iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: V Month of publication: May 2024

DOI: https://doi.org/10.22214/ijraset.2024.61899

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue V May 2024- Available at www.ijraset.com

Conversion of Plastic Waste into Fuel by Pyrolysis

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***Abstract*: Plastics have woven their way into our daily lives and now pose a tremendous threat to the environment. Over a 100 million tons of plastics are produced annually worldwide, and the used products have become a common feature at overflowing bins and landfills. Though work has been done to make futuristic biodegradable plastics, there have not been many conclusive steps towards cleaning up the existing problem. Here, the process of converting waste plastic into value added fuels is explained as a viable solution for recycling of plastics. Thus, two universal problems such as problems of waste plastic and problems of fuel shortage are being tackled simultaneously. In this study, plastic wastes (low density polyethylene) were used for the pyrolysis to get fuel oil that has the same physical properties as the fuels like petrol, diesel etc. Pyrolysis runs without oxygen and in high temperature of about 300°C which is why a reactor was fabricated to provide the required temperature for the reaction. The waste plastics are subjected to depolymerization, pyrolysis, thermal cracking and distillation to obtain different value-added fuels such as petrol, kerosene, and diesel, lube oil etc. Converting waste plastics into fuel hold great promise for both the environmental and economic scenarios. Thus, the process of converting plastics to fuel has now turned the problems into an opportunity to make wealth from waste.**
Keywords: Heat Transfer, Calorific Value, Flash Point, Fire Point, Carbon Residue

I. INTRODUCTION

A. Plastics

Plastic was invented in 1860, but have only been widely used in the last 30 years plastic are light, durable, modifiable and hygienic. Plastic is made of long chain of molecule called Polymers. Polymers are made when naturally occurring substance such as crude oil or petroleum are transformed into other substance with completely different properties. These polymers can then be made into granules, powders and liquids, becoming raw materials for plastic products.

Plastics have become an indispensable part in today's world. Due to their light weight, durability. Energy efficiency, coupled with faster rate of production and design flexibility, these plastics are employed in entire gamut of industrial and domestic areas. Plastics are produced from petroleum derivate and are composed primarily of hydrocarbons but also contain additives such as antioxidants, colorants and other stabilizers. Disposal of the waste plastics poses a great hazard to the environment and effective method has not been implemented. Plastics are non-biodegradable polymers mostly containing carbon, hydrogen, and few other elements like nitrogen. Due to its non-biodegradable nature, the plastic waste contributes significantly to the problem of waste management. According nationwide survey which was conducted in the year 2000, approximately 6000 tons of plastic were generated in India, and only 60% of it was recycled, the balance of 40% could not be disposed of. Today about 129 million tons of plastics are produced annually all over the world, out of which 77 million tons produced from petroleum.

India alone, the demand for the plastics is about 8 million tons per year, more than 10,000 metric tons per day plastics are produced in India and almost the same amount is imported by India from other countries. The per capita consumption of plastics in India is about 3kg when compared to 30kg to 40kg in the developed countries. Most of these come from packaging and food industries. Most of the plastics are recycled and sometimes they are not done so due to lack of sufficient market valve. Of the waste plastics not recycled about 43% is polyethylene, with most of them in containers and packaging. The term "plastic" covers a wide range of synthetic polymer materials. What they have in common is that they are all made by joining together or "polymerizing" a bunch of molecules (monomers). There are two main families of plastics, thermosetting and thermoplastics.

B. Types of Plastics

The types of the waste plastics are LDPE, HDPE, PP, PS, and PVC [10]. The problems of waste plastics can't be solved by land filling or incineration, because the safety deposits are expensive and incineration stimulates the growing emission of harmful greenhouse gases like CO2, NO2, SO2 and etc. These types of disposals of the waste plastics release toxic gas which has negative impact on environment.

