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Comparative Study of Bearing Vibration Estimation in Turning using Multiple Regression and GMDH

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Abstract: In modern manufacturing environments, machinery failures are predictable. Vibration monitoring is the most widely used technique. A performance study on the critical bearing vibration of a lathe was carried out. Estimation of bearing vibration was done by measuring bearing vibration along horizontal and vertical directions, flank wear (maximum and average) of the tool, machining time and tool tip temperature. From the experimental analysis it was observed that the vibration velocity depends on cutting conditions. For reliable estimate of bearing vibration, methods like multiple regression analysis and Group Method of Data Handling (GMDH) have been applied. It was observed that the multiple regression estimates give better results for higher speeds. For GMDH, three criterions were considered. Regularity and combined criterion gave better representation. The comparison studies on estimates of bearing vibration by multiple regression analysis and GMDH were made. It was found that at higher speeds, good correlation was obtained for both multiple regression and GMDH models. Among these, GMDH with regularity criterion gives better results.
Keywords: Vibration estimation, Lathe, Multiple Regression, GMDH.

I. INTRODUCTION

Effective monitoring of a manufacturing process is essential for ensuring product quality, which mainly depends on the condition of the machine tool. Machine tools are liable to deterioration mainly due to wear and tear. As the machine deteriorates, vibration increases causing further deterioration due to mechanical stresses and strains generated. Excessive vibration in the rotating machineries is the major cause for premature bearing failure, which ultimately leads to the breakdown of machine tool. Monitoring and diagnostic systems are becoming increasingly necessary in improving the efficiency and reliability of the manufacturing systems. The main demand made of these monitoring and diagnostic systems is the estimation of vibration in machining process for on-line process optimization. A variety of signals such as tool-tip temperature, forces, power, thrust, torque, vibrations, shock pulse, Acoustic Emission (AE) etc., have been used for monitoring machine tool failure. The use of multiple sensors will give a better and more accurate model of the reality. Hence research attempts have been directed towards monitoring systems with the concept of integration of information from multiple sensors [1]. The present work involves an investigation regarding estimation of bearing vibration in turning process. For the estimation, the dependent variables are flank wear (maximum and average), machining time and tool tip temperature along with the cutting conditions. The experiments have been conducted on SG cast iron using multi-layer coated carbide tool. The emphasis is on the approaches that are capable of integrating information from multiple sensors. Hence, methods like multiple regression analysis and Group Method of Data Handling (GMDH) have been applied for the estimation of bearing vibration. Finally, comparison studies of like multiple regression analysis and GMDH were made.

II. MULTIPLE REGRESSION ANALYSIS AND GMDH

The objective of multiple regression analysis is to construct a model that explains, as much as possible, the variability in a dependent variable, using several independent variables. The model fit is usually a linear model; though sometimes non-linear models such as log-linear models are also constructed. One of the major problems associated with use of regression has been the need to specify a functional formulation. The problem assumes significance where a dependent variable is to be estimated from measured variables. In such cases, while it is known that some of the measured variables are to be used, the nature of relationship and relative importance of these variables are unknown. This is the motivation for the development of self-organizing methods in modelling, GMDH is one such method. [2]

GMDH has been indicated to be capable of integrating data from multiple inputs, even when the interrelationship among various inputs is unknown. This is typically the situation when monitoring machine tool using input from multiple sensors. Here the approach is to fit a high degree polynomial using a multilayered network like structure. Each element in the network is a partial polynomial of two inputs. The coefficients of the quadratic functions are determined by data from training set (certain percentage of data-set is taken as training set to learn the model; the remaining data-set is used for checking the model).

