Design of Fixture for Boring and Drilling operation on Small end of a Connecting Rod

Digvijay Chavan[1]

[1]B.E., Department of Mechanical Engineering, AISSMSCOE, Pune, Maharashtra, India

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Abstract - *The objective of this paper is to design and develop a dedicated fixture for the drilling and boring operations on the small end of a connecting rod using a Special Purpose Machine (SPM). Initially, the features and functional requirements of the operations are studied upon, based on which a rough sketch of the fixture is made using Solid Edge. Limits, fits, and tolerances are provided for the fixturing components in between mating components wherever necessary. Since the two operations were to be performed on two different machines, various designs were considered to obtain an efficient fixture that could perform all the operations in the least amount of time.*

Key Words**: SPM, Solid Edge, Connecting Rod, Drilling, Boring, Fixture**

1.INTRODUCTION

The fixture is a device utilized for locating, holding, and clamping the given component in its respective position during manufacturing processes. Additionally, it guides the tool with the assistance of a jig plate and bushes. The value of fixture design and manufacturing typically constitutes approximately 10-20% of the overall manufacturing process cost. Various types of fixtures exist according to their applications, such as machining fixtures, assembly fixtures, and inspection fixtures. Machining fixtures are primarily classified into two types: dedicated fixtures and modular fixtures. Dedicated fixtures are employed in mass production scenarios where the setup remains constant throughout production runs. Conversely, modular fixtures are utilized in batch-type production as they can accommodate similar products within the batch, owing to their reconfigurable nature. The use of automation in fixture design is referred to as computer-aided fixture design, which significantly reduces the time required for fixture design by eliminating the traditional trial-and-error method. Several software applications are employed for fixture design, facilitating more efficient and precise outcomes. The primary objective of any fixture design is to manufacture the given component with utmost accuracy, thereby minimizing the loading and unloading time of the component. This reduction in time helps alleviate operator fatigue, subsequently enhancing productivity. Achieving interchangeability of components is crucial in fixture design as it directly impacts the accuracy of the manufactured components. Fixture design often necessitates multi-modal solutions to meet various fixturing requirements. By considering the generic fixturing requirements, a fixture layout that fulfills all necessary aspects is selected as the optimal fixture layout for a given component. This ensures that the manufacturing process operates smoothly and effectively, resulting in high-quality components produced within the specified tolerances.

1.1 Fixture Design

The fixture comprises various components, including the locating system, clamping system, and supporting system, all carefully chosen to suit the specific requirements of the component being worked on. Locators are particularly critical as they ensure consistent positioning of the component during mounting. It's essential that locators are positioned for ease of mounting, while the clamping system applies adequate force against them to secure the component firmly in place. Different types of locators, such as round and diamond pins, floating locating pins, bullet nose dowels, bullet nose pins, and cone locator pins, are employed based on specific needs. Diamond pin locators, for instance, are valuable for compensating for gaps between locating surfaces. Clamping techniques, including strap clamps, hinged clamps, quick-action clamps, and power-operated clamps, are chosen to ensure that the clamping force is directed appropriately onto the workpiece, holding it securely. In instances where multiple clamps are necessary, the use of power-operated clamping can expedite the loading and unloading process, reducing operator fatigue.

The process of fixture design typically involves four main stages: setup planning, fixture planning, unit design, and verification. During setup planning, the orientation of the component is determined, taking into account its machining features. Fixture planning involves defining the desired characteristics and requirements of the fixture and its layout to ensure effective fulfillment of objectives. Finally, fixture design verification evaluates the fixture against predetermined criteria to ensure it functions as intended. Any discrepancies or issues are addressed and resolved during this phase to guarantee the fixture's efficacy in the manufacturing process.

1.2 Objective

The objective of this paper are:

1. To design 2 fixtures, one dedicated for drilling and one for boring operation

2. To give a modularity so that it is able to fit 4 different connecting rods and perform the operations on the small end, each having different diameters.