Plastic wastes can also classify as industrial and municipal plastic wastes According to their origins, these groups have different qualities and properties and are subjected to different management strategies. Plastic wastes represent a considerable part of municipal wastes furthermore huge amounts of plastic waste arise as a byproduct or faulty product in industry and agriculture. The total plastic waste, over 78% weight of this total corresponds to thermoplastics and the remaining to thermosets. Thermoplastics are composed of polyolefin such as polyethylene. Polypropylene, polystyrene and polyvinyl chloride and can be recycled. On the other hand, thermosets mainly include epoxy resins and polyurethanes and
cannot be recycled.

II. LITERATURE REVIEW

The recovery and recycling of plastic waste disposed of in landfill has been the subject of much effort over the decades, as it is seen as a valuable resource and is high in the public's perception of what ‘waste’ is. Progress has been made in the mechanical recycling of post commercial, industrial and pre-sorted post-consumer waste, but the recovery of value from low-grade mixed plastic waste has always presented technical and economic difficulties. The conversion of plastic into oil products requires the long polymer chains that are characteristic of plastics to be broken into shorter chains typical of compounds present in crude petroleum. This depolymerization can be achieved by heating the materials to moderate or high temperatures, and elite catalysts (such as those frequently used in oil refineries) are helpful in increasing the rate of depolymerisation. The basic processes of depolymerisation are pyrolysis, gasification and thermal cracking. All of these processes have been in use in the coal, gas and petroleum refining industries for decades, and as such can be considered to be mature technologies. The use of plastic as a feedstock for these processes has been studied for 20 years, but its uptake has been limited by the relatively low price of oil and the lack of a credible collection infrastructure for this low-density, disperse-source feedstock. During the 1990s a series of demonstration plants were announced, only to disappear after a few years' operation. It is interesting to note that the majority of technology suppliers reported by Juniper in 2013 are no longer active in this field, having run out of money or sold the technology to organizations with access to the funds to continue process and project development.

The recognition that waste plastic is a valuable resource has also energized research and development activity in China and India. In Europe, the greater incentives for energy and fuel production from renewable ('biogenic') feedstock materials have meant that research programs in Europe are concentrating on the conversion of biomass, although the technologies and principles could be adapted for processing waste plastic. 7A literature review of process options and technologies for converting waste plastics to oil products was conducted. This was executed by Internet research directed at key websites, including those of universities, technology providers, industry associations and research bodies, as well as more general web searches. Studies by Agued et al,4 Schiers and Kaminsky.5 and the United Nations Environment Programme (UNEP) 6 indicated that four basic technologies were being offered as commercial plastic-to-oil-product processes in 2000: fast pyrolysis to produce a synthetic crude oil: liquid phase catalytic depolymerisation to produce a synthetic diesel grade fuel; gasification and Fischer-Tropic synthesis to produce a synthetic diesel grade fuel; and gasification and fermentation to produce fuel-grade ethanol.

III. PRODUCTION OF CRUDE OIL

A. Converting Waste Plastic into Liquid Fuel

Many may not realize throwing away plastic is throwing away a ready fuel source. Plastic is primarily petroleum and burns with high efficiency. Plastics are commonly made from fossil fuels which is usually an irreversible process, process have been developed which recycles plastic waste back into oil. Thermo Fuel technology is used to convert Waste Plastic into Liquid Fuel. Thermo Fuel is a ten-year-old commercially proven technology with nine operational plants in Japan. Thermo fuel is a process where scrap and waste plastics are converted into synthetic fuel. The system uses liquefaction, pyrolysis and the catalytic breakdown of plastics. The system can Handle almost all the plastic that is currently being sent to landfills. A major advantage of the process is its ability to handle unsorted, unwashed plastic and its extremely high efficiency. A Thermo Fuel plant can produce up to 9,500 litres of high-grade synthetic fuel from 10 tons of waste plastics, with systems ranging from 10 to 20 tons per day. This means that heavily contaminated plastics can be processed without difficulty.

