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Potential Energy Savings Area in Thermal Power Plant: A Review

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Abstract: Energy conservation is a trending issue nowadays due to scarcity of electricity across the country. Energy conservation can be achieved by either using the energy available more efficiently or by reducing the amount of energy required. Reducing the amount of energy required in thermal power plant will reduce the capacity of plant, so it is recommended to go with former i.e., using energy more efficiently. Another reason why former is recommended is because it requires a lot of investment to add a new generation power plant. Various energy savings potential areas in thermal power plant have been stated in this article. Some measures have also been suggested to achieve it. Reduction in auxiliary power consumption by means of adopting these measures have been supported by reviewing related research articles. By implementing energy conservation in thermal power plant, losses are tried to be recovered which otherwise goes to waste.

Keywords: Energy Savings Potential, Energy Efficiency, Thermal Power plant, Energy Conservation, Efficiency Improvements.

I. INTRODUCTION

Coal is the only natural resource and fossil fuel abundant in India. Consequently, it is utilized widely as a thermal energy source and additionally as fuel for thermal power plants engendering electricity. Power generation in India has incremented manifold in the recent decenniums to meet the ordinant dictation of the incrementing population. Engendering capacity has grown many times from 1362MW in 1947 to 364,960MW (as on October 2019).The energy efficiency of a conventional thermal power plant is defined as saleable energy engendered as a percent of the heating value of the fuel consumed. A simple cycle gas turbine can achieve an energy conversion efficiency from 20 to 35%. Typical coal-predicated power plants operating at steam pressures of 170 bar and 570 °C run at efficiency of 35 to 38 %, with state-of-the-art fossil fuel plants at 46% efficiency. Coalesced-cycle systems can reach higher values. As with all heat engines, their efficiency is constrained, and governed by the laws of thermodynamics. Energy security and CO2 emission truncation are two major concerns of today's world. Ameliorating efficiency of the energy systems is an essential option for the security of future energy and the abbreviation of CO2 emissions. With the growing prosperity of the civilization, our consumption of energy is growing very expeditiously. Fossil fuels remain the world's ascendant primary energy supply, with its utilize as a multifarious primary source of energy in power generation, convey and industry. However, we have finite sources of these non-renewable fossil fuels and we are consuming them at a rate that cannot be sustained, leading to the jeopardy on energy security in the future. The Intergovernmental Panel on Climate Change (IPCC), in its Fourth Assessment Report , identified carbon dioxide (CO2) emissions from burning of fossil fuels as the primary contributor to climate change. Ergo, the prudent utilization of energy is imperative and the consequentiality of ameliorating energy efficiency is now very well realized by all. The energy process is an organized approach to identify energy waste in a facility, determining how this waste can be eliminated at a plausible cost with a congruous time frame. Energy efficiency is widely used and many have different meaning depending on energy accommodation companies. Energy audit of a building can range from a short a preliminary's of the facility to a detailed analysis. It is not only accommodates to identify energy use among the sundry accommodations and to identify opportunities for energy conservation but it is withal a crucial first step in establishing an energy management program. The efficiency will engender the data on which such a program is predicated. The study should reveal to the owner, manager, or management team of the building the options available for minimizing energy waste, the costs involved, and the benefits achievable from implementing those energy conserving opportunities (ECOs). The energy efficiency discusses in this paper is carried out in aim of analyzing and identifying possible energy preserving measures, which can be implemented in a factory. This effort will avail the plant to abbreviate their monthly electrical energy consumption thus minimizing the cost of engenderment. The total energy survey is conducted by designates of onsite inspections, quantifications, questions and discussions with the maintenance staff. This energy analysis contains valuable information such as energy consumption patterns of the factory and the identification of high energy profound equipment's, possible energy preserving measures and cost benefit analysis of energy preserving measures. The over consumption of electricity demands an exigent need to ameliorate the efficiency of fossil-fueled thermal power generation to preserve fossil fuel resources while minimizing contaminants such as SO2, fly ash, and other waste gases. Thus, ameliorating the efficiency of thermal power generation has always been a core topic of the puissance generation industry. Energy loss during different stages of thermal power generation will be discussed in the paper while methods of amending the efficiency of thermal power generation in modern power plants will be introduced.

