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A Study of Design Framework for Squareness Inspection Fixture

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Abstract— Along with manufacture, the inspection of components must also be speeded up in mass production. The skill required for inspection must be reduced to lower labor costs. An inspection, fixture is used for verification of a product's geometric feature, dimensions and tolerance specification with respect to the product design specification. In the present fixture the inspection of the product is carried out manually, which leads to problems of misalignment and inaccuracy. This inaccuracy will increase the rejection of components. In order to minimize this error and reduce the rejection, it becomes essential to design a special purpose auxiliary attachment to the existing fixture. This improves the capability of the inspection fixture. So, this paper presents the solution in the form of a special purpose 'Squareness Inspection Fixture', which can be useful for checking the flatness of a component up to the desired tolerance with increased precision. Thus increasing the productivity and required skill for inspection is reduced.

Keywords - squareness inspection fixture, flatness, inspection, skill, precision

I. INTRODUCTION

The fixture helps hold the component in a particular position for an accurate manufacturing process to be carried out. In order to support and clamp the workpiece devices are provided which ensure gripped holding of the components [1]. The use of fixture eliminates frequent checking, individual marking, positioning and non-uniform quality in the manufacturing process. This increase productivity and reduce operating time. Fixtures are widely used in industries due to their quality of increasing the accuracy and minimizing the operational time. Depending on the use and the application, locators and clamps are provided or needed to hold the component on which operations are to be carried out. Locators determine the position and orientation of a workpiece, whereas clamps exert clamping forces so that the workpiece is pressed firmly against locators. Clamping of the component should be stiff and hence prevent the motion of the component in any direction to ensure accuracy in the output. The design of a fixture is a highly complex and intuitive process needing the knowledge in all aspects. It not only needs to have an accurate design data, but also the surface grinding and finishing of each and every component of the fixture is supposed to achieve the exact desired output.

Sometimes, a fixture has a separate provision for setting the tool with respect to workpiece or fixture. With this assumption in mind, a squareness inspection fixture is designed. For instance, consider a cylindrical workpiece/component such as an open impeller of a centrifugal pump. This open impeller requires accurate flatness of its vanes which have a perpendicular orientation with respect to the fixture. This type of inspection necessitates the provision of a separate inspection arrangement along an axis perpendicular to the spindle axis. Such compound arrangement constitutes a squareness inspection fixture.

II. SQUARENESS INSPECTION FIXTURE

A simple inspection fixture does not have an arrangement for inspection of flatness along the perpendicular axis to the fixture body. This process requires extreme skill on the part of the operator. Thus, in order to relieve the pressure off the operator a sliding attachment is installed to provide support to the inspecting device, making the inspection process more accurate and less time consuming.

A squareness inspection fixture comprises of a fixture body which mounts the different elements of the fixture in addition to an auxiliary modification carrying the inspection tool. The auxiliary attachment includes a sliding mechanism which works on the principle of conversion of rotational motion provided by hand driven wheel connected to a lead screw, to the translational movement of the guide plate carrying the tool used for inspection. This arrangement provides the required stability to the inspection tool which further enhances the inspection accuracy. The verification of dimensions involves holding the workpiece between the supports and manual checking using a standard measuring instrument such as a dial gauge or a vernier calliper. The main intention to use a gauge is to check the dimensions of the held component and check if the dimensions lie within the limits needed or specified.

III. FIXTURE ELEMENTS OF SQUARENESS INSPECTION FIXTURE

The following are the various elements of the fixture [3].

A. LOCATOR:

A locator is generally an immovable part of the fixture. It is used to determine the position and orientation of the component. Locator arrangement should be decided after studying the type of work, operation type and degree of accuracy required. For the design of squareness inspection fixture an internal locator such as a mandrel is considered in the inspection of cylindrical workpieces. Fig. 1 shows an example of locator [5].

Fig. 1 Mandrel used as a locator

CLAMP:

It is a mechanism used to exert a clamping force so that the workpiece/component is pressured firmly against the locator. The clamping system should be strong enough to withstand the forces developed during the operation. At the same time the force exerted due to clamping should not cause damage to the component being inspected. Fig. 2 represents type of clamping used [6].

