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Estimation of Heuristics for adaptation Flow Shops and Flow Shops with sequence Dependent Setup Times (SDST)

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Abstract: This paper presents an estimation of both the transformation flow shop and the flow shop with Sequence Dependent Setup Times (known as SDST flow shop). The paper highlights on works which includes heuristic method as a solution methodology. Usually heuristic approaches are classified into constructive heuristics and improvement heuristics. Improvement heuristics are additionally classified into neighborhood search heuristics and population based heuristics. The estimation analyzes the various methodologies used by the researchers and classifies them. Numerous researches have been accomplished on the transformation version of the flow shop scheduling problem and wide range of heuristics has been developed. Though, literature shows that there is limited application of such heuristics on a more realistic variation of the basic flow shop namely, SDST flow shop.
Keywords: constructive heuristics, transformation flow shop, Sequence Dependent Setup Times etc.

I. INTRODUCTION

Scheduling is the distribution of resources (e.g. machines) to tasks (e.g. jobs) with the intention of ensures the completion of these tasks in a rational amount of time. A flow shop encompasses a number of jobs which requires to be processed on a number of machines where each job has the equal processing route. The general flow shop scheduling problem entails a set of n number of jobs or tasks (1, 2, …, n) to be processed on a set of m number of machines or processors (1, 2, …, m) in the equal order, specifically. first on machine 1, then on machine 2 and so on until the machine m. Consequently, we suppose that the machines are ordered in the order they are visited by every job. Even though for the general flow shop, the job sequence may not be the same for every machine, here, the statement is the transformation flow shop, i.e. the job sequence is the similar on every machine. A significant and more realistic deviation of the basic flow shop is the flow shop operating in a sequence dependent setup time environment. The intention is to find a sequence for processing the jobs on the machines so that the total completion time or make span of the schedule is minimized.

II. PROBLEM FORMULATION

A. Assumptions

1) Each job is presented at time zero.
2) Each job can be processed at mainly on only one machine at a time.
3) Each machine is capable to process only one job at a time.
4) Setup of a machine can be done exclusive of the job being presented at the machine.
5) No preemption of job is permitted, i.e., a job cannot be passed to the next machine even as it is being processed on a machine.
6) The setup times of the jobs on the machines are independent and the job is not necessary to do the setup.
7) The job sequence is the similar on every machine and the machines are constantly available.
8) All the processing times and setup times are recognized in advance.
9) Setup time is reliant on the sequence in which the jobs are processed.
*10)*The sequence dependent setup time is supposed to be asymmetric; i.e., $Sijk \neq Sikj$.

III. LITERATURE EVALUATION

The transformation flow shop scheduling problem (PFSP) was proved to be NP hard by Garey *et al.* [1]. Furthermore, when the sequence reliant setup times are also measured, the problem turn out to be NP complete as shown by Gupta [2], which indicates that it cannot be resolved in polynomial time. Therefore, researchers have focused mostly on the development of heuristics and met

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heuristics. The complexity of the flow shop scheduling problems provides accurate solution methods infeasible and impractical for occurrences of more than a few jobs and machines. This is the foremost reason why a variety of heuristic methods, which obtain near-optimal solutions, are tried. The heuristic methods can be partitioned into constructive heuristics and improvement heuristics. Constructive heuristics are the heuristics that build a feasible schedule from scuff by making a series of passes throughout the list of unscheduled jobs, where at every pass one or more jobs are selected and improvement heuristics start from an initial solution and apply an improvement procedure (refer Fig.2). In constructive heuristics, a series obtained is fixed and cannot be changed i.e., it offers a single solution all the instants while in improvement heuristics, an initial solution is repeatedly improved upon i.e., it may provide diverse solutions every time. Hence the literature study is divided into two sections:
Constructive heuristics

