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Biochemical Treatment of Textile Wastewater

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Abstract: Industrial revolution has given rise to generation of artificial pollutants. These pollutants have drawn the attention of policy makers in many industries due to deterioration receiving environment. These pollutants require a more or less degree of treatment as per wastewater discharge standards. However some of these pollutants need very rigorous treatment being extremely harmful to human being. These pollutants are mostly non biodegradable so cannot be simply treated by biological methods but need some advanced type of treatment. Bio-chemical treatment methods treat the pollutants in wastewater by first stabilizing the organic matter biologically and then separating the stabilized matter by chemical addition. To meet international standards for discharge and disposal, the effluent must be treated. In this study biochemical treatment of textile wastewater has been investigated to decrease pollutant load which has been further analysed in terms of COD, BOD, TDS, TSS and change in Colour. SBR reactor was designed and coagulants were optimized in laboratory.
Keywords: Textile wastewater, Biochemical, Sequential batch reactor.

I. INTRODUCTION

Freshwater is a finite and limited resource. During industrial revolution human being has polluted the sources of underground water and surface water by discharge of untreated or semi treated industrial wastewater. Moreover in the areas where underground water resources are the only resources for obtaining water, rate of utilization generally crosses rate of replenishment. In these areas dereasing level of groundwater is an alarming situation.
The industries dealing with fabric manufacture and printing use many complex chemicals for dying and printing of the clothes. Many unit processes used in fabric manufacture contribute different quality and quantity of wastewater which makes up it complex for treatment. Textile industry thus generates large volume of refractory wastewater. Wastewater from textile industry contains organic compounds, dyes, surfactants, high TDS, moderately high temperature alongwith high ph.
Different types of colouring compounds are used to impart colour to fabric. Among these compounds azo dyes are used at a large scale globally and are difficult to be treated. Various methods are used to treat wastewater from textile industries which are conventional in nature.

A. Physico-Chemical Methods

Physico chemical water treatment processes are based on the principles of physical separation and reaction between various reagents for removal of various contaminants. Coagulation with the help of salts or metal electrodes and membrane separation are very popular physico-chemical process for treatment of wastewater from textile industries. The other processes like adsorption is also found effective for removal of dyes and organic matter in the wastewater from textile industry. However almost all the physico-chemical treatment process have some drawbacks which retard their use. High amount of hazardous sludge is generated during use of adsorption column for treatment of organic waste. Also all the phyico-chemical treatment processes impose high capital and operating costs on the industry.

B. Oxidation Methods

Oxidation refers to degradation of impurities present in wastewater by using oxygen. In advanced oxidation chemicals are used for degradation of contaminants. Hydrogen peroxide and ozone are mostly used to oxidize the impurities present in wastewater. Natural or artificial UV light is used for enhancement of the efficiency of the process. A catalyst can also be added to the process which provides the surface for occurrence of the reaction. Moreover OH radicals are also generated by the use of UV light in the presence of hydrogen peroxide. Compounds refractory to biological treatment can be easily treated using advanced oxidation. In this process the pollutants are broken down to stable compounds which are inorganic in nature. However there is little high investment cost which comes at the time of erecting the treatment plant.