Fig. 2 Headstock and Tailstock clamping

B. SUPPORT:

Any fixture consists of a fixed or adjustable element called support. A support is used to provide stability to the tool during the inspection operation. This provides more ease and precision to the operator when conducting the inspection. Fig. 3 shows the positioning of the slide on the fixture table [7].

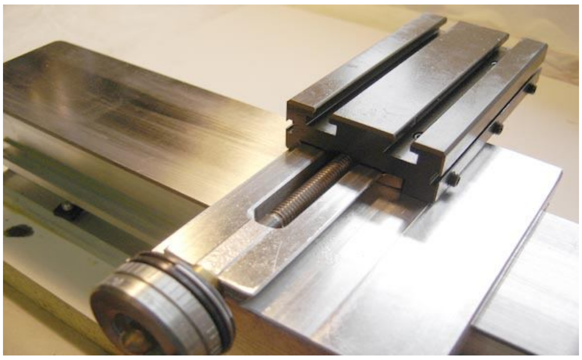

Fig. 3 Slide arrangement

C. TOOL:

The tool is any physical device used to carry out a process till the desired output is achieved by placing it against the component to be tested or machined. In this case the inspection tool used is a dial gauge which is mounted on the slide positioned at 90° to the spindle axis. This gauge will be used to determine the perpendicularity or flatness of the component. Fig. 4 depicts the kind of tool used for inspection [8].

Fig. 4 Dial Gauge

D. FIXTURE BODY:

The fixture body is a major structural element of a fixture. It accommodates all the fixture elements within the space provided in the most optimized manner. Fig. 5 is an example of the fixture base [9].

Fig. 5 Fixture body

IV. FIXTURE DESIGN PROCESS OF SQUARENESS INSPECTION FIXTURE

Successful fixture design begins with a logical and systematic plan. The designing of the fixture should be done meticulously so as to maintain its accuracy, hence helping in the inspection of the components. Mentioned below is a stepwise procedure to carry out the design of the squareness inspection fixture [4].

A. Product Specification

To start a design process the aim and scope of the project should be clearly understood. Another major aspect is to consider whether the complete design is required or changes in the existing design are sufficient to achieve the desired aim.

B. Analyze Information

In this step the designer is supposed to gather data and prepare block diagrams, process sheets and rough sketches of shapes of individual components for analysis. This stage also involves the detailed understanding of design specifications, examination of equipment used in the process and considering ease of operation and safety of workers.

C. Develop Several Options

After a careful study of requirements, the designer should select the most cost effective ways of inspection, locating and clamping by trial and error method. Locating method chosen should be consistent with clamping scheme and tool guiding arrangements.

D. Choose the Best Option

The total cost to manufacture per part depends on various parameters such as:

- Cost for operating and running the fixture
- Installation costs
- Number of components which are to be inspected
- Cost of tooling
- Cost of total quantity over the tooling lifetime

Thus the total cost of manufacturing can be calculated by using the following equation.

$$\text{Cost per part} = \text{Run Cost} + \frac{\text{Setup Cost}}{\text{Lot Size}} + \frac{\text{Tooling Cost}}{\text{Total Quantity Over Tooling Lifetime}}$$

E. Implement the Design

The last stage in the design process is to prepare drawings of assembly and individual components derived from the detailed designing of the fixture. A tolerance value is set according to the product requirement and the designer also has to decide which components should be standard and which should be machined.

V. DESIGN PROCESS CHART

Fig. 6 shows the process by which squareness inspection fixture can be designed. The part which is supposed to be inspected should first be analyzed which means its shape, size and its intricate design should be studied to determine the type of fixture which will do justice to its shape. After the part is studied the basic design of the fixture is to be made which will help hold the component easily. If the design conforms then carry on with the analysis or else repeat the first two steps. Design the fixture in 2-dimensional and 3-dimensional softwares and carry out virtual analysis and if it fails, repeat the process else carry on with the manufacturing. The manufacturing includes machining of each and every component and heat treatment, including through hardening or case hardening making sure it extends the life of the fixture. Finally the quality check is done and the repeatability of the component is also calculated so as to further install the fixture respectively.

