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Improvement in Line Efficiency of Assembly Line by Using Assembly Line Balancing Techniques

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Abstract: The focus of this paper is on improvement in the efficiency of assembly line through assembly line balancing techniques. The assembly line balancing is about evenly distribution of the work load among the workstations without violating the precedence and cycle time requirements. The three assembly line balancing techniques namely ranked positional weight technique (RPW) ,largest candidate rule technique (LCR) and kilbridge and wester column technique are utilized to improve the efficiency of assembly line with minimization of number of workstations and thereby reducing balance delay of the assembly line.

I. INTRODUCTION

In this global era assembly lines are important to manufacturing products which are capable of meeting the customer's demand. Assembly lines are very much important from point of view of manufacturers in more bottleneck competitive world manufacturing the products. Assembly line is flow oriented production systems where the stations performing the productive operations are arrange in serial manner. The work piece moves through stations usually by some means of transportation systems.

Success of the production system is greatly influenced by the balancing of assembly line. Balancing of assembly line means distribution of the work load evenly among the number of workstations so that the precedence and cycle time constraints can be satisfied . The objectives of line balancing includes the maximization of production rate and minimization of number of workstations .Line balancing is about the grouping the workstations in an efficient manner in order to get optimal or most efficient feasible solution for the assembly line balancing problem.

II. ASSEMBLY LINE BALANCING PROBLEM

In assembly line balancing problem one is given with finite set of operation required to be performed , each operation has standard time and precedence requirement of operation which indicates the permissible order or sequence of operations . The problem is to assign operations to number of workstations in such way that satisfies precedence relationships and the cycle time requirement of operation and optimization of some measure of performance like efficiency and balance delay.

III. PROBLEM STATEMENT

One of the main hurdle to produce products and delivering it to the customer at faster response time to customer is inefficiency of the assembly lines. For the purpose of the study the assembly line which is used for assembling xyz product of volvo construction equipment banglore is considered.. The study of xyz product assembly line is taken for this project in order to find the way in which the efficiency of assembly line can be improve thereby helping to volvo construction equipment to deliver the single drum compactor at faster response time along with proper quality to customer.

IV. DATA COLLECTION AND ANALYSIS OF PRESENT ASSEMBLY LINE TECHNIQUE

The data about the sequence or order in which the tasks are performed among the seven main workstations and time required for performing these tasks is collected. And analysis is carried out using following formulae.

$$LE = \frac{\sum_{i=1}^{N} STi}{m * CT}$$

Where
LE = Line efficiency
ST = Station time
m = Number of stations
CT = Cycle time

$$BD = 1 - LE$$

Where
BD = Balance delay
LE = Line efficiency
Collected data for single drum compactor assembly line is as shown in below table

Table 1 Activities time and precedence relationships at present assembly line.

Activity No	Time (Min)	Predecessor
d	0	-------
1	199.8	d
2	26.12	d
3	9.16	d
4	137.26	d
5	111.31	d
6	34.4	d
7	46.2	d
8	15.14	d
9	6.16	d
10	96.16	d
11	13.46	1
12	16.2	1
13	6.36	11,12
14	72.44	2,13
15	79.19	3,13
16	36.22	14,15
17	14.44	4,16
18	15.25	17
19	102.14	17
20	9.07	17
21	33	17
22	149.1	17
23	26.09	18,19,20,21,22
24	47.02	5,23
25	131.36	24
26	70.61	6,25
27	14.04	7,25
28	35.02	26,27
29	15.14	8,28
30	23.57	9,29
31	36.07	11
32	91.13	10
33	37.51	30,31,32
34	35.56	33

Below figure shows the precedence diagram for single drum compactor assembly line