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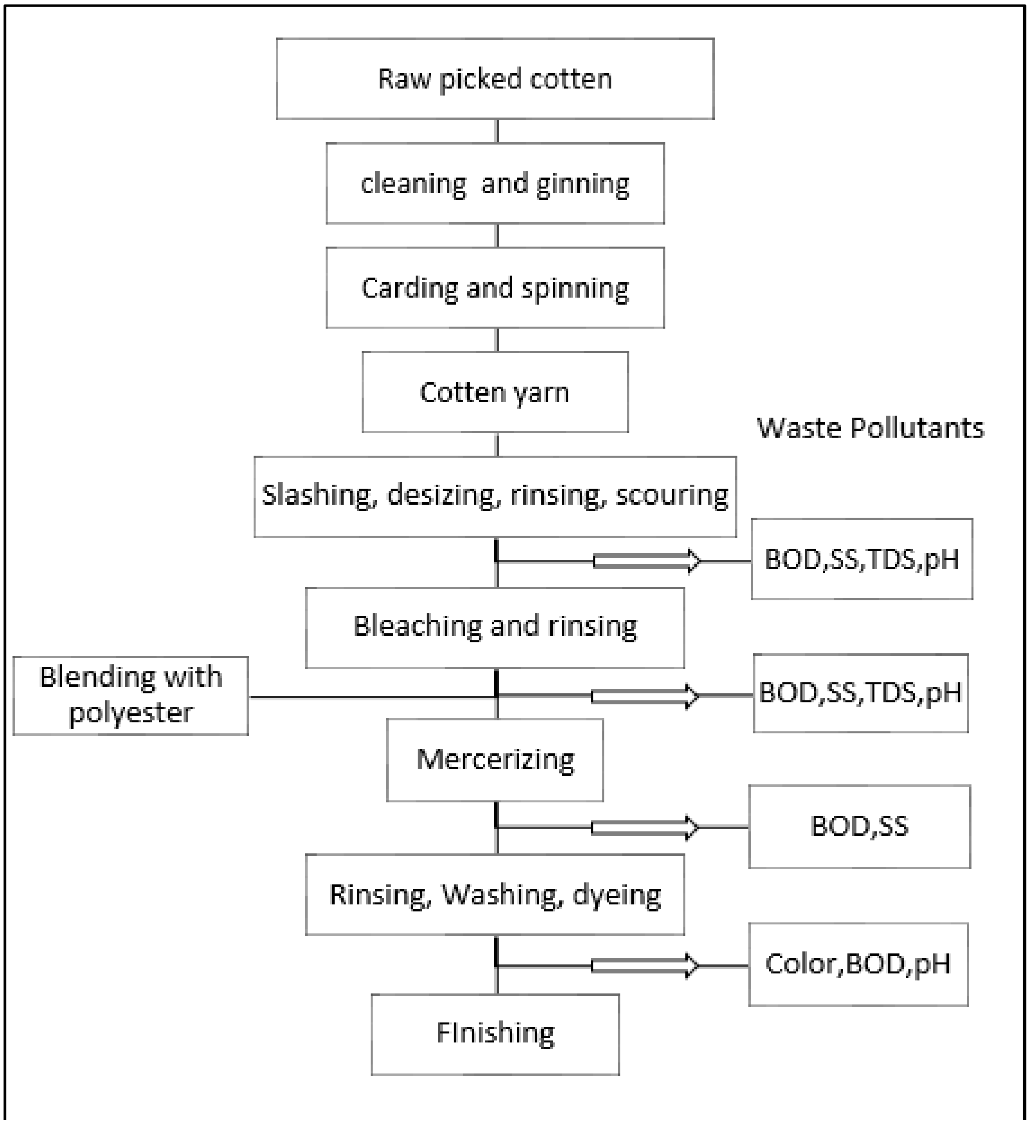

Fig-1: Processes in textile industry

C. Biological Process

Biological process is mostly used for treatment of domestic sewage along with easily treatable industrial waste. In these process either aerobic or anaerobic bacteria is used for treatment of waste. In aerobic processes air or oxygen is used for degradation of biodegradable organic matter. In anaerobic process anaerobic bacteria degrades organic matter in absence of oxygen. In both these processes the microbial cells are produced and complex organic compounds are broken into simple and stable inorganic compounds.

