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Energy Auditing and Possibility Study for Waste Heat Recovery in the Laundry Section of a Hospital

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Abstract: ***This paper is the outcome of a project work undertaken to conduct energy auditing and possibility study of waste heat recovery at the laundry division of a hospital. The major problem identified was the wastage of steam in the form of condensate from various elements of the plant, which has led to high operating costs of the laundry division. The paper outlines functioning of various elements of the plant like the boilers, driers, washing machines, driers and the calendering machines. The energy use pattern of the various elements of the plant has been established. The possibility of eliminating wastage of energy and reclaiming energy from the condensate is also studied. Detailed cost analysis has been performed to establish the actual monetary loss. The paper also brings out the savings in cost that can be achieved if the recommendations suggested are implemented.***
Keywords: Energy auditing, laundry, hospital, waste heat recovery.

I. INTRODUCTION – ABOUT THE HOSPITAL

This energy audit was conducted in the laundry section of a hospital in Coimbatore. The hospital is an 810 bedded, tertiary care hospital with qualified and experienced faculty, excellent state – of – the – art infrastructure, and a dedicated team of health care professionals, one of the largest in the state. The hospital houses various specialties such as Medicine, Surgery, Obstetrics & Gynecology, Dermatology, Psychiatry, Paediatrics, Orthopaedics, Ophthalmology, Otorhinolaryngology, Anaesthesiology, Radiology and Emergency medicine. Primary focus of the hospital has been on problems which are seen in the tropical environment. The laundry section caters to the needs of all the departments mentioned above along with the operation theatres and the 810 beds.

II. LITERATURE REVIEW

The Indian Energy Conservation Act (2001) [1], defines energy auditing as "The verification, monitoring and analysis of the use of energy and submission of technical report containing recommendations for improving energy efficiency with cost-benefit analysis and an action plan to reduce energy consumption." (Kumbhar and Joshi, 2012) have mentioned the basic components of energy auditing as the auditor's tool box, preparation for audit visit, conducting the audit, introductory meeting, audit interview, walkthrough audit, post audit analysis, energy audit report, energy action plan. (Rathod et al, 2013) say that in any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labor and materials. Energy auditing will not only save money but it also improves the quality of electrical energy supply. The detailed guidelines on conducting energy audit are given in [4].

III. FIELD STUDY

Field study was conducted to understand the operations and requirements of the laundry section. Fig.1 shows the layout of the laundry division. The laundry section requires steam for washing, drying and calendering purposes. Washing machine requires hot water at about 110℃ for removing stains. The drying tumbler and the calendering machines require steam at about 150℃. The laundry section has two boilers each of 300 kg/hour capacity of Thermax make. Steam for washing drying and calendering purposes is supplied by both the boilers. The plant is operational for at least 363 days a year. The plant has to meet the requirements from the hospital wards, operation theatres. The need for stain free and disinfected clothes is being met by the laundry section. The boilers are operational from the year 1996 and are periodically maintained. There are two tumble driers of make BTC and two of make RAMSONS each of 50 kg capacity. The plant also has two calendering machines for pressing purposes. The plant has four washing machines utilizing steam. The major problem of the plant is the high rate of steam coming out as condensate from the driers and the calendering machines which is let out into the drain without recycling. The audit was mainly carried out to quantify the amount of steam condensate coming out of the various outlets of the pipe line carrying steam and to design a suitable storage tank for recycling

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the steam condensate.

