

## Design and Analysis of Box Type of Drill Jig

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**Abstract:** The main objective of using jigs and fixtures in an industry is to achieve the Interchangeable Part Concept, and these are mainly used where production of goods is on large scale. The basic elements in the design of indexing type of drill jig is the component model, location, orientation and clamping. The scope of this paper is to design an box type of drill jig for a component having angular holes at 25 deg such the design is validated and verified. The present paper entitled "Design and Analysis of Box type of Drill Jig" is the work done for the design and analysis of Jig. Jigs are mainly used for mass production and for interchangeable parts concept, for a long period in the manufacturing of Jigs. Modeling is done using SOLIDWORKS Software and Analysis by using ANSYS

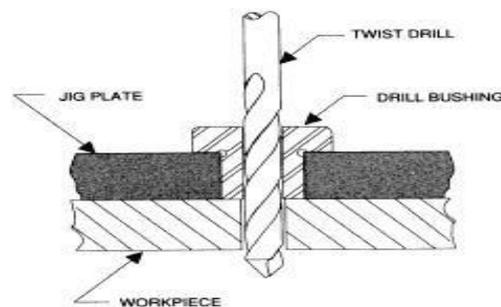
**Keywords:** Design, Interchangeable Part Concept, Jigs, Mass Production

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### I. Introduction

Over the past century, manufacturing has made considerable progress. New machine tools, high-performance cutting tools, and modern manufacturing processes enable today's industries to make parts faster and better than ever before. Although work holding methods have also advanced considerably, the basic principles of clamping and locating are still the same. Jigs and fixtures form an important category of equipment that goes a long way in achieving productivity. A jig, however, guides the cutting tool. A fixture references the cutting tool. The differentiation between these types of work holders is in their relation to the cutting tool. As shown in Figure 1, jigs use drill bushings to support and guide the tool. Fixtures, Figure 1, use set blocks and thickness, or feeler, gages to locate the tool relative to the work piece.



**Figure1:** A jig guides the cutting tool, in this case with a bushing.

In the shop, drill jigs are the most-widely used form of jig. Drill jigs are used for drilling, tapping, reaming, chamfering, counter boring, countersinking, and similar operations. Jigs are further identified by their basic construction. The two common forms of jigs are open and closed. Open jigs carry out operations on only one, or sometimes two, sides of a work piece.

Closed jigs, on the other hand, operate on two or more sides. The most-common open jigs are template jigs, plate jigs, table jigs, sandwich jigs, and angle plate jigs. Typical examples of closed jigs include box jigs, channel jigs, and leaf jigs.

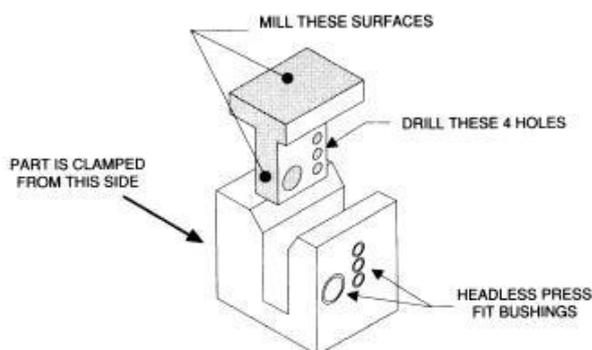
**DESIGN CONSIDERATIONS:** The principal considerations when choosing among work holder varieties fall into three general categories: tooling cost, tooling details, and tooling operation. Although each of these categories is separated here, in practice they are interdependent. The following are some design differences and considerations for permanent, general-purpose, and modular work holders.

### TOOLING DETAILS

Tooling details are the overall construction characteristics and special features incorporated into the jig or fixture. Permanent work holders are designed and built to last longer than temporary work holders. So, permanent jigs and fixtures usually contain more-elaborate parts and features than temporary work holders.

### TOOLING OPERATION

The performance of any work holder is critical to the complete usefulness of the tool. If the work holder cannot perform the functions desired in the manner intended, it is completely useless, regardless of the cost or the extent of the detail.



**Figure 2** A combination drill jig/milling fixture used for both types of operations on the same part.

### ESSENTIAL FEATURES OF JIGS AND FIXTURES

The jigs and fixture must satisfy the following conditions :

#### REDUCTION OF IDLE TIME:

The design of jigs and fixtures should be such that the process of loading and unloading the component takes the minimum possible time and enables on easy loading and clamping should be such that idle time is reduce to minimum.

