IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 5, April 2025
Impact Factor: 7.67

Incomplete Combustion Device

Shridatt Jadhav, Prathmesh Dekhane, Prathmesh Gurav, Dipak Katkar, Abhay Chavan
Prof. P. B. Kale, A.G Raut, Dr. M. S Yadav, Prof. M. R. Kamble
Department of Mechanical Engineering
JSPM's Bhivrabai Sawant, Polytechnic, Wagholi, Pune

Abstract: *Modern charcoal-making structures called Incomplete Combustion Devices are meant to effectively turn biomass into premium the charcoal while decreasing emissions and loss of energy. Inspired by conventional techniques yet improved with creative elements, this device guarantees controlled carbonization via a sealed drum, burner section, as well as airflow control systems. It reduces oxygen intake to allow pyrolysis, resulting in less moisture and ash content, denser, cleaner-burning***.**

Keywords: Incomplete Combustion Devices

I. INTRODUCTION

From ancient times if early people, Egyptians, as well as Greeks applied it for cooking, metalworking, and even mummification, charcoal manufacture has been vital for human civilization. Although frequently used, traditional techniques including brick and pit kilns were ineffective, generating too much smoke and pollution and difficult to control. Retort kilns, pyrolyzed machines, and contemporary environmentally friendly techniques that increase efficiency and lower emissions sprang from the development of charcoal-making technology.

A step forward in this development is the Incomplete Combustion Device, which effectively generates premium charcoal by combining modern engineering with conventional carbonizing methods. This system guarantees controlled combustion with minimum carbonization by including a carbonization drum, burner portion, oxygen outlet tubes, monitoring of temperatures tools, and exhaust system. For many thousands of years, the manufacture of charcoal has been an essential including methane into the CO, and wood vinegar. It runs eight times faster than traditional techniques, so increasing energy recovery and output. Applied in household fuel, metal smelting, and chemical sectors, this device encourages sustainable charcoal manufacture. Although regular maintenance is needed, its environmental advantages—such as lower smoke and improved combustion- outweigh the difficulties component of human civilization, serving as a key component in industrial processes, metallurgy, and cooking. To make charcoal, the earliest techniques, like pit kilns, consisted of placing wood beneath the ground and burning it gradually. The quality of charcoal was improved over time by techniques that developed into traditional kilns, such as kilns made of brick, the planet kilns, or Japanese Mechikisho ceramic kiln However, these kilns still had ineffectiveness like excessive smoke, environmental damage, and uneven carbonization.

Industrialization brought wood gasification methods and retort kilns in the latter half of the nineteenth century, which increased productivity while decreasing waste. However, optimizing energy recovery and reducing emissions were problems in even contemporary industrial charcoal production. Within the 21st century, environmentally friendly techniques for producing charcoal, such as pyrolysis machines and briquetting, were developed to address these problems. By combining modern technology with traditional knowledge, the Incomplete Combustion

II. LITERATURE REVIEW

Cooking is a significant source of indoor air pollution, contributing to particulate matter (PM) emissions and chemical exposure. Various cooking techniques release distinct pollutants, which can have implications for air quality and human health. This literature review focuses on two key references: Abdullahi et al. (2013) and Allais (2021), which provide insights into the emission characteristics and chemical transformations occurring during cooking. Emissions and Indoor Concentrations of Particulate Matter from Cooking

DOI: 10.48175/IJARSCT-25296

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 5, Issue 5, April 2025

Impact Factor: 7.67

Abdullahi, Delgado-Saborit, and Harrison (2013) conducted a comprehensive review of the emissions and indoor concentrations of particulate matter (PM) from cooking activities. Their study highlights that cooking generates significant amounts of PM, including fine (PM2.5) and ultrafine particles, which can penetrate deep into the respiratory system. The composition of these particles varies depending on the cooking method, fuel type, and ingredients used. Key findings from their review include:

Emission Sources: Cooking with solid fuels (e.g., wood, charcoal) releases higher concentrations of PM compared to gas and electric cooking. Frying, grilling, and roasting also contribute to elevated PM emissions. Chemical Composition: The PM emitted from cooking contains organic compounds such as polycyclic aromatic hydrocarbons (PAHs), aldehydes, and volatile organic compounds (VOCs), which are known to have adverse health effects.