A. *Constructive heuristics for transformation flow shop*

Johnson's work was the first important one on flow shop scheduling [3]. Johnson's algorithm is the earliest recognized heuristic for the transformation flow shop scheduling problem (PFSP), which offers an optimal solution for two machines. Additionally, it can also be used as a heuristic for the *m* machine problem by clustering the *m* machines into two virtual machines. His initiating work was the real encouragement for all of the future researches in the flow shop scheduling, in which the general ideas of Johnson's rule have been used. Another technique is assigning a weight or index to every job and after that arranging the sequence by sorting the jobs according to the index. This scheme was given by Palmer [4]. He developed a simple heuristic, in which a slope index is evaluated for every job and then the jobs are organized in decreasing order of this index. Campbell *et al.* [5] lengthened Johnson's algorithm to develop a heuristic algorithm (called CDS heuristic). By clustering *m* original machines into two fabricated machines and solving the two machine problem hence generated by replicated applying Johnson's algorithm, (*m*-1) schedules are built. Nawaz, Enscore and Ham's NEH heuristic [6] is considered as the best heuristic till today for the PFSP. Their thought was that the jobs with highest processing times on all the machines be supposed to be scheduled as early in the series as possible.
The overall processing time for each job on all the machines is first evaluated. Subsequently the jobs are sorted in the declining order of total processing time. The first two jobs are taken and the best schedule is chosen out of the two possible schedules. After that, one job is taken at a time from the sorted list and added at every possible position and the best sequence obtained is selected. The process is recurred until the last job is selected from the sorted list. Chakra borty and Laha[7] adapted the NEH heuristic for make span minimization in PFSP. The modified algorithm was run on 28 different problem sizes. Analysis exposes important enhancement in the worth of the solution while the algorithmic complexity remained the identical. Their conclusion was that both innovative NEH and modified NEH outperform the best competitor to date.

B. *Constructive heuristics for SDST flow shop*

Rios-Mercado and Bard [8] expanded a branch-and-cut algorithm for SDST flow shop which acquired the optimum solutions for illustrations of up to eight jobs and six machines. The same authors Rios-Mercado and Bard [9] also developed a branch-and-bound method which was capable to explain SDST flow shop problem instances of up to ten jobs and six machines with a maximum difference of about 1% from the optimal solution. Rios-Mercado and Bard [10] also recommended an expansion of NEH heuristic for the SDST flow shop and their heuristic is called NEHRB.

