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Dimensional Stabilization of Engineered Wood Floor Using Linseed Oil and Paraffin Wax Impregnation

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Abstract: Engineered wood flooring comprises three or more layers of wood veneer adhered together to create a plank. The surfaces were coated to scale back water absorption. However, as wood is a hygroscopic substance, it loses and gains moisture from the atmosphere. This affects the dimensional stability of the floor badly, which emanates wide gaps between boards, cupped edges, crowning edges, and bulking of boards. Hence, the main intention of this study was to stabilize the engineered wood flooring by filling the wood cavity with linseed oil, paraffin wax, and a mixture of both, and evaluate the physical, mechanical property of treated and non-treated engineered wood flooring boards. The treatments were conducted at different temperature and durations.
Keywords: Dimensional stabilization, Wood modification, Wood floor, Linseed oil, Paraffin wax, Impregnation

I. INTRODUCTION

Wood is a vital engineering material due to its physical and mechanical properties and low price (Wacker, 2010). Because of its water dependency, an oversized effort was conducted to change and improve the properties of wood with different techniques, including physical and chemical modification processes (Ramsden, 1997). The size of wood may be stabilized either by blocking the wood cell lumen, which reduces water absorption, or swelling and bulking the fibers of the semipermeable membrane structure (Deka et al., 2000, Duygu et al., 2015). The deposition of water-insoluble materials within the semipermeable membrane structure is a good and practical approach for keeping the semipermeable membrane structure during a partially or completely swollen state. This may be achieved via impregnation treatment with various appropriate agents, like resin and wax by which the dimensional changes owing to atmospheric moisture will be considerably minimized (Stamm et al., 1947, Dick et al., 2017).

Heat treatment of wood using hot oils can reduce moisture from 30 to 52%, suggesting a discount in hygroscopicity. At the identical time, the equilibrium moisture content of the wood treated at 220 °C for 4 hours was reduced by about 50% (Wang et al., 2011). Baka and Nemetha (2012) state that better wood properties are often achieved by using hot vegetable oils compared to the gaseous atmosphere. But, the strength properties of oil tempered wood are critical (Wang, 2007). Impregnating wax into solid wood is an efficient method for improving wood quality. Thanks to their hydrophobic properties, waxes are widely employed in the coating industry as water repellents for wood surfaces (Liu et al., 2011). Wax used as wood modifying agents, it improves dimensional stability, weathering durability, white rot, and brown- rot fungi resistance, and mechanical properties (Palanti et al., 2011, Bruno et al., 2014, Boštjan et al., 2010). Wax treatment physically fills the massive cell lumens to slow the sorption rate of moisture. Wax may also be deposited within the wood semipermeable membrane structure to change its properties and reduce swelling and shrinking (Scholz et al., 2010).

II. MATERIALS AND METHODS

The preparation and testing of all the specimens during this work were carried out as per the procedures followed by Devi et al., 2004; Pandey et al., 2009 and as given in IS 1734:1983, ASTM D2394-17.

A. Preparation Of Specimens

Engineered wood floor samples for the study were collected from the Pre-Finishing plant of The Western India Plywoods Ltd, Baliapatam, Kannur, Kerala and sizes are 150 x 75 x 12 mm for the measurement of density, moisture content, water absorption, and anti-swelling efficiency (ASE), and 25 x 25 x 12 mm for compressive strength and 50mm radius disc for abrasion test.

B. Treatment Of Specimens

The specimens were initially kept in a hot air oven to achieve a constant mass. Then the 1st set of the specimen was dipped in linseed oil, 2nd set was dipped in molten wax and 3rd set was dipped in the mixture of linseed oil and molten paraffin wax of 8:2 ratios. The specimen was treated at 100°C for 15 minutes, the second specimen at 30 minutes and the third specimen for 45 minutes. And the experiment repeated for different temperatures such as 140 and 180 °C respectively (Table.1).

