums are not adequate to enable the fuel to be totally oxidized and full burning to happen. The procedure is to a great extent exothermic however some warmth might be required to initialize and maintain the gasification procedure.

The principle item is a syngas, which contains carbon monoxide, hydrogen and methane. Normally, the gas created from gasification will have a net calorific estimation of 4 - 10 MJ/Nm³. The other fundamental item delivered by gasification is a strong deposit of non-burnable materials (powder) which contains a moderately low level of carbon. Syngas can be utilized as a part of various distinctive routes, for instance:

- Syngas can be scorched in a kettle to produce steam which might be utilized for control era or modern warming.
- Syngas can be utilized as a fuel in a committed gas motor.
- Syngas, subsequent to improving, might be reasonable for use in a gas turbine
- Syngas can likewise be utilized as a substance feedstock.
-

1.1 Application of gasification of domestic wastage by different process:-

There are various ways to gasify the solid wastage but all process are depend upon the according to the need. For the industrial purposes we use chamber kind of gasifier which can consume the wastage at very large scale.

1.1.1 Gasification by counter current fixed bed gasifier (Vertical upward Gasifier):-

In this gasification process gas agent (SYN) gas flows in counter current direction and gases velocity are very fast. Counter current type gasifier are frequently due to its high efficiency. Thermal efficiency of this gasifier is high but temperature of gas is quite low because no any external pressure is applied and gas is free to move upward. The real favorable circumstances of this sort of gasifier are its effortlessness, high charcoal wear out and interior warmth trade prompting low gas leave temperatures and high hardware productivity, and the likelihood of operation with many sorts of feedstock (sawdust, oat bodies, and so forth.) .

1.1.2 Co-current fix bed (vertical downward Gasifier):-

This is very similar to counter current fixed bed gasifier only the direction of gas is changed. In this kind of gasifier gas flows downward and heat added to the system is upper part of the body. Contingent upon the temperature of the hot zone and the habitation time of the delay vapors, a pretty much entire breakdown of the tars is accomplished.

The primary favorable position of downdraught gasifier lies in the likelihood of creating a without tar gas reasonable for motor applications.

1.1.3 Fluidized ash reactor:-

Fuel is fluidized in oxygen ateam or air. In this process very high corrosive nature of ash is founded. Temperature in this process is slightly high because the uses of oxygen or air. Process of gas flow is counter flow direction.

Air is blown through a bed of strong particles at an adequate speed to keep these in a condition of suspension. The bed is initially remotely warmed and the feedstock is presented when an adequately high temperature is come to. The fuel particles are presented at the base of the reactor, immediately blended with the bed material and momentarily warmed up to the bed temperature. Because of this treatment the fuel is pyrolysis quick, bringing about a part blend with a moderately expansive measure of vaporous materials. Promote gasification and tar-transformation responses happen in the gas stage. Most frameworks are outfitted with an inner tornado so as to limit scorch victory however much as could reasonably be expected. Fiery remains particles are additionally continued the highest point of the reactor and must be expelled from the gas stream if the gas is utilized as a part of motor applications. continued the highest point of the reactor and must be expelled from the gas stream if the gas is utilized as a part of motor application.

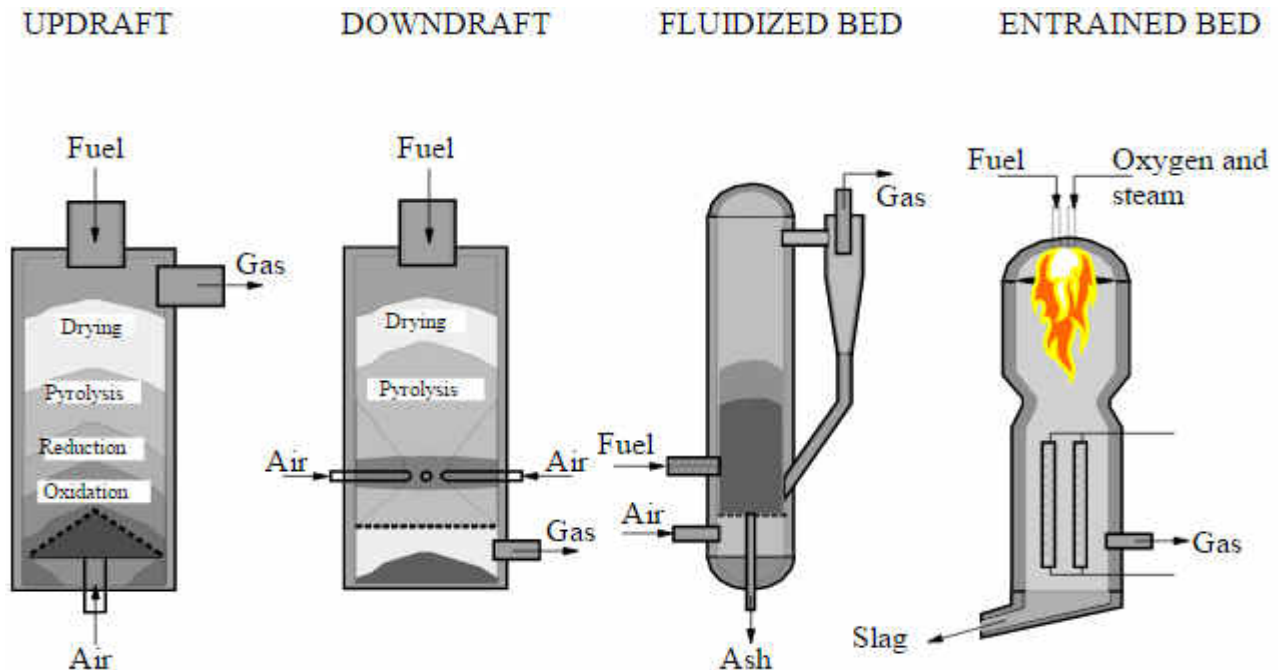


Figure .2 (types of gasifire)

1.1.5 PLASMA

Plasma is the fourth condition of matter and an extremely fundamental wonder of universe which is available in

the sun, star, lighting and all additional earthbound substance having high temperature around 5000°C to 7000°C and in our venture its temp is 1000°C high substance of warmth vitality. By making plasma misleadingly we can utilize this warmth vitality to change over all kind of strong waste into exceptionally helpful items like manufactured gas, distill ethanol and distill hydrochloric vitality that crumble the carbonic material to the essential component i.e. which responds with the ionized steam to shape syn gas.



