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Hazard Analysis and Risk Assessment of Biomass Power Station with Safety Control Measures

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Abstract: ***The Biomass is the electricity generation unit and is developed from organic material and renewable and sustainable source of energy. It is used to create the electricity or the other form of power. It is carbon neutral electricity and generated from the renewable organic waste that would otherwise be dumped in the landfills, openly burned and left as fodder for the forest fire. In biomass power station, the wood waste and other waste is burned to produce steam that run a turbine to generated the electricity and provides heat to homes and industries. The main aim of hazard analysis and risk assessment in Biomass power station is to analysis and identified the physical, chemical and biological and environmental hazard and calculate the consequence and the frequency of the hazardous event. The risk level is also help and analysing the hazard and the required safety control to minimize the risk and eliminate the Hazards.***

Keywords: Biomass, Hazard analysis, Risk matrix, Severity Rate, Frequency Rate.

I. INTRODUCTION

The biomass is plant or animal materials used as a fuel to produce heat and electricity. For example, energy crops and waste from the forest, farm and yard. The biomass is also used to produce fibers and chemical industries. Based on the sources of biomass, the bio fuel is classified broadly into three major categories: First-generation biofuels are derived from food sources, such as sugarcane and corn starch. Sugars present in this biomass are fermented to produce bioethanol, an alcohol fuel which serve as an additive to gasoline, or in a fuel cell to produce electricity. This paper highlight report on HIRA applied Biomass power station it involving the methodological steps to identifying the hazards related to the operation and condition and material. It assesses the risk level with risk matrix of hazards and apply the safety control and the corrective action to minimize the level of risk. The hazard identification and risk assessment are to developed a Comprehensive source of events and risks. The hazard identification is the process of defining and describing a hazard, including its magnitude and severity, physical characteristic, causative factor, frequency and probability and location and area affected.

II. SYSTEM DOMAIN

The Biomass encompasses a variety of material that includes agricultural residues, wood and both animal and human waste. These materials can be used for heating buildings and to a lesser extent for producing power or a combination of heat and power. With biomass systems there needs to be more operator interaction than with other forms of renewable energy such as with solar or wind. Operators of biomass systems will have to order and/ or deliver fuel, remove ash, and maintain all the moving parts. While this seems like it may be a lot of maintenance it actuality requires no more than a few minutes a day plus a few hours per year for an annual inspection and cleaning. This small amount of extra care may turn some people off to the idea of a biomass system versus a solar or wind option; however, unlike its clean energy counterpart's biomass systems have the great advantage of dispatch ability. This means that the system is controllable and provides heating when it is needed. The one big disadvantage to this is that fuel needs to be purchased, delivered, and stored. Additionally, biomass combustion produces emissions that have to be monitored to ensure that they comply with government regulations.

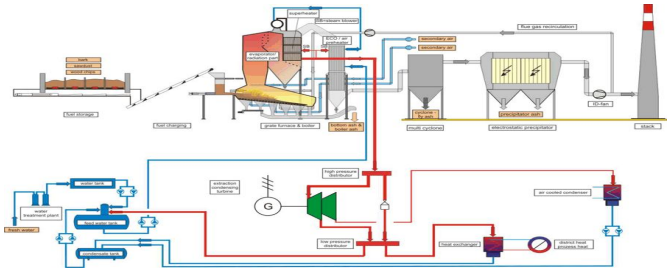

Fig:1 Biomass Power Station

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Biomass systems typically use direct combustion to produce heat. In this type of combustion, the biomass is burned to produce hot gas which then is either used to directly heat the building or fed into a boiler to create hot water or steam. In the boiler system the steam can be used to transfer the heat to the building. There are several key components to a biomass system which include the following:

1) Fuel storage and handling or conveying.
2) Demineralized water plant
3) Boiler
4) Switchyard & Transformer
5) Pumps House
6) Turbine and generator
7) Cable gallery
8) System controls
9) Automatic ash handling
10) Backup boiler
11) Heat distribution system

III.PROBLEM FORMULATION

The Biomass power plant consist of several hazard and risk in the various part of the plant and its operational processes. This may cause harm to property, people and environment. Those hazards are for example "biomass dust and explosion" in the biomass storage area and biomass mill where the fine particles of biomass present may occur when the concentration of coal and biomass are within the explosive range. It can also occur in the plant where the biomass and coal dust collector are present due to failure and low efficiency of the collector system.