II. ENERGY SAVINGS POTENTIAL

A. Cooling tower

A cooling system is a heat rejection device that rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. Cooling towers may either use the evaporation of water to get rid of process heat and funky the working fluid to close the wet-bulb air temperature or, within the case of closed circuit dry cooling towers, rely solely on air to chill the working fluid to close the dry-bulb air temperature. The cooling tower performance & energy efficiency mainly depends on the wet bulb temperature, airflow through the cooling tower and energy consumed by the fan motors.

B. Replacing VCRS with VARS

Due to some aspects during which vapor absorption cooling system is different from that of vapor compression refrigeration systems. the most principle is that the same for the 2 systems. Both absorption and compressor refrigerators use a refrigerant with a low boiling point (less than −18 °C (0 °F)). In both types, when this refrigerant evaporates or boils, it will take some heat away with it, providing the cooling effect. the most difference between the 2 systems is that the way the refrigerant is modified from a gas back to a liquid in order that the cycle can repeat. An absorption refrigerator changes the gas back to a liquid employing a method that needs only heat and has no moving parts aside from the refrigerant itself.

C. Compressed Air System

Use of compressed air system in industry and in-service sectors is common as its production and handling are safe and easy. In most industrial and commercial facilities, compressed air systems is necessary to manufacturing. Compressed-air systems is energy intensive, and for most industrial and commercial operations, energy cost fraction of compressed air is significant compared with overall energy costs. therefore, there is a vacuum of relatible information on the energy efficiency of a typical compressed-air system. As a rule, compressed air should be used only if safety enhancements, significant productivity gains, or labour reduction, will result as it is very expensive. Annual operating costs of air compressors, dryers, and supporting equipment, can account from 70% to 90% of the total electric bill.

D. Auxiliary Power Consumption

The auxiliary power consumption is the essential power used by the auxiliary equipment. The auxiliary power is tapped at Unit Auxiliary Transformers (UAT) during normal running of the plant and from Station Transformers (ST) during starting of the plant. The auxiliary power can be broadly classified into in-house auxiliary power whose loading vary with change in plant load of particular unit and outlying or common auxiliary power. The typical in-house auxiliary equipment are: Boiler feed pumps (BFP), Condensate Extraction pumps (CEP), Induced draft fans (ID), Forced draft fans (FD), Primary air fans (PA), Mills, etc. The typical layout of auxiliary equipment are: Circulating water pumps (CWP), Ash slurry pumps, HP & LP water pumps, DM pumps, Crushers, Conveyors, Wagon tipplers, etc.

E. Air & Flue Gas Cycle

As we know the function and working of the boiler. In which the boiler combustion takes place and coal’s chemical energy is converted into the heat energy. That energy is utilised to heat the water and the water is converted into steam which drive the turbine and ultimately energy is generated. In this process, in order to burn the coal we require the air. Because for the combustion we require three things which are Ignition Energy, Fuel and Oxygen. The total amount of air in the furnace is also ensuring the complete combustion of coal. After burning of coal, It is converted into the ash and flue gases. This flue gases contain air as well as lightweight ash particles. For removal of these flue gases out of furnace we require some amount of pressure or we called it Draft. Because of that draft flue gases evacuated from the furnace.

For this we use Forced draft fan and Induced draft fan in the power plant. As we know that, air is the main component for the burning of fuel (coal).

So for this, Forced draft fan provides air to furnace for proper combustion of coal. The amount of air required for the complete combustion is called Stoichiometric Ratio with respect to the fuel input. But in actual implementation apart from the air, we have to give some amount of excess air for ensuring that the whole surface area of the coal gets the proper amount of air. If we give less amount of air for combustion then there is a chance of incomplete combustion which results in unburnt coal particles in bottom ash hopper and generation of Carbon oxide instead of Carbon dioxide. Similarly if we give excess amount of air then there is a chance of heat loss. Because of that both condition is avoided with these coal and air.