Plasma alludes to each gas of which no less than a rate of its iotas or atoms are mostly or completely ionized. In a plasma condition of matter, the free electrons happen at sensibly high fixations and the charges of electrons are adjusted by positive particles. Therefore, plasma is semi unbiased. It is produced from electric releases, e.g. from the entry of current (consistent, substitute or high recurrence) through the gas and from the utilization of the dispersal of resistive vitality keeping in mind the end goal to make the gas adequately hot. Plasma is described as the fourth condition of matter and contrasts from the perfect gases, in light of the fact that it is portrayed by aggregate marvels'. aggregate wonders start from the extensive variety of Coulomb strengths.

Plasma technology is exceptionally extraordinary because of the nearness of profoundly responsive nuclear and ionic species and the accomplishment of higher temperatures in examination with other warm techniques. Truth be told, the greatly high temperatures (a few thousand degrees in Celsius scale) happen just in the metal of the plasma, while the temperature diminishes significantly in the negligible zones.



Figure 3(Plasma Generation)

1.2 DESCRIPTION AND IMAGE OF MAJOR COMPONENTS WITH THEIR SPECIFICATION:-

Serial No.	Equipment's and specification	Image of equipment
1.	<p>Magnetron:- This is main part of any domestic microwave which generate the microwave for heating . Source of microwave. AC current is used . 2.45Khz wave is produced. Responsible for generating resonate frequency.</p>	
2.	<p>Wave Guide:- Second important part of the experiment which is responsible for the wave propagation in proper direction. Giving direction to the wave Difficult to find the resonate parameter Material should consist high thermal conductivity Low resistivity material should be coated like Cu etc.</p>	

3.

Transformer and electrical setup:-
For performing the experiment ,there is need to modify the electrical setup so that resonat frequency should be generated and high voltage arc produced.
High voltage is required
Earthing should be there either poteinal of the system will be not zero.
AC cricuit with low impendence in required.
Capcitor should be in high capcaity so that it can store the energyin the form of $\frac{1}{2}(cv^2)$





<p>4.</p>	<p>Glass flask and beaker:- Gasification process requires highly reputed material which can bear high temperature and pressure. Glass should be transparent and highly refractive index which will give the better output. Output of the gas should be fast in the velocity.</p>	
<p>5.</p>	<p>Ar gas supply:- Ar gas is used for ignition . Inert is in the nature Removal of argon is required.</p>	

Table.1 (List of all equipment and its specification)

CHAPTER 2 REVIEW OF LITERATURE

There are so many research is going on this field mainly researches are focusing to find out the alternative solution of any kind of wastage mainly domestic wastage which is giving more pollution to our environment. Plasma is used for the gasification of wastage

[1] Madhusudan and Tanmay et al.

In this project give the idea of susceptor assisted microwave processing of materials which increase the heating effect of heat generation. They have also focused on the idea of content of wastage which is present in domestic wastage.

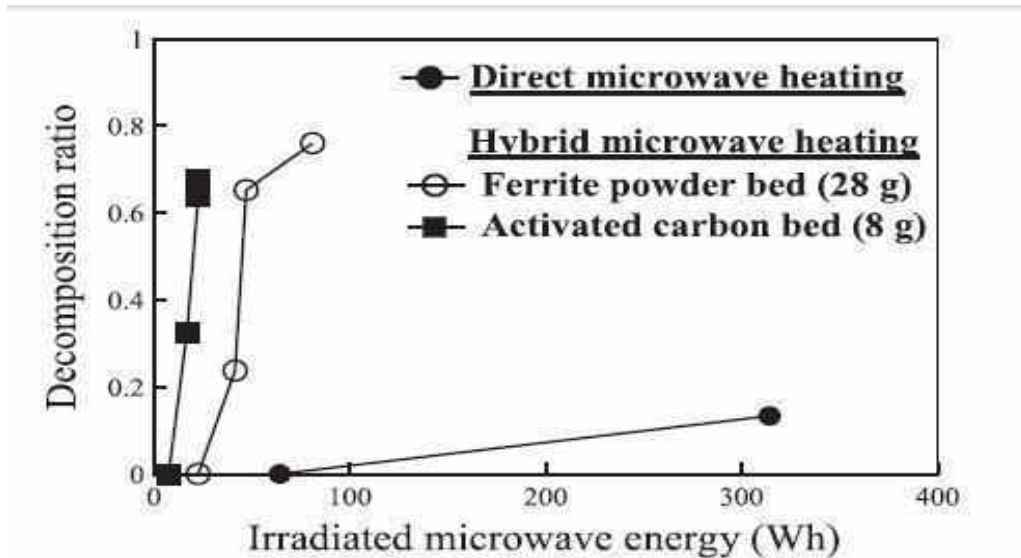


Figure 4 (Graphical Representation of Carbon Content)

In figure, It is clearly shows that direct microwave heating is more efficient for less decomposition ratio and activated carbon bed is used for high decomposition ratio.

In this research paper it has explained that how we can use the susceptor and rise in temperature. Madhusudan and Tanmay et al also tells us that component presence in the kitchen waste. This paper is also giving the idea of finding out the percentage of carbon content which is present in the domestic wastage.

[2] Parin Khongkrapan et al.

In this examination, microwave plasma pyrolysis of waste paper was researched. The test runs were conveyed with a 800W microwave control and different argon stream rates. From the discoveries, increment in proximate and natural arrangement of the strong deposits was apparent because of carbonization. Roast yield and its HHV were 25.95% and 38.5 MJ/kg, individually. The most extreme ignitable portion (CO, CH₄ and H₂) of the item gas, warming quality and carbon transformation were found at 0.75 kg. The normal gas yield and normal aggregate substance of flammable part in the gas item were 2.56 m³/kg

what's more, 36%, which can be utilized as fuel gas. This is of down to earth enthusiasm for usage of strong squanders for the motivation behind fuel gas creation.

Plastic wastage which is usually of Bakelite and polythene which produces carbon monoxide and carbon di oxide from this paper data and calorific value can be easily determined. plastic waste which is very important. Generally plastic are organic polymerized which is useful because it consist more no. of carbon and produced heat sufficiently found in the domestic wastage gave the idea of plastic pyrolysis of plastic wastage plastic are generally polymer polythene and it consist more no of carbon molecule which give carbon monoxide and dioxide after the combustion.

[3]Fr_ed_eric Fabry and Christophe Rehm et. al:-

SYN gas analysis is given in this research article. After the combustion of organic molecule syn gas produces which is main aim to obtain from the wastage. Chemical reaction is involved during the combustion which is described in this paper.

