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Jigs and Fixtures in Manufacturing

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ABSTRACT
Standard machine tools can be converted into speciality machine tools with the help of jigs and fixtures. Jigs and fixtures continue to be employed, either alone or in conjunction with other technologies, despite the general trend toward higher quality production. Although several writers have provided valuable details on some aspects of fixture design, there is still a need for a unified approach to creating jigs and fixtures. This paper examines the fundamentals of fixture and jig design. 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 workpiece distortion brought on by clamping and cutting force, in addition to the high productivity and machining repeatability it would otherwise provide.

Keywords – Jigs, fixtures, design, manufacturing.

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I. INTRODUCTION

Manufacturing industries have been recognized as having a significant impact on a nation's economic growth over the last century. Jigs and Fixtures are terms that refer to several types of equipment that are used in industry to facilitate production operations, particularly labour that involves machines. The ideal jigs and fixtures can both repeat operations and are interchanged, enabling the manufacturing of identical parts. Jigs and fixtures are the most significant devices that can help workers in the manufacturing business make their production process more accessible. These devices are used in the manufacturing industry. Jigs and fixtures are essential tools that are used in manufacturing. The tool that carries the most significant forces can determine the workpiece's ultimate form.

The demand for produced items has increased significantly throughout the years. Producers have developed creative methods for producing high-quality products to meet the rising demand. The production processes have undergone significant change and evolution with the development of various revolutionary manufacturing concepts. Innovative methods have prompted the necessity for inexpensive, dependable instruments and work-holding devices.

For successful running of a manufacturing firm, it requires a prompt and straightforward work positioning strategy for correct operations, which is dependent mainly on the interchangeability of machine components and workpieces; management of its supply chain to remain competitive is essential for industry, reduce the enormous manufacturing cost, and increase their profitability. This has also increased the desire for more efficient and cost-effective work-holding equipment to improve product quality, cut lead time, and enhance throughput.

A jig is holding and locating a device for the workpiece in its location while also guiding the cutting tool during a machining operation, whereas a fixture is a device that locates, holds, and supports a workpiece during a manufacturing activity. Fixtures are critical components of manufacturing processes since they are required in most automated manufacturing, inspection, and assembly procedures. Fixtures must appropriately position a workpiece about a cutting tool, measurement equipment, or another component, such as assembly or welding. Such a place must be invariant because the devices

must clamp and secure the workpiece for the specific processing procedure.

Many conventional work holding devices are frequently used in workshops and are generally maintained in stock for general purposes, such as collets, drill chucks, machine vices and jaw chucks. Workpiece-specific operations typically require their own custom-designed and fabricated fixtures. Like fixtures, jigs keep the part in place when drilling or boring. These instruments are collectively referred to as jigs and fixes.

When producing a component in bulk, jigs and fixtures are the most cost-effective means of doing it. Because of this, jigs and fixtures are utilized, serving as one of the most significant facilities in the mass production system. This is a specialized device for holding the work and guiding the tool. The quality of the jigs and fixtures utilized for a particular process significantly impacts the performance quality of that process. Each fixture is explicitly crafted to accommodate a given component or shape that distinguishes one fixture from another. The primary function of a fixture is to position and, in certain instances, hold a workpiece while the process is being performed. A jig is not the same as a fixture because, in addition to locating and maintaining the workpiece, it also directs the tool to the correct position or movement during the process. A fixture's sole purpose is to hold the tool in place.

To mass-produce identical or nearly similar products, factories use jigs and fixtures. They are specialized tool guidance and work holding systems developed for industrial-scale machining and assembly. Jigs and fixtures serve many purposes, including cutting production costs, speeding up production, ensuring flawless goods, making parts interchangeable, making complex shapes easy to machine, and lowering quality control expenses.

Eliminating the need for a unique setup for each workpiece, jigs and fixtures facilitate production and ensure that each workpiece is created within a predetermined tolerance.

With jigs and fittings, you won't have to set up each component separately manually. It was pointed out that if a jig or fixture is set up correctly, it is possible to mass-produce identical components with little to no additional effort. When standard components are used, the key advantages of jigs and fixtures are their longevity, ease of setup, increased productivity and decreased need for operator decision-making.

A jig is a device used in machining to hold, position, and support a workpiece while guiding the cutting tool's movement. This tool's primary function is to regulate others' positioning and motion, but it also ensures a consistent level of precision, interchangeability, and duplication in the final output.

Jigs are custom-made tools that position and manipulate other tools (Nanthakumar & Prabakaran, 2014 [1]). They realized that a jig's primary role in the production was to guarantee repeatability, precision, and adaptability. Jigs for drilling and boring are the most common, yet they are all essentially the same apart from the bushings' shape, kind, and placement.