#### PROVISION FOR COOLANT:

The jigs and fixtures must have adequate arrangement for the cutting edges of the tools so that the tool is cooled and at the same time the swarf or chips produced are washed away, so that the operator does not have to waste time in adjusting the coolant flows and cleaning of the swarf or chips.

#### HARDENED SURFACES:

All locating and supporting surfaces such as faces of locating pins should be hardened materials as far as conditions permit, so that they are not quickly worn out and their accuracy is retained for a longer time.

#### SAFETY:

The design of jigs and fixtures should be such that it should not constitute a danger to operator.

#### FOOL PROOF

Since the use of jigs and fixtures allows for the employment of unskilled workmen, the design of such equipment should be such that it would not permit the work piece or the tool to be inserted in any position other than the correct one.

## II. Design Procedure Of Box Type Of Drill Jig

Initially the component was designed, modeled and edited to get the necessary details for designed of the jig. Secondly the individual parts such as Base Plate, Locator, Clamping Devices Bushes Jig Plate, and Indexing Mechanism has been developed. All these parts have been designed, Modeled, Drafting has been done individually. The whole Design Procedure was completed with the help of CAD software by which the software helps for Designing, Drafting Assembly and Analysis which may be useful for customized applications and manipulations.

Component Description: The component for which the jig is deigned is a Casted Component which is having angular holes inclined at 25 deg equi-spaced.

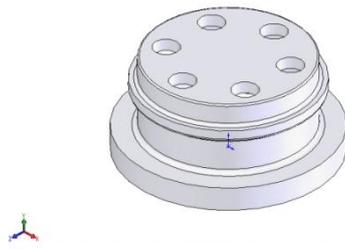


Figure 3: 3D Model of the Component

#### DESIGN OF BASE PLATE:

The Base Plate is one of the vital parts in the design of jigs. Base is generally taken as a support for the other parts. In general base are in the form of vertical, inclined, and horizontal plates. The base plate in the design is developed according to the dimensions of the work piece, so that during the machining and non-machining the structure is not distorted.

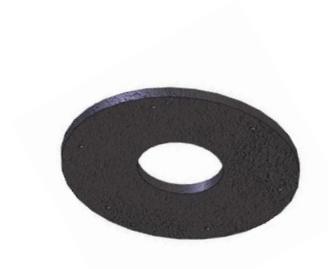


Figure 4: 3D Model of Base Plate

#### DESIGN OF LOCATOR

A minimum of three locators are used to locate the work piece. The type of locator used in this design is locator for circular surfaces in which the inner diameter is taken as the locating surface of the component. The locating diameter for the component is  $108(+/- 0.15)$  mm. From this locating surface clamping and other mechanisms are developed.

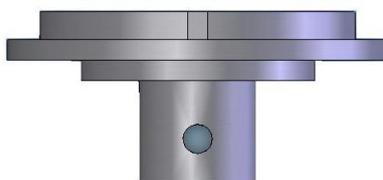


Figure 5: 3D Model of Locator

#### DESIGN OF CLAMPING DEVICE

While performing a manufacturing operation it is necessary to provide some kind of CLAMPING mechanisms to hold the work piece in the desired position and to resist the effects of gravity and operational forces. Clamp From the calculation it is found the clamping force is greater than the drilling force (machining force) hence the jig design is safe, and the clamp chosen is also satisfied by its per formability.

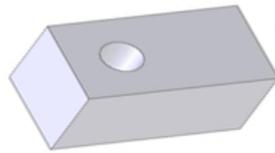


Figure 6: 3D Model of Strap Clamp

### DESIGN OF BUSHES

Bushings are used to guide drills, reamers, and other cutting tools into proper position on the work piece. In the design of indexing type of drill jig the type of bushes used are;

- Liner Bushes
- Renewable Bushes
- Taper Bushes

**LINER BUSHES:** These are taken from standards IS 666 according to the dimensions of the drilled hole the liner bushes used here are



Figure 7: 3D Model of Linear Bush

### RENEWABLE BUSH

In this design the renewable bush used is a lock and screw type in which the bushes can be replaced easily. For the diameter of the drilled hole three renewable bushes are used which are taken from IS 666.

