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Drill Indexing Jig for Industrial Applications

[1]Atharva G. Khaire, [2]Tejas K. Ghodake, [3]Mujjamil A. Jamadar, [4]Mitanshu R. Hire, [5]J.S.Supekar

[1,2,3,4]Student, Department of Mechanical Engineering, AISSMS College of Engineering, Pune, Maharashtra, India

[5]Assistant Professor, Department of Mechanical Engineering, AISSMS College of Engineering, Pune, Maharashtra, India

***Abstract* - In modern manufacturing industries, achieving high productivity and machining accuracy is essential for mass production. Drill jigs are widely used to guide cutting tools and accurately locate workpieces during drilling operations. This project focuses on the design and fabrication of an automatic indexing drill jig for an actuator support component requiring holes to be drilled at 90° intervals. The developed system eliminates the conventional process of marking and measuring the workpiece before drilling, thereby reducing setup time and improving dimensional accuracy. The indexing mechanism consists of a drill jig, support shaft, indexing arrangement, and hydraulic system that enable precise positioning of the workpiece during successive drilling operations. The fabricated setup securely holds the component and guides the drill tool to the required locations with improved repeatability. Experimental testing demonstrated smooth indexing and accurate hole placement. The developed system reduces operator effort, minimizes human errors, decreases production time, and enhances overall productivity. It provides a simple, cost-effective, and reliable solution for repetitive drilling operations in mass-production environments while maintaining consistent quality and machining accuracy.**

Keywords: Automatic Indexing Drill Jig, Drilling Machine, Automation, Mass Production, Indexing Mechanism, Manufacturing, Productivity, Hole Drilling, Workpiece Positioning, Machining Accuracy.

I. INTRODUCTION

In today's competitive manufacturing environment, industries continuously seek methods to improve productivity, accuracy, and product quality while reducing production time and labor costs. Drilling is one of the most commonly performed machining operations in manufacturing industries and is used to create holes for assembly, fastening, and functional purposes. Conventional drilling methods require marking, measuring, and positioning of the workpiece before each drilling operation, which increases setup time and may introduce human errors. These limitations become more significant in mass-production environments where a large number of identical components must be manufactured with high precision and repeatability.

To overcome these challenges, drill jigs are widely employed in manufacturing processes. A drill jig is a special work-holding device that accurately locates and firmly holds the workpiece while guiding the cutting tool during drilling operations. The use of drill jigs eliminates the need for repeated marking and measurement, thereby reducing machining time and improving dimensional accuracy. In addition, drill jigs ensure interchangeability of parts and help maintain uniform quality in mass production. They are extensively used in automotive, aerospace, machine tool, and general engineering industries where repetitive drilling operations are required.

For components requiring multiple holes at equal angular intervals, indexing mechanisms are integrated with drill jigs to facilitate accurate positioning of the workpiece. Indexing is the process of rotating a workpiece through a predetermined angle so that machining operations can be performed at multiple locations without removing or repositioning the component manually. An indexing drill jig significantly improves productivity by enabling quick and precise movement of the workpiece between drilling positions. It also reduces operator dependency and minimizes errors associated with manual indexing.

The actuator support component considered in this project requires drilling of holes at 90° intervals around its circumference. Producing these holes using conventional methods involves repeated marking, alignment, and positioning, which can be time-consuming and prone to inaccuracies. Therefore, an automatic indexing drill jig is developed to simplify the drilling process and ensure consistent hole spacing. The indexing mechanism allows the workpiece to be rotated accurately through 90° after each drilling operation, ensuring uniformity and precision.

The proposed system consists of a drill jig, support shaft, indexing arrangement, hydraulic mechanism, and clamping system. The workpiece is securely held in position while the jig guides the drill tool to the required locations. The indexing arrangement enables smooth and accurate rotation of the component, reducing setup time and improving machining efficiency. The hydraulic mechanism assists in the operation of the indexing setup and enhances ease of handling.

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The fabricated automatic indexing drill jig offers several advantages, including reduced production time, improved accuracy, lower operator effort, and increased productivity. The elimination of manual marking and repeated setup operations results in better process efficiency and consistent product quality. The developed system provides a practical and economical solution for repetitive drilling operations in mass-production industries and demonstrates the importance of automation in modern manufacturing processes.

II. LITERATURE SURVEY

The increasing demand for high productivity and precision in manufacturing industries has led to the development of various drilling jigs and fixture systems. Researchers have focused on improving machining accuracy, reducing setup time, and increasing production rates through automated and indexing-based jig mechanisms.

Patil et al. [1] developed an indexing drill jig for repetitive drilling operations in mass production industries. The proposed system eliminated manual marking and improved hole positioning accuracy. The study concluded that indexing mechanisms significantly reduce production time and enhance component quality by ensuring uniform hole spacing.