Indoor Air Quality: Poor ventilation exacerbates the accumulation of cooking-related pollutants, leading to prolonged exposure and potential respiratory issues. Their findings emphasize the need for improved ventilation strategies and the adoption of cleaner cooking technologies to mitigate the health risks associated with indoor air pollution from cooking.

The Chemistry Behind Cooking on a Barbecue

Allais (2021) explores the chemical transformations that occur during barbecue cooking, as discussed in the Handbook of Molecular Gastronomy. The study delves into the scientific principles underlying flavor development and the formation of compounds during grilling. Key aspects covered include:

Maillard Reaction: A crucial chemical reaction responsible for the browning and flavor enhancement of grilled food. It involves the reaction between amino acids and reducing sugars under high temperatures.

Lipid Oxidation: The breakdown of fats during grilling leads to the formation of volatile compounds that contribute to aroma and taste.

Smoke Composition: The combustion of charcoal and wood generates smoke containing phenolic compounds, which enhance flavor but also introduce potential carcinogens.

This work underscores the complex interplay between chemistry and culinary techniques, highlighting both the benefits and risks associated with barbecue cooking.

Both references provide valuable insights into the environmental and chemical aspects of cooking. Abdullahi et al. (2013) focus on the air quality and health implications of cooking emissions, while Allais (2021) examines the molecular transformations that contribute to the sensory attributes of grilled food. Additionally, research on incomplete combustion devices highlights their detrimental effects on air quality, human health, and climate change, stressing the need for cleaner cooking technologies. Future studies should continue exploring innovations in clean cooking solutions to mitigate the environmental and health risks associated with traditional cooking methods.

By incorporating improved combustion technologies, alternative fuels, and effective policies, the transition toward sustainable cooking practices can be accelerated, benefiting both public health and the environment

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 5, April 2025
Impact Factor: 7.67

III. METHODOLOGY

Identification of Problem & Literature Review.

↓

Design a component and material selection.

↓

Preparation of 3D CAD model.

↓

Fabrication of the components.

↓

Assembly of the components.

↓

Testing of the project.

↓

Result and discussion

Working principle

It works on Lavoisier's Laws which state that, "It states that States that mass cannot be created or destroyed in a chemical reaction, only transformed. During carbonization, biomass undergoes pyrolysis, breaking down into gases, liquid by-products, and solid charcoal, without changing the total mass.

The diagram of Incomplete Combustion Device is shown in fig. Drum (Carbonization Chamber): - The main cylindrical body where biomass is placed for carbonization.

The carbonization system converts biomass into charcoal through a controlled heating process. Biomass is placed inside a heat- resistant drum, which is sealed to minimize oxygen entry.

A burner heats the drum externally, raising its temperature to 200-400°C. The temperature thermometer monitors internal heat levels, ensuring optimal conditions for carbonization.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 5, April 2025
Impact Factor: 7.67

The airflow control valve regulates oxygen supply, preventing excess combustion and improving efficiency. The pressure gauge monitors internal pressure to ensure safe operation.

After about 8 hours, the biomass fully converts into charcoal. The drum is then cooled gradually to prevent the charcoal from turning into ash. This process ensures efficient charcoal production with minimal emissions and controlled combustion.