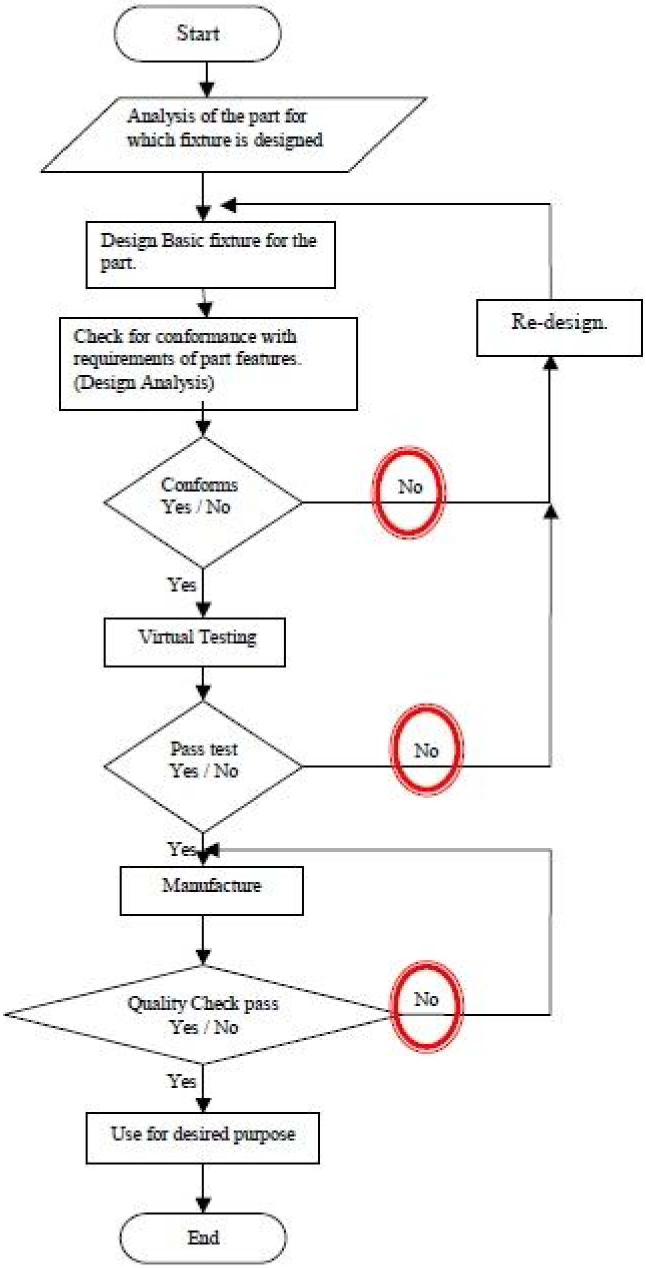

Fig. 6 Design process chart for Squareness Inspection Fixture

VI. Features and Limitations of Squareness Inspection Fixture

Apart from the general advantages of using a fixture, a squareness inspection fixture has a few more plus points.

- Improved Efficiency and accuracy of the inspection
- An increase in the number of parts inspected in a specified time span
- Reduced operator fatigue
- Minimized wastage of parts
- Less inspection time required per part
- Elimination of highly skilled operator
- Minimize human error during the inspection
- The separate provision of the slide fits within the space of a simple fixture, thus there is no requirement for manufacturing a whole new fixture which asks for a lot of capital.

Other than its features squareness inspection fixture also has its set of restrictions

- Initial investment in building such a fixture is increased due to the addition of separate attachment
- Maintenance cost increases due to increase in the number of parts
- Such a fixture can only be used for cylindrical parts. Parts other than cylindrical shapes cannot be inspected using this fixture.

VII. CONCLUSION

The design of squareness inspection fixture enhances the efficiency and reliability of the system and the outcome is more appreciable. To reduce the cycle time required for checking the flatness of a particular component, this approach is useful. The proposed fixture will not only minimize the inspection period, but it will also reduce operator fatigue and wastage. Thus more than compensating for the initial investment in the manufacturing of slide mechanism.

Thus, in the near future, a squareness inspection fixture can be viewed as a better alternative for inspection of a large number of similar parts and this paper provides a comprehensive documentation of the same.

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