Treatment	Sample	A	B	C	D	E	F	G	H	I
Linseed oil	Temp (°C)	100	100	100	140	140	140	180	180	180
	Duration (min)	15	30	45	15	30	45	15	30	45
Treatment	Sample	J	K	L	M	N	O	P	Q	R
Paraffin wax	Temp (°C)	100	100	100	140	140	140	180	180	180
	Duration (min)	15	30	45	15	30	45	15	30	45
Treatment	Sample	S	T	U	V	W	X	Y	Z	AA
Combination of both	Temp (°C)	100	100	100	140	140	140	180	180	180
	Duration (min)	15	30	45	15	30	45	15	30	45

Table.1: Treatment of specimens and conditions

Fig.1 (a) Engineered wood floor (b) Boiling in linseed oil (c) Boiling in molten paraffin wax (d) Boiling in a mixture of linseed oil and molten paraffin wax

C. Testing Parameters

The initial density and final density were calculated and noted. For the water absorption and anti-swelling efficiency (ASE), the initial volume and weight were measured then the specimen submerged horizontally under fresh water for 24 hours. Then sample were wiped off with a damped cloth, and the final volume and weight were measured. Compressive strength was calculated with Universal Testing Machine (UTM). For abrasion resistance test, the initial weight was noted. Then specimen was placed in the re-facing wheel of the abrasion tester and completes 1,000 rotations. And measure the final weight and weight loss was calculated.

III. RESULTS AND DISCUSSION

A. Density

The results of the change in density of treated specimens are shown in fig.2. There is a gain in density in every specimen concerning control. The most value obtained within the case of Linseed oil-treated specimen D (140 °C for 15 minutes). According to C, F, and I, we can see a drop in density. Paraffin wax treatment almost shows a gain in density consistent with the rise in temperature and time. The utmost value obtained was 836.733 Kg/m^3 for specimen M. In combination with both oil and wax treatment the time depends on gaining the density. The maximum density was obtained in 15 minutes duration. At higher temperatures we can see a decrease in density, it's due to the degradation of cells and evaporation of water from the specimen. Also, the specimen turns darker.

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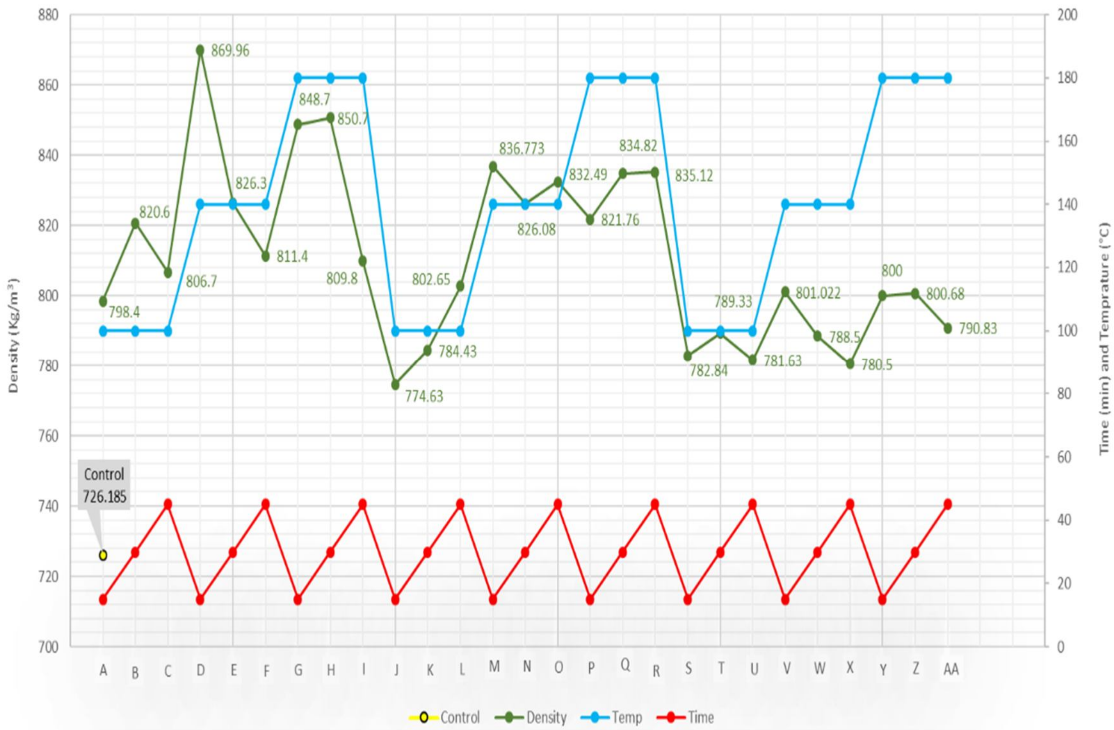