The other most hazardous area of the cogeneration power plant is boiler room which include boiler tank, furnace, steam and water tubes and exists for by product of biomass combustion operation like suspended ash, flue gases and fly ash. In the boiler room there are several risks of fire and explosion may cause due to the improper ignition of fuel, cracks and metal fatigue in boiler body, over pressure and over temperature, lack of air supply in the combustion chamber, improper pulverized biomass material, and the periodical inspection of the boiler is done as per "The Indian Boiler Act" but due to some sudden occurrence of hazardous event may occur.

The flue gas of the by-product of the combustion in the furnace. They produce high pollutants like NOx, CO2, Sox and the fumes of the heavy metals like Mercury (Hg), Arsenic (Ar), Boron (B). When this fume emits in excess amount in the atmosphere from the permissible limits, they can cause hazard to flora and fauna. In power plant they use various type of fuel used to generate electricity like coal, biomass, wood waste, diesel fuel, oil, propane and natural gas but in coal ash which is the largest quantity of by product from process of power plant. It can be released in the two form, first fly ash and the second is the suspended ash on the bad of the furnace.

They are the pollutants for soil, air and water. They increase their minerals level and change its pH level made them alkaline. These by product can use for the several other industries but generated quantity is far more than the utilization quantity and the improper storage can introduce these by product to the environment.

And there are the several other hazards which can be listed to analysed for reduction are thermal exposure, electrocution, chemical exposure hazard, physical hazard, chronic and health hazards, noise in turbine room and other. So, in the power plant we are analysing that there are several problems in the plant and we found out that although the various safety measures are already existed in the power plant which limited the risk on the certain level but there needs to find out some addition safety measures to reduce the risk to further level.

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IV. METHODOLOGY

The Hazard analysis and risk assessment is a tool that can be used to assess which hazards pose the greatest risk in terms of how likely they are to occur and how great their potential impact may be. It is not intended to be used as a prediction tool to determine which hazard will cause the next generation. There are four steps to create and maintain a HIRA:

Fig: 2 The HIRA process

1) *Hazard Identification:* In this step the hazard that could impact your community are separated from those that cannot. This requires a review of all hazards and their causes to determine whether they may be threat to your community. This may require the consultation of the scientific community, historical records and government agencies.
2) *Risk Assessment:* In this step the level of risk for each hazard is examined. This may involve speaking with hazard experts, researching past occurrences and possible scenarios.
3) *Risk Analysis:* The information collected in this risk assessment step will be analyzed in this step. The desired outcome of the risk analysis is the ranking of the hazards.
4) *Monitor and Review:* It is important to remember that HIRA is an ongoing process and hazards and their associated risks must be monitored and reviewed.

V. RESULT AND DISCUSSION

In Cogeneration power plant and because of very nature of the operation, method and procedure and complexity of the system. They always involve some amount of the hazards. The hazard identification and risk assessment is carried for the identification of the undesirable event that can lead to the hazards and the analysis of the hazard mechanism and by which this undesirable event could occur and usually the estimation of extent, likelihood and magnitude of the harmful effects.

As the part of the project work, the hazard identification and risk assessment were carried out for a Cogeneration power plant and the hazard were identified and the risk assessment was carried out. The various type of activities was divided into low, medium and high depending upon on their likelihood and consequences. It is presented in chapter no. 5. The high and dangerous activities have been rated ‘C’ and ‘D’ are un-accepted and it must be reduced. And the risk which are rated “B” are the tolerable but the efforts must be made to reduce the risk and the risk which are to be rated “A” have the risk level is so low that is not to be required for taking any action to be reduced its magnitude any further and risk raring calculation was carried out by qualitative methods is mentioned in the table.

During my project training period there are number of points was observed on various aspects of In-plant Safety Inspection. So, some of these findings are statutory and non-statutory. The expected outcomes are given for all the necessary findings where there is noncompliance. The recommendations are entirely based on my knowledge possessed during the industrial safety course.

Table 1: Risk Classification Table:

S. NO.	Hazard Description	Initiating Event Likelihood	Unmitigated Consequences		Risk Class
			Life Safety	Property Damage	
1.	Boiler Hazard				
a.	Burn injury due to hot water and hot steam pipeline leakage	3	3	3	B
b.	Slip, trip and from the height during routine work, maintenance or inspection	4	4	2	B
c.	Boiler explosion due to improper combustion of fuel.	1	4	4	C
d.	Diesel supply line fire	3	3	3	B
e.	Catches in moving part of the machinery like F.D. fans or motors	3	2	1	A
f.	Exposure in machineries and hot surface of the pipelines	3	1	-	A
g.	Burn on hot fly ash	4	1	-	A
h.	Burst of the equipment body due to over pressure and over temperature	3	1	4	A
i.	Water tube burst due to Failure in boiler water level control	2	-	4	C
j.	Exposure to the hot surface of pipeline or machineries.	3	1	-	A
2.	Biomass Handling Plant Hazard				
a.	Struck by falling objects	4	2	1	B
b.	Transport line accident	4	2	1	A
c.	Respiratory problem due to the biomass dust	3	3	-	B
d.	Fall from height during the work on conveyor control room and conveyor belt	3	4	-	C
e.	Catches on the conveyor belt	2	2	2	B
f.	Slip & trip injury during handling	4	1	-	A
g.	Fire in Biomass storage	2	1	2	B
3.	D.M. Plant Hazard				

a.	Chemical burn by the spillage of sulphuric acid and caustic soda during unloading and damage on storage tank or the pipelines.	4	3	2	A
b.	Fire hazard	2	3	3	B
c.	High noise level	1	3	-	A
4.	Switch Yard Hazard				
a.	Electric burn and electric shock, routine work, maintenance and inspection of electrical panels in switch yard.	5	4	1	B
b.	Maintenance on switch yard on working on height during routine work and slip, trip hazard	4	4	1	B
c.	Fire on transformer	3	-	4	C
5.	Turbine and Generator hazard				
a.	Damage on generator due to the lack of lubrication in the coupling shaft	2	1	4	A
b.	Fire and explosion in hydrogen tank	2	5	4	D
c.	Fire on cooling oil	3	3	3	B
d.	High noise level	1	3	-	B
c.	Explosion in turbine cue to the cooling system failure	1	4	5	C
6.	Other Hazard				
a.	Respiratory problem and eye irritation from the exposure of the ammonia leakage from the pipeline and storage tank	4	1	-	A
b.	Fire on ammonia storage tank	2	4	4	C
c.	Fire hazard in control room	2	1	3	A
d.	Fire hazard on fuel storage tank	2	4	4	C

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VI. SAFETY CONTROL MEASURES OF HAZARDS

Table 2: Risk reduction in Boiler

Hazards assessed	Risk reduction actions & recommendation
Boiler explosion due to the temperature and over pressure	To control overpressure explosion in boiler maintenance of faulty parts and equipment which can cause overpressure and monitoring of overpressure indicator.
Exposure to the machineries and pipeline and the hot surface	Regular maintenance and inspection
Slip, Trip and fall from height during inspection and maintenance and routine work.	Proper supervision, PPE's and proper training
Burn by hot fly ash	Proper exhaust and maintenance
Burst of the equipment body due to the over temperature and over pressure	Regular maintenance and inspection
Catches on machineries moving part like motors and F.D. fans	Proper fencing on the moving part of the turbine
Water tube burst due to the failure in the boiler and water level control	Continuous maintenance and monitoring
Boiler explosion due to the improper combustion of fuel	Regular maintenance and inspection
Leakage in pipelines	As soon as intimation is received about any leakage and fire. All the task forces will come in to a action specially maintenance and fire task force who will explore the possibility of isolation the pipelines to prevent further aggravation CO2 fire extinguisher and DCP extinguisher will be used to extinguish the fire. Preventive maintenance: Preventive maintenance is taken annual overhauling in every year for all boilers, generator, turbines and their equipment auxiliaries, gas pipelines, measuring instrument and steam.

Table 3: Risk reduction in turbine and generator

Hazards assessed	Risk reduction actions and recommendation
Fire on cooling oil	Proper isolation and proper storage from the ignition sources
Explosion in turbine due to the cooling system and failure	Regular maintenance and inspection.
High noise level	Ear muff and ear plug should be provided
Damage on generator dur to the lack of lubrication in the coupling shaft	Regular maintenance and inspection.
Fire and explosion on hydrogen tank	Proper isolation and proper storage from the ignition sources

Table 4: Risk reduction in Coal and Biomass handling plant

Hazards assessed	Risk reduction action and recommendation
Injury during coal handling like slip and trip	PPE's like Safety helmet, Safety shoes, Dust mask, Googles, and hand gloves
Coal dust explosion in coal conveyor bunker	Spark proof electrical equipment and proper ventilation for keeping the coal dust composition low.
Catches on conveyor belt	Safety guard on the moving part of conveyer belts and other electrically operated machineries.
Transport line accident	Proper speed limit on plant area for the transport vehicles
Struck by falling object	Safety net should be placed where continuous threat of falling objects and safety helmet
Fire in coal storage	Regular inspection of the storage area for the suspected ignition point and condition that may cause fire, isolation form the ignition sources like direct fire and electric spark and direct fire.
Injury during the maintenance on ball mills	Training in safe procedure of changing grinding wheel, PPE's wear by the maintenance worker and proper supervision of experienced worker