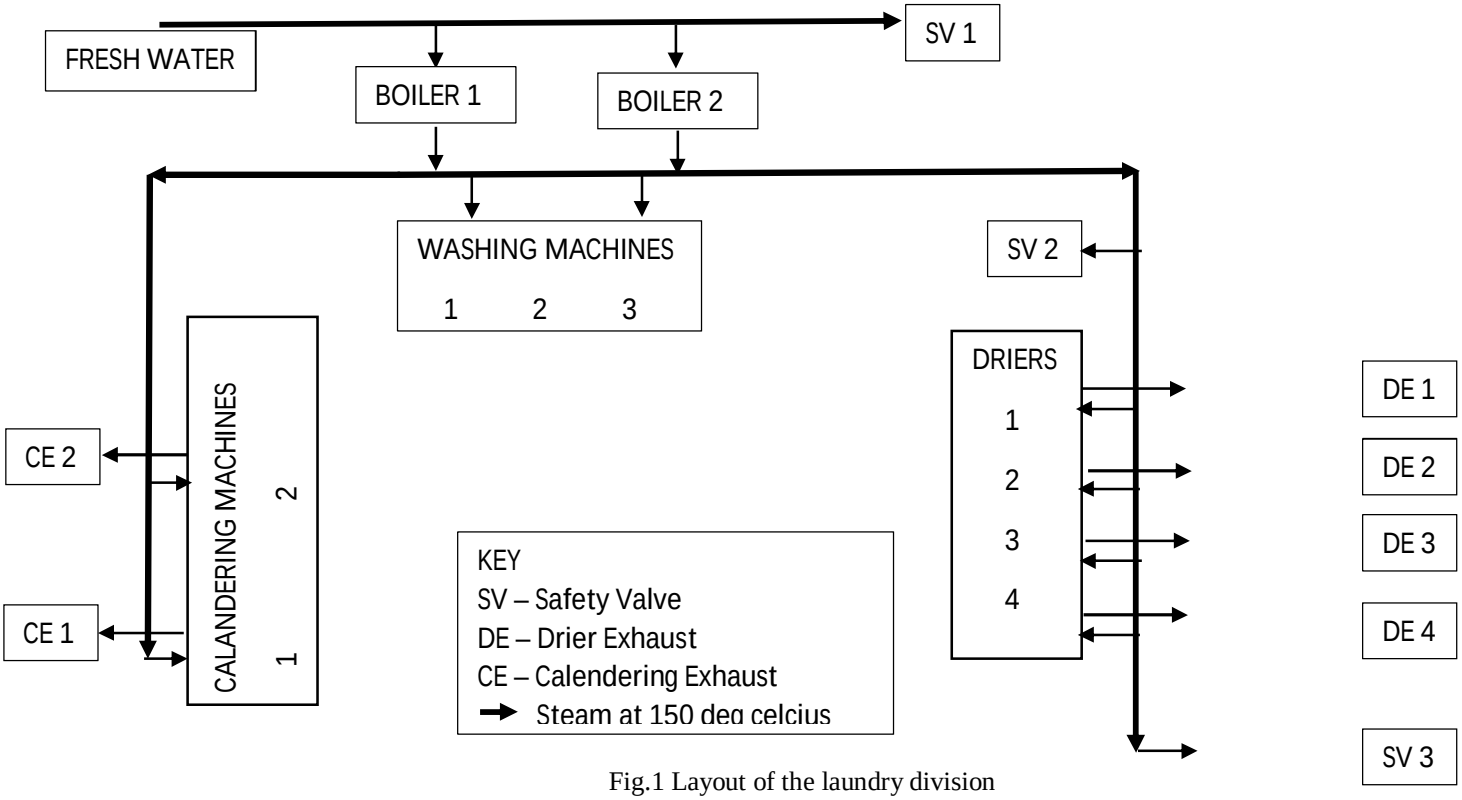

Fig.1 Layout of the laundry division

IV. DATA COLLECTION – DETAILED AUDIT

The data collection – detailed audit was conducted to collect various details regarding the specifications of each machine, steam usage of each machine and the amount of condensate coming out of each of the machines and the safety valves, operating cycle time of the washing machines, driers and the calendering machines, temperature of the condensate, fuel consumption by the boilers, operating time of the boilers etc. Total fuel consumed by both the boilers is 278.179 liters per day (for 620 mins) and total water consumed at the rate of 5.4 liters per min per boiler is 5724 liters. For the drier machine 1, the condensate for 10.3 hours is 438.96 liters at a temperature of 95.4˚C. For the drier machine 2, the condensate for 10.3 hours is 282.72 liters at a temperature of 88˚C, for the drier machine 3, the condensate for 10.3 hours is 348 liters at a temperature of 95.6˚C and for the drier machine 4, and the condensate for 10.3 hours is 438.96 liters at a temperature of 95.4˚C. The boiler efficiency is 63%. The total condensate for the calendering machine 1 for 7 hours is 119.7 liters at 93.28˚C. The total condensate for the calendering machine 2 for 7 hours is 133.56 liters at 93˚C. Safety valves are provided in the boilers and across the steam conveying pipes. There are three such safety valves in the plant. The safety valves are provided in the pipes conveying steam to maintain the required pressure. When the pressure reaches above the required pressure, the safety valve opens and the steam is let out. The amount of condensate from the boiler safety valve is 296.825 liters at 88˚C for 10.3 hours. The amount of condensate from the safety valves which are present in the steam conveying pipes is 269.7 liters at 97.25˚C and 1429.1 liters at 91˚C for 10.3 hours. The total condensate from the driers, calendering machines and the safety valves is quantified to be 3952.825 liters at an average temperature of about 93˚C.

