

## DESIGN AND MANUFACTURING OF JIG FOR ELBOW

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### Abstract

This work focuses on the design and manufacturing of a jig for an elbow component used in piping systems. The main objective is to improve production efficiency, accuracy, and repeatability during machining operations such as drilling and positioning. The sponsored company is engaged in machining of pipe Elbow casting. The elbow component has a complex geometry, which makes it difficult to hold firmly using conventional methods. To overcome this problem, a specially designed jig is developed to properly locate and clamp the component. The jig is designed based on the principles of locating, clamping, and guiding to ensure precise machining and reduced setup time. Proper selection of materials and manufacturing processes is considered to achieve durability and cost-effectiveness. The use of the jig minimizes human error, increases productivity, and ensures uniform quality in mass production. The final outcome of this work demonstrates that the designed jig significantly enhances machining accuracy and reduces production time for the elbow component, making it suitable for industrial applications.

**Keywords:** Jig Design, Locating and Clamping, Productivity Improvement.

### INTRODUCTION

A jig is an essential work-holding and tool-guiding device widely used in manufacturing industries to ensure accuracy, repeatability, and productivity in machining operations. It is specifically designed to hold the work piece in a fixed position and guide the cutting tool, particularly in operations such as drilling, reaming, and tapping. By eliminating the need for repeated marking and measurement, jigs significantly reduce human error and improve dimensional precision. In modern production systems, the use of jigs plays a crucial role in mass production by reducing setup time and increasing operational efficiency. They are commonly manufactured from durable materials such as steel or cast iron to withstand machining forces and maintain stability during operation. The design of a jig depends on the shape, size, and complexity of the component,

as well as the type of machining process involved. With advancements in manufacturing technology, jig design has evolved to incorporate ergonomic considerations, modular construction, and computer-aided design (CAD) techniques. These improvements enhance flexibility, reduce manufacturing costs, and ensure consistent product quality. Therefore, the study and development of efficient jig designs remain an important area of research in the field of mechanical and production engineering. The main types of jigs commonly used in manufacturing are as follows,

- i. Template Jig.
- ii. Plate Jig.
- iii. Channel Jig.
- iv. Leaf or Latch Jig
- v. Box Jig.
- vi. Angle Plate Jig,
- vii. Indexing Jig.
- viii. Trunnion Jig.
- ix. Pump Jig.
- x. Sandwich Jig[1].

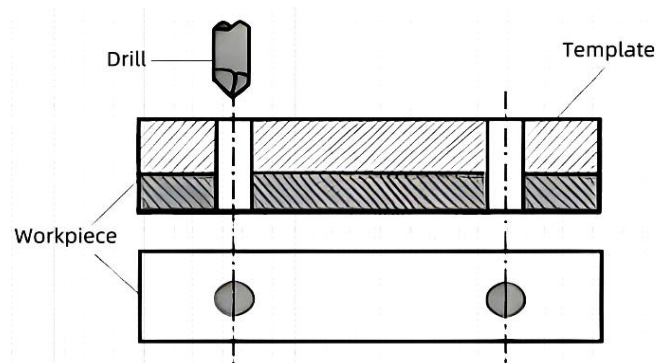


Fig. 1. Template Jig[1].

## 1. LITERATURE REVIEW

Falko Fiedler, et al., presented a review paper. They try to present current state-of-the-art jig and fixture concepts, their categorization, and an overview of their development over the last decade. For this purpose, a systematic literature review (SLR) done on all fixture concepts currently in use, as well as all new developments and research. A complete overview of all current review papers and new solutions approaches will be given as a basis for this review paper. The main focus will be on new fixture concepts since 2013, which will be defined, classified, and qualitatively, quantitatively, and historically evaluated. New fixture technology drivers, such as from the automotive industry, economic constraints, or introducing of new production-relevant technologies, will be crucial[2].

