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Fixture Design for Shaft Type Pinion on Doosan Machine (HMC)

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Abstract: ***The jigs and fixtures are the economical ways to produce a component in mass. The fixtures and jigs are used, and serve as the important facility for mass production system. Fixtures and jigs are work holding and tool guiding devices. Quality of performance of a process is largely influenced by the quality of jigs and fixtures used for this purpose. Fixtures are unique such that each fixture is built to fit a particular component or part or workpiece. The main aim of mass production system is to increase the productivity and to increase the accuracy of components manufactured. This can be achieving by minimising and reducing the set up cost and fatigue to the operators, workers. Thus mass production can be achieved by the use of jigs and fixtures. In case of mass production system and large scale production system of different components lot of time is wasted for set up of the devices and clamping the devices, workpieces to the machine base. Numbers of trails are carried out for aligning the axis of hole with the axis of drill. For these conditions lot of time is being wasted for maintaining the accuracy of the operations and components. So it leads to increase the manufacturing workers fatigue. The fixtures are production tool since they are essentially used in production systems. The main purpose of fixtures is to hold, locate and support the workpiece, components properly so that the required machining operations will become easy performed. A fixture should be manufactured so that it can be easily fastened to the machine table or machine pallet. As a result the work can be done.***
Keywords: ***Jigs and Fixtures, productivity and increase the accuracy, production tool, locate, hold and support the work securely***

I. INTRODUCTION TO FIXTURES

A. Fixtures

The fixtures are the devices that are used for locating, clamping, holding and supporting a workpiece during the manufacturing operations on the particular components. It is an essential element for production processes as various machining operations required automated manufacturing, inspection, and assembly operations. Fixtures must correctly locate a workpiece in a given orientation with respect to a cutting tool or measuring device, or with respect to another component, as for instance in assembly or welding. Such fixture devices should clamp and secure the workpiece in the proper location for the required manufacturing operations. Various standard work holding devices are used for fixtures such as collets, chucks, drill chucks, machine vices, jaw chucks, etc. that are extensively used in industries and workshops. Fixtures are normally designed for a particular operation and for a particular component to process a specific operation on it. So they are required to designed and manufactured individually. Jigs are very much similar to the fixtures, but they are not only locates and hold the workpiece but also guides the cutting tools for the drilling and boring operations. Such work holding devices are known as jigs and fixtures.

B. Fixture Elements

Usually, all the fixtures are having the following elements, they consists of

1) *Locating Devices:* The locating devices are usually the fixed components of a fixture. They are used to establishing and maintaining the correct position of a workpiece in the fixture by constraining all of its movements. If the workpieces are with varying in design, shapes and geometrical conditions, the adjustable locators can be used.
2) *Clamping Devices:* The clamps are the force-actuating mechanism for clamping a part to the fixture. The force exerted by using clamps. It helps for holding a part securely in the fixture against all the external forces and the machining forces during operations.
3) *Supporting Devices:* The supports are the fixed or adjustable elements. When there is part displacement and movement is generated by the action of excessive clamping and machining forces, supports are required to add and they are placed below the work for preventing and constraining the work deformation.
4) *Fixture Assembly:* Fixture assembly is the main important structural element to the fixture. The spatial relationship is required to be maintained between the fixture elements mentioned above and the machine tool. The fixture body maintains such

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relationships between the fixturing elements and the machine tool on which the part is going to be manufactured.

C. 3-2-1 Principle

We have two objectives while mounting a part in a fixture for machining operations:

1) Correct positioning of the workpiece at its specified co-ordinates for the positioning.

2) Restricting the all possible six degrees of freedom of component.

A widely used method of accomplishing these two objectives uses the 3-2-1 principle, so called because it entails three steps that employ three, then two, then one fixed points of known location. It is also known as six point method since it adds up to its six fixed points. In the three steps of the 3-2-1 method, three mutually perpendicular planes, called datum planes, are introduced, one at each step. The datum planes are used for defining the work position and oppose the clamping forces for constraining the work.