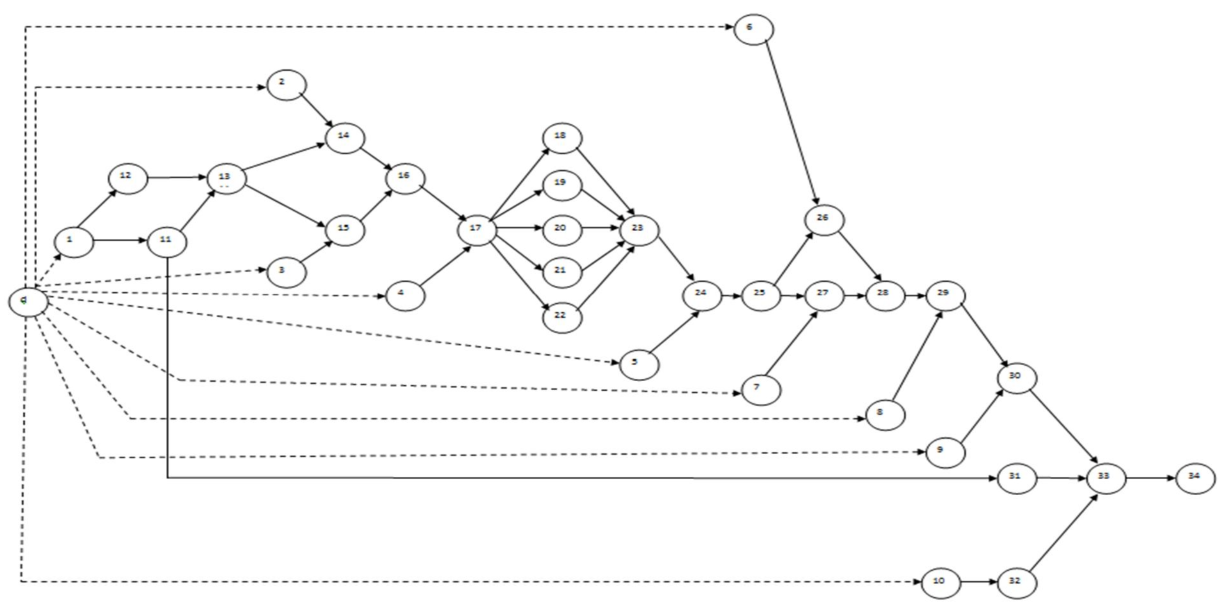

Figure 1 Precedence diagram for xyz product assembly line

Table 2 Station time at present assembly line

Activities	Station	Station Time (Min)
d,1.11,12,13	1	235.82
2,3,14,15,16	2	223.13
4,17,18,19,20,21,22,23	3	486.35
5,24,25	4	289.69
6,7,26,27,28	5	200.27
8,9,29,30	6	60.01
10,31,32,33,34	7	296.43

Analysis of single drum assembly line for present method

Summary of data

Sum of task time = 1791.7

Cycle time = Largest of station time =486.35

Number of stations = 7

$$LE = \frac{\sum_{i=1}^{N} STi}{m * CT}$$

$$= 0.5262$$

$$BD = 1 - LE$$

V. HEURISTIC TECHNIQUES OF LINE BALANCING

Heuristics specifies a particular approach for solving the problem , it helps in decision making and control over the situation. These techniques are simple. They serves as thumb rule for solving complex problems. The objective is to provide the ways for solving problems which will help for rigorous logical analysis.

The main heuristic techniques for assembly line balancing problems are as follows

A. Ranke positional weight method.(RPW)

1) Draw the precedence diagram
2) Calculate ranked positional weight (RPW). Rank positional weight of task is its own time and duration of all succeeding tasks in precedence diagram.
3) Arrange the task in descending order of ranked positional weights.
4) Assign tasks to the number of work stations. Assignment of task to the workstation should done in such way that satisfies the precedence requirements and without violating cycle time constraints.
5) Repeat the above step until all tasks in precedence diagram are assign to the number of workstations

Analysis of assembly line by the RPW technique is as shown below.