Harshwardhan Chandrakant Pandit , in his work he focused on the design of fixture and jig These principles of location, clamping, and automation in fixture design form the heart of effective jigs and fixture design, which evolves irrespective of the rapid evolution of machine tools and manufacturing technologies. The ideal fixture would solve the work piece distortion brought on by clamping and cutting force, in addition to the high

productivity and machining repeatability it would otherwise provide[3].

Mohsin Lalabhai Shaikh, et al., this proposed method has to design and fabricate the Multipurpose Jig and Fixture, for that component which has been to reduce the manufacturing cycle time. When the component produced on a small size previously this is to produce the large quantities of requirements. The selective components requires for machining operations such as step milling, angle milling & boring and reaming. The Fixture design will serve for the economic production for the component. The successful running of all over mass production depends upon the interchange ability to facilitate easy to assembly and reduction of unit cost[4].

## 2. DEFINATION OF PROBLEM

**Leena Engineering Works** engaged in the production of components like **Elbow fittings**, requires high precision, consistency, and efficiency. The conventional drilling process for such components often involves manual positioning and clamping, which leads to several challenges such as misalignment of holes, increased setup time, operator fatigue, and variation in product quality. Due to the curved geometry of the elbow component, achieving accurate hole positioning becomes difficult without proper work holding and guidance. This result in rejection of parts, reduced productivity, and increased manufacturing cost.

Therefore, there is a need to design and develop an efficient drilling jig that can accurately locate and firmly hold the elbow component during machining. The jig should ensure proper alignment of the drilling tool, reduce human error, minimize cycle time, and improve repeatability in mass production. The main problem addressed in this research is to develop a cost-effective, robust, and easy-to-use drilling jig that enhances machining accuracy and productivity while maintaining quality standards in the manufacturing of elbow components.

## 3. OBJECTIVES

- i. To study the existing drilling process of the elbow component.
- ii. To identify problems in conventional drilling such as misalignment and time consumption.
- iii. To design a suitable drilling jig for accurate positioning of the elbow component.
- iv. To ensure proper clamping and stability during drilling operations.
- v. To reduce setup time and increase production efficiency.
- vi. To improve repeatability and minimize rejection rates.
- vii. To develop a cost-effective and user-friendly jig design.

## 4. SCOPE OF STUDY

- i. The study is limited to the design and development of a drilling jig for the elbow component.
- ii. It includes analysis of component geometry and drilling requirements.
- iii. The work focuses on improving accuracy and productivity in drilling operations.
- iv. It covers jig design, material selection, and basic manufacturing considerations.
- v. Testing and validation are limited to performance evaluation in workshop conditions.

## 5. METHODOLOGY

- i. **Study of Component-** Analyze the geometry, dimensions, and material of the elbow component.
- ii. **Problem Identification-** Observe the current drilling process and identify issues such as errors and Inefficiencies.
- iii. **Concept Development-** Generate different jig design concepts suitable for the component.
- iv. **Design of Jig-** Prepare detailed design including locating elements, clamping system, and drill guide bush.
- v. **Material Selection-** Select appropriate materials for durability and cost-effectiveness.
- vi. **Fabrication-** Manufacture the jig components using suitable machining processes.
- vii. **Assembly and Testing-** Assemble the jig and test it under actual working conditions.
- viii. **Performance Evaluation-** Compare results with conventional methods in terms of accuracy, time, and productivity.

## 6. DESIGN OF JIG

After studying the drawing While designing a jig for drilling holes on flanges, special attention is given to the geometry and positioning of the flange to ensure accurate hole placement, especially when holes are arranged in a circular pitch (PCD) of rectangular flange. The jig should properly locate the flange using the central bore as a reference, following the 3-2-1 locating principle to restrict all degrees of freedom without over-constraining the component. A rigid base and suitable supports must be provided to prevent deflection during drilling. Proper clamping mechanisms, such as toggle or screw clamps, should securely hold the flange without causing distortion, particularly for thin sections. Drill bushes must be precisely positioned on the required pitch circle to guide the drill and maintain uniform hole spacing and alignment. The jig design should also allow easy loading and unloading of the flange, ensure effective chip removal, and maintain operator safety. Additionally, the use of standard and replaceable components like bushes and fasteners helps reduce cost and simplifies maintenance. Overall, the jig should ensure high accuracy, repeatability, and productivity in flange drilling operations. Finally by considering all above parameters CAD design of jig is created in CATIA Software. Both flanges of the Elbow will rest on the base plate and the same will be secured by tightening of Allen bolts. Due to such tightening arrangement loading and unloading of job becomes easier.