B. Working Process

The working process includes heating the reactor, noting the temperature readings, condensing the vapours and collection of plastic oil. We initially heated the reactor bottom for first 40 minutes by sealing the reactor and fixing the pressure bar (200kg/cm³ capacity), thermocouple probe and valve is made to OFF position.

And the temperature reading is noted as 150°C, at this temperature all the plastic is turns into vapours and starts to escape out with high pressure. We put ON the valve at 150°C and left with heat supply. The vapours started coming out and started gas molecules bubbling inside the water container. Finally, we got a pale-yellow coloured oil with a petroleum odour smell between the temperature ranges of (160°C to 220°C).by continuing the heat supply of 1 hr. 30 min hours all the temperatures are noted by the digital Exhaust Gas Temperature Pyrometer. Finally, a thermo fuel is obtained with a pale-yellow colour in a span of 1hours 45 minutes continuous heat supply. We finally come to know that the plastic is decomposed and the fuel collection is stopped by the time when the temperature starts gradually decreasing. And finally, we have collected 1165 ml of plastic oil approximately by using 1.6 kg of polystyrene plastic waste.


Fig.1.Reactor setup


Fig.2.Condensation process


Fig.3.Oil collection

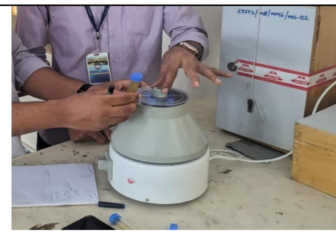
Fig.4.Centrifugation

Table -1 Oil obtained according to temperature

SI. No.	TIME (min.)	TEMPERATURE (°C)	FUEL (ml)
1	0	35	-
2	15	60	-
3	30	101	-
4	45	151	150
5	60	196	355
6	75	241	760
7	90	281	980
8	105	321	1165

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ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue V May 2024- Available at www.ijraset.com

- At the temperature of 106 ºC the plastics start vaporization.
- At the temperature of 120 ºC the plastic starts collecting the crude oil in collecting tank.