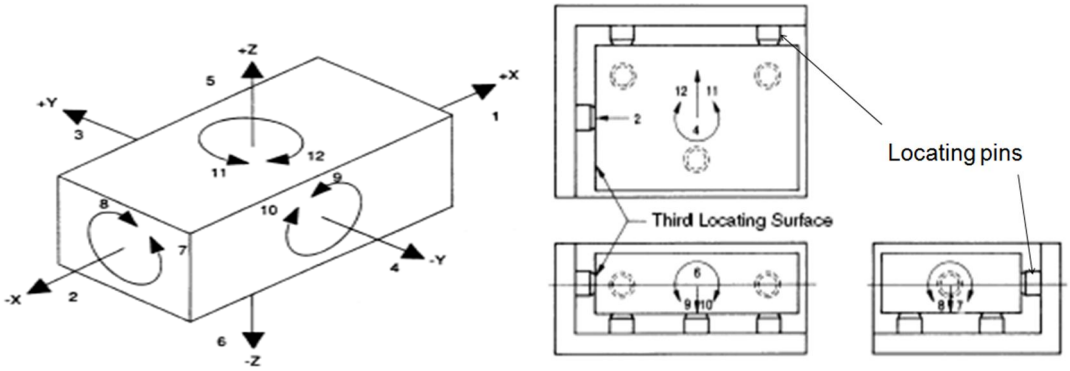

Fig.1 3-2-1 Principle

II. METHODOLOGY FOR DESIGN

A. Design Criteria for Fixtures

For fixture design the following fixture design is required to be observed:

1) Design parameters and specifications

2) Factory standards

3) Simplicity of fixtures for use and safety

4) Economy

B. Procedure of Designing a Fixture

In the fixture design for a work, a specific sequence of design processes is involved. They can be grouped into three broad stages of design development.

1) *Process One:* In the process one the information is gathered and analysis of it is carried out. The product analysis methods like design specifications study, process planning, examinations of processing equipments by considering the safety to workers. In this all the critical dimensions of work datum areas are examined and determined in detail.

2) *Process Two:* Process Two involves the consideration of clamping and locating schemes. The clamping method should use such that it will not interfere into in the path of cutters and tools. It should be compatible to the proposed locating areas and surfaces. The locating elements consist of standard elements like locating pins and pads which are designed to be consistent for clamping and tool guiding arrangements.

3) *Process Three:* Process Three is the designing the fixture body structure. They are generally built for a workpiece as a single element. It consists of linking the other elements that are used for clamping, locating work, guiding the tool into an integral frame work. The above procedures are quite general and can be modified depending on the relative importance of the various elements in providing for the required accuracy of the workpiece to be located and secured into the fixturing device. With the popular adaptation of modular fixturing elements, the fixture body frame is usually a standard block with fixed arrays of locating and fixing holes or slots. It is necessary to select the most comfortable and suitable body frame for consisting of the various elements which provide support to the work and free access to the tools and cutters for the cutting movements.

4) Based on applications the fixtures are classified into the three categories

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a) Fixtures for manufacturing
b) Fixtures for repairing
c) Fixtures for inspection

The above fixtures are unique for a particular process and every fixture is having its own functions. Fixtures are needed for proper locating and clamping the work.

5) Fixtures for manufacturing are consist of the following stages
a) Analysis of work or part
b) Design of fixture
c) Analysis of Design
d) Manufacturing of fixture
e) Applying the fixture to production