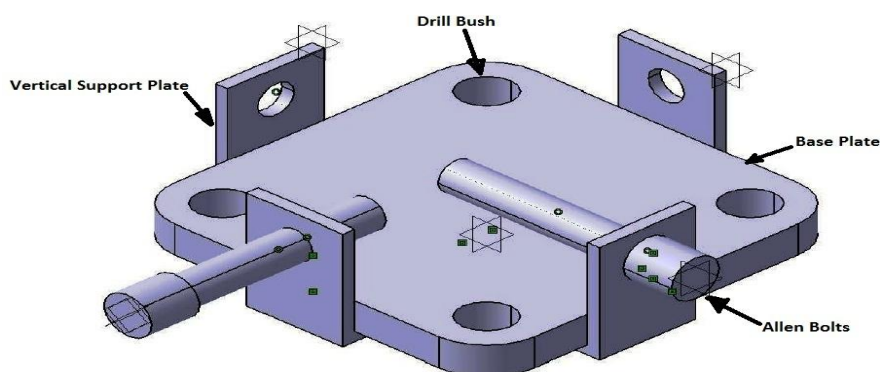


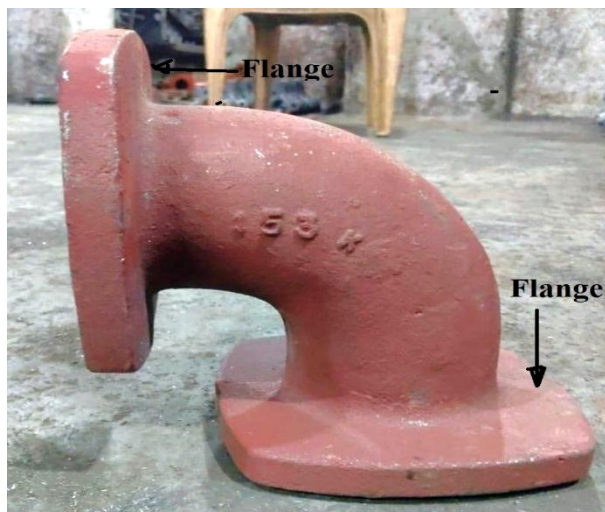
Fig. 2. 3D Model of Drilling Jig.

Table 1. List of Materials.

| Sr No. | Name of Part            | Material          | Quantity |
|--------|-------------------------|-------------------|----------|
| 1      | Base Plate              | Mild Steel (MS)   | 01       |
| 2      | Vertical Support Plates | Mild Steel (MS)   | 04       |
| 3      | Drill Bush              | High Carbon Steel | 04       |
| 4      | Allen Bolts             | Alloy Steel       | 02       |

### 7. DRILLING OF ELBOW

We can see in the below image both flanges are without drilling operation. Both flanges one by one mounting on the base plate of the jig and by suitable clamping devices all drilling operation have been carried out. In the next image we can see drilling operations. After drilling the dimensions of hole checked, this found the correct as per drawing i.e-  $\varnothing 14$  mm.



Elbow Before Drilling



Elbow After Drilling with Jig

## 8. CONCLUSION

After completing this work, we can conclude the following things,

- i. The drilling jig designed for the elbow pipe component improves accuracy and ensures proper alignment of holes.
- ii. It reduces machining time and human error, making the process more efficient.
- iii. It also enhances productivity and consistency in manufacturing.

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