D. Sequential Batch Reactor

Batch reactors are generally designed to carry the operation or process in batch mode. These reactors closely resemble biological treatment process which occurs in either presence or absence of oxygen. However in batch mode single or different reactors are used to carry out the process in orderly manner. All the processes occur in a single or different reactor vessel. This reactor has four steps- Fill, React, Settle and Draw. Each step occurs in orderly manner one after the other. SBR can be used in aerobic or anaerobic mode. In aerobic mode SBR uses air diffusers or mechanical aerating devices. Air diffusers are found to be more effective than mechanical aerators as they create small air bubbles which have larger surface area for efficient oxygenation of waste. Success of biological treatment process depends upon the settling characteristics of sludge. In this case SBR produces sludge having good settleability. Now a day’s automation is also used to increase the efficiency of the process.

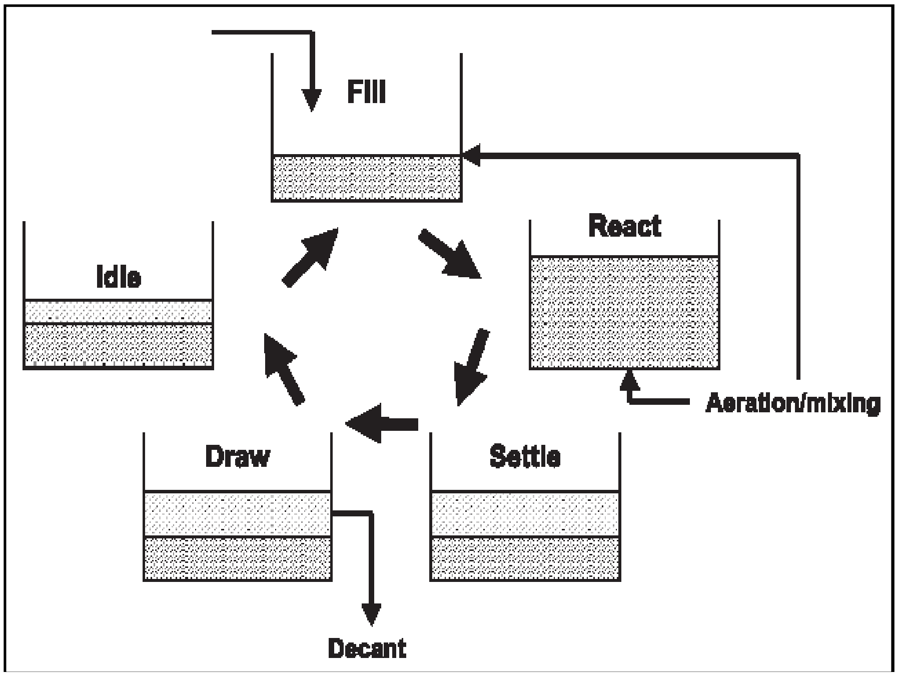

Fig-2: Sequential Batch Reactor (SBR)

II. LITERATURE REVIEW

Irvine et. al. (1979) reported working of SBR and its use for effective removal of contaminants from wastewater. Lin et. al., (1999) studied chemical and biological process for treatment of leachate. Refractory compounds present in leachate can be easily treated suing Fenton process combined with coagulation. After this process if SBR is also used improves the effluent quality according to discharge sandards.

Strauseret. al., (1998) used SBR for oxidation of ammonium ion. SBR has various advantages over other conventional biological treatment system. It has the advantages of solid phase separation, equal distribution of chemicals or biomass in the reactor and reliability of operation.