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All possible combinations of input taken two at a time, are evaluated. Three different criterions are considered like Regularity, unbiased and combined. The combinations that are allowed to pass to the next year and self-organizing is terminated when optimum complexity is reached by evaluation of a criterion function from data in the checking set. Regularity criterion has good predictive power but sensitive to noise. Unbiased criterion selects models that are insensitive to data from which it is built and hence gives good noise immunity but may not have good predictive power. Combined criterion is the combination of regularity and unbiased criterions. [3]

A multiple regression model was developed that was capable of predicting the in-process surface roughness of a machined work piece using turning operation by using vibration signals. The multiple regression model uses machining parameters such as feed rate, spindle speed, depth of cut and vibration information as predictors. The prediction accuracy was high to above 90%. [4]

III.METHODOLOGY

Experiments were performed by turning S. G. Cast iron using multi-layer coated carbide tool (HK15). Experiments were conducted by varying the cutting speed and depth of cut at a constant feed of 0.208 mm/rev. Totally nine sets of readings were obtained. For the first three sets of readings depth of cut was maintained at 0.1 mm, for the second three sets of readings 0.3 mm, and similarly 0.5 mm for the third three sets of readings. For each depth of cut, three cutting speeds were selected viz. 70.371 m/min, 98.96 m/min and 157.079 m/min with the feed rate kept constant at 0.208 mm/rev. Turning was done without the application of cutting fluid. The cutting operation was interrupted at regular intervals and the flank wear (Max and AVG) was measured using Toolmaker's Microscope. The temperature readings were obtained by using Digital Infrared Thermometer (WAHL HEAT SPY). Vibration signals were recorded at front bearing and rear bearing by using the instrument Machine Condition Tester T-30 in horizontal and vertical directions. The experimental data obtained was used to estimate bearing vibration by applying analysis methods like multiple regression analysis and group method of data handling. GMDH estimates were obtained for different percentage of data viz., 50%, 62.5% and 75% in the training set using Regularity (RMS), unbiased and combined criteria. Finally, the estimates of bearing vibration obtained by multiple regression analysis and group method of data handling were compared with the measured bearing vibration.

IV.CONCLUSIONS

Experimental and theoretical analysis results are plotted, so as to get a clear understanding about the signals involved. The results obtained from turning a S.G. Cast iron using coated carbide tool was used to study the variation of critical bearing vibration. Fig.1 gives the measured vibration in horizontal direction at cutting speed of 157.079 m/min, and depth of cut 0.5 mm with the constant feed of 0.208 mm/rev.

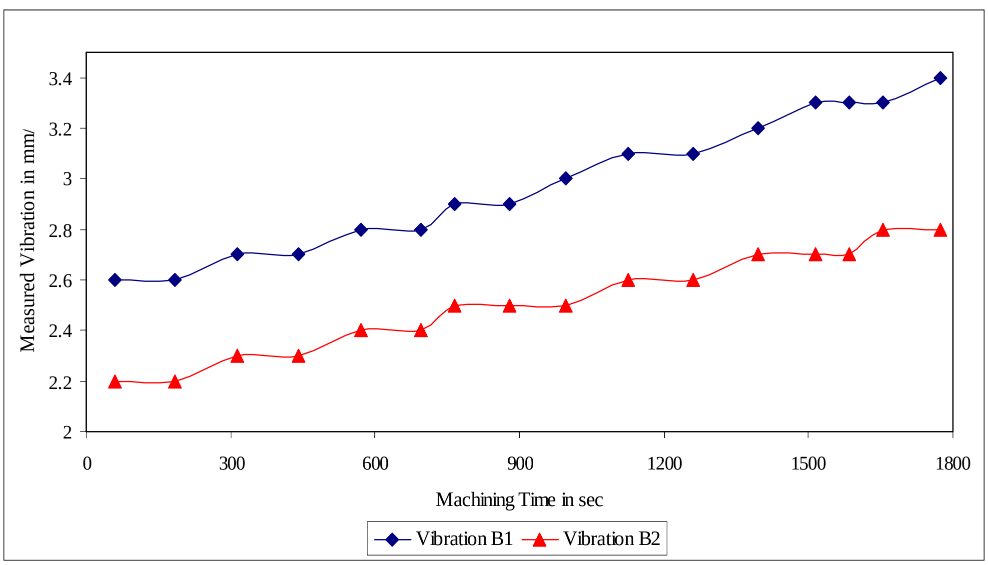

Fig. 1: Measured vibration in horizontal direction with machining time at cutting speed of 157.079 m/min, depth of cut 0.5 mm