Fig.2 Density of specimen

B. Water Absorption

The water absorption of the specimens showed some interesting values. The wax treatment gave the low water absorption (M), but specimen D is denser than M (as given in fig 2 and 3). The water resistance were decreasing due to the escaping of oil during the socking process. In the case of high temperature and long duration (I), the specimen turning to carbon (degradation) and micro-cracks were appearing. So, the oil can't remain there for long intervals in those micro canals (melting point of linseed oil -24°C). While considering the wax treatment, the molten wax was entered into the cell cavity and seal the pores of the specimen. Wax is a good repellent of water. At room temperature, it stays in solid state (melting point of paraffin wax >46°C) with good bonding to the surface. Although, the treated specimen shows very less water absorption than an untreated specimen.

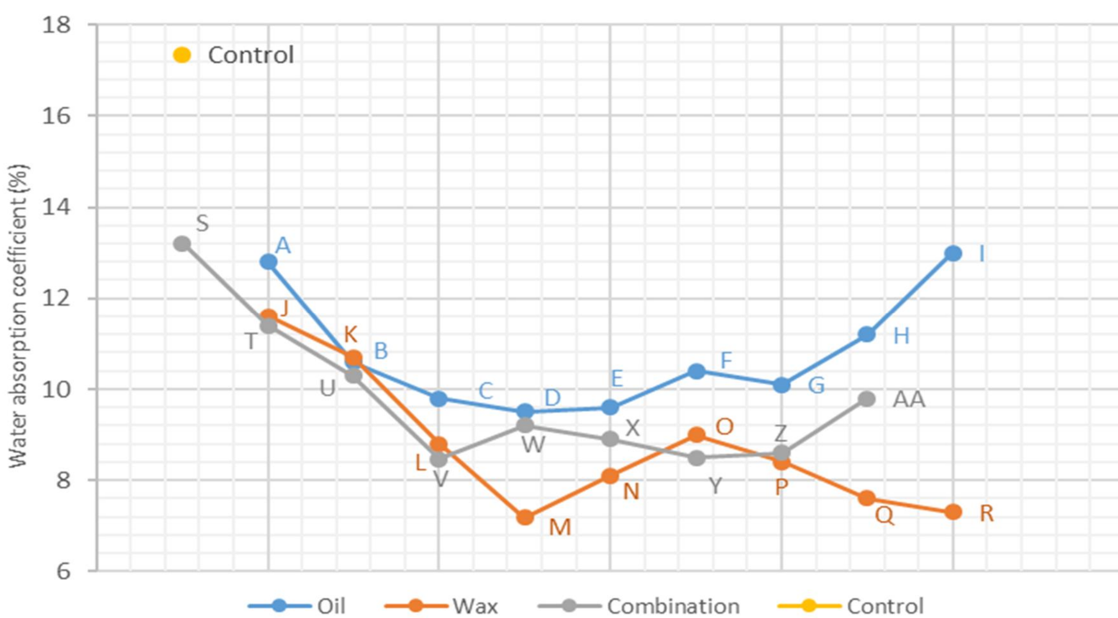

Fig.3 Water absorption of the specimen.

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C. *Anti-Swelling Efficiency (Ase)*

The highest ASE value obtained in Paraffin wax treatment (fig.4) specimen M got 79.14%. A reduction in swelling was obtained by every treatment. According to fig.3 ASE is slightly depend up on the water absorption coefficient. The dimensional stability was comparatively low in the case of oil-treated specimens. There is a spike in ASE during the 140 °C / 15 minutes combination. The penetrated wax in the cell cavity gives an internal compression by bonded with surrounding surfaces. This will also help to maintain the dimensional stability of the specimen than that of oil-treated specimens.