C. Element Required for Fixture

1) *Mounting Elements:* Mounting elements form the body of the fixture. It consists of the tooling plates, which may be flat or square or round or angular, depends upon the product specifications. These tooling plates are used for mounting of the locating devices and clamping the accessories.
2) *Locating Elements:* These are the most essential part of fixtures and serve to locate a part accurately on the fixture so as to ensure flawless fabrication or inspection of the part. For the locating purpose various types of locating pins can be used for locating of plane or edge and point location consisting of locating elements. The important standardized and scientific principles used for locating elements are 3-2-1 principle, V- location, Radial and concentric location, etc.
3) By the V-location principle, work pieces which are having circular or semicircular or cylindrical body are located by using a V block. The block used for locating workpiece should be accurate, so that, if the variations are made in the workpiece sizes can be easily accommodate the workpiece.
4) *Elements for Clamping:* Clamping elements are used for securely holding the part as in fixture. The clamping elements provide the required support to the workpieces against the cutting forces produced during operations. It is important that the clamps do not damage the part surface or edges, and do not obstruct the cutting path or cutter. While clamping the workpiece to fixture there should not any unnecessary deflection and deformation of work due to over clamping which leads to changing product quality. For this purpose the care should be taken during the clamping of parts for milling, lapping and grinding operations where deformation of work under the elastic deformation.
5) *Special Accessories in Fixture:* These types of accessories include the blocks for supporting to the workpiece over the fixture plate. Blocks used for elevating the level of part on the fixture are called riser blocks. Sometimes blocks are needed to provide adequate chip disposal and clearance while in other instances they prevent damage to the fixture body or the machine bed due to machining over travel and approach allowances.

D. Things to Remember while Designing a Fixture

1) Application of the fixture (manufacturing/repair/inspection).
2) The Number of parts for which the fixture will be used.
3) The Level of accuracy required.
4) The criticality of the part with respect to the aircraft.
5) Standardization of fixtures and Fixturing principles.

III. DOOSAN MACHINE FIXTURE

A. Problem Statement

Railway shaft type pinions are manufactured by the TRM division at KPCL. The issue being time required for setting of the fixture for the drilling and facing operation is more approximately 45 min. Numbers of pinions machined on Doosan machine during a shift is four. Hence expectation is to provide solution for reducing the setting time.

B. Objectives for Design of fixture

1) Reduce the time required for setting of fixture

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2) Incorporate Poka Yoke
3) Reducing the fatigue to the operators
4) Ensure safe and quick mounting of fixture
5) Increasing the production rate

C. Scope for Design

Jigs and fixtures are production-work holding devices used to manufacture duplicate parts accurately. Jigs are special devices that are used for holding, supporting, and placing workpiece on machine for its operations. The fixture is used as tool for production which locates, holds and supports the work securely so the required machining operations can be performed. A fixture should be securely fastened to the table of the machine upon which the work is done. When the workpiece on milling machine is changes its shape from square to cylindrical shape, the operations in the machining processes on the workpiece are also changed. There are many types of jig and fixture used for different operations, the new jig and fixture is required to be design for different operations. Furthermore, the right dimension for the jig and fixure must be determined.

Fig. 2 Dooasan Machine (HMC)

It is not important neither the design of jig and fixture is simple nor complex but the most important thing is the design follow the specification which is the milling machine needed. This project is concern with the study of the basic rules used for locating of workpiece, correct positioning of the locating devices, tool profiles and work locations. Also the basic rules of clamping, including positioning the clamps, tool forces, clamping forces and type of clamps selected. In order to complete this project, the initial design of jig and fixture for milling machine cylindrical parts need to explore and analyzed, generate a detailed drawing with assembly of jig and fixture proposed and provides alternatives material recommended.

D. Design Principles for Fixtures

When a person is designing a fixture for a particular operation on a particular machine it is important to overlook the basic principles and aspects regarding the fixture design. It is not necessary that these kinds of situations arise only due to lesser technical knowledge. The urge for completing the work in a short time, continuously working on a same kind of job, tiring work conditions and bypassing the work may each cause these situations to occur. As a consequence of improper fixtures, the need for more supervisory or inspection work could arise. Also inadequate information could lead to a poorer design compromising product quality. These types of drawbacks could be eliminated when sufficient fool proofing is done, with any procedure. The jigs and fixtures are produced such that they are different for different types of product and for different machines and operations. There is no one a specific type of fixture that can fulfil the demands of machining operations on the product. For that the standardized fixture principles are used. The correct positioning of the workpieces is employ with the help of locators, for the proper constraining of all degrees of freedoms. Constraining of the degrees of freedom is having high importance. The proper use of clamps to resist multi-directional cutting forces, the facilitation of effective cutter action, provision of chip clearance and cleanup allowance, easy and repeatable part loading/unloading can also each be standardized based on vast experience drawn by designers. The size, shape and other variants of the particular locators, clamps and contact points of surfaces and areas. But there is no change in the working

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principle of the configuration of machining fixture. Determination of fixture is made on the past experience which helps for charting the do's and don'ts activities while designing. It is having following advantages:

1) The charting can be used for fool-proofing.
2) Can be used by both skilled and semi-skilled worker.
3) Accuracy of the work even when the work is in hurried.
4) The time and material can be saved.