Kadam and Kulkarni [2] designed a drill jig with an automatic indexing arrangement for circular components requiring multiple holes at equal angular intervals. Their work demonstrated that automation reduced operator dependency and improved machining consistency. The developed mechanism increased productivity while maintaining dimensional accuracy.

Shinde et al. [3] investigated the design and fabrication of a hydraulic-operated indexing drill jig. The incorporation of hydraulic actuation reduced manual effort and enabled smooth indexing of heavy workpieces. Experimental results showed improvements in machining efficiency and reduced cycle time compared to conventional drilling methods.

Deshmukh and Pawar [4] proposed a multi-purpose drill jig capable of drilling, reaming, and tapping operations. The study highlighted the importance of accurate workpiece location and tool guidance in achieving high-quality machining results. The developed jig minimized setup errors and improved repeatability.

Jadhav et al. [5] presented an automated fixture system integrated with a pneumatic indexing mechanism. The researchers reported that the use of automated indexing significantly reduced idle time and improved production throughput. The system was particularly suitable for batch and mass-production applications.

Kamble and More [6] studied various jig and fixture designs used in modern manufacturing industries. Their review emphasized that properly designed jigs reduce manufacturing costs, improve interchangeability of parts, and enhance machining accuracy. The study recommended the adoption of automated jig systems for repetitive operations.

Waghmare et al. [7] designed a rotary indexing table for drilling operations on circular workpieces. The indexing table enabled precise angular positioning and reduced machining errors associated with manual indexing. The results indicated improved productivity and better hole alignment.

Joshi and Patil [8] developed a semi-automatic drilling fixture for automotive components. The fixture reduced operator fatigue and ensured accurate component positioning. The authors reported substantial reductions in cycle time and improvements in production efficiency.

Mane et al. [9] focused on the optimization of drill jig design using manufacturing principles. Their work demonstrated that effective fixture design reduces setup time and improves overall machining performance. The study also highlighted the importance of proper clamping and locating mechanisms.

More and Desai [10] developed an indexing fixture for components requiring equally spaced holes. The indexing arrangement provided accurate angular movement and eliminated cumulative positioning errors. The system proved effective in maintaining dimensional consistency across large production batches.

From the reviewed literature, it is evident that indexing drill jigs and automated fixture systems play a vital role in enhancing manufacturing efficiency. Most studies focus on improving accuracy, reducing cycle time, and minimizing operator intervention. However, there is still a need for simple, cost-effective, and reliable automatic indexing drill jigs specifically designed for actuator support components requiring holes at 90° intervals. The present work addresses this requirement by developing an automatic indexing drill jig that improves productivity while maintaining machining accuracy.

III. RESEARCH GAP

A review of the existing literature indicates that various drill jigs and indexing mechanisms have been developed to improve machining accuracy, reduce setup time, and increase production efficiency. Many researchers have proposed pneumatic, hydraulic, and manually operated indexing systems for repetitive drilling operations. These systems have

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demonstrated improvements in productivity and dimensional accuracy compared to conventional drilling methods.

However, most of the existing studies focus on general-purpose drilling fixtures or complex indexing arrangements that may increase manufacturing cost and maintenance requirements. In addition, limited work has been reported on the development of a simple and economical **automatic indexing drill jig specifically designed for actuator support components requiring holes at 90° intervals**. Several designs also require skilled operators for setup and alignment, which can affect production consistency.

Furthermore, there is a need for a compact indexing mechanism that can accurately position the workpiece, reduce operator intervention, eliminate manual marking, and provide reliable performance in mass-production environments. Existing systems often emphasize automation but may not adequately address ease of fabrication, cost-effectiveness, and adaptability for small- and medium-scale industries.

Therefore, the present work aims to design and fabricate an **automatic indexing drill jig** that provides precise 90° indexing, improves machining accuracy, reduces production time, minimizes human errors, and offers a practical and economical solution for repetitive drilling operations on actuator support components.

IV. SYSTEM DESIGN

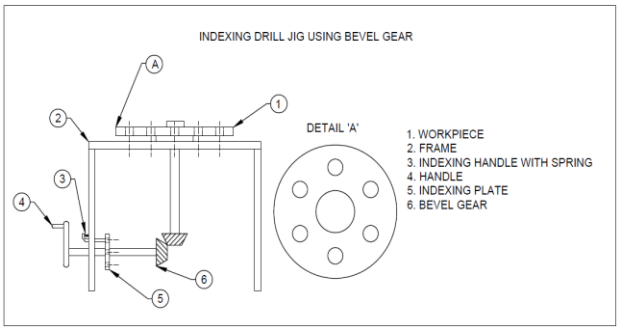

Figure 1: Proposed Model

The proposed **Indexing Drill Jig using Bevel Gear** is designed to perform accurate drilling operations at equal angular intervals without the need for repeated marking and measurement. The system consists of a work-holding arrangement, indexing mechanism, and power transmission elements that ensure precise positioning of the workpiece during drilling.