Graphs obtained

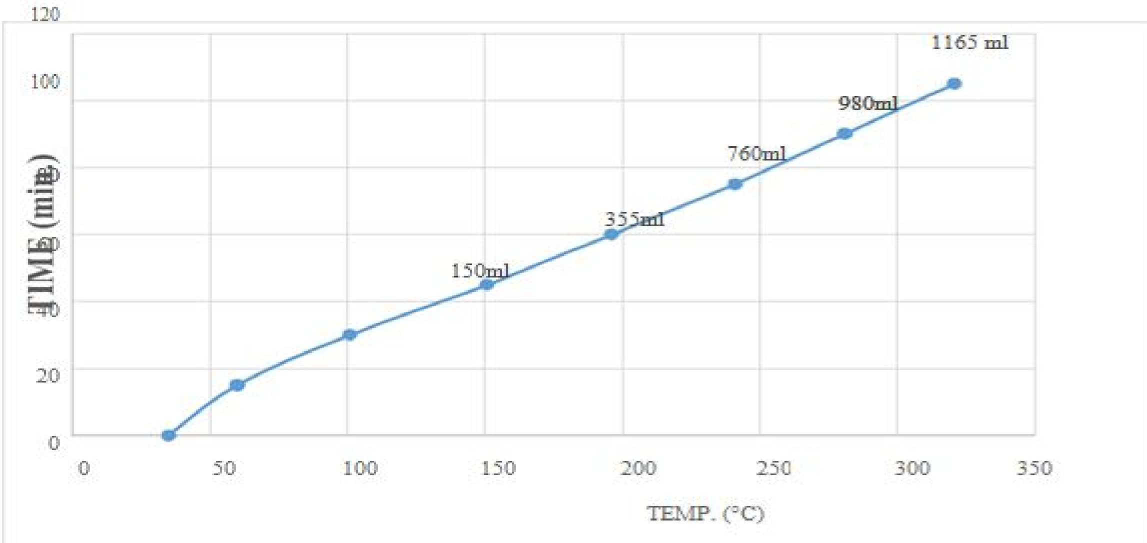
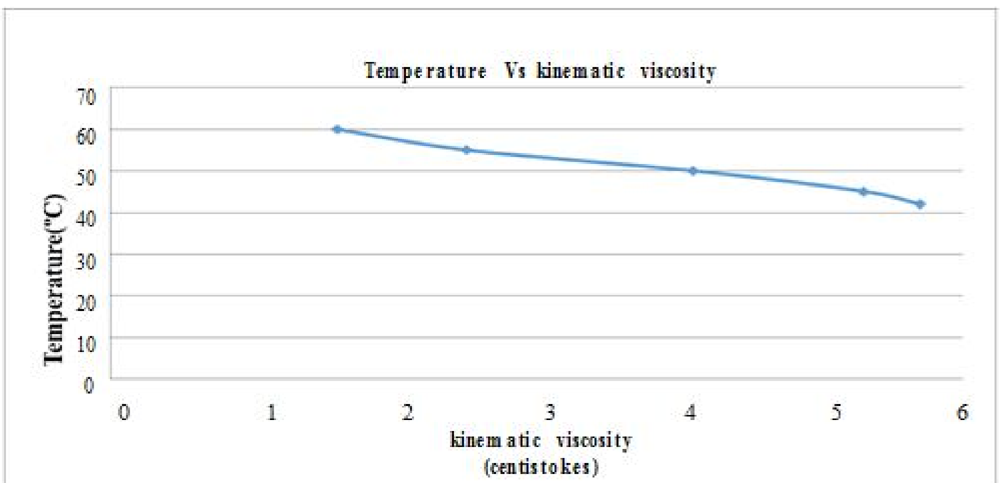
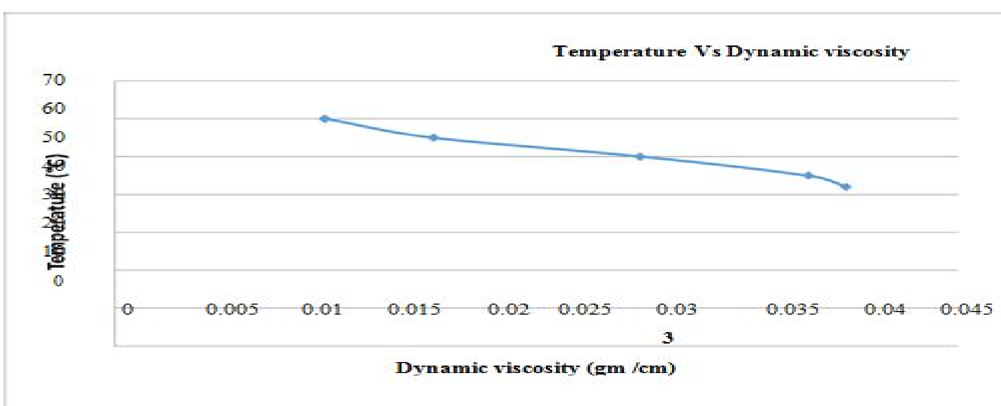