IV. FIXTURE DESIGN

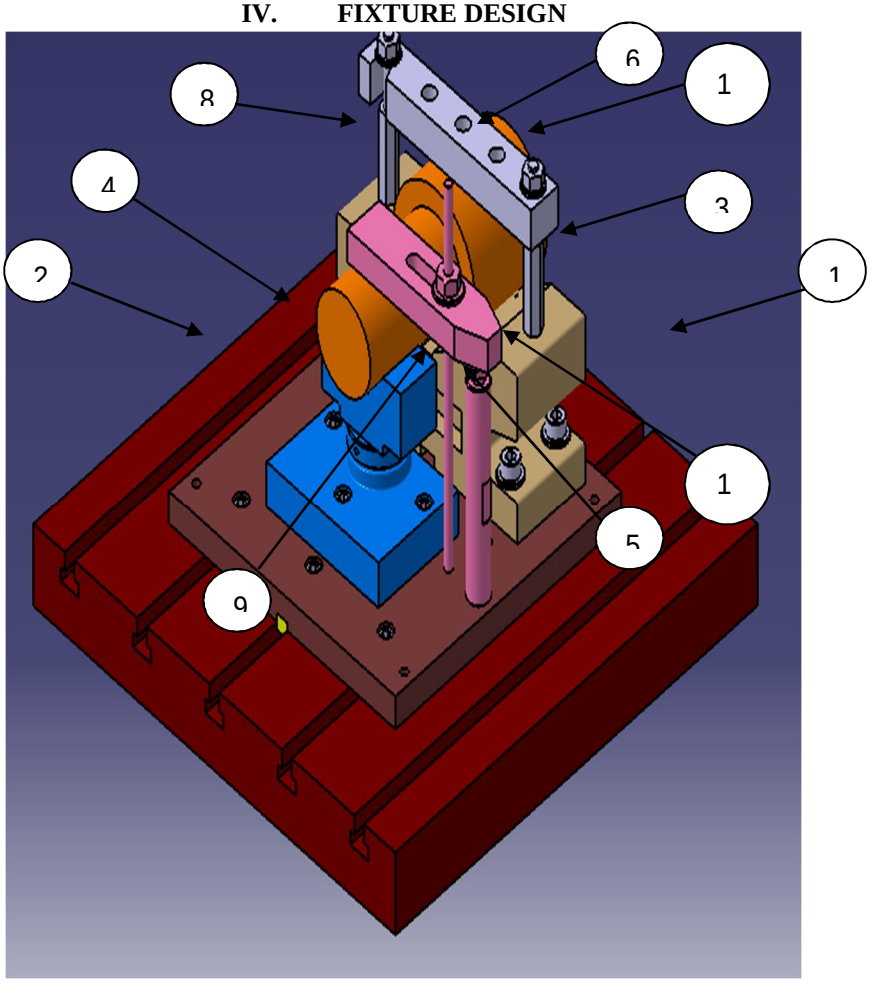

Fig. 3 Fixture for Doosan Machine (HMC)

A. Components of Doosan machine (HMC) Fixture

1) Doosan machine Pallet
2) Base Plate
3) V Block (Large)
4) V Block (Screw Type)
5) Height Piece
6) Strap Clamp for large V block
7) Hex Bolts
8) Stud for Large V Block
9) Stud
10) Hex Nut
11) Allen Bolts