Drill bushings and other tool-guiding devices are installed in jigs to control the tool's position within the workpiece, as described by Joshi (2010) [2]. Because of the need to press the jig against the table to align the many bushes in the jig with the spindle, he found that they were rarely fastened to the machine table. Some examples of jigs are drilling jigs, open-type jigs, and template jigs.

Fast, accurate, and reliable machining with repeatable quality, sharable components, and shorter production times are all made possible with the help of fixtures, which are mechanical devices that are both robust and long-lasting. Fixtures are only helpful for holding work steady; adjusting the machine is required for proper positioning, guiding, and locating the cutting tool.

Peshatwar and Raut (2016) [3]: An eccentric shaft fixture design solution for ginning machines was presented in their study. Depending on the nature of the industry's application, a certain kind of fixture may be necessary. The designer creates the fixture following the dimensions required by the industry to meet our production targets. In the conventional production method, acting on the eccentric shaft is essential. A fixture is vital to keep a workpiece correctly while manufacturing activity is being completed. Because of the eccentric nature of the shaft, the designer was tasked with creating the appropriate fitting for eccentric shafts as part of the manufacturing process. Fixtures reduce the time spent performing operations, boosting productivity and making it easier to perform operations to a high standard.

In addition to defining jigs and fixtures in detail, Kumbhar and Pandit (2017) list the numerous advantages of using jigs and fixtures in production, including some of the following: a rise in output, a drop in cost, interchangeability and high accuracy of components, a decrease in the cost of inspection and quality control, a decrease in accidents due to better safety, a noticeable improvement in the automation of machine tools, and ease of machining A specific type of fixture might be required according on the application's nature in the business. This can be done by choosing the ideal location for the fixture's different parts, including the clamps and locators. The fixture must be assembled by hand to use the component. As a result, a longer cycle time is necessary for loading and discharging the material.

During industrial and machining processes, a fixture's principal purpose is to identify and, in some cases, hold a workpiece, as stated by Kaija and Heino (2006)[15]. What sets fittings apart, he said, is that they are custom-made to fit a given profile or element.

II. FIXTURE ELEMENTS

In general, all fixtures are made up of the following components [6]:

1. **Locators:** A fixture has a locator as one of its components. Limiting the motion amount may help establish and keep a part in its designated location within a fixture. A locator's settings can be modified to accommodate work components with more remarkable morphological and topographic diversity.
2. **Clamps:** The mechanism that exerts a force on a fixture is known as a clamp. The forces applied by the clamps prevent any other external forces from acting on a component from dislodging it from its position within the fixture.
3. **Supports**: A support is a fixture member that can be either fixed or adjustable. When significant component movement or deflection is anticipated as a result of the action of imposed clamping and processing pressures, supports are added and placed below the workpiece to prevent or constrain the deformation that would otherwise occur. The supports need to be compatible with the locators and clamps, even if they are more extensive than required to determine the part's positioning.
4. **The jig body**, The primary component of a jig's framework is what is often referred to as the tool body. It maintains the spatial connection between the other pieces, including the locators, clamps, supports, and the machine tool used to treat the item.

The usage of fixtures provides advantages such as eliminating individual marking locations and periodic checking before the machining operation begins, resulting in significant savings in setup time. Furthermore, using work holding devices reduces operator labour by simplifying finding and clamping operations and allows for the substitution of expert labour.

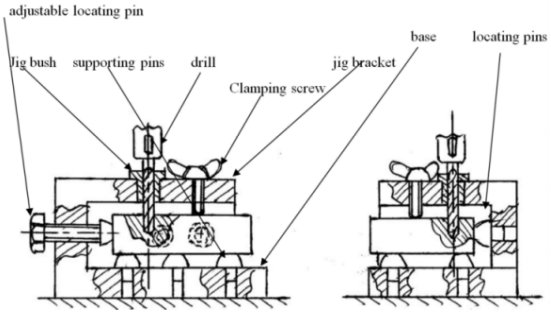

Fig. No. 1. Elements of Jigs and Fixtures [6]

III. GENERAL FIXTURE REQUIREMENTS

An operating fixture must meet specific characteristics to fully perform its functions as a work holding device and keep the workpiece stable during the machining process. While designing a feasible fixture, the following limitations must be met.

1. Deterministic positioning: A locator holds the workpiece in place so it may be machined. To correctly position the workpiece in the machine's coordinate frame, errors in positioning induced by locators and workpiece locating surfaces must be minimized.
2. Containment of deflection: Workpiece deformation is inevitable for reasons including the workpiece's own elastic/plastic properties and the external pressures caused by clamping actuation and machining operations. The amount of

deformation must be kept within acceptable limits if the tolerance standards are met.

3. Geometric Restrictions: All fixturing components must be able to touch the datum surface, which is ensured by the geometric limitation. Further, they watch over the fixture parts to make sure they don't get in the way of the machine's blades.
4. The design of a fixture should also have desirable features, such as a minimal number of components, mobility, accessibility, design for several cutting operations, quick loading and unloading, and an affordable price.