Fig-Working of the model

Observation Table:

Material	Mass (kg)	Volume (m^3)	Density (kg/m^3)
Almond Leaves (Input)	200	1.111	180
Almond Leaf Ash	50	0.143	350
Lemon Leaves (Input)	200	1.000	200
Lemon Leaf Ash	45	0.129	350
Waste Material fuel	85	0.170	500

IV. CALCULATION

Given Data:

Input material: 100 kg coconut shells
Output: 40 kg biochar
Temperature: 500°C
Pressure: 70 bar
Time taken: 7 hours
Combustion chamber fuel: 85 kg of waste materi
Biochar Yield (%):

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 5, April 2025
Impact Factor: 7.67

$$biochar\ yield = \frac{output\ mass}{Input\ mass}\ x\,100$$

$$= \frac{40}{100}\ x100$$

$$= 40\ \%$$

Conversion Rate (kg/hr)

$$Conversion\ Rate = \frac{Input\ \ mass}{Time}\ x\,100 = \frac{100}{7}$$

$$= 14.29\ \text{kg/hr}$$

Biochar Production Rate (kg/hr):

Biochar Production Rate= 40/7

= 5.71 kg/hr

Heat Required Estimation (for pyrolysis):

5 kJ/kg.K

Assume starting temperature = 30°C Temperature difference = 500-30= 470°C

Q= mcΔT = 100 × 1.5 x 470 = 70, 500 k

Energy From Waste Combusted:

Assume average calorific value of waste material = 15 MJ/kg

Energy from combustion=85×15=1275 MJ

=1,275,000 k

Energy Efficiency (Ideal pyrolysis energy / supplied energy):

$$\text{Efficiency} = \frac{70{,}500}{1{,}275{,}000}\ x\,100$$

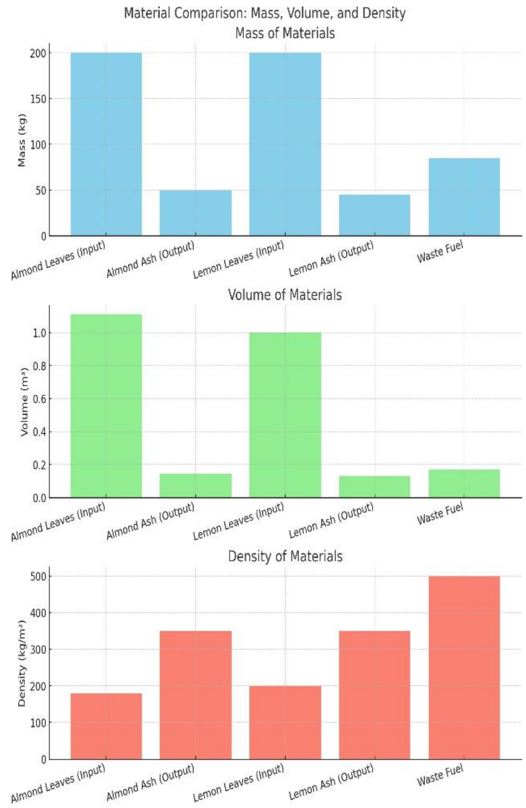
= 5.53%

Densities:

Material	Mass(kg)	Volume (m^3)	Density (kg/m^3)
Coconut Shell (input)	100	0.167	600
Biochar (output)	40	0.1	400
Waste Fuel	85	0.17	500

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 5, April 2025
Impact Factor: 7.67

Graph:



Result :

Material Type	Input Mass (kg)	Output Ash Mass (kg)	Yield (%)	Remarks
Almond Leaves	200	50	25%	High ash yield from dry almond biomass
Lemon Leaves	200	45	22.5%	Slightly lower ash yield than almond
Coconut Shell	100	40	40%	High charcoal yield due to dense shell carbon
Waste Fuel Used	85	-	-	Used to maintain combustion temperature

NOTE: The output of the system depends on the type and amount of waste material used as fuel. (In this experiment, 85 kg of waste provided the heat for pyrolysis. This directly affected the temperature, pressure, and biochar yield)

Temperature Gauge

"Ji" Japsin Instrumentation Temperature Gauge, Bimetal Dial Thermometer, 4" Dial, Range 0 to 600°C, 15" Long Stem, Direct Mounting Back Entry, 1/2" BSP (M) Connection,
SS Case & SS Wetted Parts