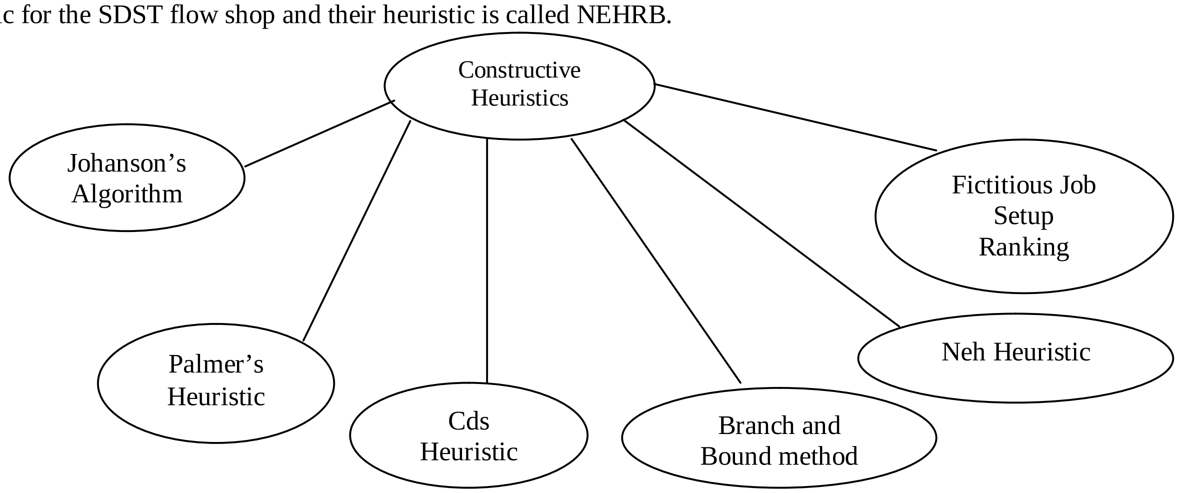

Fig.1.Constructive heuristics for flow shops

Rajesh Vanchipura and R. Sridharan [11] proposed two new constructive heuristics for solving the SDST flow shop scheduling problem with the minimization of makespan as the objective. The primary heuristic called as the setup ranking algorithm (SRA) produces the sequence using only the setup times of jobs. The second heuristic algorithm, fictitious job setup ranking algorithm (FJSRA), is expanded using theory of fictitious jobs. Fictitious jobs are the pairs of jobs with minimum setup time between them. *A.*

C. Improvement heuristics

The improvement heuristics constantly start with an initial solution and concern some enhancement procedure which recovers the solution iteratively. Improvement heuristics are formulated more than the constructive ones due to their flexibility. These comprise meta heuristics such as Genetic Algorithm (GA), Ant Colony Optimization (ACO), Bee Colony Optimization, Particle Swarm Optimization (PSO), Tabu Search (TS) and Simulated Annealing (SA) etc. (refer Fig.2). Improvement heuristics have been utilized to solve both transformation flow shop and SDST flow shop. Therefore, the literature of improvement heuristics can be further divided into:

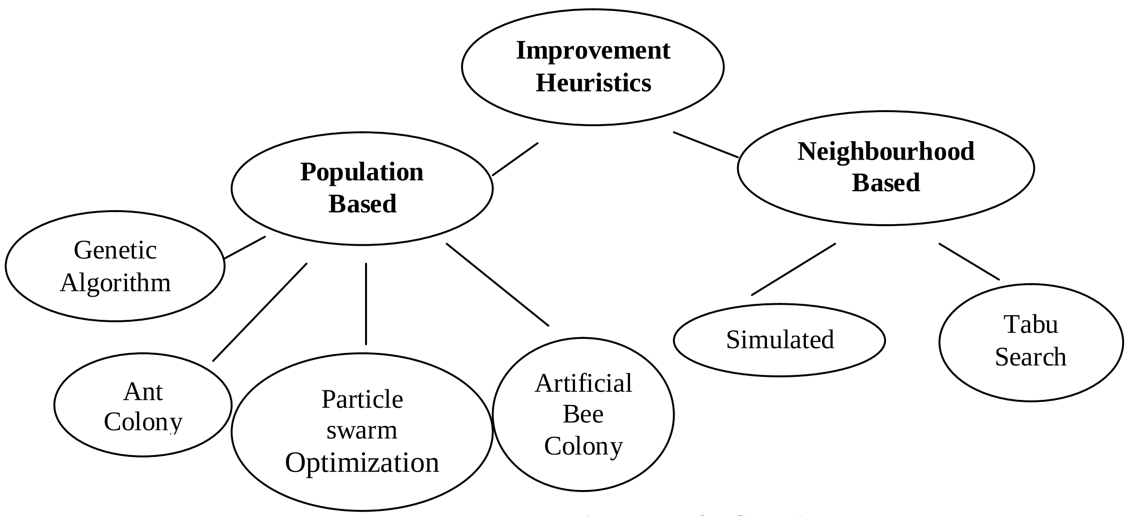

Fig.2.Improvement heuristics for flow shops

D. Improvement heuristics for transformation flow shop

Simulated Annealing (SA) algorithm, based on the equivalence of annealing process of metals, was worked on by Osman and Potts [12]. They expanded a set of four different SA based heuristic algorithms for the PFSP and proved that their algorithm offers improved results compared to the NEH heuristic. Rajesh Gangadharan and Chandrasekharan Rajendran [13] judged suggested annealing for transformation flow shop scheduling problem (PFSP) with the identical-objective of minimizing makespan and total flow time. They recommended two new heuristics to provide the seed sequences for the SA heuristic. An additional imitated annealing based heuristic with bi-criteria minimization of makespan and maximum tardiness was expanded by Chakravarthy and Rajendran [14]. Chen et al. [15] extended a simple Genetic Algorithm (GA) for the PFSP with a variety of improvements. The preliminary population was developed with CDS heuristic and RA heuristic. Only the intersect operator was used with no alteration and the crossover used was fractionally mapped crossover or PMX. Reeves [16] also developed a GA in which the off springs engendered do not reinstate their parents but individuals that have fitness value below average. He used a crossover called C1 or one-point order crossover and used a shift alteration. Two new hybrid genetic algorithms with minimization of makespan as objective has also been proposed by Ruiz *et al.*[17]for PFSP. Their algorithms use new genetic operators, advanced techniques like that of the hybridization with a local search and an proficient population initialization and also a new generational format. Now icki *et al*. [18] recommended a fast tabu search algorithm for finding least make span using a modified NEH algorithm to acquire initial solution. Their algorithm is based on tabu search method with a explicit neighborhood definition which utilizes a ‘block of jobs’ notion. Computational experiments of up to 500 jobs and 20 machines show its outstanding numerical properties.

Suliman [19] suggested a two-phase improvement heuristic. In the first phase an preliminary job sequence is generated using one of the available, eminent and well-organized heuristics, while the sequence engendered is improved in the second phase in stipulations of makespan using a pair exchange mechanism connected with directionality restraint. The ensuing algorithm is found to have performance analogous to NEH which runs faster. Ant colony optimization (ACO) is another advance for solving the flow shop

problem. Rajendran and Ziegler [20] employs two ACO algorithms with the purpose of minimizing makespan and total flow time of jobs. The efficiency of the algorithms was calculated by considering benchmark problems and values of makespan given by Taillard [25]. Particle swarm optimization (PSO) by Tasgetiren *et al.* [21] is another important work done on the transformation flow shop scheduling problem. They believed objectives of minimizing makespan and the total flowtime of jobs and applied PSO to the 90 benchmark occurrences provided by Taillard. Artificial bee colony algorithm (ABC) was worked on by Tasgetiren *et al.*[22] to resolve the PFSP. They presented a discrete artificial bee colony algorithm (DABC) hybridized with a deviation of the iterated greedy algorithms to uncover the transformation with the smallest total flowtime Backtracking Search Algorithm (BSA) is one of the new-born algorithms that was suggested first by Civicioglu [23] and used in constant numerical optimization problems. It is a type of evolutionary algorithms (EA) which mimics the natural evolution process.
BSA, which is mainly used for constant numerical optimization problems, was applied to the PFSP by Qun Lin *etal.* [24] with makespan criterion. Taillard [25] offers benchmark problems for job shop, transformation flow shop and open shop scheduling problems. In his paper, he suggested 260 randomly generated scheduling problems whose sizes are greater than sizes of the rare examples published and communicate to real dimensions of industrial problems.

E. Improvement heuristics for SDST flow shop

Parthasarathy and Rajendran [26] considered simulated annealing to reduce total weighted tardiness in SDST flow shop. They proposed a perturbation scheme called random insertion perturbation scheme, which resulted in a advantage of about 70% over the existing heuristic. Rios-Mercado and Bard [10] put forward a metaheuristic based on a greedy randomized adaptive search procedure (GRASP) for solving the SDST flow shop.
One of the most significant works done on SDST flow shop is the fusion genetic algorithm developed by Ruiz *et al.* [27]. The hybrid version includes a special initialization of population (a modification of NEH heuristic) and two selection schemes, tournament selection and roulette wheel selection and also a local search. Four types of crossover and a powerful restart scheme were also developed. Gajpal *et al.* [28] presented an ant colony optimization algorithm for flow shop scheduling with sequence reliant setups for the makespan objective. A tabu search heuristic with makespan and weighted tardiness criteria for SDST flow shop was expanded by Fred Choobineh *et al.* [29]. They demonstrated that recommended heuristic gives optimal or near to optimal solutions in a realistic time.Rajesh Vanchipura *et al.* [30] offered the application of variable neighborhood descent (VND) approach for solving SDST flow shop scheduling problem. They incorporated the VND approach with two constructive heuristics, NEHRB and FJSRA. The investigation reveals that the performance of VND-based algorithms depends on the constructive algorithm utilized for providing the initial solution.