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Fig. 2 gives the measured vibration in vertical direction at cutting speed of 157.079 m/min, and depth of cut 0.5 mm with the constant feed of 0.208mm/rev. From the above figures we can observe that vibration in front bearing housing is more when compared to rear bearing housing, because front bearing is nearer to the source of vibration. The lathe structure is stiffer in the vertical direction. Hence, the vibration in horizontal direction is more when compared to vertical direction. Since the vibration at front bearing housing is more, front bearing is considered as the critical bearing.

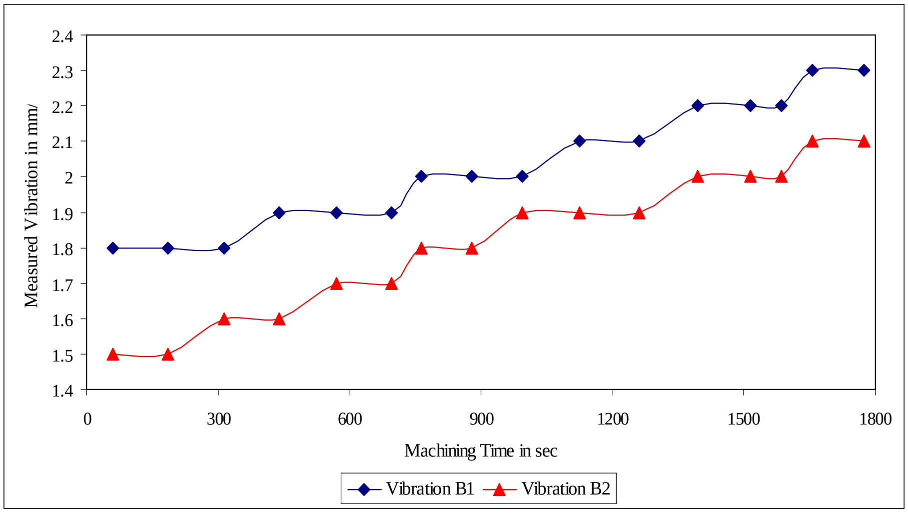

Fig. 2: Measured vibration in vertical direction with machining time at cutting speed of 157.079 m/min, depth of cut 0.5 mm

From the analysis of the signals measured during machining, it is not possible to arrive at a decision about the condition of the bearing. Thus, there is a requirement for more sophisticated methods of signal analysis, such as, Multiple Regression Analysis and Group Method of Data Handling (GMDH) for vibration estimation. These methods are robust for random variations in the variables and are capable of integrating information such as, measured variables, with speed, feed, depth of cut etc. Multiple Regression analysis estimates of bearing vibration along horizontal direction and for a front bearing is as shown in the Fig.3. Fig. 3 shows the Multiple regression analysis estimates of bearing vibration in horizontal direction at cutting Speed of 70.371 m/min considering flank wear (Max). Similarly estimates of bearing vibration are done for other cutting speeds. Referring to figures, it is seen that most of these estimates closely represent the observed trend of bearing vibration especially at higher cutting speeds. Under these conditions, there will be a large scale tool wear, which has resulted in better correlation between cutting conditions and vibration. It is also observed that the estimates of bearing vibration in horizontal direction correlate well with the measured vibration when compared to estimates of bearing vibration in vertical direction.