Mainly gases produced from the wastage are carbon monoxide and carbon di oxide which is generated from the mainly kitchen wastage in the form of combustible gases. And collection of that combustible gas is stored and used for domestic purposes.

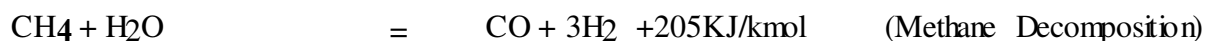
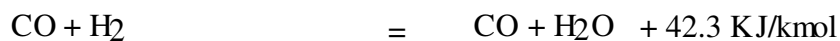
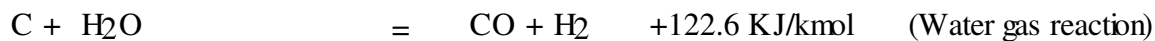
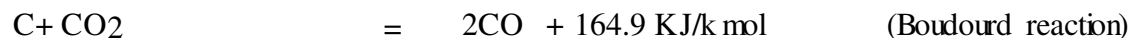
[4] John F. Gerling et.al:-

Wave guide play a important role in this experiment. There are two type of the wave guide is possible first one rectangular and second one is tapered we will use tapered waveguide with desired dimension; cut off frequency can be generated with desired frequency only. Wave guide dimension calculation is also very important because resonating frequency is generated on the specific dimension. There are two type of wave guide is used in the microwave propagation tapered and rectangular waveguide dimension is calculated by the cutoff frequency.

Wave guide designed by using the formula which is comes out in term of LCR circuit resonating point which is also known as cutoff point.

[5] Christopher J. Lupaand Steve R. Wylie et.al:-

In this research paper author are concluded that the basic chemical reaction involve in the syn gases. This paper also gives the idea of calorific value and all other thermal and chemical properties. Our main aim to find out their calorific value of gases which comes out from kitchen wastages after the combustion. Plasma gas temperature our main interest concerns the heat transfer between the plasma and wastes. Plasma and the gas, which justifies the investment in describing the electromagnetic and the hydrodynamic characteristics of combustible gases. The goal is to define the work conditions for the power coupling between the microwave generator and the plasma, then the heat transfer from the plasma to the gas, in order to obtain an efficient gas heating. The microwave power flow decreases along the plasma column since the wave power is progressively absorbed by the plasma electrons. Subsequently, electrons dissipate this power in collisions with gas particles and redistribute it among the different internal and translational modes of heavy particles via a variety of mechanisms.



Above reaction is showing the nature of organic compound after the combustion which important feature of the project. Reaction is showing free radical and carbon cation and anion reaction

[6] Susan Björkqvist et. al:-

This paper is summarize for the alternative solution of household as compare to traditional method. In this article stating about the usefulness of bio gas if bio gas is used as a fuel then specially methane.

It is also stating that investigation of methane is easy by analytical method and giving the prospective idea that if 70% methane is present in household wastage it can be good fuel. Methane, ethane and other alkane compound create good source of carbon and this paper give the clear idea of percentage of carbon.

[7]:- Sebastian Werle and Mariusz Dudziak:-

Wastage of sewage sludge and its chromatogram has given in this paper. After the chromatogram the specification of combustible gases can be identify. Character of gases which generally produces like methane ethane and other organic compound and its percentage is given by the author. If 60% methane is there then we can use as combustible gas .

CHAPTER 3

RESEARCH GAP AND OBJECTIVE

Although many research is going on this field, previously researchers have done experiment with different kind of gasifier but with the help of plasma at domestic only limited research is going on. With the help of domestic microwave this is revolutionary experiment and future scope of this experiment is broad.

3.1 Research gap and problem statement:-

Research is going on this field but modification is necessity of any experiment. Microwave plasma with susceptor is new concept in this field .

In this experiment no one is using clay as a role of susceptor or silicon rod for coolant.

Previously scientist have used the plasma torch for cutting the material but by using plasma arc at atmospheric pressure is new concept in this field.

3.1.1 Problem Statement:-

Problem statement “Thermo chemical analysis of gasification of domestic waste using induced plasma at atmospheric pressure”.

3.2 Objective of Study:-

Main objective of this project is to obtain SYN gas from the domestic wastage from the induced microwave plasma. Plasma can be induced by two methods that are electric and microwave. We are concentrated on microwave plasma. Microwave source can be easily get from domestic microwave.

The main objective of this project is to find out the gas % in domestic wastage by chromatography and find out is calorific value.

Kitchen wastage are the major problem and it goes to river and it is very harmful for the wild life.

It creates the pollution into the ocean. To overcome with this issue, it can be transformational project. It is easily compact able at domestic level. Material heating and gasification is application of microwave. At low scale, it is very beneficial for the environment.

Chromatography and find out the percentage of gases into the wastage is our main objective.

3.3 Scope of the study:-

Now a days pollution is major problem for us. More number of researches is going to remove or recycle all the wastages and problems. Domestic wastage, food wastage is a kind of problem for the human being; to overcome from this problem we are doing a research on such thing which can reduce such problem. Gasification of domestic wastage by microwave plasma induction is very important because it can use at kitchen level and from there we can generate heat and perform the work. Plasma technique is already exists but it is not available at domestic level. Our research is focused for gasification of kitchen wastage at domestic level. We take an example of orange pill which consist more content of water molecule which can gasify at low temperature. We cannot take any wastage which consist ferrous element because it is difficult to gasify.

Our project is very good for the environment so scope is very broad because it will reduce NOx gases percentage and green house causes.

CHAPTER 4

RESEARRCH METHODOLOGY

4.1 Introduction to Methodology:-

The methodology adopted to perform any experiment can be many and the results procured from that could also vary to a scale. This topic could also be performed by using different methodologies. Any experiment can generally imply these following methodologies to perform the tests and to get the result.

4.1.1 Constructing the Experimental setup:-

For performing the different tests in an experiment, methodology could be adopted. An experimental setup could be constructed as per the requirements for performing the same. The testing is then done in it and results are obtained. Here, for this topic also same approach or more appropriately similar methodology is adopted. Firstly, the setup of induced plasma is constructed and then the domestic wastage component is used for the testing is done to procure the result in the form of chromatography by using analytical approach.

4.1.2 Working or Experimenting on a commercial Model:-

The same tests could also be performed on a commercial model as well which is used by the world. This methodology is also used by various researchers to watch or observe the direct implication of the experiment and to check its feasibility for the future. This topic had also been performed using the same methodology earlier.