Table 5: Risk reduction in D.M. plant:

Hazards assessed	Risk reduction action and recommendation
Fire hazard	Extinguish the fire by extinguisher from the initial level of fire and eliminate the possible ignition source from near the flammable material.
High noise level	Ear plug and ear muff should be provided to the worker and sound proof cabinet made to isolate them to the continuous noise.
Chemical burn by the spillage of sulphuric acid and caustic soda during the unloading and overflow, Damage on storage tank or pipe lines.	Wash rinse exposed area, proper supervision, training maintenance etc.
Electric motor short circuit and fire	The fire and the short circuit can be handled by using suitable fire extinguisher provided near by the task force will come in to the action and if incident is major. The electrical maintenance team will take care of motor isolation and other basic requirement. Any explosion and fire will be intimated to the emergency control centre and the task force will take over the responsibility as briefed in this plan.
Accidental leakage splashing of chemicals hazardous in nature.	In case of any accidental contact with concentrated chemicals the remedial action to be taken is given in separate annexure. PPE's are provided in this area. Chemicals are handled very carefully & under controlled conditions. Suitable measure is taken to contain any leakage of such chemicals. Experienced supervisors are deployed to handle any leakage. In case of any fire / leakage of direct contact with such chemicals will bring task forces in action. Personnel affected by direct contact will be immediately taken to water spray / shower systems to dilute the concentration followed by immediate shifting to hospital (if required).

Table 6: Cable Gallery

Hazards assessed	Risk reduction action recommendation
Fire risk due to overheating, short circuit and ignition in the accumulated coal dust	As soon as cable gallery fire is intimated high-level emergency is declared. Electrical maintenance staff is responsible for de-energize power supply. Fire staff uses torches & breathing apparatus to enter the area & extinguish the fire by using DCP & CO2 extinguishers. In extreme case if access to gallery is not possible both the fire doors will be closed & high expansion foam generator will be used to pump foam inside the gallery to extinguish the fire.

Table 7: Fuel Storage Tank / Pump House and Battery

Hazards assessed	Risk reduction action and recommendation
Drain and spillage is risky because it may be result in to back fire and consequent damage to the plant.	To handle any emptying tank are provided and to fight fire in surrounding or tank itself, Foam monitor and water monitor are provided. Foam monitor are provided to blanket any surface fire of leaked or spilled oil and water monitor are used to keep the tank cool. Storage area is fenced as per explosive norms. In case of leakage fire and maintenance task forces will be come into action and maintenance staff will try to stop contain the excess leakage after fire is extinguished. The proper ventilation in the battery room is maintained throughout the time so that no accumulation of explosive fumes is there which may probably cause explosion and fire.

Table 8: Risk reduction in Transformer and switch yard

Hazards assessed	Risk reduction action and recommendation
explosion of transformer / Pneumatic actuator cylinders installed nearby	To prevent this water spray monitor & foam monitors are provided which can be used as soon as supply is tripped due to fire or if tripped manually (as the case may be) Other Fire Extinguishers of DCP & CO2 type are also available.
Transformer oil may splash up to long distance if transformer gets exploded due to fire	Under circumstances task force, maintenance task force (Elect.) & other teams will come into action as per standard procedure briefed in this report, switch yard room is also having fire risk which can be handled by portable equipment's provided nearby. Suitable Personal Protective Equipment's are provided in this area to fight the same.
Fire on transformer	Regular inspection for any fault on equipment, maintenance as per requirement of equipment.
Electric shock and electric burn routine work, maintenance or inspection of electrical panels in switch yard	Training of safe working procedure and necessary precaution to be taken during operation, PPEs should provide and promptly used by worker.
Slip, trip and from the height during routine work, maintenance on switch yard	Safety harness attached with rigid anchor point, safety net below the working platform should placed, training and supervision of supervisor or experienced person.

VII. CONCLUSION

The first step for maintaining the safe workplace and for emergency preparedness is defining and analysing the hazards. Although all hazards should be addressed and resource limitation usually do not allow this to happen at the one time. The hazard identification and risk assessment can be used to established the priorities so that the most dangerous situation is to be addressed first and those least likely to occur and least likely to cause the major problems can be considered later.