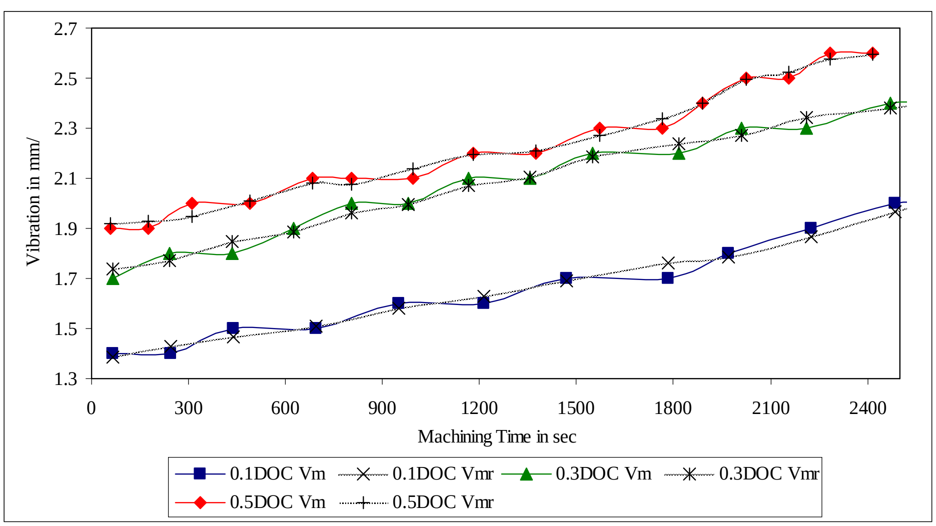

Fig.3: Regression analysis estimates of bearing vibration in horizontal direction at cutting Speed of 70.371 m/min considering flank wear (Max)

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Different GMDH models were obtained for different percentages of data in the training set and different criteria used for guiding the self-organization procedure. The estimates of bearing vibration for different cutting conditions obtained for regularity, unbiased and combined criteria were plotted. Fig 4 shows the GMDH estimates of bearing vibration at a cutting speed of 70.371 m/min considering maximum flank wear as one of the parameter with 75% of data in the training set. Also GMDH estimates were obtained for other cutting conditions with 50%, 62.5% and 75% of data in the training set by considering three criteria's. From the plots obtained the regularity criteria gives better predicted vibration estimates when compared with unbiased and combined criteria's. Also it was observed that the least error and best fit is found when 75% of data in the training set is used.

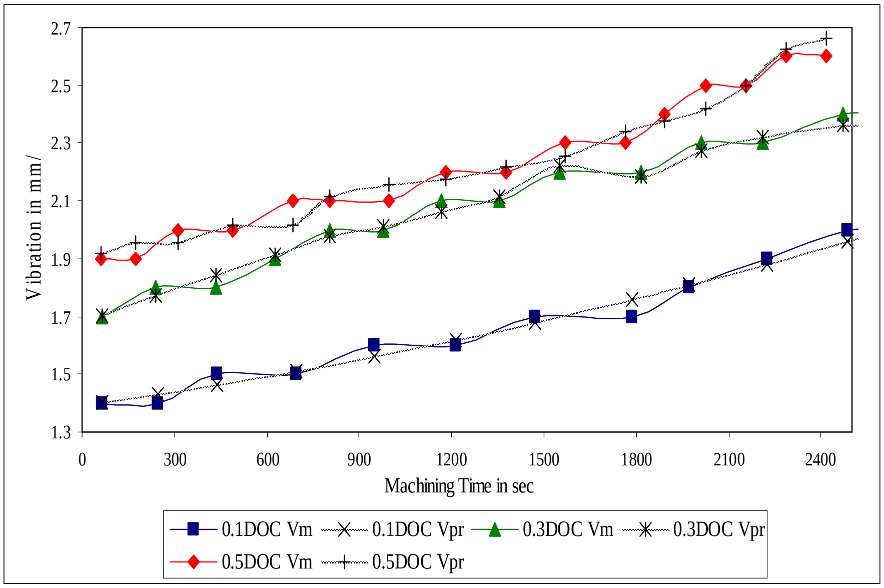

Fig. 4: GMDH estimates of bearing vibration in horizontal direction at cutting speed of 70.371 m/min considering flank wear (Max)