4.1.3 Using Computers for Simulation:-

Again it is also one of the methodology adopted by number of researchers now a days. There is no need of making any physical setup, in the computer only the virtual setup can be created and defining the conditions of inner and outer regions of the system drawn. Further the simulation can be done to perform the experiment, it is like performing the tests in the same way just the setup is virtual. The results can be procured in this also and final verdict can be made.

4.2 Experimental setup construction:-

For performing the experiment it is necessary to construct the experimental setup or modify the setup according to the need. Main objective of this experiment to induced plasma at one atmospheric pressure and after that make a system in which combustion takes place. For performing the experiment first schematic diagram should be draw because it give the clear view of the project.

The following step is taken during the construction of the experimental set up.

4.2.1 Schematic diagram (pen paper mode):-

Before constructing the all experimental set up very first schematic diagram should be drawn and make all the diagram such that modification should possible according to the need.

4.2.2 Making list of all the equipment's:-After the making of schematic diagram second step is to make the list of all the equipment's which will participate in the experiments. List of all the apparatus and its specification is given below which is frequently used in this experiment is given below.

1. Domestic Microwave oven:-It is used for producing microwave which is main part of the experiment. Domestic microwave produces microwave at 2.45KHz.

2. Magnetron:-Semi goal of the experiment is to produced plasma at atmospheric pressure then little bit modification is required .Magnetron part of domestic waste to keep outside so that magnetron will give microwave which is our main objective.

3.Wave Guide:-Wave guide is second important thing in this experiment designing of wave guide is little bit is difficult ,for the cutoff frequency dimension must be accurate. Generally waveguide is made up off copper or any metallic material which having low resistance and high conductivity.

Conductivity is inversely proportional to resistance .

For better output we can do the silicon coating on wave guide so that less heat despite outside.

4.Borosil Flask:- Borosil flask is used to collect the plasma at one place. This is the thing in which domestic wastage is put the upper side of the flask and plasma is act a source of energy.

5 Thermosetting plastic pipe or rubber pipe:-It is used for giving the direction of flowing gas. This is optional for use. Without this, there will be no effect on experiment.

6.Ar gas source:-To ignition of plasma there is a need of inert gas. Ar gas is best gas for this because at atmospheric pressure Ar gas can ionized easily.



Figure.5 (Complete experimental set up in Lovely Professional University)

4.3 Stages involved in the experiment:-

Various stages involved in this experiment very first process is plasma generation and after that assembly for the putting domestic waste. All the stages are given below in the detail.

4.3.1 Stage 1:- Plasma generation with microwave cavity:-

In this experiment we have generated the plasma in the inner side of microwave. We have put some orange pills and domestic waste into the inner side of microwave and we have started the microwave power source, after some time plasma generated with high temperature and combust the waste.



Figure. 6 (Gasification of Domestic waste in cavity of Microwave)

In figure we have generated the plasma in inner side of microwave and we can see clearly at topmost combustible gas is burning.

4.3.2 Stage 2 Plasma generation at atmospheric pressure:-

Plasma generation in this case occurred at atmospheric pressure, setup is modified so that equipment to create plasma in the atmosphere. In this case main kept out the magnetron which is the main source of microwave and further connect with the wave guide. In this experiment from the outer side supplied .Ar gas is supplied as external agent to initiate the plasma. Main purpose of supplying the Argon gas is to combust the waste by initiated plasma. Most important feature in this case to design the wave guide with proper dimension so that plasma can generate. And also generate the heat efficiently. We should use borosil flask as a close chamber less refractive index glass will give better output. Below figure is real image of our project in which we are generated plasma at the atmospheric pressure and also we are able to combust the kitchen wastages.



Figure. 7 (wave guide attach with glass beaker)



Figure. 8 (Plasma Generation)

4.3.3 Stage 3 Collection of gases and analysis:-

Currently we are focusing to generate plasma in the atmospheric pressure and combust the domestic waste and collect these gases for chromatography so that we can measure the chemical and physical properties.

After the proximate and ultimate we can finalize the project work and do the analysis of the gases after the combustion.



Figure. 9 (Combustible Gas exerting from the glass tube)

4.4.4 Equipment properties and limitations:-

The plasma state is generated when a gas is subjected to sufficient energy to break down its molecular integrity and dissociate it into ions, electrons and other sub-atomic species. Photons are generated during recombination. The initial interest in thermal plasma technology occurred in the 1960.

Plasma sources are required for a wide range of technological such as etching, cleaning, plasma chemistry, surface modification, cutting, thin film technology, textile, etc. Atmospheric pressure plasma source have been utilized as a tool for modifying polymer and metal surface. The simple microwave plasma source at atmospheric pressure has been constructed by using the magnetron tube from a commercial microwave oven. The prototype of MPS consists of a rectangular waveguide connected to a magnetron tube operated at the 2.45

GHz, waveguide applicator. The magnetrons used in this work were manufactured by Galanz Electronics, model M24FB-610A. Therefore, this plasma system is simple, compact and economical.

Gasification is a process that converts organic contains saturated or fossil based carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the

Material at high temperatures ($>700^{\circ}\text{C}$), without combustion, with a controlled amount of oxygen and/or steam. The resulting gas mixture is called SYNGAS (from synthesis gas or synthetic gas) or producer gas and is itself a fuel. The power derived from gasification of biomass and combustion of the resultant gas is considered to be a source of renewable energy, the gasification of fossil fuel derived materials such as plastic is not considered to be renewable energy.

Electromagnetic waves lie between the frequencies 300 KHz to 330MHz. These waves are the function of Sine or Cosine function having node and antinode. Basically, in microwave oven generally nodes do not participate in heating because of zero intensity. For making a homogeneous process of heating, we can modify the location of magnetron at different location in microwave oven. In old days, generally people used the conduction process for heating, good thermal conductive material give better output. In case of microwave oven magnetron produces electromagnetic waves having some intensity and wavelength which lies in to the range.

Having good thermal conductivity material gives better efficiency. It is differentiating that how the microwave works. However, it can be increase by using suceptor. Suceptor is a type of material which can increase by polishing the wall of the cavity or polished the waste material.

Analysis of the waste material is very important as it can further use for combustion.

Microwave oven is best example of wave guide, Wave guide give the direction of wave propagation.

.Closed system is required for proper wave propagation. Cut off frequency play major role for plasma generation.

It is made up of copper (Cu) because it has high thermal conductivity and very low thermal resistivity. Waveguide are basically converging in nature which increase the intensity the wave propagation. In this experiment, we will be able to know working system of microwave with wave guide and plasma generation.