Table 3 calculated RPW's for activities

Activity	Time(Min)	RPW	Predecessor
d	0	1791.7	-------
1	199.8	1185.33	d
2	26.12	893.7	d
3	9.16	883.49	d
4	137.26	896.18	d
5	111.31	521.14	d
6	34.4	251.83	d
7	46.2	207.06	d
8	15.14	126.94	d
9	6.16	102.8	d
10	96.16	260.36	d
11	13.46	966.59	1
12	16.2	969.33	1
13	6.36	953.13	11,12
14	72.44	867.58	2,13
15	79.19	874.33	3,13
16	36.22	795.14	14,15
17	14.44	758.92	4,16
18	15.25	451.17	17
19	102.14	538.06	17
20	9.07	444.99	17
21	33	468.92	17
22	149.1	585.02	17
23	26.09	435.92	18,19,20,21,22
24	47.02	409.83	5,23
25	131.36	362.81	24
26	70.61	217.42	6,25
27	14.04	160.86	7,25
28	35.02	146.82	26,27
29	15.14	111.8	8,28
30	23.57	96.64	9,29
31	36.07	109.14	11
32	91.13	164.2	10
33	37.51	73.07	30,31,32
34	35.56	35.56	33

Summary of data
Sum of tasks time = 1791.7
Cycle time = 486.35
Number of Stations as per RPW method = 4

$$LE = \frac{\sum_{i=1}^{N} STi}{m * CT}$$

= 0.9209

$$BD = 1 - LE$$

= 0.0791

Table 4 Activities arranged as per RPW technique and assigned to stations

Activity	Time	RPW Descending	Predecessor	Station	Station Time
d	0	1791.7	----	1	
1	199.8	1185.33	d	1	
12	16.2	969.33	1	1	
11	13.46	966.59	1	1	
13	6.36	953.13	11,12	1	
4	137.26	896.18	d	1	
2	26.12	893.7	d	1	
3	9.16	883.49	d	1	408.36
15	79.19	874.33	3,13	2	
14	72.44	867.58	2,13	2	
16	36.22	795.14	14,15	2	
17	14.44	758.92	4,16	2	
22	149.1	585.02	17	2	
19	102.14	538.06	17	2	453.49
5	111.31	521.14	d	3	
21	33	468.92	17	3	
18	15.25	451.17	17	3	
20	9.07	444.99	17	3	
23	26.09	435.92	18,19,20,21,22	3	
24	47.02	409.83	5,23	3	
25	131.36	362.81	24	3	
10	96.16	260.36	d	3	469.26
6	34.4	251.83	d	4	
26	70.61	217.42	6,25	4	
7	46.2	207.06	d	4	
32	91.13	164.2	10	4	
27	14.04	160.86	7,25	4	
28	35.02	146.82	26,27	4	
8	15.14	126.94	d	4	
29	15.14	111.8	8,28	4	
31	36.07	109.14	11	4	
9	6.16	102.8	d	4	
30	23.57	96.64	9,29	4	
33	37.51	73.07	30,31,32	4	
34	35.56	35.56	33	4	460.55

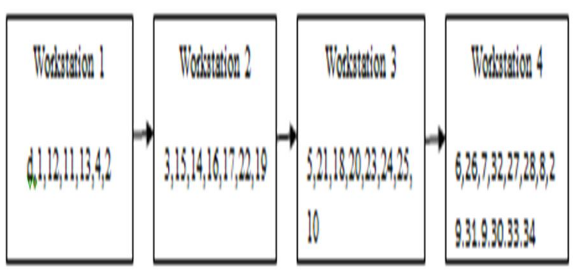

Figure 2 Configuration of assembly line as per RPW technique

B. Largest candidate rule method. (LCR)

1) List all work task elements in descending order of their completion time.

2) Allocate the tasks to the number of workstations such that precedence and cycle time constraints satisfied with the assignment of task to the workstation.

3) Repeat the above step until all tasks have been allocated to the number of workstations.