Main Components

1. **Workpiece (1):** The component on which drilling operations are to be performed. It is mounted securely on the indexing plate.
2. **Frame (2):** A rigid supporting structure that holds all components of the indexing drill jig and provides stability during operation.
3. **Indexing Handle with Spring (3):** Used to rotate and lock the indexing mechanism. The spring-loaded arrangement ensures positive engagement and accurate indexing.
4. **Handle (4):** Allows manual operation of the indexing system for rotating the workpiece to the next drilling position.
5. **Indexing Plate (5):** A circular plate containing equally spaced indexing holes. It controls the angular movement of the workpiece and ensures accurate positioning.
6. **Bevel Gear (6):** Transmits rotary motion between perpendicular shafts and facilitates smooth indexing of the workpiece. The bevel gear arrangement provides accurate angular displacement during rotation.

V. WORKING PRINLCIPLE

The indexing drill jig operates on the principle of controlled angular rotation using a bevel gear indexing mechanism. Initially, the workpiece is firmly mounted on the indexing plate and aligned beneath the drilling tool. The indexing handle engages with one of the holes in the indexing plate, locking the workpiece in position.

When the first hole is drilled, the locking pin is disengaged by operating the spring-loaded indexing handle. The operator then rotates the handle, which drives the bevel gear mechanism. The bevel gear converts the rotational motion and rotates the indexing plate along with the workpiece through a predetermined angle. For a component requiring four equally spaced holes, the indexing plate is designed to rotate by 90° after each drilling operation.

Once the required angular position is reached, the spring-loaded indexing pin automatically engages the next indexing hole, accurately locking the workpiece. The drilling operation is then repeated at the new position. This process continues until all holes are drilled around the circumference of the component.

The use of a bevel gear indexing mechanism ensures precise angular positioning, eliminates manual marking, reduces operator effort, minimizes human errors, and improves production efficiency. The system is particularly suitable for repetitive drilling operations in mass-production environments where accuracy and productivity are of primary importance.

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VI. DESIGN CALCULATION

The design calculations for the indexing drill jig are carried out to ensure safe operation, proper indexing, and sufficient strength of the supporting components.

1. Design of Indexing Mechanism

For drilling 4 holes equally spaced around the circumference of the actuator support component:

Angular Indexing Required

$$\theta = \frac{360^\circ}{N}$$

Where:

- θ= Indexing angle
- N= Number of holes

$$\theta = \frac{360^\circ}{4}$$
$$\theta = 90^\circ$$

Therefore, the workpiece must rotate through 90° after each drilling operation.

2. Design of Indexing Plate

Assume:

- Number of indexing holes = 4
- Pitch Circle Diameter (PCD) = 100 mm

Radius,

$$R = \frac{100}{2}$$
$$R = 50\ mm$$

Circumference of indexing circle,

$$C = \pi D$$
$$C = 3.142 \times 100$$
$$C = 314.2\ mm$$

Distance between adjacent indexing holes,

$$S = \frac{C}{4}$$

$$S = \frac{314.2}{4}$$

$$S = 78.55\ mm$$

3. Torque Required for Indexing

Assume:

- Weight of workpiece = 5 kg
- Weight of indexing plate = 3 kg
- Total load = 8 kg

Force acting:

$$F = mg$$
$$F = 8 \times 9.81$$
$$F = 78.48\ N$$

Taking indexing radius:

$$r = 50\ mm = 0.05\ m$$

Torque required:

$$T = F \times r$$
$$T = 78.48 \times 0.05$$
$$T = 3.92\ N - m$$

4. Shaft Design

Assume:

- Torque transmitted = 3.92 N-m
- Allowable shear stress for mild steel

$$\tau = 40\ MPa$$

Using torsion equation:

$$T = \frac{\pi}{16}\tau d^3$$

Substituting values:

$$3920 = \frac{\pi}{16}(40)d^3$$
$$d^3 = 499.2$$
$$d = 7.93\ mm$$

Factor of safety = 2

$$d_{safe} = 16\ mm$$

Hence, a 16 mm diameter mild steel shaft can be selected.

5. Bevel Gear Design

Assume:

- Number of teeth on driving gear = 20
- Number of teeth on driven gear = 20

Gear ratio:

$$i = \frac{Z_2}{Z_1}$$
$$i = \frac{20}{20} = 1$$

Thus, a 1:1 bevel gear ratio is obtained, providing equal angular motion transmission.