IV. CONCLUSION

From the literature study, it is obvious that some accurate approaches for SDST flow shop have been developed, but they are only appropriate to two machine case and m machine case can be resolved using these methods only for very small instances. Additionally, the general heuristics presented have high CPU time requirements and therefore not suitable for medium and large instances. Furthermore, there are very few work considering the SDST flow shop with the makespan criterion. In addition, sequence dependent setup time (SDST)is one of the most frequent additional complications in the scheduling problem. A large amount of the existing work have integrated the setup time in the processing time, but to advances the performance of manufacturing system setup time has to be considered separate since it is one of the significant factors.
The constructive heuristics are enormously difficult to be devised for these problems. Only a small number of constructive heuristics are available till now. More researches are done on improvement heuristics such as heuristic algorithms and hybrid metaheuristics in flow shop scheduling. SDST flow shop scheduling is an area where the number of existing researches is limited.
Future research on flow shops operating under sequence dependent setup times environment is enviable.

REFERENCES

[1] Garey M.R, Johnson D.S and Sethi R.R. ,"The complexity of flow shop and job shop scheduling", Operations Research.vol 1, pp. 117-129, 1976.
[2] Gupta J.N.D. ," Flow shop schedules with sequence dependent setup times, Journal of the Operations Research Society of Japan", vol 29, no.3, pp. 206-219, 1986.
[3] Johnson S.M. ,"Optimal two-and three-stage productionschedules with setup times included", Naval Research Logistics Quarterly, vol. 1, pp. 61-68, 1954.
[4] Palmer D.S. ,"Sequencing jobs through a multi-stage process in the minimum total time a quick method of obtaining a near optimum", Operations Research Quarterly, vol. 16, no. 1, pp. 101-107, 1965.