Analysis of assembly line by the application of largest candidate rule technique is as shown below

Table 5 Activities arranged as per LCR technique

Activity	Time(Min) Descending	Predecessors
d	0	-----
1	199.8	d
22	149.1	17
4	137.26	d
25	131.36	24
5	111.3	d
19	102.14	17
10	96.16	d
32	91.13	10
15	79.19	3,13
14	72.44	2,13
26	70.61	6,25
24	47.02	5,23
7	46.2	d
33	37.51	30,31,32
16	36.22	14,15
31	36.07	11
34	35.56	33
28	35.02	26,27
6	34.4	d
21	33	17
2	26.12	d
23	26.09	18,19,20,21,22
30	23.57	9,29
12	16.2	1
18	15.25	17
8	15.14	d
29	15.14	8,28
17	14.44	4,16
27	14.04	7,25
11	13.46	1
3	9.16	d
20	9.07	17
13	6.36	11,12
9	6.16	d

Table 6 activities assigned to stations as per LCR technique

Activity	Time (Min)	Predecessor	Station	Station Time
d	0	----	1	
1	199.8	d	1	
12	16.2	1	1	
11	13.46	1	1	
31	36.07	11	1	
13	6.36	11,12	1	
4	137.26	d	1	409.15
5	111.31	d	2	
10	96.16	d	2	
32	91.13	10	2	
7	46.2	d	2	
6	34.4	d	2	
2	26.12	d	2	
14	72.44	2,13	2	477.76
8	75.14	d	3	
3	9.16	d	3	
15	79.19	3,13	3	
16	36.22	14,15	3	
17	14.44	4,16	3	
22	149.1	17	3	
19	102.1	17	3	
21	33	17	3	
18	15.25	17	3	
20	9.07	17	3	462.67
23	26.09	18,19,20,21,22	4	
24	47.02	5,23	4	
25	131.36	24	4	
26	70.61	6,25	4	
27	14.04	7,25	4	
28	35.02	26,27	4	
29	15.14	8,28	4	
9	6.16	d	4	
30	23.57	9,29	4	
33	37.51	30,31,32	4	
34	35.56	33	4	442.08

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Summary of data
Sum of task time = 1797.1
Cycle time = 486.35
Number of Station as per LCR technique = 4

$$LE = \frac{\sum_{i=1}^{N} STi}{m * CT}$$
$$= 0.9209$$
$$BD = 1 - LE$$
$$= 0.079$$

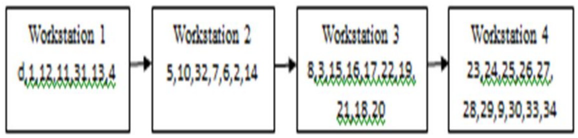

Figure 3 Configuration of assembly line as per LCR technique

C. Kilbridge and wester column method. (KWC)

1) Construct the precedence diagram.
2) Arrange the nodes representing the task into number of columns.
3) Tasks in the column are assigned to workstation in such way that stratifies the cycle time and precedence requirement restrictions.
4) Repeat above step until all task have been assigned to number of workstations.

Analysis of assembly line by the application of kilbridge and weste column method is as shown below

Table 7 Activities arranged as per KWC technique

Activities	Column	Predecessor	Time (min)
d	1	----	0
1	2	d	199.8
12	3	1	16.2
11	4	1	13.46
13	5	11,12	6.36
2	6	d	26.12
3	6	d	9.16
14	7	2,13	72.44
15	7	3,13	79.19
4	8	d	137.26
16	8	14,15	36.22
17	9	4,16	14.44
18	10	17	15.25
19	10	17	102.14
20	10	17	9.07
21	10	17	33
22	10	17	149.1
5	11	d	111.31
23	11	18,19,20,21,22	26.09
24	12	5,23	47.02
6	13	d	34.4
7	13	d	46.2
25	13	24	131.36
26	14	6,25	70.61
27	14	7,25	14.04
8	15	d	15.14
28	15	26,27	35.02
9	16	d	6.16
29	16	8,28	15.14
10	16	d	96.16
30	17	9,29	23.57
31	17	11	36.07
32	17	10	91.13
33	18	30,31,32	37.51
34	19	33	35.56