2. Literature Review

J. Strah and P. W. Zipse., Fixtures are essential tools in manufacturing processes, providing support and stability for workpieces during various operations. They consist of elements like locating systems and clamping mechanisms, chosen based on the specific requirements of the component being worked on. Locators, such as round and diamond pins, ensure accurate positioning of the workpiece, while clamping systems apply the necessary force to hold it securely in place. The design and development of fixtures play a crucial role in optimizing manufacturing processes, with considerations for efficiency, accuracy, and operator ergonomics.

Machining Handbook, Drilling and boring operations are common machining processes employed in the manufacturing industry. These operations involve the removal of material from workpieces to create holes or enlarge existing ones. Fixtures are often utilized to hold workpieces steady during drilling and boring, ensuring precise and consistent results. Factors such as tool selection, cutting parameters, and fixture design influence the quality and efficiency of drilling and boring processes.

V. P. Saini., Special Purpose Machines (SPMs) are tailored to perform specific manufacturing tasks efficiently and effectively. They are designed to optimize production processes, including drilling, boring, and other machining operations. SPMs offer advantages such as increased productivity, reduced cycle times, and improved accuracy, making them indispensable in various industries.

Connecting rods are crucial components in internal combustion engines, transmitting motion between pistons and crankshafts. The manufacturing of connecting rods often involves intricate machining operations, including drilling and boring, to achieve precise dimensions and tolerances. Fixtures play a vital role in ensuring the accuracy and consistency of these machining processes, contributing to the overall performance and reliability of the final product. Studies and research in fixture design, drilling and boring techniques, special purpose machines, and connecting rod manufacturing continue to evolve, driven by the constant pursuit of improved efficiency, quality, and innovation in manufacturing industries.

3. Component Study

Fig -1: Connecting Rods

Table -1: Connecting Rod Details

Connecting Rod	Small End Diameter	Center Distance	Depth of Cut (mm)
1	27,2	180	150
2	29.4	140	150
3	19	150	150
4	30	145	150

4. Fixture Design

In addition to the careful design considerations for both rough drilling and finish boring fixtures, there are further aspects to consider to ensure optimal performance and safety in machining operations. One crucial aspect is the material selection for the fixture components. High-quality materials with appropriate mechanical properties are chosen to withstand the forces and stresses encountered during machining processes. This ensures the durability and longevity of the fixtures, reducing the risk of premature failure and downtime.

Furthermore, the design of clamping mechanisms in both fixtures plays a vital role in securing the workpiece firmly in place during machining. The clamps must provide sufficient gripping force to prevent any movement or vibration that could compromise the accuracy of the machining operations. Additionally, quick-release mechanisms may be incorporated to facilitate efficient loading and unloading of workpieces, minimizing downtime between machining cycles. Another consideration is the integration of coolant systems into the fixture design to manage heat generated during machining and to aid in chip evacuation. Proper cooling helps maintain cutting tool integrity and prolongs tool life, while effective chip evacuation prevents chip buildup and potential damage to the workpiece or cutting tool. Moreover, ergonomic considerations are essential to ensure ease of use and operator safety. The design of the fixtures should allow for convenient access to tooling and workpiece loading areas, reducing the risk of operator fatigue and potential ergonomic injuries.

Lastly, thorough testing and validation procedures are conducted on both rough drilling and finish boring fixtures to verify their performance and reliability. This includes dimensional accuracy checks, functional testing under simulated operating conditions, and assessment of safety features to ensure compliance with industry standards and regulations. By addressing these additional considerations, manufacturers can enhance the overall effectiveness, safety, and reliability of the fixture designs for rough drilling and finish boring operations, ultimately contributing to improved productivity and quality in machining processes.