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[5] Campbell H.G, Dudek R.A, Smith M.L. ,"A heuristic algorithm for the n-job m-machine sequencing problem", Management Science vol.16, no. 10, pp. 169-174, 1970.
[6] Nawaz M., Enscore E., Ham I., "A heuristic algorithm for the m-machine n-job flow shop sequencing problem", Omega, vol. 11, no. 1, pp. 91-95, 1983
[7] Chakraborty U.K., Laha D., "An improved heuristic for transformation flow shop scheduling", International Journal ofInformation and Communication Technology, vol. 1, no. 1, pp. 89-97, 2007.
[8] Rios-Mercado R.Z, Bard J., "Computational experiencewith a branch-and-cut algorithm for flow shop scheduling with setups", Computers and Operations Research, vol. 25, no. 5, pp. 351-366, 1988
[9] Rios-Mercado R.Z, Bard J., "A branch-and-bound algorithm for transformation flow shops with sequence-dependent setup times", IEE Transactions, vol. 31, pp. 721-731, 1999
[10] Rios-Mercado R.Z, Bard J. ,"Heuristics for the flowline problem with setup costs", European Journal of OperationalResearch, vol. 110, pp. 76-98, 1998
[11] Rajesh Vanchipura, Sridharan R., "Development and analysis of constructive heuristics algorithms for flow shop scheduling problems with sequence dependent setup times", International Journal of Advanced Manufacturing Technology, vol. 67, pp. 1337-1353, 2012
[12] Osman I.H., Potts C.N., "Simulated annealing for transformation flowshop scheduling", OMEGA, vol. 17, no. 6, pp. 551-557, 1989.
[13] Rajesh Gangadharan, Chandrasekharan Rajendran, "A Simulated Annealing Heuristic for Scheduling in a Flowshop with Bicriteria", Computers ind. Engng, vol. 27, no. 1-4, pp. 473-476, 1994.
[14] Chakravarthy K., Rajendran C., "A heuristic for scheduling in a flowshop with the bi-criteria of makespan andmaximum tardiness minimization", Production Planning and Control, vol. 10, pp. 707-714, 1999.
[15] Chen C.L, Vempati V.S, Aljaber N., "An application of genetic algorithms for flow shop problems", European Journalof Operational Research, vol. 80, pp. 389-396, 1995.
[16] Reeves C.R., "A genetic algorithm for flowshop sequencing", Computers andOperations Research, vol. 22, no. 1, pp. 5-13, 1995.
[17] uiz R, Maroto C, Alcaraz J., "Two new robust genetic algorithms for the flowshop scheduling problem", TechnicalReport, Universidad Politecnica de Valencia, Valencia, Espana, Grupo de Investigation Operativa GIO, OMEGA, The International Journal of Management Science, 2003
[18] Nowicki E, Smutnicki C., "A fast tabu search algorithm for the transformation flow-shopproblem", European Journal of Operational Research, vol. 91, pp. 160-175, 1996
[19] Suliman S.M.A., "A two-phase heuristic approach to the transformation flow-shop scheduling problem", InternationalJournal of Production Economics, vol. 64, pp. 143-152, 2000.
[20] Rajendran C., Ziegler H., "Ant-colony algorithms fortransformationflowshopschedulingtominimizemakespan/total flowtime of jobs", European Journal of Operational Research, vol. 155, pp. 426-438, 2004
[21] M. Fatih Tasgetiren , Yun-Chia Liang, Mehmet Sevkli, Gunes Gencyilmaz, "A particle swarm optimization algorithm for makespan and total flowtime minimization in the transformation flowshop sequencing problem", European Journal of Operational Research Volume, vol. 177, no. 3, pp. 1930-1947, 2007
[22] M. Fatih Tasgetiren , Quan-Ke Pan , P.N. Suganthan, Angela H-L Chen., "A discrete artificial bee colony algorithmfor the total flowtime minimization in transformation flow shops", Information Sciences, vol. 181, no.16, pp. 3459-3475, 2011.
[23] Pinar Civicioglu, "Backtracking Search Optimization Algorithm for numerical optimization problems", Applied Mathematics and Computation, vol. 219, pp. 8121-8144, 2013
[24] Qun Lin, Liang Gao, Xinyu Li, Chunjiang Zhang, "A hybrid backtracking search algorithm for transformation flow-shop scheduling problem", Computers & Industrial Engineering, vol. 85, pp. 437-446, 2015.
[25] Taillard E., "Benchmarks of basic scheduling problems", European Journal of Operation Research, vol. 64, pp. 278– 285, 1993
[26] S., Rajendran C.A., "A simulated annealing heuristic for scheduling to minimise weighted tardiness in a flow shop with sequence dependent setup times of jobs - a case study", Production Planning and Control, vol. 8, no. 5, pp. 475-483, 1997.
[27] Ruiz R., Maroto C., Alcatraz J., "Solving the flow shop scheduling problem with sequence dependent setup times using advanced meta-heuristic", European Journal of Operational Research, vol. 165, no. 1, pp. 34-54, 2005.
[28] Gajpal Y., Rajendran C., Ziegler H., "An ant colony algorithm for scheduling in flowshops with sequence-dependent setup times of jobs", International Journal of Advanced Manufacturing Technology, vol. 30, no. 5-6, pp. 416-424, 2006.
[29] F. Fred Choobineh, Esmail Mohebbi, Hansen Khoo, "A multi-objective tabu search for a single-machine scheduling problem with sequence-dependent setup times", EuropeanJournal of Operational Research, vol. 175, no. 1, pp. 318-337, 2006
[30] Rajesh Vanchipura, R. Sridharan, Subash Babu, "Improvement of constructive heuristics using variable neighbourhood descent for scheduling a flow shop with sequence dependent setup time", Journal of Manufacturing Systems,vol.33,pp.65-75,2014