Chao et. al., (1995) obtained 91, 98 and 99% removal efficiency in chemical oxygen demand, total nitrogen and phosphate at SRT of 10 days and HRT of 6 hours. Shock loading of nitrogenous effluent also doesn't inhibit the process. There's been studies done by Ulrika Welander (2010) on synthetic wastewater. This synthetic wastewater is quite similar to the real textile wastewater to perform the tests. The experiments were performed in continuous mode in anaerobic environment. A solution of 200 ppm of Reactive Black 5, 200 ppm of Procion Red and 1 ppm of yeast extract was taken for the experimental work. Yeast extract was used for degradation of synthetic dyes in this study. Degradation of dyes from wastewater is observed among different tested parameters like no. of reactors, amount of yeast extract, continuous system, wastewater flow rate and washing the system with wood chips etc. It has been found that degradation of dyes is related to the flow rate. Manu and Sanjeev have worked on simulated wastewater containingazo and vat dyes (HE7B H3R), in anaerobic environment with long hydraulic retention time. They observed 95, 90 and 92% COD removal. It is also observed that there is 98-99% of colour removal. COD removal is achieved 90% with 95% colour removal. In studies done by Marisa punzi (2015) on textile wastewater using advanced oxidation processes (AOPs), It is observed that this technique is little expensive and complex. In his work the treatment of wastewater has been done in dual AOPs, photo-Fenton oxidation and ozonation. Before treating with these processes, wastewater was first processed with anaerobic biofilm. After these processes, it is found that degradation of azo dyes and removal of toxicity takes place. After this all biodegradable elements in the wastewater are disintegrated. In the next process of treatment by photo-fenton oxidation a large reduction in the COD is observed. There's been considerable decrement in toxicity by the use of Vibrio fishery bacteria.

III. MATERIALS AND METHODS

A. Acclimatization

The sewage water was acclimatized for a week with textile waste water to allow the microbes to adjust in its new environment where it could survive the pH change, food availability and other stresses**.**

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Fig-3 Acclimation of sewage

B. Wastewater Characteristics

Actual wastewater from textile industry was used for experiments. Characteristics of sample textile wastewater are:

TABLE-1
CHARACTERISTICS OF RAW WASTEWATER

Parameter	Average
Total Dissolved Solids (ppm)	4100
pH	9.8
Total Suspended Solids (ppm)	1470
COD(ppm)	2100
BOD(ppm)	697

C. Experimental design

The experimental designincludes a plastic container of 5 L capacity. The experiment was conducted in batch mode. During all the phases reactor contents were kept homogeneous and aerobic conditions were maintained with the help of diffused aeration.
Excess sludge has been wastedto prevent anaerobic conditions and for maintenance of SRT. At the end of treatment the wastewater was removed from the reactor.

Fig-3: Experimental Set up of SBR

The effluent from the SBR was then subjected to clariflocculationfor treatment of colloidal impurities. A jar test was conducted for obtaining optimum value of coagulants and the pH. The coagulants used were ferric chloride ($FeCl_3$) and aluminum Sulphate[$Al_2(SO_4)_3$]. The pH was optimized by examining minimum turbidity in effluent, formed at fixed amount of coagulants (1g) and varying pH from 3 to 8 in 6 different jars.

The effluent at different pH were flocculated for half an hour and then the pH of jar containing maximum sludge was noted. Now the same procedure was carried out for optimizing the amount of coagulants. The effluent was maintained at the optimum pH obtained and the amount of coagulants was varied from 1ml to 8ml and the amount of coagulants in the jar containing minimum turbidity was noted.

Fig-4 Aeration in SBR reactor.

IV. RESULTS

A. Effect of HRT

The organic and inorganic matter was effectively degraded by the SBR and the chemical coagulation-flocculation, and the efficiency of treatment was investigated by reduction in COD, BOD, TDS, TSS and Colour. The treatment efficiency of SBR was observedwith change in HRT. The SBR was operated at different HRT. The SBR was operated for HRT of 3, 6, 18 & 24 hours. The results were analysed for all these HRT's and was optimized from the point of view of maximum efficiency and best economy.