From the study carried out in the cogeneration power plant and risk rating were made and analysed show that the various risks in the plant were more and over a certain distance. The improper use of the personal protective equipment can also be managed by the appointing the security specially to check if all are wearing personal protective equipment and if not the entry in the working is should be prohibited. In this project report we observe present scenario of existing safety measures and its efficiency. The risk rating of the present and possible hazard is evaluated which divide them into acceptable, tolerable and unacceptable risk level. Which risks are in unacceptable level their possible corrective action also recommended to improve safety measure and analysis. The results of this analysis will be of valuable to find out the consequence on emergency situation that may occur. With this knowledge, the level of preparedness can be assessed and measures taken to enhance capabilities through training and preparation of a more effective response to such occurrences

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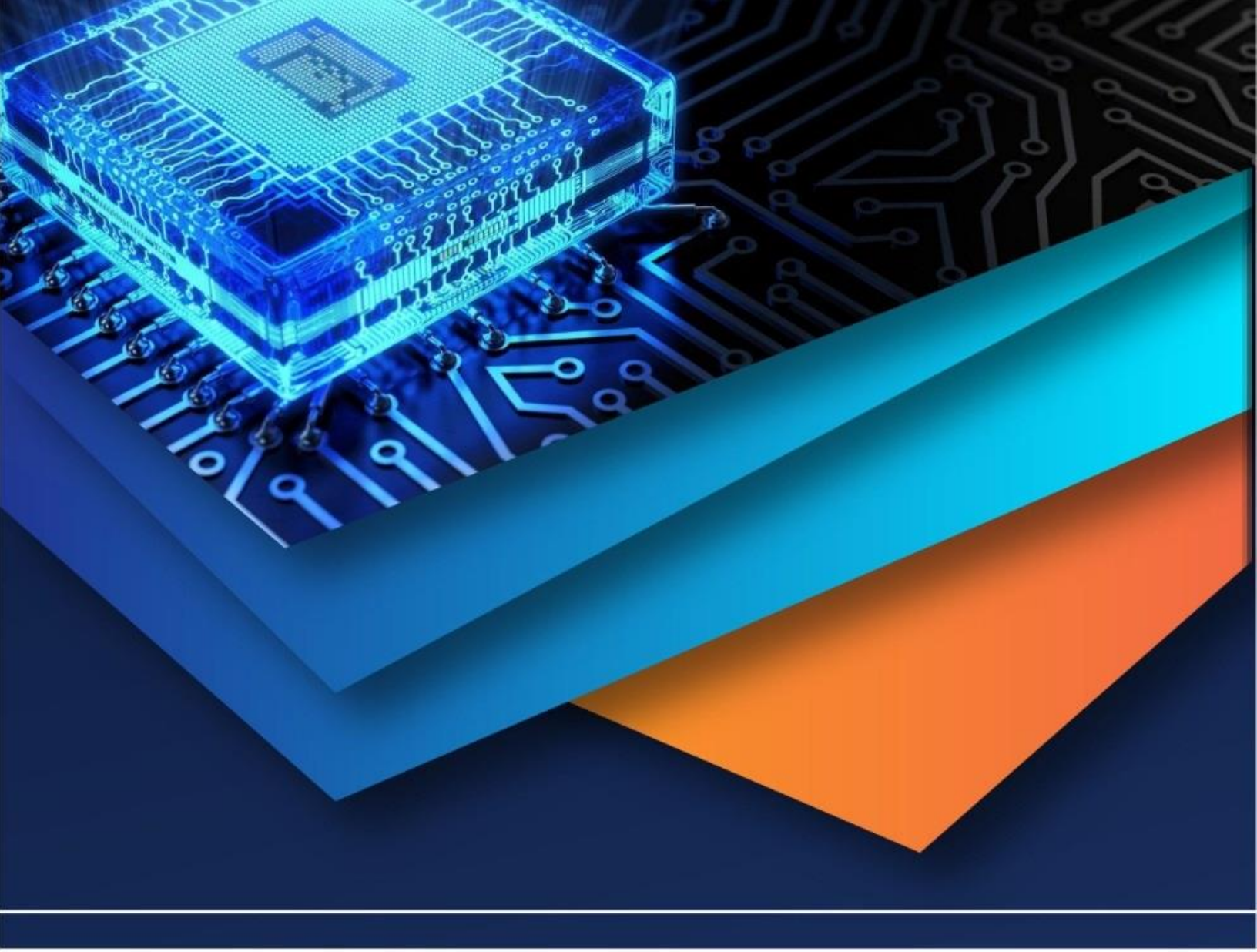

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