Microwave are generally are Electromagnetic wave having Magnetic as well as electric field. Direction of electric filed lines and magnetic field are perpendicular to each other. Magnetic field situated at the surface of wave guide whereas electric field line are situated at the perpendicular of flow. Cut off frequency is that frequency on which wave is propagating Microwave as by monochromatic wave. Cut off frequency this term is a very important because its play a role of measuring the dimension of wave guide. It also tells that the direction and intensity of propagating wave.

Cut off frequency can be calculated by the formula,

$$\lambda_c = \frac{2}{\sqrt{(m/a)^2 + (n/b)^2}} = \frac{2}{\sqrt{(1/a)^2 + (0/b)^2}} = 2a$$

Where a and b are length respectively.



Figure.10 (Magnetron attach with wave guide)

Above figure wave guide is showing which is made up of conducting material because it has free electron which can allow to flow of heat. For making the wave guide resonate frequency play important role. For constructing wave guide convective heat transfer must flow in good level.

We have designed and constructed the simple microwave plasma source (MPS) at atmospheric pressure in laboratory scale. A 2.45 GHz magnetron tube from a commercial microwave oven was utilized as the microwave source. The MPS consists of magnetron tube and a tapered waveguide. The magnetron power supply for these systems was constructed. The measurement of the microwave power output was obtained by using calorimetric method. We can easily generate plasma at atmospheric pressure with argon as a plasma gas by using an auxiliary igniter. The plasma system is simple, compact and economical.

The wave guide used in the prototype of MPS is tapered or rectangular to effectively deliver microwave power into the simple torch region or any cavity. The experimental set-up block diagram of the MPS is shown in Fig.7. The power transferred in the rectangular tapered waveguide is calculated from the Pointing theorem or cut off frequency generation. The main product of the microwave plasma gasification is a low to medium calorific value syngas which

is a fuel gas, composed of carbon monoxide, hydrogen, methane, nitrogen and very often some carbon dioxide. This gas can be burned to produce heat which is either used for cooking food or with the help of syngas by burning it we can produce steam by boiling water and these steam is send to turbine blade for producing electricity which is one of the major problem of our country. Solid wastes from plasma gasification include a vitrified, glass-like, inert slag and small

volumes of other solids that come from cleaning of filters and disposal of chemicals collected in

the gas scrubbing process. In gasification process carbon dioxide (CO_2) can be split in to carbon mono oxide (CO) and then combined with hydrogen to form syngas. Microwave gasification is a process with the help of which we can produce carbon monoxide from carbon dioxide, produced syngas is cooled from about $1,200^\circ\text{C}$ to 200°C . The gasification of solid waste is investigated

using magnetron as source of microwave which is very helpful in creating plasma. Our main objective after the gasification of solid waste is to maximize the gas yield and to access its quality as a fuel and as a source of syngas. The amount of gas produced is 38% of H_2 and 66% for $\text{H}_2 + \text{CO}$.



Figure .11 (Combustion of wastage through microwave plasma.)



Figure .12 (Basic Experimental Setup In Lovely Professional University)

Magnetron is acting a source of microwave having frequency of 245MHz to 285Mhz. In our set up Magnetron is taken from DMO (Domestic Microwave). Power source is also using from DMO. It requires proper power set up for generating microwave. Basically magnetron is high- powered vacuum tube that works as self-excited microwave oscillator.

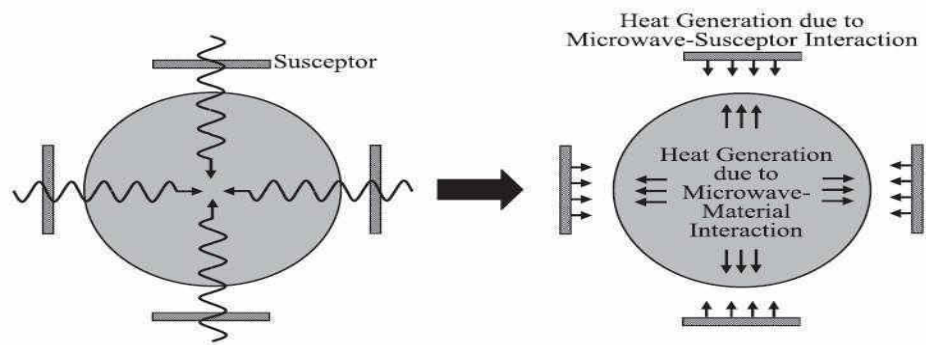


Figure. 13 (Differentiate between with susceptor and without susceptor)

In above figure there is unique technique are using for heating. We are using susceptor in this case which increases the heat generation in the chamber. But this method is not applicable for our method because we are generating the plasma in not in close chamber.

For the plasma generation hot medium is required for the ignition.

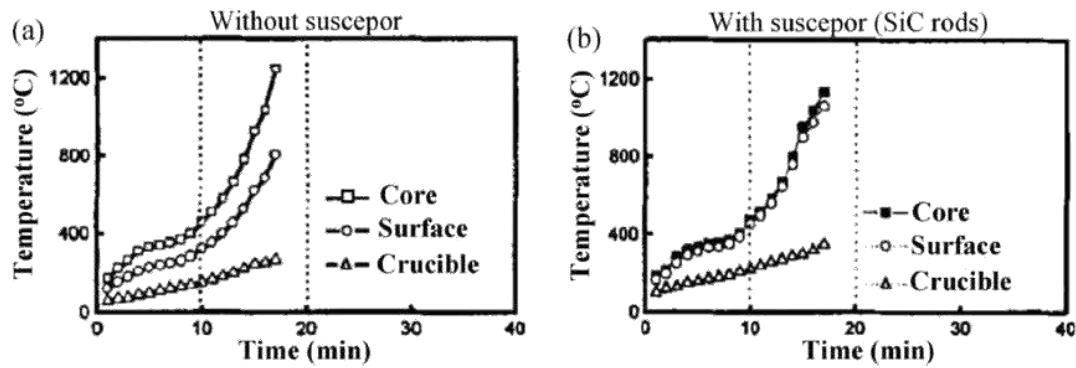


Figure .14 (Time variation and temperature change throughout the geometry)

In figure .It is clearly shown that by that that output increases after putting the susceptor.

In the susceptor assisted microwave processing of materials did the work with susceptor increases time temperature distribution in the graph.

Microwave heating is the also depend the material to material some of the factor we have to consider in that thing like metallic character of material. We are focusing on domestic waste which contains metal non-metal.