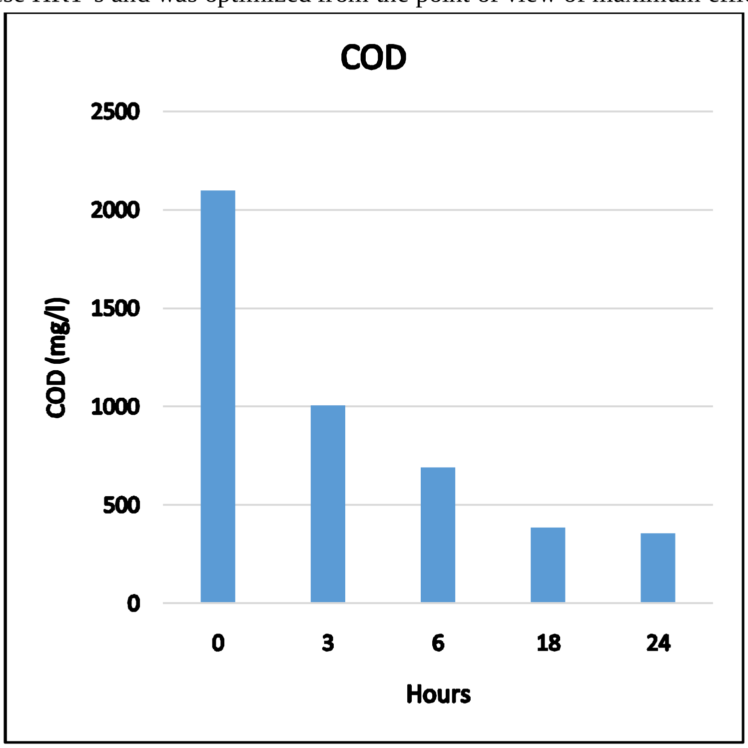


Fig-4: Effect of HRT on COD of the effluent

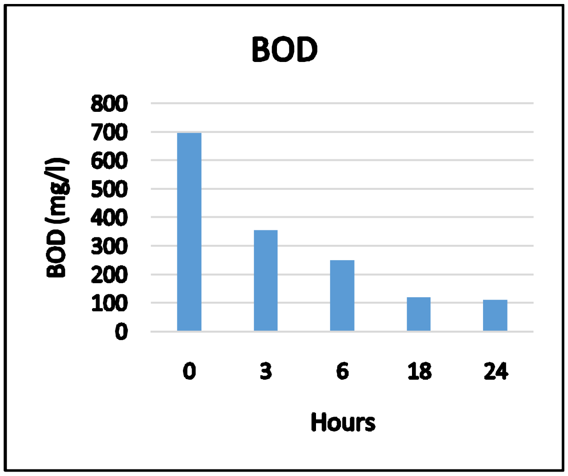


Fig-5: Effect of HRT on BOD of the effluent

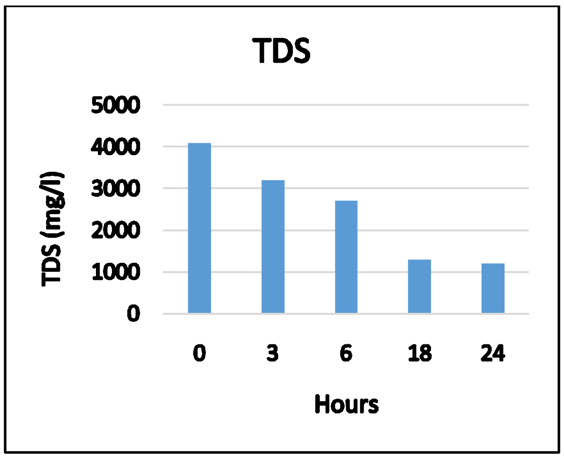


Fig-6: Effect of HRT on TDS of the effluent

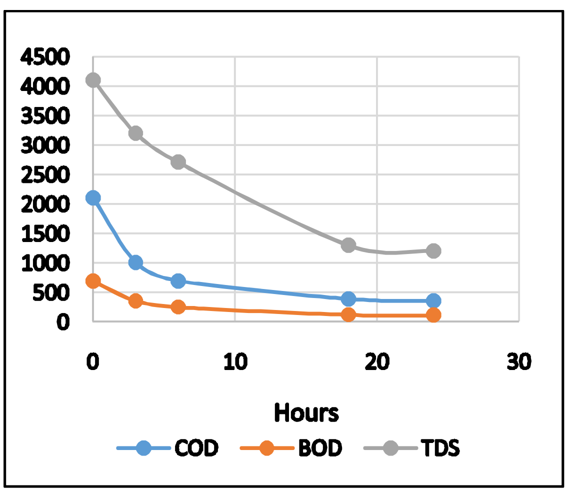


Fig-7: Effect of HRT on COD, BOD and TDS of the effluent

The investigation of these diagrams demonstrated that there isn't much difference between the efficiency with 18 and 24 hour of HRT, however the economy of the treatment procedure diminished because of increment in HRT. This is on account of an expansion in HRT implies an expansion in air circulation period which lessens the economy of treatment. Hence we picked the HRT of 18 hours, being the most effective and economical. The treatment cycles of SBR were repeated a few times to acquire the ideal efficiency.

B. Adoption of coagulation-flocculation

Although, COD, BOD and TDS are decreased yet didn't meet the standards for discharge of wastewater. Also, TSS was increased up to 2500mg/l because of an expansion in MLSS. Consequently to meet the national standards for discharge of effluent stimulated a need to additionally treat the wastewater. Decrease of TSS by Chemical coagulation-flocculation was embraced and observed to be very viable.

Table 2
Wastewater characteristics after sbr and coagulation flocculation

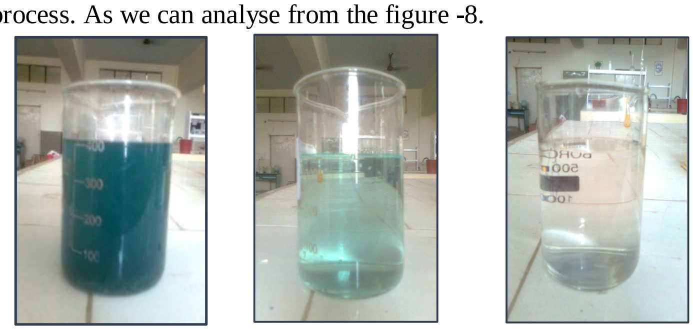
Parameters	characteristics		Efficiency
	Influent	Effluent	
COD (mg/l)	2100	215	89.7%
BOD (mg/l)	697	26	96.2%