V. FINDINGS

Total fresh water consumed is 5724 liters at 30 ˚C. Total water lost as condensate is 3952.825 liters at 93.13˚C. Hence, the percentage of water lost is 69.05 %.

A. Cost Of Salt Water Purification

Water is purified at the hospital premises by the Reverse Osmosis (RO) process. At present, water is available free of cost. The cost of purification by the RO process is Rs.2.32 for 100 liters including the pumping cost. As the laws regarding the natural resources

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are set to be changed then underground water cannot be pumped free of cost. Then the cost of water treatment would come up to Rs.9.32 for 100 liters. Water lost as condensate is 3952.825 liters. The cost of purification (without cost of water) is Rs.91.70 and the cost of purification (with cost of water) is Rs.368.40.

B. Cost Of Draing Condensate At 93˚C

Water at 93˚C is drained out from the driers whereas water at about 30˚C is fed into the boiler. Therefore water at 93˚C can be used to heat water at 30˚C and the heated water can be let into the boiler. Now the cost of heating the water from 30˚C to 93˚C is calculated as mentioned below.

Power =28 kW

Mass flow rate of diesel required = 0.00063kg/s

Quantity required for 10.3 hours = 23.3 liters.

Cost of 23.3 liters = Rs.1280.

Total loss in rupees =Rs.1648.

VI. ENERGY USE PATTERN

Fig.2 shows the energy use pattern of various elements of the laundry division. This graph is obtained by employing the mass balance equation. The total mass of steam in should be equal to the total mass of steam out (in the form of condensate).

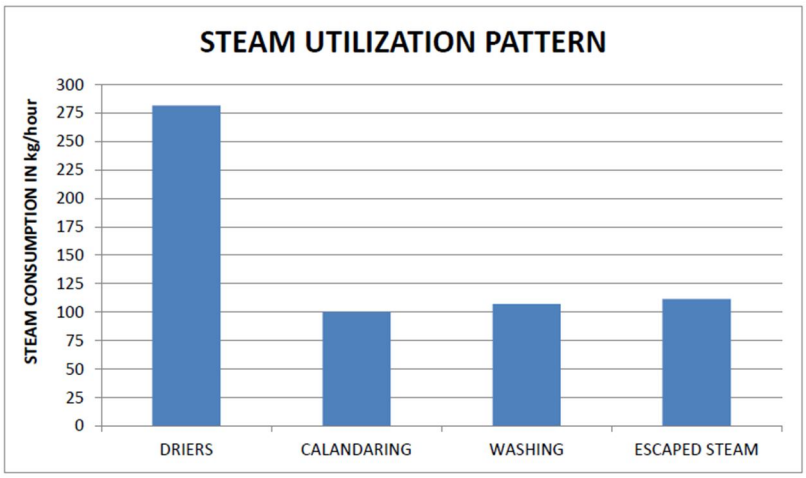

Fig.2 Energy use pattern

VII. MAJOR FINDINGS

Based on the energy audit conducted, it has been found that

Efficiency of the boiler is about 62 %.

Very high rate of steam condensate flowing from the driers and the safety valves.

The steam condensate at 93˚C is not recycled and is let off into the drain.

Wasted condensate bears with it the cost of water, pumping.

VIII. RECOMMENDATIONS

A) To Improve The Boiler Efficiency

Water can be let into boiler by preheating with an economizer

Water can be let in from a solar heater so that the mean temperature of inlet water is raised to about 60 degrees.

B) Recycling Of Condensate

Recycling of the condensate is very much essential for the plant as the condensate coming out is about 69.05% of the total fresh water intake. The condensate which is drained out possesses energy with it which can be utilized effectively. The energy possessed

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by the condensate can be utilized in two ways. The two ways of utilization is discussed in detail.

1) *Utilization Of Condensate To Heat The Feed Water:* The condensate water can be used to heat the fresh water which is entering into the boiler. This can be accomplished with the help of a heat exchanger. Fresh water can be made to pass into the heat exchanger which has the hot condensate circulating. The temperature that could be achieved comes to around 56˚C. Fresh water at 56˚C when let into the boiler eliminates the cost of heating fresh water from about 30˚C to 56˚C. The cost of heating fresh water from 30˚C to 56˚C comes up to Rs.51 per hour. For this plant working for about 10 hours a day, the cost comes up to about Rs.510 per day and to Rs.1, 86,150 per year which is a substantial saving