Based on the interactions with both the electric and magnetic fields, the resultant heat generation rate per unit volume of the material (Q_{MW}) can be written as

$$Q_{MW} = \underbrace{\pi f \epsilon_0 \epsilon_r'' |\mathbf{E}|^2}_{\text{Heating by Electric Field}} + \underbrace{\pi f \mu_0 \mu_r'' |\mathbf{H}|^2}_{\text{Heating by Magnetic Field}}$$

There are some different method to find out the power generation if we connect a water tank to our system then $Q = mC_p(T_f - T_i)$ can be applied to find out the total power generation.

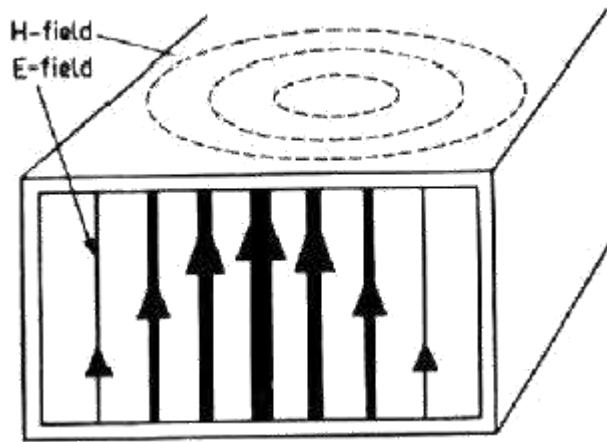


Figure .15 (Direction of magnetic and electric field for electromagnetic wave)

Above figure is showing the direction of electric and magnetic field which are perpendicular to each other. Movement of these lines can be computed by the Fleming left hand rule. Microwave is electromagnetic wave so direction give the result.

Our main purpose is to produce SYN gases from the domestic waste after that we will analyze the thermal properties of the sin gases. Domestic waste produces harmful gases. Through the plasma generation we can use grassfire these wastage and can produce gases which are combustible

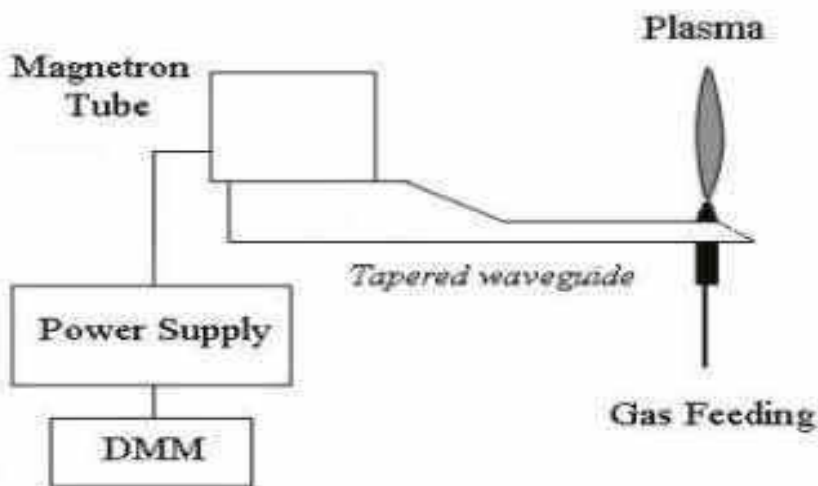


Figure .16 (Block Diagram for plasma generation)

In above figure is the schematic diagram for the plasma generation in which magnetron is directly attached with wave guide so that the waveguide plasma is generated. Gas feeding is used for ignition.

We collected the data of kitchen wastages from Madhusudan and Tanmay at al[1]. from this paper we able to know that the importance of kitchen wastages. To overcome with this issue we have tried to gasify the wastages so that we can use after the combustion.

In the previous we have already discuss our procedure of our project

There are two major global issues –

1. Solid waste management
2. with the help of produce SYNGAS, it is used for cooking purpose
3. SYN gas is also used for power generation of electricity

These problems can be solved by the plasma gasification up to some extent. Although some solution regarding the management of solid waste are in practice most popular techniques are

- (1):-Land filling
- (2):-Incineration
- (3):- Recycling biological reprocessing etc.

Land filling and incineration is the major used technique around the globe but these conventional techniques have some major disadvantages –

Land filling: - Kill surface vegetables, greenhouse gases like CO₂ and CH₄, Odor problem.

Incineration:- Emission of pollutant like dioxins

In India, about 54780 million tons of municipal solid waste and about 4200 million cubic metres of liquid waste are generated annually. Large quantities of solid and liquid wastes are generated by the industry and kitchen .Most of the generated wastes find their way into land and water bodies without proper treatment, causing severe water pollution. These also emit greenhouse gases like methane and carbon dioxide, adding to air pollution.

Municipal solid waste management (MSWM) is one of the major environmental problems of India cities. Improper management of municipal solid waste (MSW) cause hazard to inhabitants. Various studies reveal that about 90% of MSW is disposed of unscientifically in open dumps and landfills, creating problem to public health and environment. Various adopted treatment technologies for MSW are critically reviewed, along with their advantage and limitation.

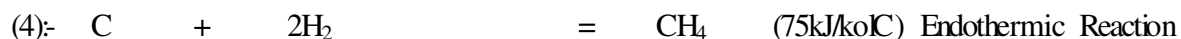
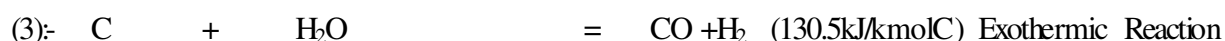
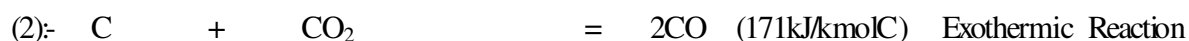
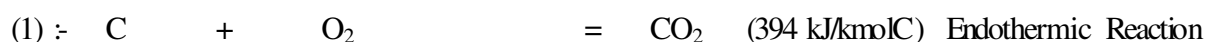
We want to analyze the thermal properties and chemical properties of domestic waste gasification by Microwave plasma generation.

CHAPTER 5 RESULTS & DISCUSSION

After performing the experiment, result comes out in terms of various parameter. This paper will conclude all the result and summarize by chart and graph. Mathematically and experimentally it is easy to identify the whole process.

5.1 Results procured after performing the experiment:-

After the combustion of any organic compound or any wastage which consisting the more number of carbon. The main component of any organic compound after the combustion is CO, CO₂, H₂, H₂O.