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Fig. 4 Actual Fixture

V. ANALYSIS OF COMPONENTS

A. *V Block Large*

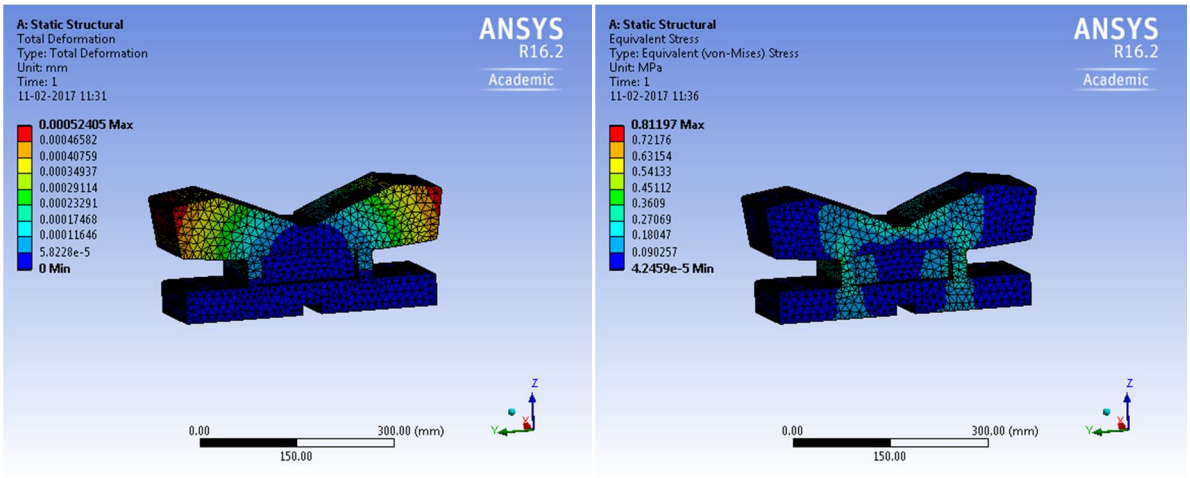

Fig. 5 V Block (Large) stress and deflection at 3000N Load

B. *V block (Screw Jack)*

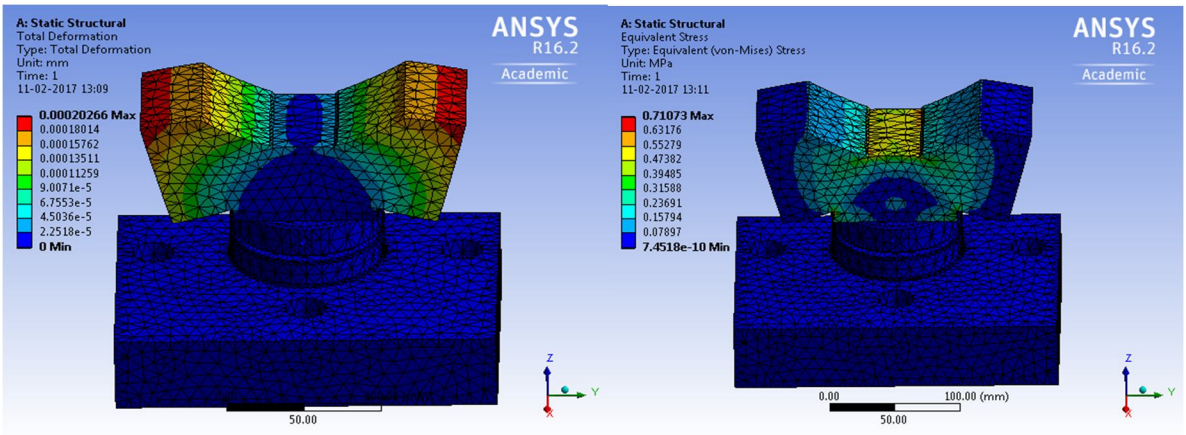

Fig. 6 V Block (Screw Type) stress and deflection at 1000N Load

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VI. CONCLUSION

The changes made in fixture design have reduced the setting time as estimated from the time study. The design of fixture mechanism is leading for improvement in work ergonomics for workers. As the poka yoke is well implemented in design, the chances of mistakes are greatly reduced. Due to the nullified probability of damage to the workpiece or elimination of truing process, the rate of rejection has ultimately come down. Since the time is saved behind every workpiece it has led to increase in the productivity of the company. In conventional lathe machines one setup is not sufficient for performing multiple operations but in case of HMC's it is possible to perform operations in one setup. Also HMC comes in dual pallets. It is usually better, from an economic standpoint, for a fixture to result in a small cost reduction for a process in constant use, then for a large cost reduction for process used only occasionally.