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6. Spring Force Calculation

Assume:

- Spring stiffness $k = 20\ N/mm$
- Compression $x = 5\ mm$

Spring force:

$$F = kx$$
$$F = 20 \times 5$$
$$F = 100\ N$$

Therefore, the indexing pin is held in position by a spring force of 100 N.

VII. RESULT AND DISCUSSIONS

The indexing drill jig using a bevel gear mechanism was successfully designed, fabricated, and tested for drilling holes at 90° intervals. The fabricated model was developed according to the proposed design and installed on a conventional drilling machine. The system was evaluated for indexing accuracy, ease of operation, and overall performance.

Fabricated Model of Indexing Drill Jig

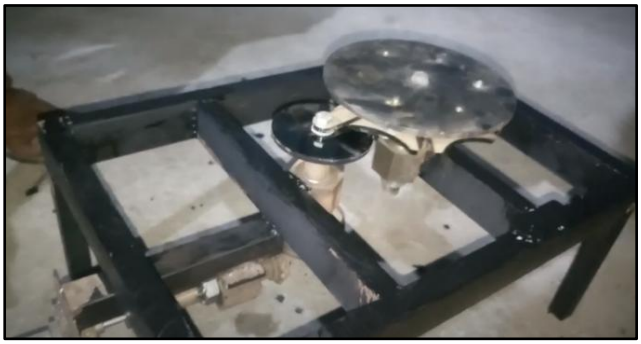

Figure 2: Fabricated Indexing Drill Jig Using Bevel Gear

The fabricated model consists of a rigid supporting frame, bevel gear arrangement, indexing plate, shaft, handle, and spring-loaded locking mechanism. The assembly was manufactured using standard machining and fabrication processes. The indexing plate was securely mounted on the shaft and connected to the bevel gear mechanism, enabling precise rotational movement of the workpiece.

The developed setup successfully performed indexing at 90° intervals. The spring-loaded indexing pin accurately engaged the indexing holes, ensuring proper locking during drilling operations. The bevel gear arrangement provided smooth transmission of motion and facilitated easy indexing with minimum effort.

Experimental testing showed that the workpiece remained firmly clamped throughout the drilling process, resulting in accurate hole positioning and uniform spacing between holes. The elimination of manual marking and repeated alignment reduced setup time and improved production efficiency. The system also minimized operator intervention, thereby reducing the possibility of human error.

The fabricated indexing drill jig demonstrated reliable performance and satisfactory stability during operation. The results confirm that the developed system is suitable for repetitive drilling operations and can be effectively used in mass-production environments requiring accurate hole placement at equal angular intervals.

VIII. CONCLUSION

The present work successfully achieved the design and fabrication of an **Indexing Drill Jig using a Bevel Gear Mechanism** for drilling holes at **90° intervals** on an actuator support component. The developed system effectively eliminated the conventional process of marking and repeated alignment of the workpiece, thereby reducing setup time and improving machining efficiency.

The bevel gear indexing arrangement provided accurate angular positioning and smooth rotation of the workpiece during drilling operations. The spring-loaded locking mechanism ensured proper indexing and maintained positional accuracy throughout the machining process. The fabricated setup demonstrated satisfactory performance in terms of stability, repeatability, and ease of operation.

The results obtained from experimental testing confirmed that the indexing drill jig improved drilling accuracy, reduced operator effort, minimized human errors, and increased production rate. The system proved to be a simple, reliable, and cost-effective solution for repetitive drilling applications. Furthermore, the developed jig is suitable for batch and mass-production environments where consistent quality and productivity are essential.

Overall, the project demonstrates the effectiveness of integrating an indexing mechanism with a drill jig to enhance manufacturing performance. The developed system can be successfully adopted in small-scale and medium-scale industries for accurate and efficient drilling operations, contributing to improved productivity and product quality.

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AUTHORS BIOGRAPHY

Atharva G. Khaire,
Student, Department of Mechanical Engineering, AISSMS College of Engineering, Pune, Maharashtra, India.

Tejas K. Ghodake,
Student, Department of Mechanical Engineering, AISSMS College of Engineering, Pune, Maharashtra, India.

Mujjamil A. Jamadar,
Student, Department of Mechanical Engineering, AISSMS College of Engineering, Pune, Maharashtra, India.

Mitanshu R. Hire,
Student, Department of Mechanical Engineering, AISSMS College of Engineering, Pune, Maharashtra, India.

J.S.Supekar,
Assistant Professor, Department of Mechanical Engineering, AISSMS College of Engineering, Pune, Maharashtra, India.

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