Fig.5. Time (Vs) Temperature





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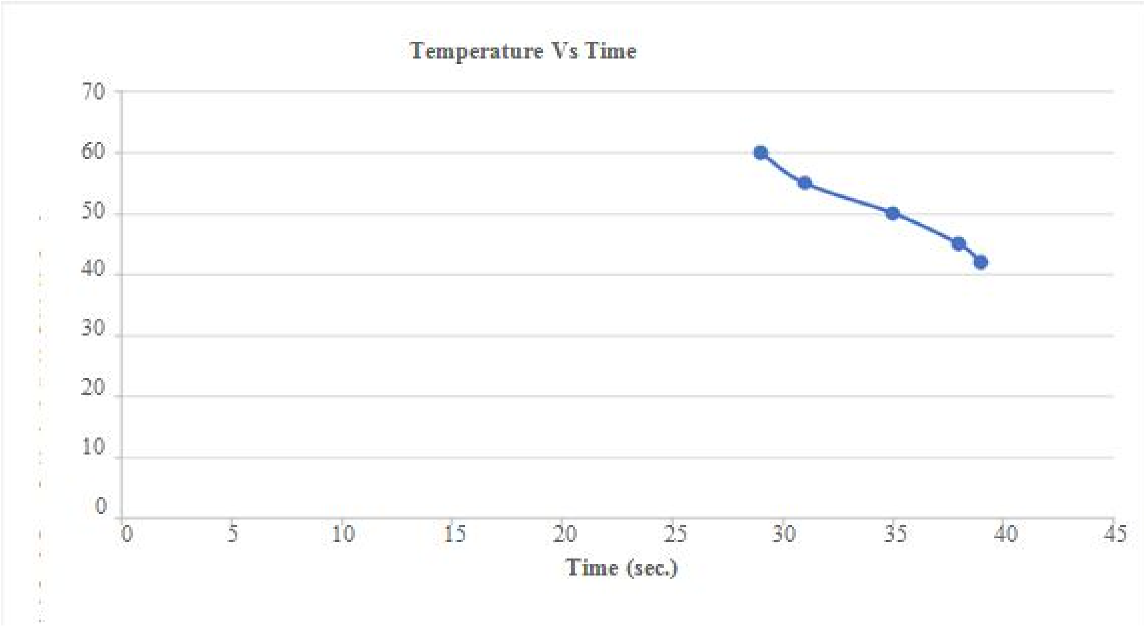

IV. RESULT

We got Kinematic Viscosity = 3.84 Centistokes
Dynamic Viscosity = 0.026 gm/cm^3
flash point at **45ºc** and fire point at **48ºc**
Carbon Residue = 0.38%
Calorific value = 44 MJ\Kg

V. CONCLUSION

We conclude that Thermo Fuel is a truly sustainable waste solution, diverting plastic waste from landfills, utilizing the embodied energy content of plastics and producing a highly usable commodity. The Thermo fuel system converts these waste plastics into high-grade "green" distillate fuel. The result of this process is claimed to be a virtually non-polluting. (100%) synthetic fuel that does not require engine modification for maximum efficiency. Post-consumer, post-industrial unwashed and unsorted waste plastics are the feedstock for the Thermo fuel process, and with an expected production efficiency of over 93%, the resultant diesel output would almost equal the waste material input.

The cost for fuel is increasing day by day and also the problem arising due to improper waste disposal of plastics are increasing in our country. This plastics to fuel process can solve both these problems in the most efficient manner.

VI. ACKNOWLWDGEMENT

We hereby express our sincere gratitude to the Management of Christu Jyothi Institute of Technology & Science for their kind encouragement bestowed upon us to do this project.

We earnestly take the responsibility to acknowledge the following distinguished personalities who graciously allowed our project work successfully.

We express our sincere thanks to our director Rev.Fr. D. Vijaya Paul Reddy, and Principal Dr. S. Chandrashekhar Reddy. for their encouragement, which motivated us to strive hard to excel in our discipline of engineering.

We greatly indebted to the Associate professor and Head of the Department Mr. P. Karunakar, for his motivation and guidance through the course of this project work. He has been responsible for providing us with lot of splendid opportunities, which shaped our career. His advice ideas and constant support has engaged us on and helped us get through in difficult time.

We express our profound sense of gratitude to our guide, Dr. K. Yakoob Associate Professor for providing generous assistance, and spending many hours of valuable time with us. His excellent guidance has made the timely completion of this Major project.

Finally, yet importantly, we express our gratitude to the Faculty and Lab Technicians of the Department of Mechanical Engineering for continuous support in technical Assistance.