TDS (mg/l)	4100	1230	70.0%
TSS (mg/l)	1470	97	93.4%
pH	9.2	7.6	-

It diminished the TSS level to an acceptable level. The TSS was found to decrease to 97mg/l with an effectiveness of 93.4%, the COD, BOD and TDS were observed to be 215, 26 and 1230mg/l separately relating to efficiencies 89.7, 96.2 and 70% individually. The following table shows the overall reduction in various parameters after the complete treatment process:

V. CONCLUSION

Biochemical treatment is considered as practical option for treatment of textile wastewater. It is likewise an environmentally sustainable and economical approach for treatment of troublesome wastewater. It has been observed that using coagulation after sequential batch reactor produces desired results for treating waste water.

The TSS, BOD, COD and TDS were observed as 1470, 697, 2100 and 4100 mg/l individually in raw wastewater. We noticed that COD, BOD and TDS were first decreased by SBR to 388, 118.5, 1300mg/l and TSS was discovered extended to 2500mg/l because of microbial cells. TDS, COD, BOD, and TSS has been diminished to 1230, 215, 26 and 97mg/l with the assistance of subsequent coagulation-flocculation process. As we can analyse from the figure -8.



Untreated sample

Biologically Treated Effluent

Final Effluent

Fig-8 Effluent during treatment process

These parameters were ideal for discharge of effluent set by CPCB. It can be concluded that biochemical treatment is an economical option for troublesome wastewater produces from textile industry.