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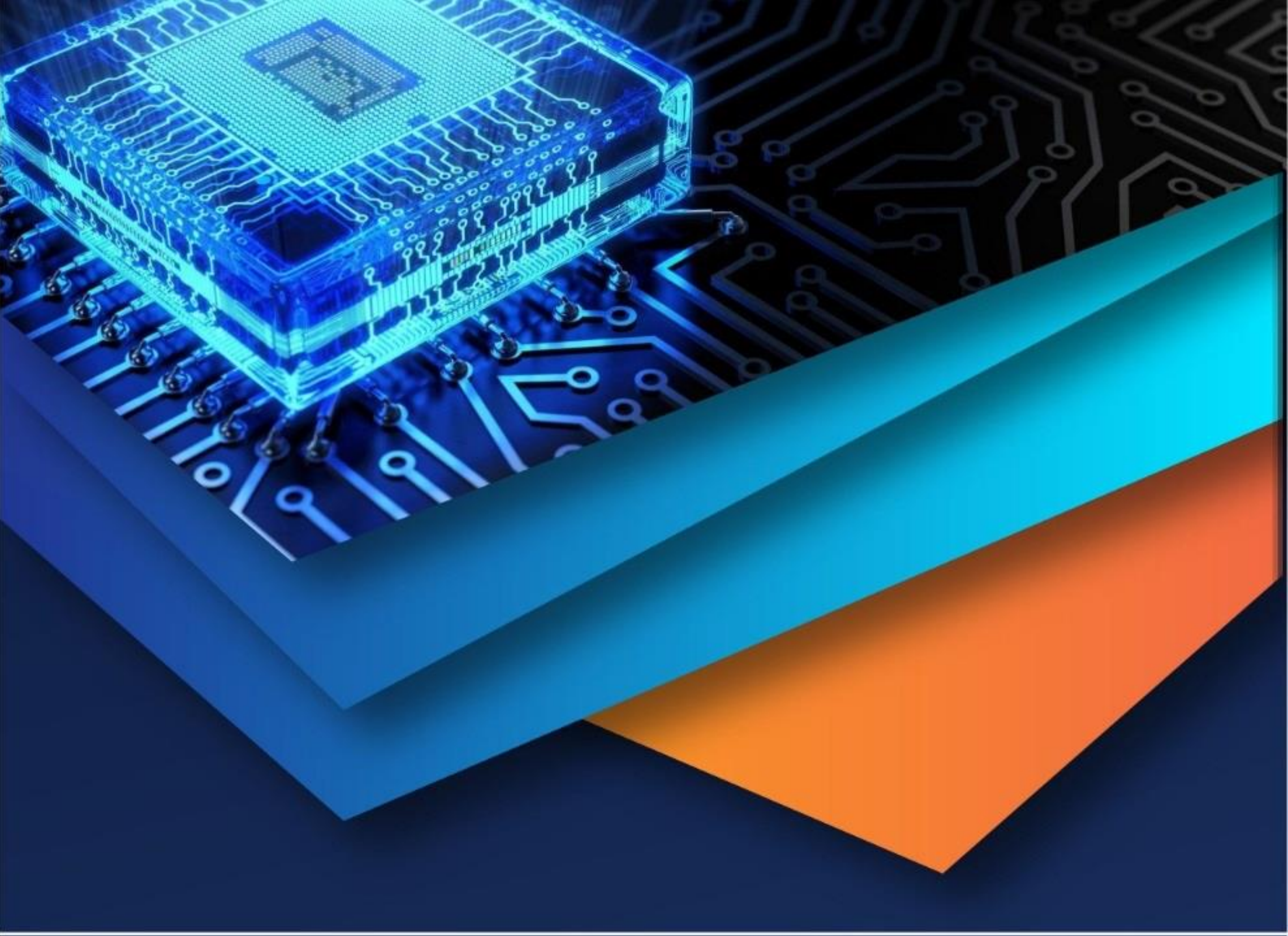

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