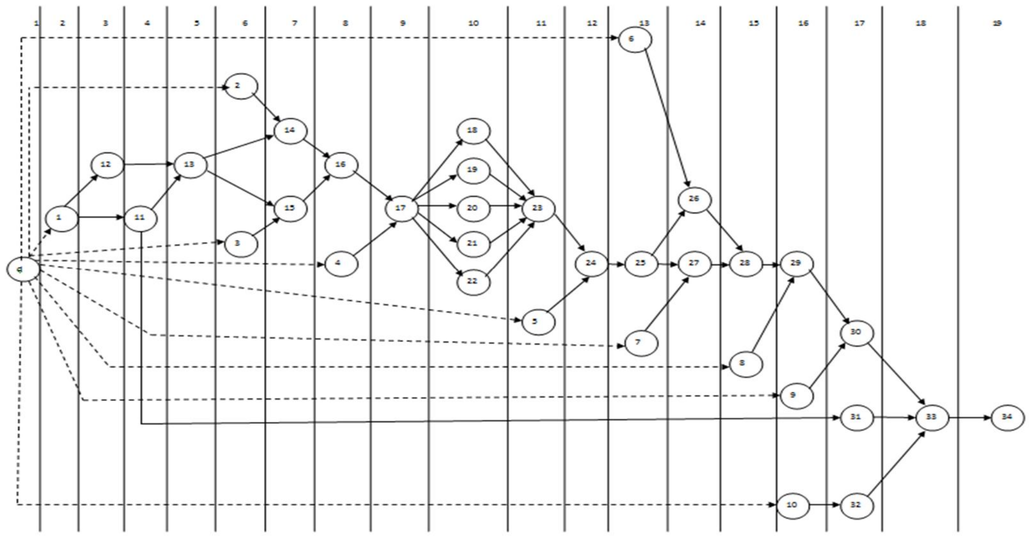

Figure 4 Precedence Diagram for KWC technique

Table 8 Activities assigned to stations as per KWC technique

Activities	Column	Predecessor	Time (min)	Station	Station Time
d	1	----	0	1	
1	2	d	199.8	1	
12	3	1	16.2	1	
11	4	1	13.46	1	
13	5	11,12	6.36	1	
2	6	d	26.12	1	
3	6	d	9.16	1	
14	7	2,13	72.44	1	
15	7	3,13	79.19	1	422.73
4	8	d	137.26	2	
16	8	14,15	36.22	2	
17	9	4,16	14.44	2	
18	10	17	15.25	2	
19	10	17	102.14	2	
20	10	17	9.07	2	
21	10	17	33	2	374.38
22	10	17	149.1	3	
5	11	d	111.31	3	
23	11	18,19,20,21,22	26.09	3	
24	12	23	47.02	3	
6	13	d	34.4	3	
7	13	d	46.2	3	414.12
25	13	24	131.36	4	
26	14	6,25	70.61	4	
27	14	7,25	14.04	4	
8	15	d	15.14	4	
28	15	26,27	35.02	4	
9	16	d	6.16	4	
29	16	8,28	15.14	4	
10	16	d	96.16	4	
30	17	9,29	23.57	4	
31	17	11	36.07	4	443.27
32	17	10	91.13.	5	
33	18	30,31,32	37.51	5	
34	19	33	35.56	5	164.2

Summary of data
Sum of task time = 1791.7
Cycle time = 486.35
Number of station as per KWC technique =5

$$LE = \frac{\sum_{i=1}^{N} STi}{m * CT}$$

= 0.7367

$$BD = 1 - LE$$

= 0.2633

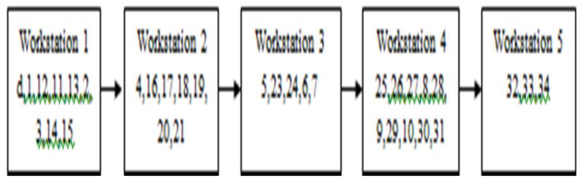

Figure 5 Configuration of assembly line as KWC technique

VI. RESULT AND CONCLUSION

Below table shows the result of xyz product assembly line after analyzing the same through the application of ranked positional weight technique, largest candidate rule technique , kilbridge and wester column technique of assembly line balancing problem

Method	Line Efficiency	Balance Delay	Number of Stations
Present	0.5262	0.4738	7
RPW	0.9209	0.0791	4
LCR	0.9209	0.0791	4
KWC	0.7367	0.2633	5

Table 9 Line efficiency, balance delay and number of stations of different techniques

After comparing results of above three techniques it is found that any one of the both rank positional weight technique and largest candidate rule technique applicable for the line balancing as both of these techniques are able to assign the activities to the number of workstations in more efficient manner than kilbridge and wester column technique.