F. Steam, Feed Water and Condensate Cycle

In thermal power plant, there are mainly three cycles i.e. Steam Cycle, Feed water cycle and Condensate cycle. Conventional steam cycle plants are used to produce amount of energy from vapour dominated reservoirs. These three cycles are very important in efficiency point of view. As we know Regeneration is (water preheating before sending it to boiler) increases the efficiency of our plant. If we send preheated water to boiler drum, then lesser amount of heating of water is required in the drum which decreases the heat-rate and the fuel consumption will be reduced and it will be very economical for the power plant. the Condensate cycle in which it includes the flow of water from Condenser to Deaerator. The equipment's involved are Condenser, CEP (Condensate Extraction Pump), Gland steam cooler, LP heaters (Low Pressure Heaters).The feed water cycle includes Deaerator, FST (Feed Storage Tank), Booster Pump, BFP (boiler Feed Pump).

G. Boiler

The major potential operational efficiency of a boiler is determined by its technological capabilities, so it is important to install a highly efficient boiler to begin with. However, even if a highly energy efficient boiler is installed, it will not lead to energy savings if it is not operating in an energy efficient manner. Methods of improving the boiler's actual operational efficiency include, for example: using multiple small capacity boilers rather than one large capacity boiler, and adjusting the number of boilers running at the same time depending on the load; fine-tuning boiler operation time based on the volume of steam required by plant processes. The operational energy efficiency of a boiler is an expression of the percentage of heat energy generated from the heat energy input.

H. HVAC System

Energy consumption for air-conditioning in power plant and industrial sectors has increased year by year. Therefore, from the viewpoints of both energy conservation and reduced Carbon dioxide emissions, further energy saving measures are necessary. Moreover, because heating and cooling loads are concentrated in the daytime hours, technical development to enable load leveling in electric power consumption is also desirable. In response to these needs, regenerative air conditioning systems using water or ice as a cooling storage medium have been widely adopted. With the cooling storage using chilled water, the refrigerator can be operated at a high coefficient of performance (COP), but using a storage tank of the same capacity, the quantity of cooling storage is smaller than with ice. On the other side, with ice, power consumption is high due to the low COP of the refrigerator. Used to wind turbo ventilators instead of conventional motor driven exhauster.

I. Electrical and Plant lighting system.

Optimizing Voltage level of distribution transformer in which we found that Operating voltage level is on higher side than required causing more losses. It will required to reduce the voltage level by tap changing. Use of Auto star/delta/star converter for under loaded motor Lighting to use of electronic chock instead of conventional use copper Chock, Use of CFL, White LED, Replacement of mercury vapor lamp by metal Halide lamp. Use of timer setting for area lighting is the methods can be used. Lighting has tremendous potential of saving.

III.REVIEW OF APPLIED TECHNOLOGIES

Mandi, R. P et al., provides an analysis of induced draft cooling tower (CT) performances. The present heat transfer effectiveness of the cooling towers is in the range of 46.4 – 50.9 %. The automation of CT fan operation reduces the energy consumption. The overall CT fan efficiencies are varying between 25.9 – 42.8 %. These effectiveness and efficiencies are lower due to design deficiencies, hesitation in adopting new technology, etc. In this paper, detailed performance results of replacing the existing Glass Reinforced Plastic (GRP) blade by the modern technology Fibre Reinforced Plastic (FRP) blades is presented. The operational optimization of cooling tower is also discussed in detail. The replacement of these fans releases an additional energy of about 2.1 MU per year for one 210 MW thermal power plant, the effectiveness of cooling towers is improved to 71.7 – 80.7 % and the efficiency is improved to 39.5 – 64.2 %. This technology up-gradation shows the reduction of auxiliary power of Cooling tower by 30 – 35 %. The specific energy consumption (SEC) of fan has reduced.

Chattopadhyay, S et al., says that there are two types of refrigeration cycles, avapour compression refrigeration (VCR) cycle and a vapour absorption refrigeration (VAR) cycle, have been modelled and analysed. Both cycles have same operating cooling loads and both the cycles operate between the same temperature limits. R134a has been considered as refrigerant for the Vapour compressor refrigeration cycle whereas LiBr-H2O has been considered as the working fluid for the VAR cycle.Energetic and exergetic performances have been evaluated for both the cycles and compared. The effects of condenser temperature, environmental dead and evaporator temperature state temperature on the performances of these cycles are also discussed.