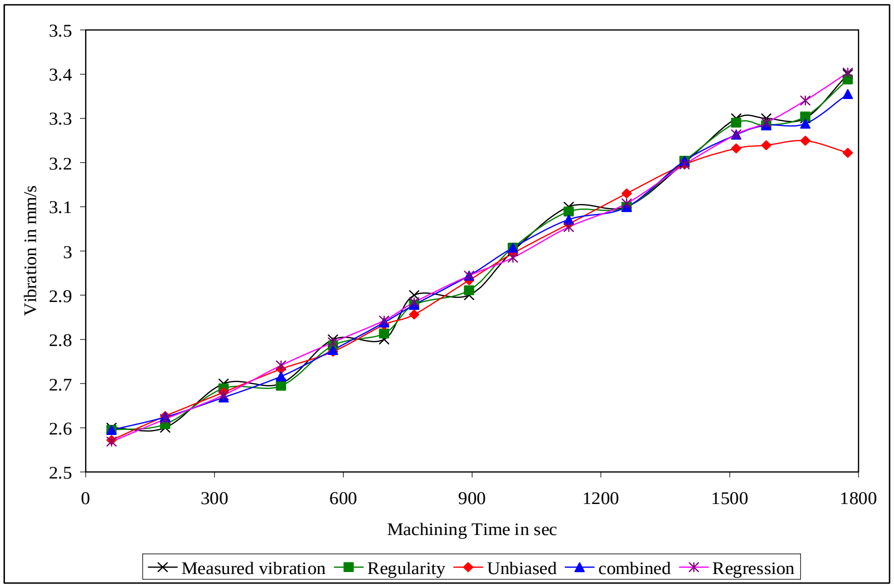

Fig. 5: Comparison of GMDH and Regression estimates

Finally, the bearing vibration estimates from multiple regression and Group Method of Data handling using regularity criteria for 75% data used in the training set are compared. Fig 5 gives the GMDH and multiple regression estimates of bearing vibration at cutting speed of 70.371 m/min, depth of cut 0.3 mm with a constant feed of 0.208 mm/rev.. From the results, it can be observed that good correlation was obtained for both multiple regression and GMDH models. Among these, GMDH with regularity criterion gives better results.

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V. CONCLUSIONS

From the experimental data it was observed that the vibration velocity increases with the increase in the spindle speed and depth of cut. Also the vibration velocity in horizontal direction was more compared to vertical direction. Bearing vibration estimation was done by using the data obtained from the experiments. Multiple regression and GMDH approaches were used. For the GMDH three different criterion functions have been used. It is observed that the regularity criterion correlates well for the set of input variables. Depending upon the number of data in the training set, different models were obtained for 50%, 62.5% and 75%. It is found that the least error, best fit and optimum complexity is found when 75% of data is used. In multiple regression analysis, estimates of vibration were obtained by considering flank wear, tool tip temperature, machining time and cutting conditions as the independent variables. It was observed that the regression estimates give better results for higher speeds. It was also observed that the regression estimates of bearing vibration in horizontal direction correlates well with the measured vibration. When multiple regression and Group Method of Data Handling [GMDH] estimations for the bearing vibration was compared, it was observed that at higher speeds, good correlation was obtained for both multiple regression and the GMDH models. Among these GMDH with regularity criterion gives better results for bearing vibration estimation.

REFERENCES

[1] Tse P. W., and Atherton, D. P.,1999. “Prediction of machine deterioration using vibration based fault trends and recurrent neural networks”, Journal of Vibration and Acoustics, 121, pp. 355-362.
[2] Takeshi Yoshida, Kazunori Nagasaka, Yoshihiro Kita and Fumo Hashimoto, 1986, “Identification of a Grinding Wheel Wear equation of the Abrasive cut-off by the modified GMDH”, International Journal of Machine Tool Design and Research, 26, pp. 283–292.
[3] Ivaknenko, A.G, 1971, “Polynomial theory of complex systems”, IEEE Transactions on systems, man and cybernatics, pp. 346-378.
[4] Luke Huang and Dr. Joseph C.Chen., 2001, “A Multiple Regression Model to Predict In-process Surface Roughness in turning operation via Accelerometer”, Journal of Industrial Technology, 17. pp. 156-165
[5] Stanley J. Farlow., 1981, “ The GMDH Algorithm of Ivakhnenko”, Journal of The American Statistician, 35, pp. 211-216