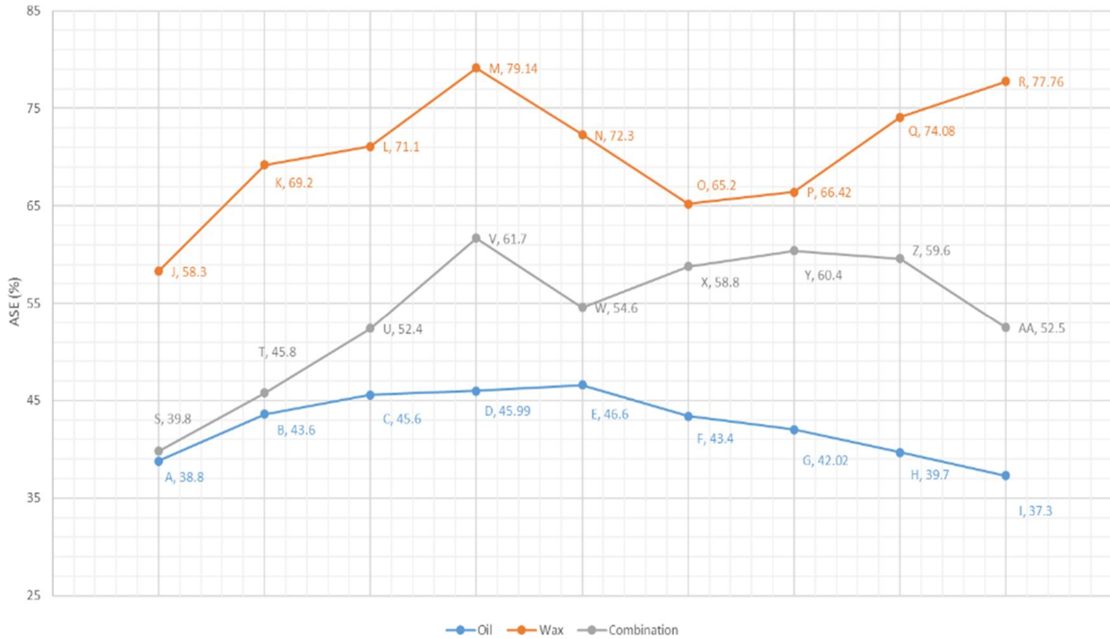

Fig.4 Anti-swelling efficiency of the specimen.

D. *Compressive Strength*

After the treatment, the compressive strength of all specimens was reduced and the results are shown in fig.5. Among this experiment, the wax-treated specimen shows the good value. Specimen J (100°C/15 minutes) gives 2750 Kg/cm^3. Meantime the Oil treated (A) and Combination of oil and wax treated (S) specimen got 2450.67 Kg/cm^3 and 2682.32 Kg/cm^3 respectively. While consider the fig.2 we can understand that, whenever temperature and duration increases the compressive strength were decreases. This is due to the degradation of hemicellulose. Because of high temperature there occurred micro cracks in the specimen, which means breakage of cells.