Energy analysis disclose that the coefficient of performance (COP) of the VCR cycle is considerably higher than that of VAR cycle. However, exergy analysis disclose that the energetics coefficient of performance (ECOP) of the VAR cycle is very close to that of VCR cycle. For environmental dead state temperature beyond 35°C, the ECOP of VAR cycle is more than that of VCR, implying the VAR's better energetic performance at higher environment temperature. The energetic COP or ECOP is thus found to be a better performance indicator, which considers both quantity and quality of energy interactions. An energetics approach can therefore be used to compare different refrigeration systems and could even be applied to judge Combined Power and cooling cycles.

Luo, X et al., The paper presents the mathematical models of an A-CAES system component and developed a new whole system model of A-CAES with low temperature thermal storage. The model is implemented in Matab/Simulink software environment. With the system model developed in the paper, the system energy efficiency is analysed, especially, a comprehensive study is performed on how much the system parameter variations affect the system overall efficiency. From the analysis, it is found that the isentropic efficiencies of compressors and turbines and the heat transfer rates of HEXs are the key parameters to give the dominant influences on the system efficiency. In addition to system parameters, the system configuration can also lead to system efficiency improvement. From the study, multi-stage compression and expansion can improve system efficiency but it does not mean the system can have unlimited number of stages. Regulating the A-CAES charging time and discharging time via flow control can also lead to different system efficiencies. These are considered as the important factors for efficient system design in practice. The results from optimal design study of low temperature A-CAES systems show that the system cycle efficiency and the heat energy recycle efficiency can potentially reach to around 68% and 60% respectively. The results confirm that the current relative low efficiency of CAES systems can be improved to address the main concern of CAES system design and deployment.

Mandi, R. P et al., tells about the energy conservation measures and the results of performance test conducted on 23 units of 210 MW sub-bituminous coal fired power plants in Thermal Power Plant with tangentially corner fired and balanced draft system in Thermal Power Plant and also about how the power consumption can reduce auxiliary power by about 0.2 – 0.3 % of gross energy generation and improve the plant load factor of the plants by operating the plant at optimum excess air to improve Energy Efficiency by about 1.5 – 2.1 %, optimizing operation, deciding advanced control measures and implement energy conservation techniques for reduction in the auxiliary power additional power at grid. Cui, L. et al, tells about China's coal production and consumption levels rank first in the world. Coal fired power plants currently hold the approximate account for 65.5% of the total electricity output of China's power grid. Coal fired thermal power is the main industrial power plant consuming coal in China and the main source of atmospheric pollutants. To alleviate environmental pollution, the Chinese government recently released stringent flue gas emission standards for coal-fired power units. These standards require that the emission of dust, sulfur dioxide, and nitrogen oxides does not exceed 10 mg/m3 , 35 mg/m3 , and 50 mg/m3 , respectively, to achieve ultra-clean emissions. Life-cycle assessment and life cycle costing methods are combined to analyze and compare the environmental and economic effects before and after ultra-clean emission retrofit in a 315 MW unit. The environmental impact of flue gas processing for 1000 kWh power plants decreased from 0.1529 to 0.1295 after ultra-clean emission retrofit. Desulfurization and discharged flue gas after treatment are the key processes examined in this case study, while power consumption during desulfurization and residual mercury in flue gas are key substances. Therefore, looking ahead, decreasing power consumption in desulfurization and using mercury removal technology are important aspects for decreasing the environmental impact of flue gas treatment systems in coal power units.

Espatolero S, et al., Coal will continue playing a major role in worldwide electricity generation during next years. This trend will augment CO2 emission to the atmosphere. Improving plant efficiency could reduce the negative effect of coal consumption on CO2 emissions. Major efforts have been focused on supercritical boiler technology (once-through units) and materials development (austenitic steels) with the aim of accomplishing high steam parameters that allow this efficiency enhancement. therefore, improvement in supercritical steam parameters should be followed by an exhaustive review of the steam cycle design. This paper shows a strategy for the optimization of the feedwater heaters network and the flue gas heat recovery system design. Starting with the lay-out of a supercritical steam cycle using the best available technology, this paper analyses not only the steam cycle itself, but also its integration with the boiler cold-end. In which by means of thermodynamic optimization it is possible to propose new feedwater heat exchanger network configurations and reducing steam consumption from turbine bleeds, achieving optimum power plant efficiency. Evasions have been carried out using Aspen Plus software and optimization procedure is based on a sequential quadratic programming method that maximized overall power plant efficiency taking turbine bleeds pressure as independent variables. Results show a eventual improvement of the overall plant efficiency of 0.7 points in comparison with state-of-the-art reference plant. This increase indicates a direct reduction of CO2 emissions of about 1.3% compared with the best plant currently available. Moreover, an economic analysis confirms the feasibility of the proposals analysed and shows important additional yearly incomes.