2) *Utilization Of Condensate As The Boiler Feed Water:* The hot condensate at 93˚C can be directly fed into the boiler as feed water. The mass flow rate of fresh water into the boiler is about 555.72 liters per hour (lph). The flow rate of hot condensate is about 383.76 lph. The hot condensate can be collected in a storage tank that could handle liquid about 500 lph and could be fed into the boiler. This reduces the demand for fresh water to about 172 lph. In the boiler, when water at 93˚C at 383.76 lph mixes with water at 30˚C at 172 lph, the intermediate temperature reached is about 55˚C. This implies that the cost of heating water from 30˚C to 55˚C is saved. There is also savings in the cost of pumping and purification. The total savings in rupees if this method is adopted comes to about Rs.60 per hour and to about Rs. 2, 19, 000 per year which is again a substantial saving. The storage tank is designed such that the tank can handle steam condensate at the rate of 600 lph. The material of the tank is selected such that the heat loss to the surroundings is very minimal. The storage tank should be appropriately insulated. The dimensions of the storage tank can be arrived at by considering the volume of condensate required to be handled by the tank. Volume of the tank is to handle 600 liters in one hour.

Considering a square tank, side of the square tank = 0.85m

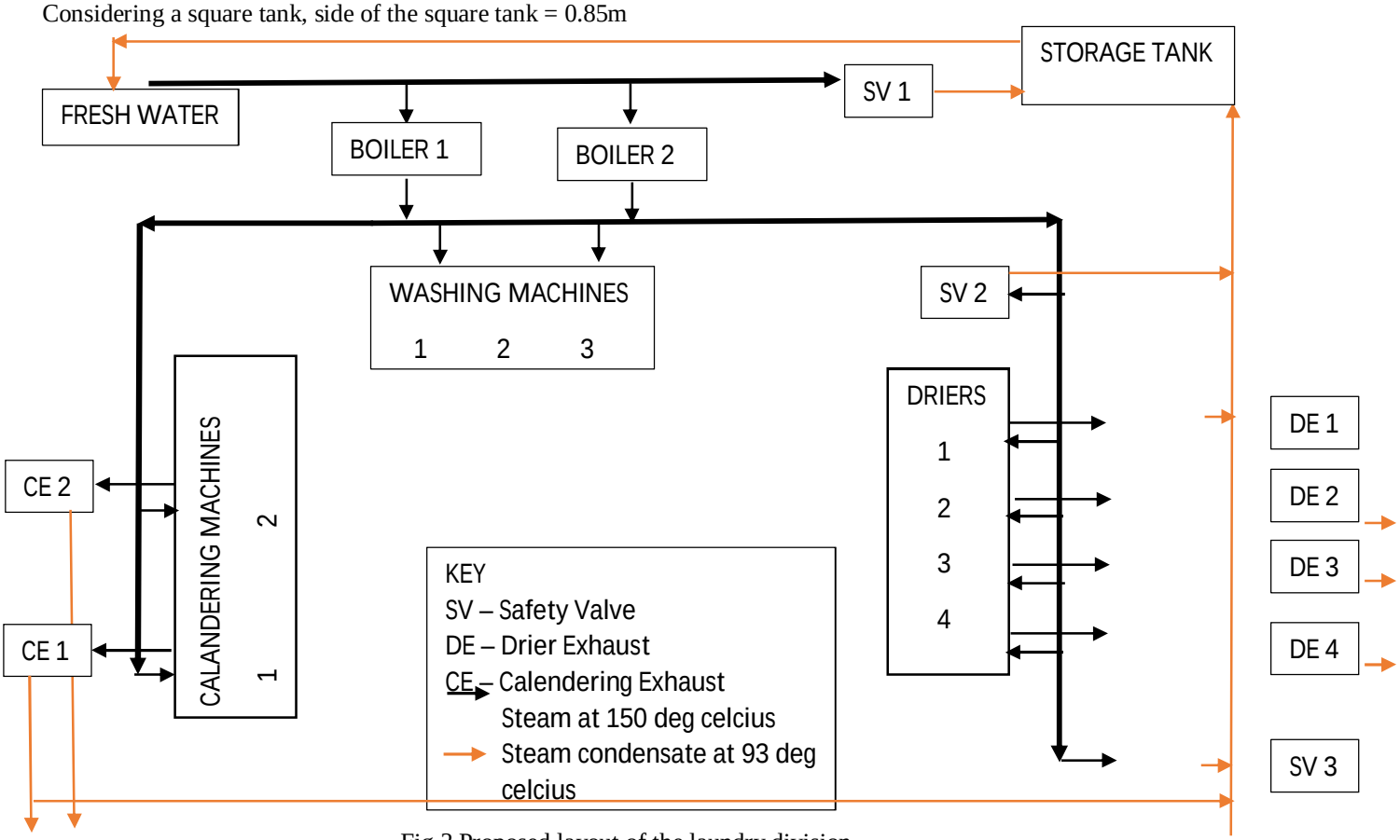

Fig.3 Proposed layout of the laundry division

IX. CONCLUSION

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The condensate which is let out into drainage can be used to heat fresh water such that the cost of diesel can be reduced. The water can be taken for purification instead of being let into the drain so that the cost of salt water and the cost of pumping can be reduced. The proposed layout consists of a storage tank for the condensate which is collected from all the steam condensing points. Hot condensate from the storage tank can be used to heat fresh water or can be let into the boiler itself if the condition of the condensate is same as that of the fresh water let into the boiler. Fig.3 shows the proposed layout of the laundry division.

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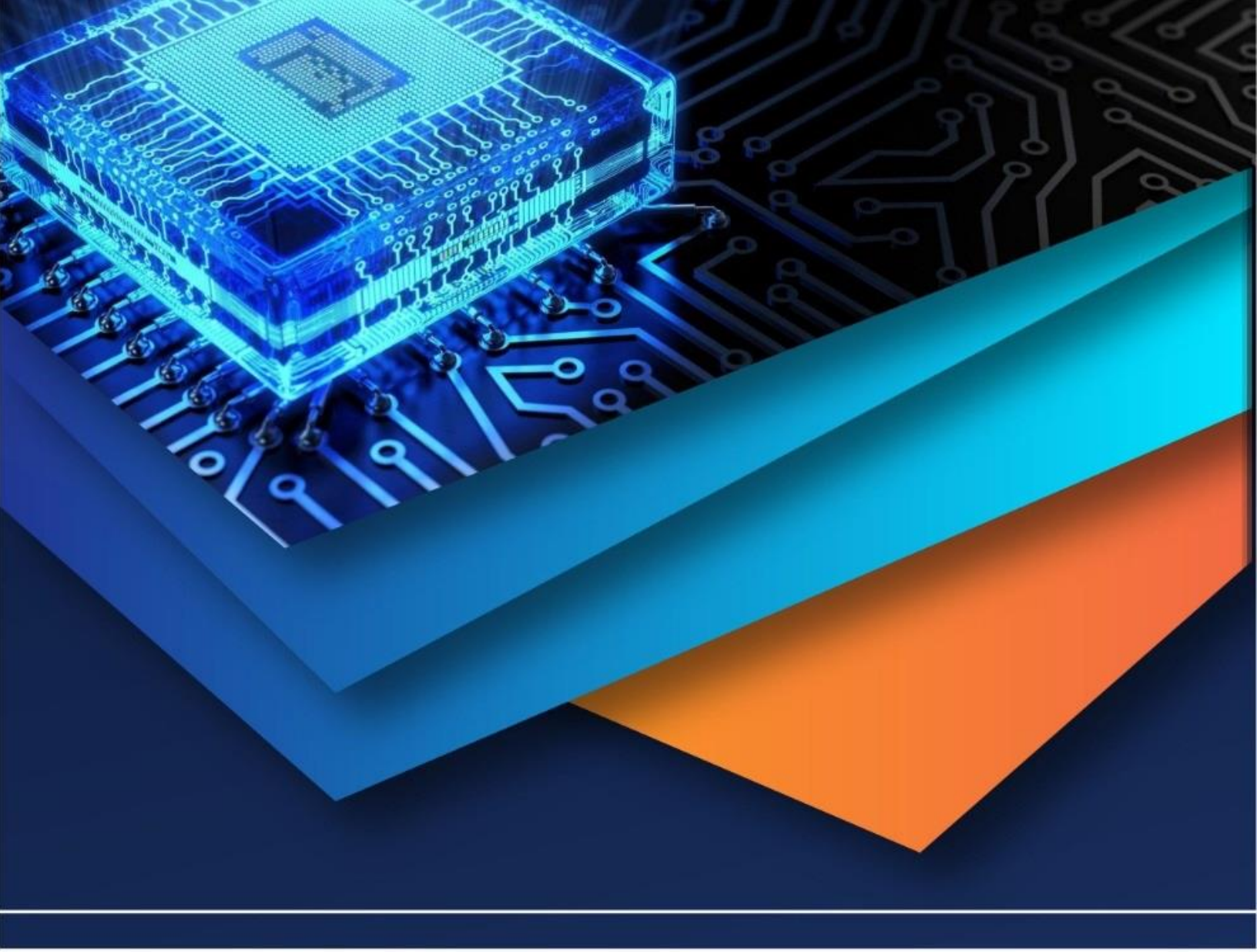

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