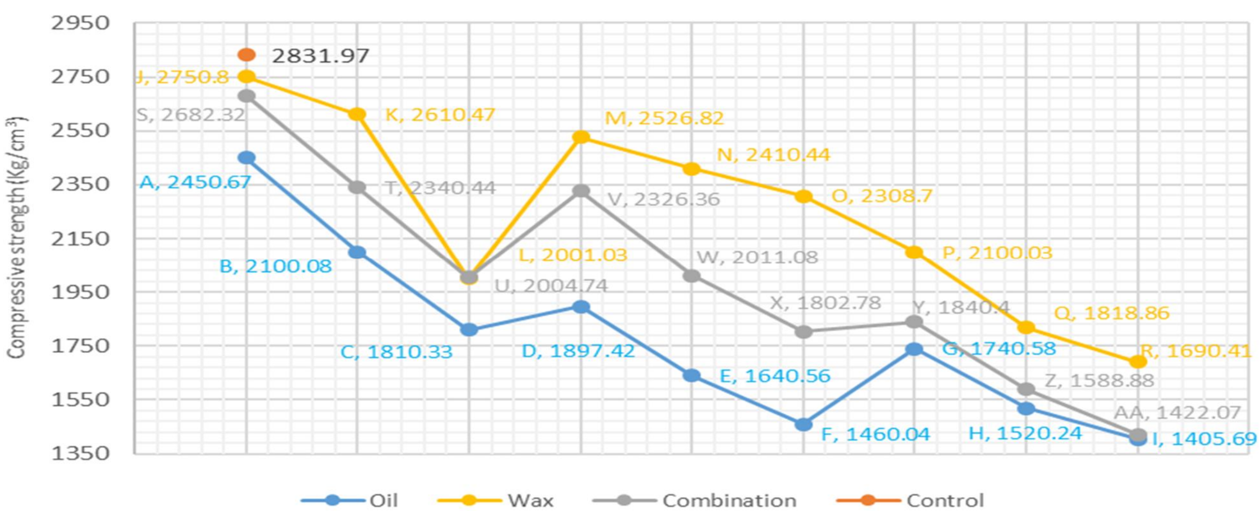

Fig.5 Compressive strength of the specimen.

E. Abrasion

The highest weight loss was found in oil-treated specimens and the lowest for wax-treated specimens. Combination treatment shows comparatively less abrasive. Oil treatment makes the surface of the specimen more brittle than the wax-treated specimen. In wax-treated specimen, wax act as a lubricant. Surface hardness is important in long-lasting surface stability.

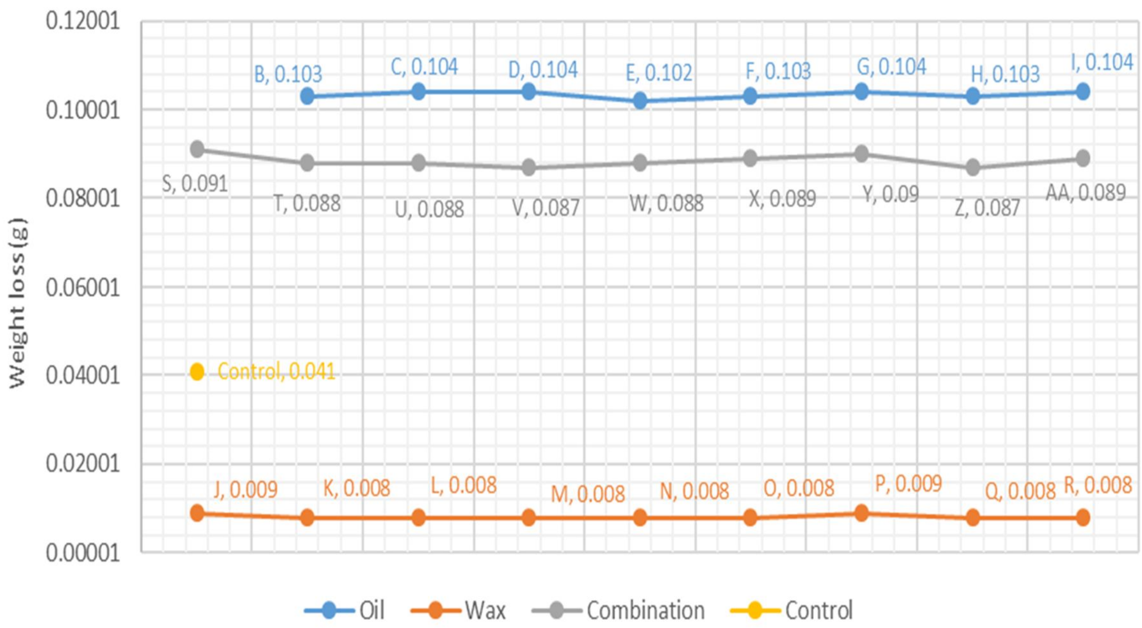

Fig.6 Abrasion test of the specimen

IV. CONCLUSION

The engineered wood flooring boards treated with linseed oil, paraffin wax, and a mixture of both showed improved wood properties in comparison to untreated samples with regard to higher dimensional stability and density, higher abrasion resistance and a low water absorption. The optimum results were obtained at 140˚C and quarter- hours of duration with paraffin wax treatment. On the other hand, these treatments reduced the mechanical properties slightly and a colour change occurred in the case of those coated for long duration.