In endothermic reaction observer has to apply the heat externally so that all sigma bond should break and desired product formed.

Exothermic reaction produces the heat and basically these are very use full for the experiment Because it work as source of heat.

Saturated organic compound break easily and giving more output it required less heat input due to only sigma bonding.

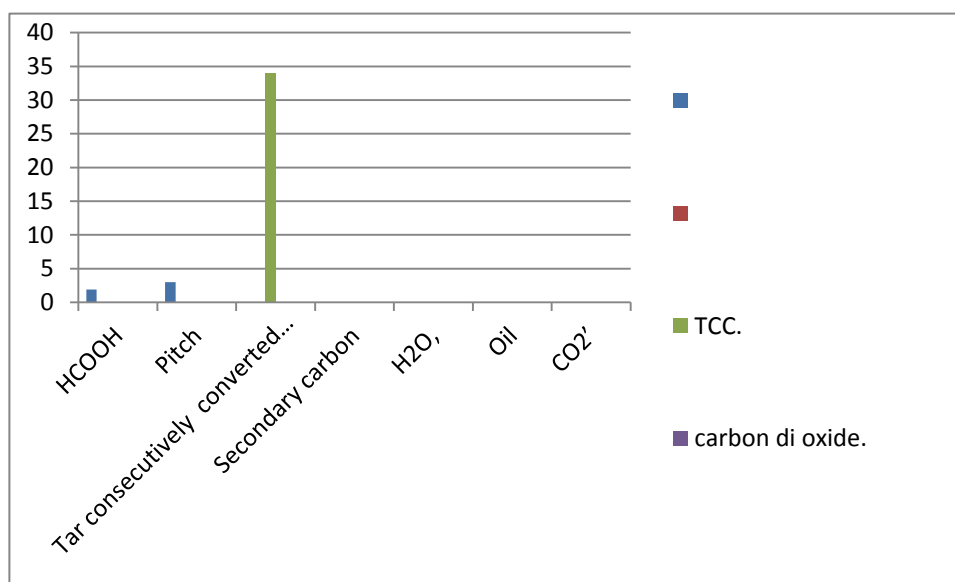
Unsaturated hydrocarbon or any resonating giving less output and also. It requires more heat because these compound are very stable.

5.1.1 Combustion of dry wooden piece having less content of water:-

Production distribution of 550 gram of wooden piece (% by weight) which is dry in the nature.

Percentage	Organic compound
21.8%	Primary carbon
15.8%	H ₂ O
6.5%	CO ₂
4.11%	CO
6.5%	CH ₂ COOH
2.6%	CH ₃ OH
1.9%	HCOOH
3-2%	Pitch
34%	Tar consecutively converted into
23%	Secondary carbon
07%	H ₂ O,
2.9%	Oil
4.2%	CO ₂ ,

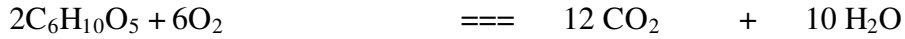
Table.1 (Content % of all elements in wooden piece)



5.1.2 Combustion of paper (Gases Distribution):-

After the combustion of paper same gases are produced as compared to wood only the percentage of organic compound is different.

Chemical equation is involved during the combustion in the paper.

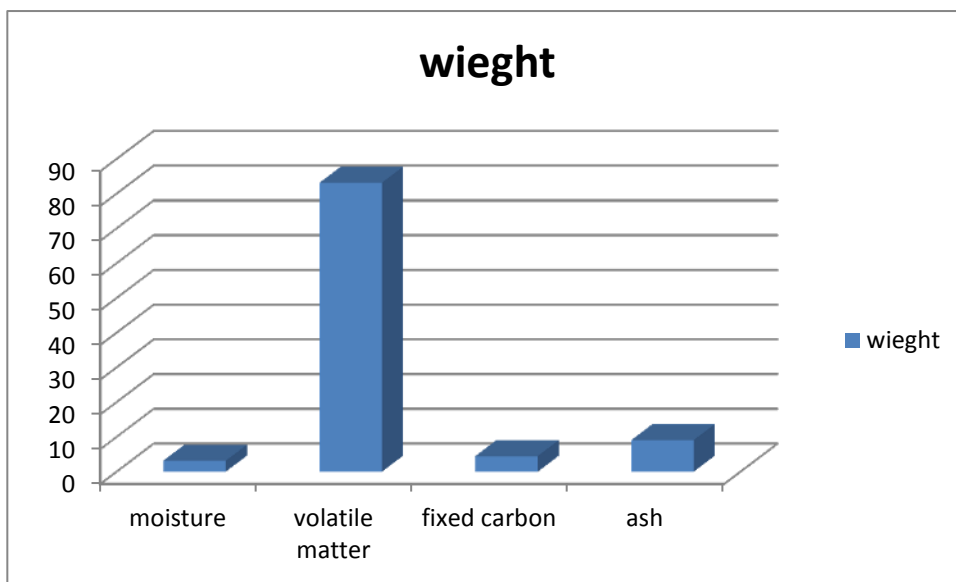


Proximate and ultimate analyses of waste paper and its character

Waste paper analysis by proximate method and by default method:-

Weight	Weight by percentage
Moisture	3.19
Volatile matter	83.15
Fixed Carbon	4.53
Ash	9.09

Table .2 (Waste paper analysis after the combustion)

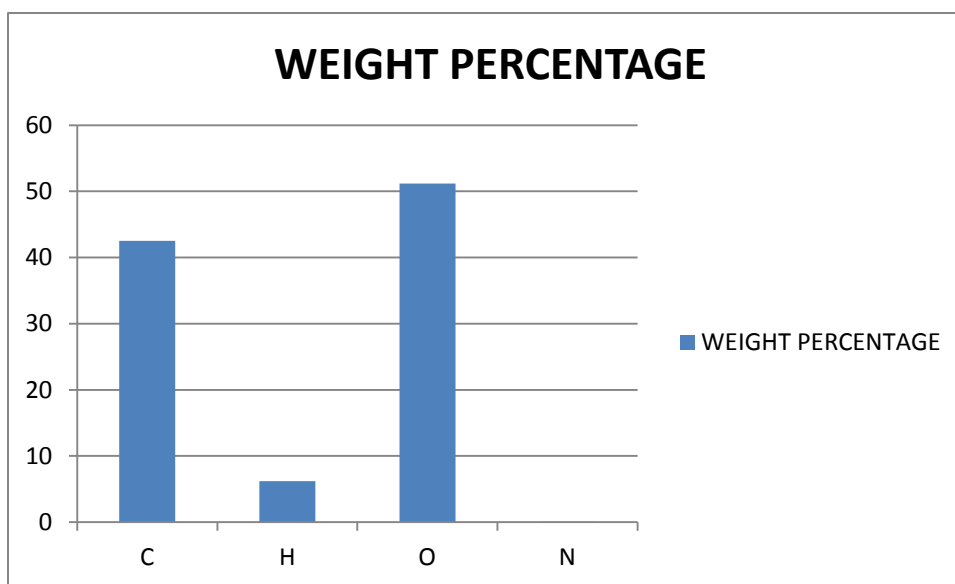


Weight percentage calculation by ultimate analysis:-

Element	Weight by percentage
C	42.52
H	6.21
O	51.16
N	0.07

HHV (High heating value) in the pyrolysis is 20.10 (MJ/Kg).