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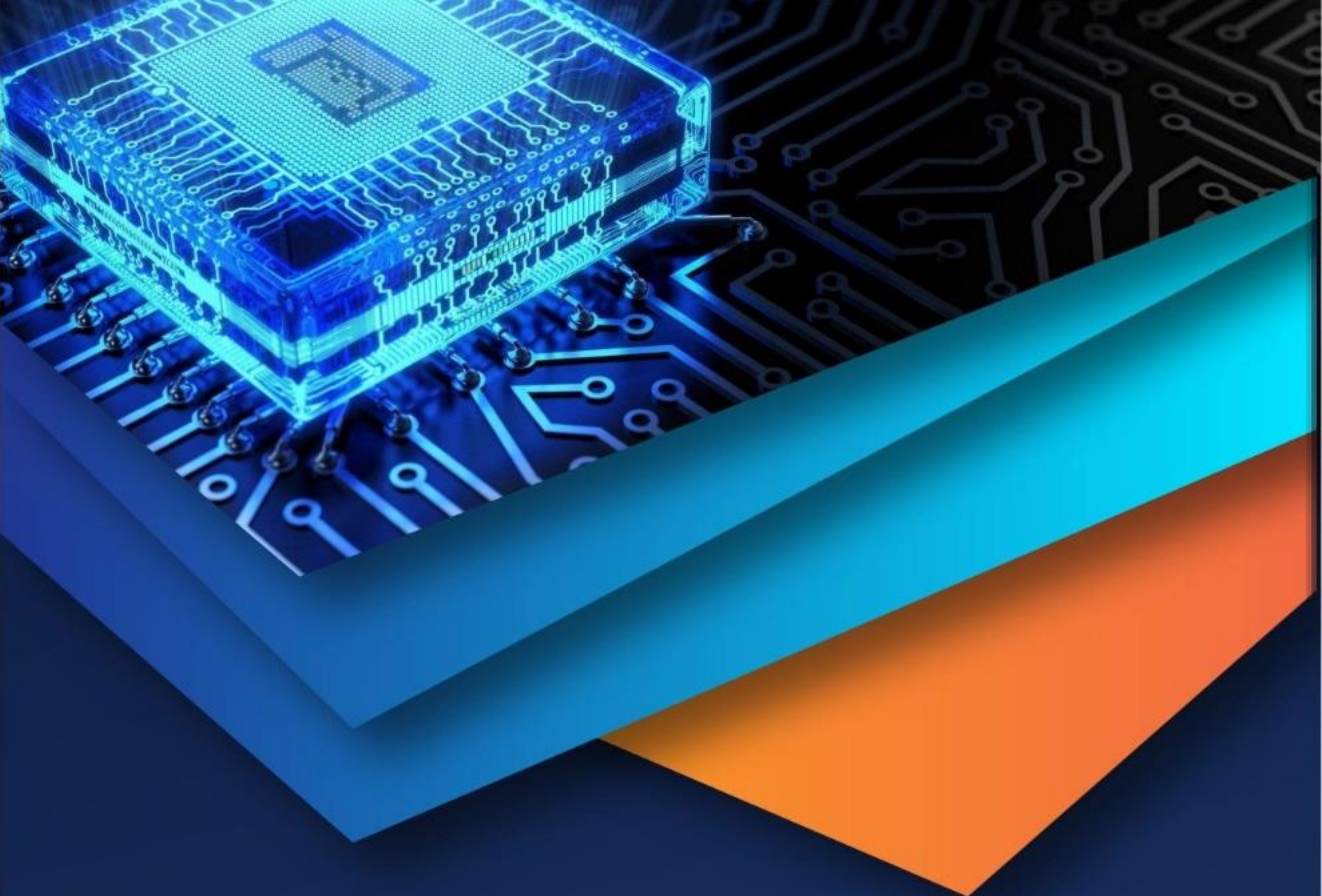

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