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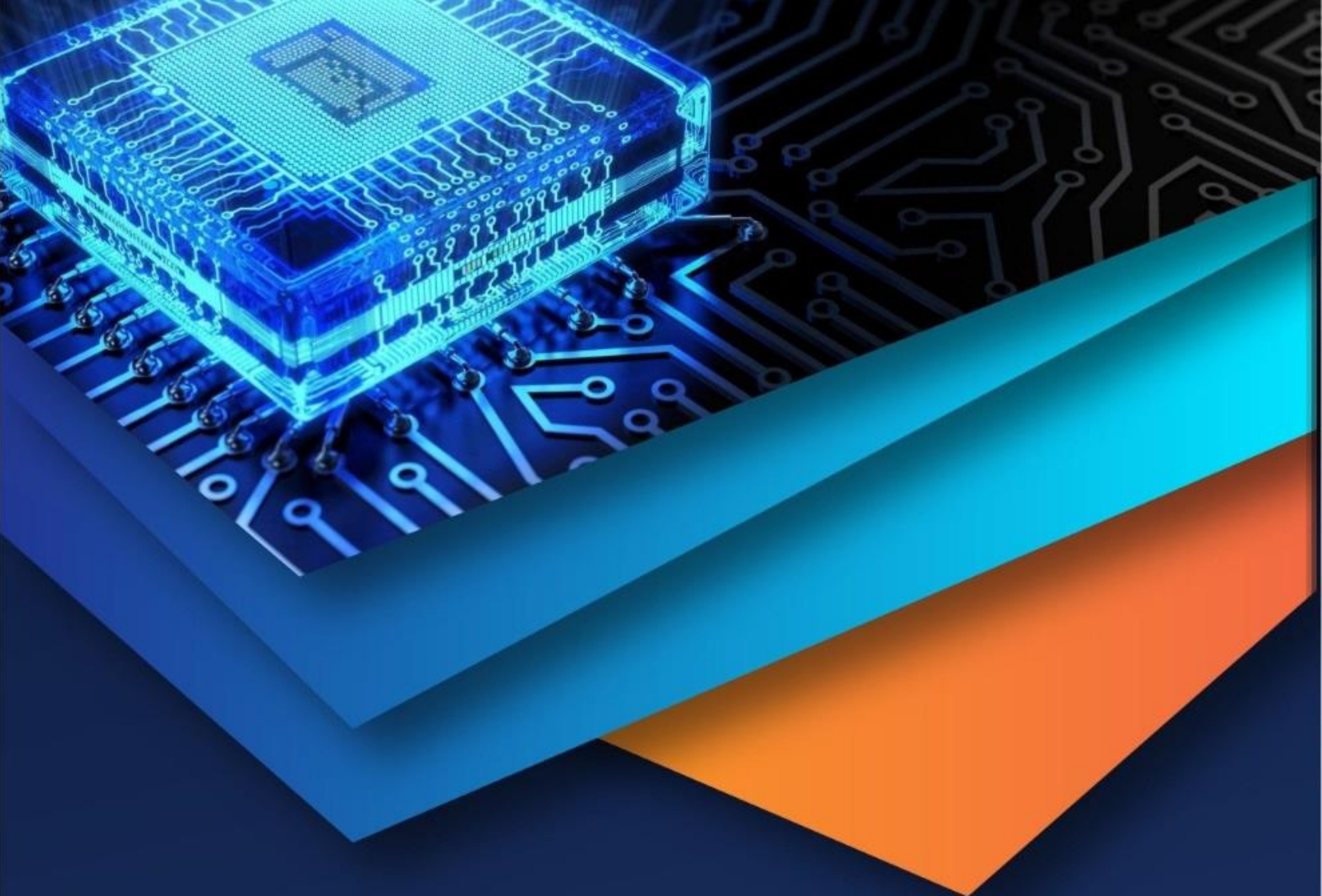

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