Table.3 (content of element by ultimate analysis)



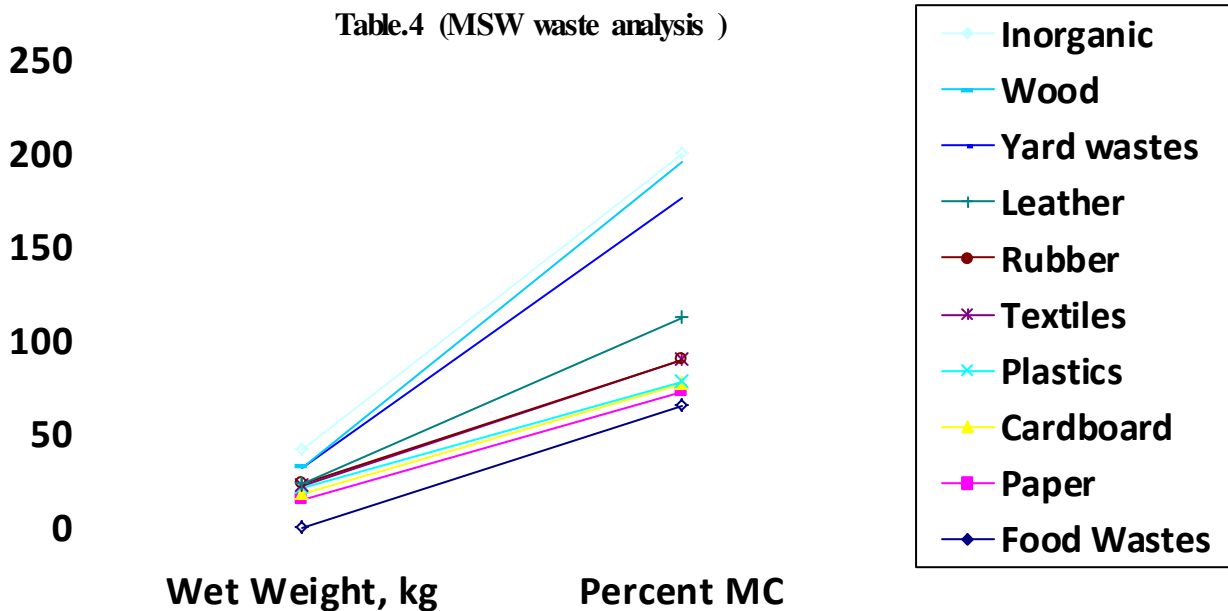
5.1.3 Combustion analysis of kitchen wastage and municipal solid wastage (MSW):-

After the combustion of kitchen wastage which are containing more number of water content. It is giving the different result. Municipal solid wastage consisting heavy metal as well as kitchen wastage also.

Here MSW analysis is given in tabular form.

Component	Wet Weight, kg	Percent MC
Food Wastes	4.08	68
Paper	14.96	8
Cardboard	3.17	4
Plastics	2.72	1
Textiles	1.36	11
Rubber	0.68	0
Leather	0.226	23
Yard wastes	7.9	63
Wood	0.90	19
Inorganic	9.29	4

Table.4 (MSW waste analysis)



5.2 Formula and method is used to find out the percentage of element and compound present in the wastage:-

There are two part in this experiment first calculation of heat generation from the microwave and second is to calculation of organic compound and their properties by proximate and analytical method.

5.2.1 Calculation of heat generation from the plasma:-

Heat can be calculated in two ways

(1):- Microwave is electromagnetic wave which have electric field and magnetic field then total energy can be calculated by the empirical formula that is known as Lorentz force formula.

$$F = F(\text{Electrical}) + F(\text{Magnetic})$$

= $Q \cdot E + QV \times B$ (If any dielectric medium is there then multiplication of ϵ_r must be required)

* ϵ_r :- Dielectric Medium

(2):- Heat calculation can be done by externally because temperature difference will be there due to the raising the temperature.

$$Q = m C_p (T_2 - T_1)$$

Example of doing proximate analysis :-

Concentration of substance = (no of mole/total volume occupied)

Number of mole = Weight /Molecular weight.

Take an example for Methane ,

Molecular weight for the methane is 16 (12+4*1)

Weight of Methane gas 32 gram

Number of moles can be calculated as = 16/32 = 0.5

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

6.1 Conclusion of whole Study:-

This is an alternative way which is giving the usefulness of the waste as a broad prospect. This experiment is also important because waste is used as fuel so it may be a revolutionary experiment in the field of pollution control.

After the combustion of wastes, plastic and all kinds of unwanted material they produce very harmful gases in the environment due to this atmosphere is polluting day by day. Main experiment is done to resolve this issue and giving a broad idea so that waste can be used at domestic level.

At present day pollution level is on peak and so much waste is produced by home.

Main objective of project to overcome the waste at domestic level.

This project is categorized for gasification by plasma only. Generally plasma generated for the gasification of waste which produces SYN gases and doing the analysis of that gas.

6.2 Experimental Scope of the experiment:-

Experimental setup is based on domestic level. Good scope is available in the industry and house level. From this experiment further modification is possible in terms of instrument which is given below.

1. Wave guide (Material change)
2. Inert gas supply (He or Xe)
3. Susceptor used (silica rod)
4. Big Cavity generation.

6.3 Future Scope of the project from this experiment:- This experiment is giving a clear cut idea to resolve the waste problem by domestic microwave.

Experimental setup can be manufactured and its cost is also very less. This experimental setup requires very less space.

Reason for using at domestic level is given below:-

1. Easy to use
2. Availability of domestic waste
3. It requires less space.
4. It consumes less energy.
5. Electrical energy is used as power source so it is easily found everywhere.

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