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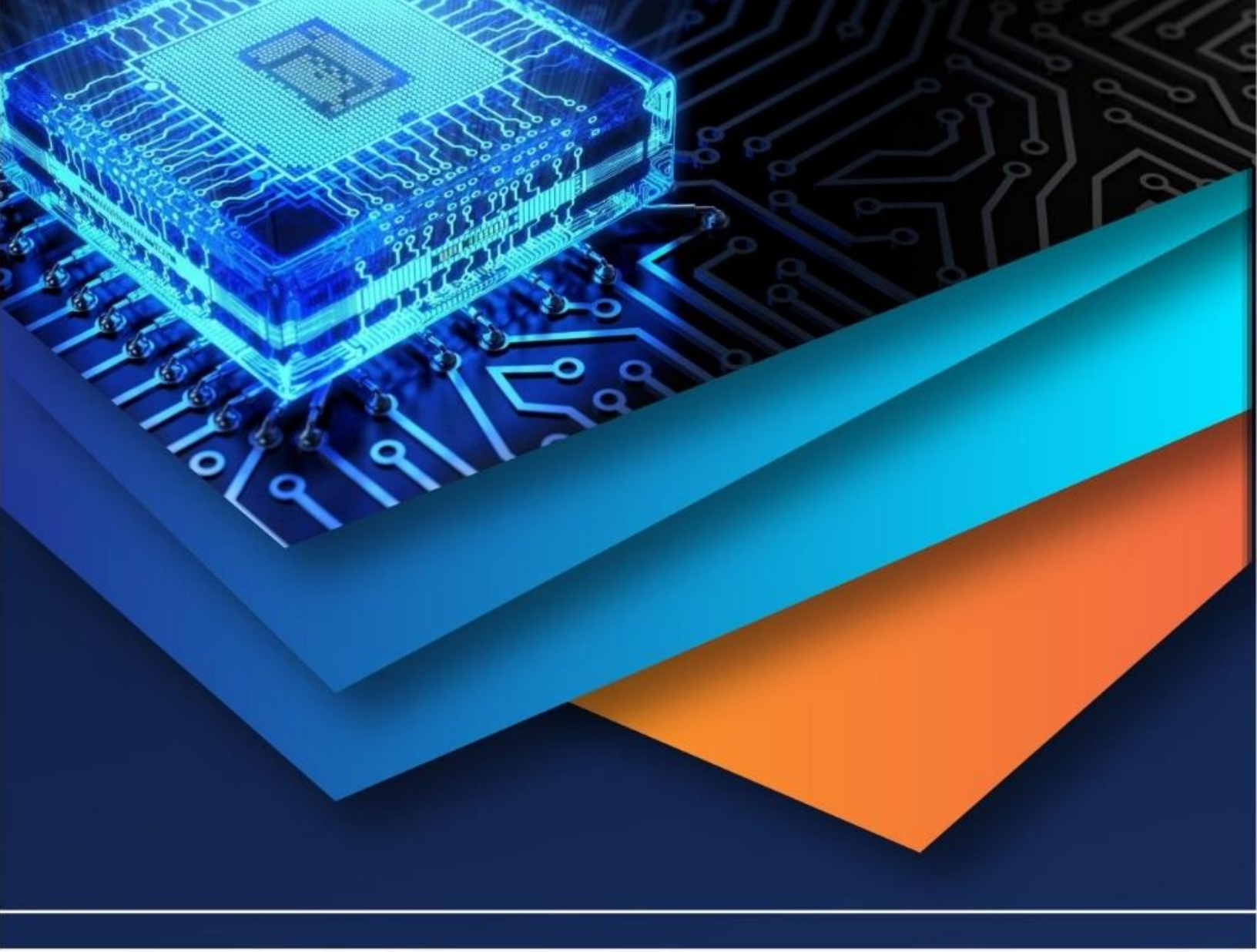

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