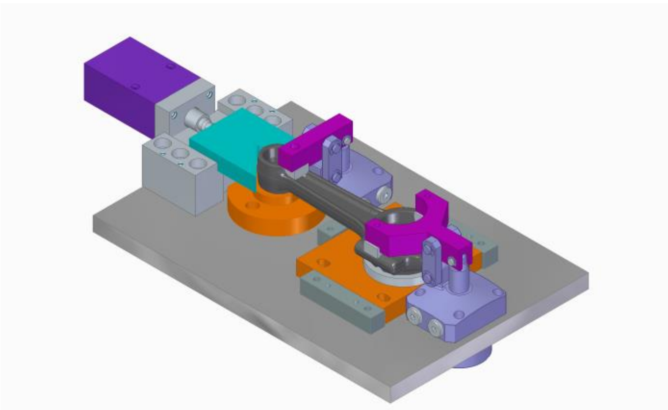

Fig -2: Rough Drilling Fixture

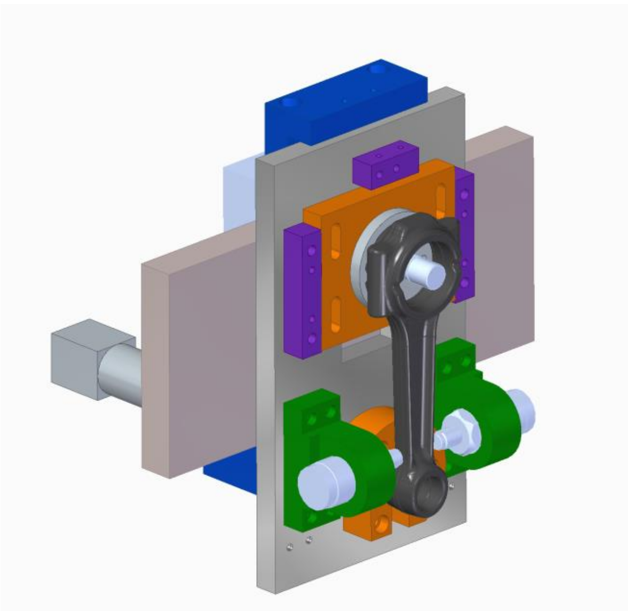

Fig -3: Finish Boring Fixture

Fig -4: Finish fixture without Component

Job Time: Job time encompasses the duration required for the entire drilling or boring process, from mounting the workpiece on the fixture to dismounting the finished component. It includes setup time, machining time, and any additional processes such as tool changes or inspection.

Tool Life: Tool life refers to the duration for which a cutting tool maintains its effectiveness before requiring replacement or resharpening. It depends on various factors such as cutting speed, feed rate, depth of cut, tool material, and workpiece material. Maximizing tool life is essential for minimizing production downtime and tooling costs.

Table -2: Machining Data

Parameter	**Drilling**	**Boring**
Cutting Speed	150m/min	250m/min
Feed Rate	0.2 mm/rev	0.2 mm/rev
Job Time	12 min	15 min
Tool Life	500 holes	650 holes

Table -3: Bill of Materials

Sr. No.	Component	Quantity
1	Base Plate	1
2	Big end Locator Plate	4
3	Plate Guide	2
4	Small end plate	2
5	Small end Locator	4
6	Work holding cylinder	2
7	V-block	1
8	V-Block Mount	1
9	Clamping cylinder	2
10	Clamp	8
11	Locating cylinder	1
12	Locating cylinder mount	4
13	Big end holding plate	4
14	V-Block attachment	1
15	Block cylinder	1
16	M8 bolts	32
17	M4 bolts	16
18	M10 bolts	14
19	Clamp end brass tips	16
20	Screw block	2
21	M4x0.25	2

5. CONCLUSIONS

Avoiding changes in the orientation and position of the component during machining operations is crucial for maintaining accuracy and consistency in the manufacturing process. By minimizing these changes, errors introduced during repositioning are significantly reduced, leading to increased overall accuracy. The use of well-designed fixtures plays a pivotal role in achieving this objective, as they securely hold the component in place and guide the machining tools with precision.

After successful manufacturing and testing of the fixtures, it was demonstrated that they were able to achieve an impressive accuracy rate of 98.6% across 20 test jobs. This high level of accuracy is essential for ensuring the quality and reliability of the finished components, meeting stringent manufacturing standards and customer requirements.

Furthermore, the versatility of the fixtures allows them to be used for drilling and boring operations on both the smaller and larger ends of the connecting rod. This flexibility enhances the efficiency of the manufacturing process, as the same fixtures can be employed for multiple machining tasks without the need for reconfiguration or adjustments.

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