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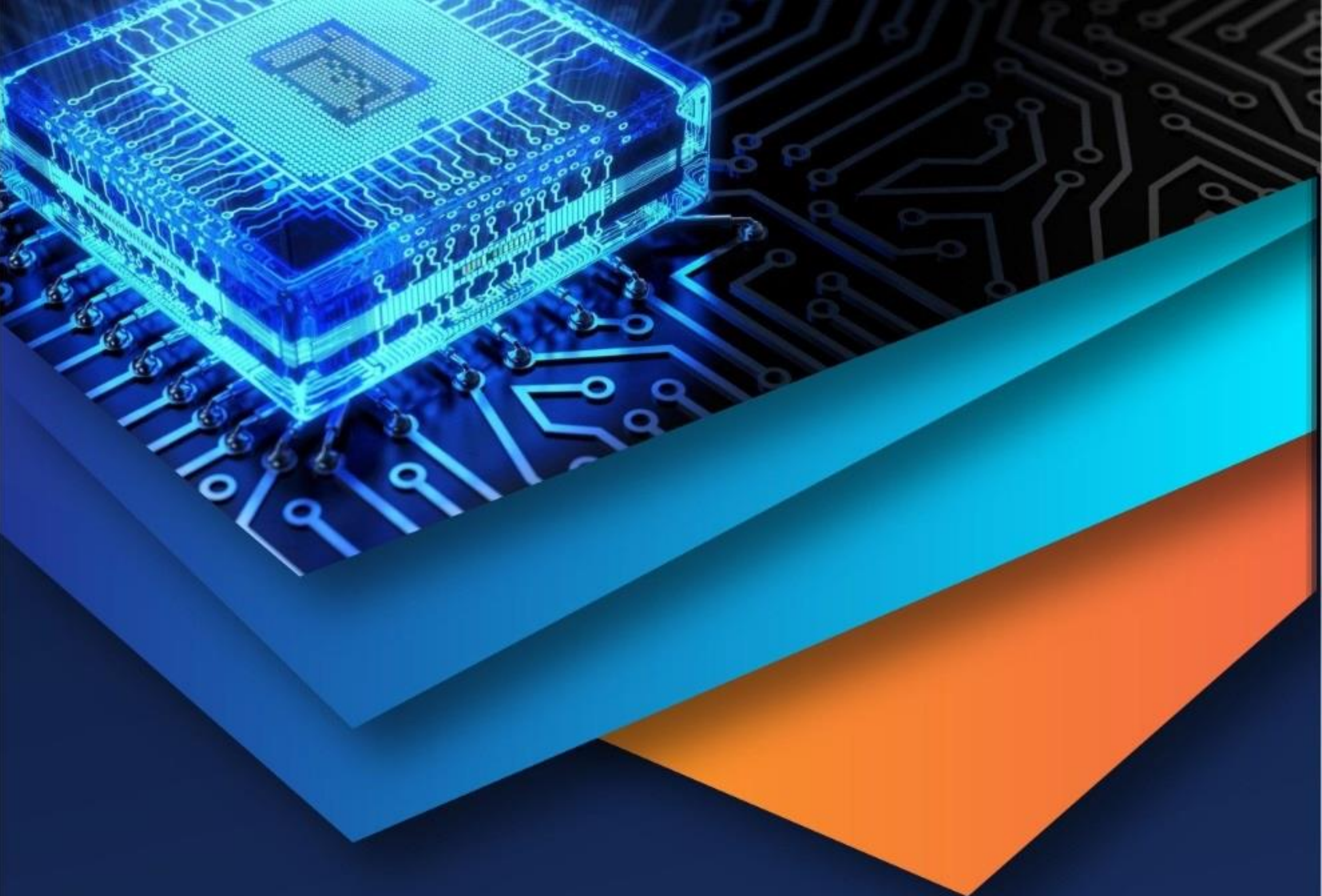

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