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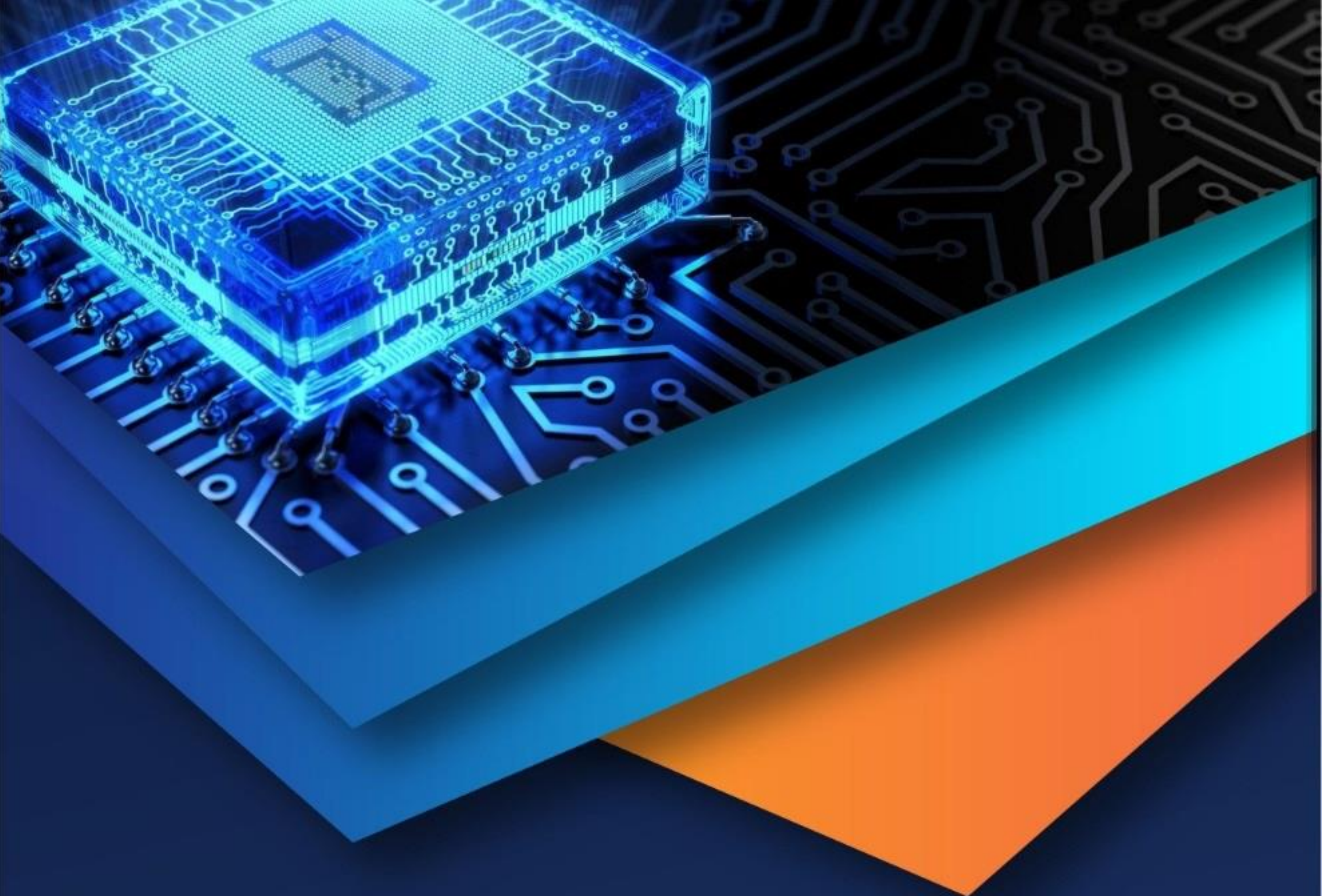

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