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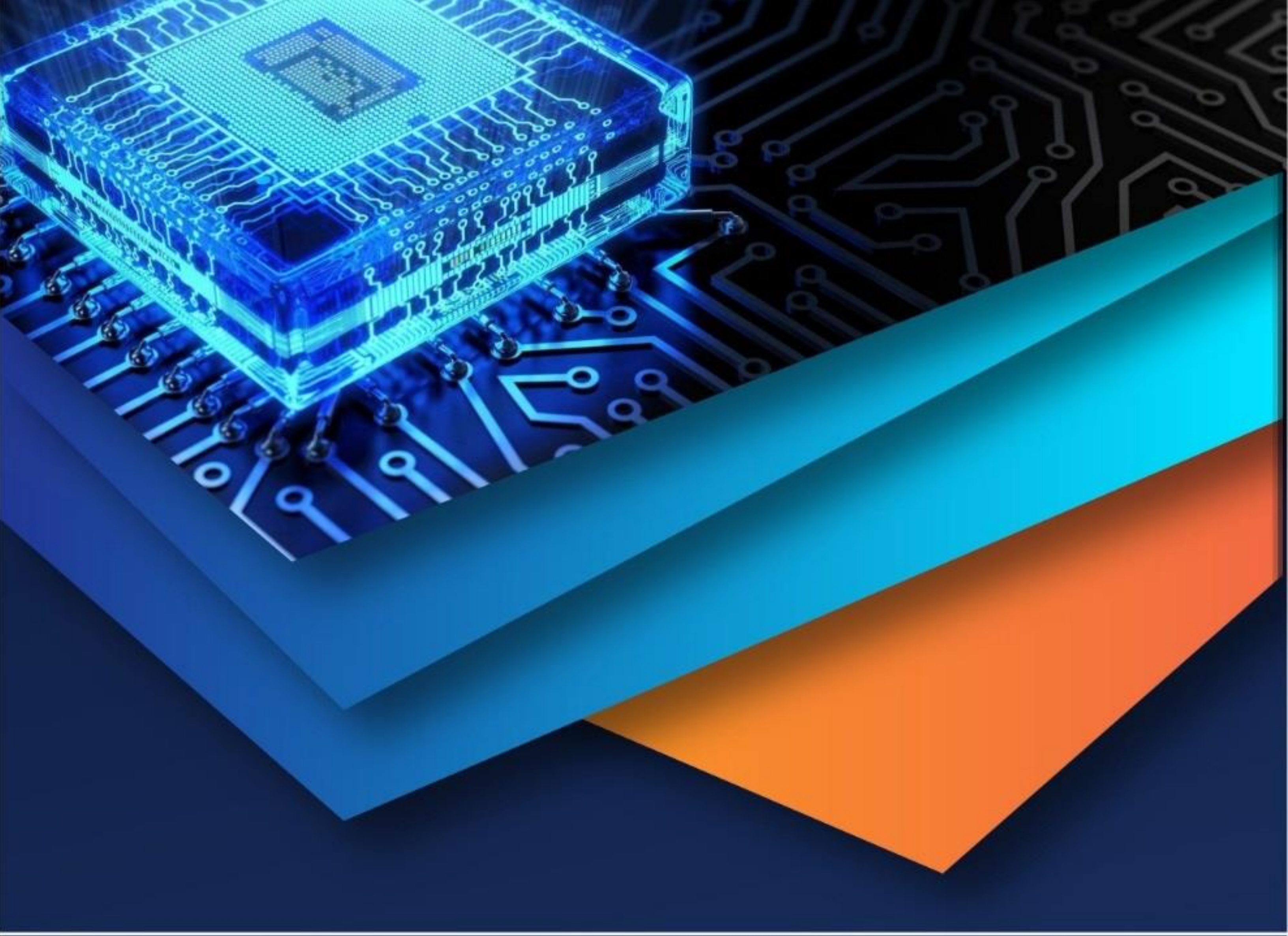

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