IV. ADVANTAGES OF JIGS [6]

Among the benefits of jigs and fixtures are, but are not limited to, the following:

- Production expansion;
- Low variation in dimensions, resulting in the consistent quality of manufactured goods;
- Expense reduction;
- Guarantees the interchangeability and high precision of parts;
- Reduces costs associated with inspection and quality control;
- Reduces accidents by increasing safety;
- They are simple for semi-skilled machine operators to operate, hence reducing labour costs;
- The machine tool is automatable to a significant degree;
- Complex and heavy components can be machined with relative ease;
- Simple assembly procedures reduce labour costs and the number of defective goods;
- They eliminate the need for measurement, marking out, punching, placement, aligning, and setting up for each item of work, hence decreasing the cycle and setup time;
- Enhances the technological capabilities of machinery;
- It is possible to apply many tools concurrently to a workpiece;
- Due to the improved clamping capability of jigs and fixtures, it is possible to set greater values for certain operating circumstances, such as depth of cut, speed, and feed rate.

V. DESIGN OF JIGS AND FIXTURES [6]

Numerous variables are studied to determine the optimal design for jigs and fixtures to achieve maximum output.

Jigs must be rotated numerous times so that holes may be drilled at different angles. Because of this, they should be sturdy and lightweight materials so they can be easily handled. It is recommended that four feet be provided for any jigs that are not bolted to the machine tool. This may allow the operator to be notified immediately if the jig is not in the correct position on the table. The procedures of accurately locating the workpiece concerning the cutting tool, rigidly supporting the workpiece during machining, tightly clamping the workpiece, directing the tool position, and securing the jig to the machine tool are all provided by drill jigs.

To accomplish their intended purposes, jigs and fixtures comprise numerous components:

- The degree of automation, capacity, and kind of the machine tool that can utilize jigs and fixtures;
- Clamping-equipped frame or body and base; The availability and precision of plates or indexing systems;
- Bushings and tool guiding frames for jigs; blank orientation availability and positioning devices in the machine;
- Auxiliary components; the machine tool strength under consideration; the required product precision level requirements; fastening components; the machine tool's accessible safety measures.
- Fluctuation levels of a machine tool also need to be considered.

VI. MATERIAL OF JIGS AND FIXTURES

Jigs and fixtures can be produced from various materials, each of which has distinct advantages. The materials can potentially be used to produce fixtures resistant to wear and tear. Often undergo tempering and hardening. In addition, phosphor bronze has a more significant number of non-ferrous metals, composites, and nylons to reduce the amount of wear that mating components experience and prevent damage. Prevention strategies are also

implemented during the manufacturing process. a few of the following topics are covered in this section:

1. **Phosphor Bronze [6]:** It is utilized in producing fittings and fixtures for procedures such as the production of interchangeable clamping nuts. Vices and uncontrolled feedings are two examples of systems that require screws. Phosphor-made bronze retaining nuts that are replacement bronze are often used to reduce the degradation and wear of screws. This is possible since the fabrication of screws is highly complicated, costly, and time-consuming.

2. **Die Steels [6]**: the three kinds of die steel – are high chromium (12%), high carbon (1.5 to 2.2%), and low temperature. Working steels are used to manufacture jigs and fixtures. Equipment for manufacturing thread forming rolls, in addition to the fabrication of press tools. In alloys containing vanadium and molybdenum, it can keep their hardness at extremely high temperatures. Die steels manufacture high-temperature jigs and fixtures for high-temperature work, including extrusion, forging, and casting processes.

3. **High-Speed Steels [6]:** These are high-speed steels with chromium added. The greater the percentage of tungsten and the lower the percentage of chromium and vanadium, the more significant the better strength. Hardenability, high-temperature hardness retention, excellent resistance to wear, tear, and impact are all characteristics of a material that can be hardened. When they are used in making jigs and fixtures, they are referred to as "used." Instrumentation for machining processes such as boring, reaming, drilling, and sawing.

4. **Carbon Steels [6]:** carbon steels are tempered with oil. Several pieces of jigs and fixtures are manufactured with these techniques. Which are subject to wear and tear like locators—jig bushes.

5. **Mild steels [6]:** mild steel has a carbon content of approximately 0.29l. Because of carbon's inherent simplicity, it can be obtained at a meagre cost. When making fixtures with jigs, the best material to choose is typically the readily available one. Other materials used in producing jigs and fixtures include nylon and fibre, steel castings, stainless steel, high-strength steel, and high-strength steel castings.

VI. CONCLUSION

Jigs and fixtures are the production tools in the hands of the designer. A proper, well thought and efficient design of these tools can improve the production performance and impact productivity and the production rate, thus avoiding the wastage of crucial resources.

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