Zhang. Q et al., explains about to reduce energy losses which were due to the heat loss of flue gas and unburnt carbon, both of which account for about 10% of energy loss. Moreover, the quality of coal, boiler capacity, and load also influence the efficiency to a certain degree and so for conservation of energy and emission reduction in coal-fired boilers are significant to mitigate climate change and alleviate environmental pollution. The study is about the potential for efficiency promotion is assessed by understanding the factors affecting boiler performance. The results are based on thermal tests of 141 coal-fired industrial boilers in Liaoning province, China. Additionally, an exergy analysis model suitable for coal-fired industrial boilers is proposed under the framework of the first and second laws of thermodynamics to improve the operation of boilers. The energy efficiencies as well as CO2 emissions have been discussed as well. The results indicate that the heat loss of flue gas and unburnt carbon represent the main heat losses. Exergy loss is dominated by destruction due to irreversibility in coal combustion and heat transfer. Average energy efficiency and CO2 emission of 141 boilers were estimated to be 76.08% and 147.13 kg-CO2/GJ, respectively. Exergy efficiencies of typical samples were estimated at about 12.88% for hot water boiler and 27.97% for steam boiler. Raising the efficiencies of 141 boilers to the target level proposed in the standard will lead to a decrease of coal consumption by 155 kt, emission reduction of 341 kt for CO2, 3.72 kt for SO2, and 3.48 kt for NOx per year.

Haniff M. F, et al., endow a spacious review on heating, ventilation and air conditioning (HVAC) scheduling techniques for buildings towards energy-efficient and cost-effective operations. The scheduling techniques can be divided into three main classes, which are the basic techniques, conventional techniques and advanced techniques. The essential scheduling technique involves only the tampering of the ‘ON’ and ‘OFF’ states of the HVAC system whereas the conventional scheduling technique uses pre-cooling or preheating techniques to reduce the peak demand with the use of several setpoint temperatures. The features, as well as the energy and cost saving potentials for each strategy are presented. The blooming scheduling technique, which is the improved version of the basic and the conventional scheduling techniques is found to have the highest energy and cost saving potential. The Impediments of the scheduling techniques have also been identified and possible solutions to overcome these limitations and improve the scheduling performance further have also been briefly stated. Hence then the conventional HVAC scheduling technique is the most popular techniques to improve electrical energy consumption implemented in buildings. Its main characteristics are that the HVAC system operates for 24 h a day, it manipulates the setpoint temperatures of the HVAC system and uses the ‘night setback’ approach to achieve its energy saving objectives. For an air conditioning system, the ‘night setback’ is a way to reduce energy usage by increasing the setpoint temperature during unoccupied period, whereas for a heating system, this setpoint temperature is set to be lower than in normal operations. A higher setpoint is used in the night setback of an air-conditioning system in order to compensate for the lower temperature at night so that the resulting temperature is the normal room temperature. There are three conventional ways for scheduling the HVAC operations for the cooling system, as discussed. They are the baseline, step-up and linear-up scheduling techniques. The baseline technique is the most used technique for the HVAC systems. The step-up and linear-up technique revolves around the precooling of a space for the purpose of reducing the peak demand. The following sections discuss all the three conventional HVAC scheduling techniques in details. This may include pre-determining the setpoint temperatures based on, for example, the weather forecast information. Finally, to ensure a comfortable operation, the new technique needs to take into account some comfort indices such as the PMV.

Das, S et al ., about the Lighting voltage for lighting at LDB 1 &2 varies from 218 V to 238 V (phase-neutral). The discharge lamps can be operated at 205-210 V with optimum efficiency. The deficiency of voltage will slightly reduce the lumens output. Which is negligible. LDB 1 & 2 is already installed with transformers so, adjust tap settings for minimizing the lighting voltage. Lighting energy curator is installed in the ash handling plant at PP-2. The voltage of lighting circuit varies from 202 V to 208 V.