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 5, April 2025
Impact Factor: 7.67

Fig - Temperature Gauge

Pressure Gauge

"Ji" Japsin Instrumentation Pressure Gauge, 4" Dial, Range 0-10.6 kg/cm2 with Dual Scale of 150 PSI, Surface Mounting Bottom Entry, 3/8" BSP

(M) Connection, MS Case & Brass Internals

- Process Control

Fig- Pressure Gauge

360 degree wheel with brake

SM Sunni Mix 3Inch White PP Swivel Plate Caster Wheels 90kg 200lbs Trolley Cart, Environmentally Friendly and wear- Resistant - with Brake

Fig- 360 degree wheel with brake

IV. FUTURE SCOPE

Sustainable energy integration is a key area of focus. Hybrid heating systems using solar or biomass energy will reduce dependency on conventional fuels, making carbonization eco-friendlier and more cost-effective.

The expansion of biochar applications will drive further research and development. Enhanced charcoal quality can improve its use in agriculture, water purification, and even renewable energy storage solutions.
Emission control and waste heat recovery can significantly reduce environmental impact.
The future of carbonization technology lies in automation and smart control systems. Implementing IoT sensors, AI-based monitoring, and real-time feedback mechanisms will improve process efficiency, reduce manual intervention, and optimize fuel consumption.
Improved filtration systems and carbon capture techniques will help minimize greenhouse gas emissions and utilize waste heat for other industrial applications.
Government support and industry adoption will play a crucial role in the large-scale implementation of carbonization systems. Policies promoting clean energy, incentives for sustainable practices, and investment in research will accelerate advancements in this field.

V. CONCLUSION

Carbonization technology plays a vital role in sustainable energy production and waste management. By converting biomass into charcoal, it provides an efficient and eco-friendly alternative to conventional fuels while reducing environmental pollution.
The process also generates valuable by-products such as biochar, wood vinegar, and syngas, which have applications in agriculture, industry, and renewable energy.
Advancements in automation and smart monitoring are expected to enhance process control and efficiency. Integrating IoT, AI-based analysis, and automated feedback systems will reduce human intervention, optimize combustion conditions, and ensure consistent quality in charcoal production.
The adoption of hybrid heating systems using solar, biomass, and waste heat recovery methods will further improve energy efficiency. Such integrations will reduce dependency on fossil fuels, making the carbonization process more environmentally friendly and economically viable.
Additionally, emission control technologies, including carbon capture and filtration, will minimize the environmental impact of exhaust gases.
Expanding the utilization of biochar in soil conditioning, water purification, and energy storage presents new opportunities for the industry. As more research focuses on biochar's potential benefits, its applications will continue to grow, driving demand for advanced carbonization techniques

REFERENCES

[1]. Abdullahi, K.L., Delgado-Saborit, J.M., Harrison, R.M., 2013. Emissions and indoor concentrations of particulate matter and its specific chemical components from cooking: a review. Atmos. Environ. 71, 260–294
[2]. Badyda, A., Krawczyk, P., Bihałowicz, J.S., Bralewska,K. ,Rogula-Kozłowska, W., Majewski, G., Oberbek, P., Marciniak, A., Rogulski, M., 2020. Are BBQs significantly polluting air in Poland? A simple comparison of barbecues vs. domestic stoves and boilers emissions. Energies 13 (23), 6245
[3]. Disorders of Consciousness Published in Philip B. Gorelick, Fernando D. Testai, Graeme J. Hankey, Joanna M. Wardlaw, Hankey's Clinical Neurology, 2020 Rick Gill, Sean Ruland Carbon monoxide poisoning (Figure 4.20).
[4]. Investigations on the carcinogenic burden by air pollution in man. XIII. Assessment of the contribution of passenger cars to air pollution by carcinogenic polycylic hydrocarbons Zentralbl Bakteriol Orig B. 1975 Oct;161(2):10