IV. CONCLUSION

Therefore, increasing efficiency of the energy systems is an essential option for the security of future energy and the abbreviation of CO2 emissions. With the growing prosperity of the civilization, our consumption of energy is growing very expeditiously. Hence, the saving potential will decrease the utilization of Fossil Fuels as a multifarious primary source of energy in power generation, convey and industry and hence Co_2 Emissions can be reduced effectively.

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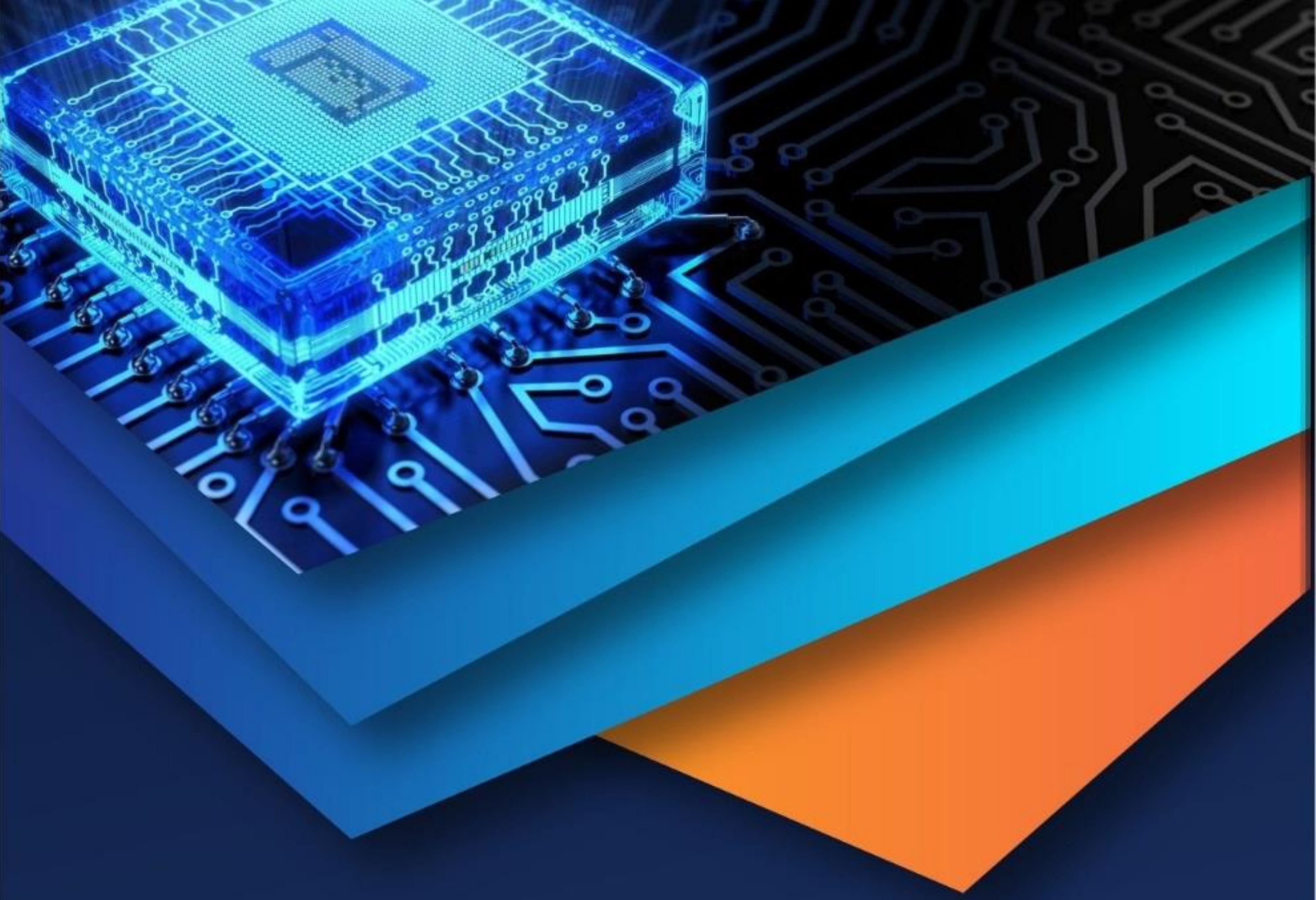

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