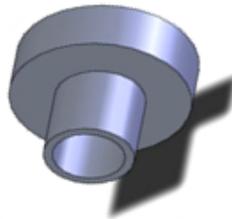


Figure 8: 3D Model of Renewable Bush

## III. Box Type Drill Jig Assembly

### FRONT VIEW OF THE MODEL

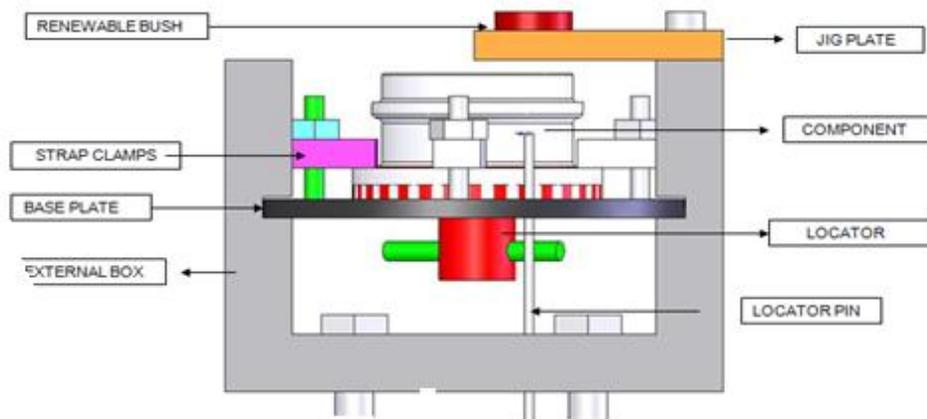
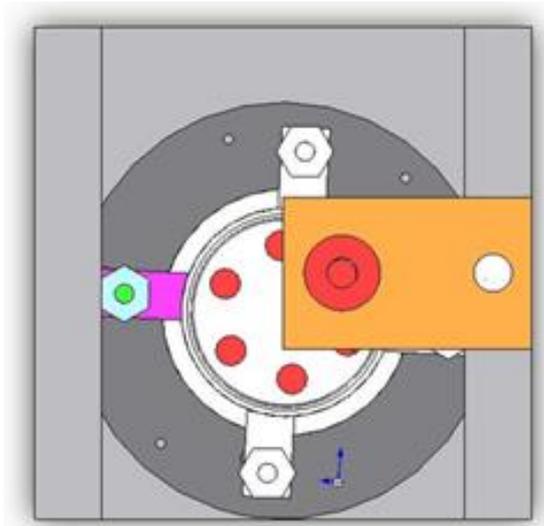
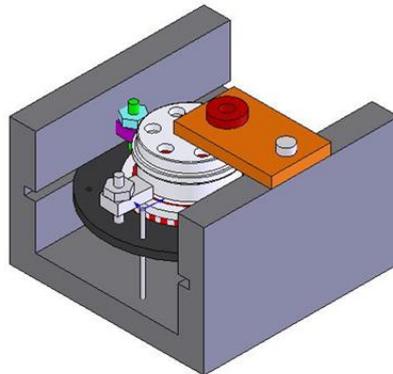


Figure 9: Front View of the Box Type of Drill Jig



**Figure10 :** Top View of The Model

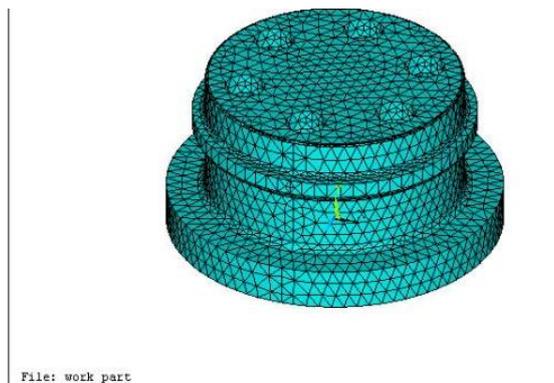
Here it is clearly observed that the drill axis coincides with the hole axis hence the design is satisfied for hole positioning. In the design of drill jig the most vital part is the locator pin, because it is very much important that how the relationship is maintained hence for this a locator pin is used. Hence the concept of Fool Proof design is also satisfied, it means that any unskilled operator can easily operate the jig since the component is arrested in the desired position and there is no other chance for any positional errors.



**Figure11 :** Isometric View of the model

#### IV. Analysis Of Box Type Drill Jig Using Ansys

Analysis of the Component



**Figure12 :** Meshed Model of the Component

ELEMENT SOLUTION

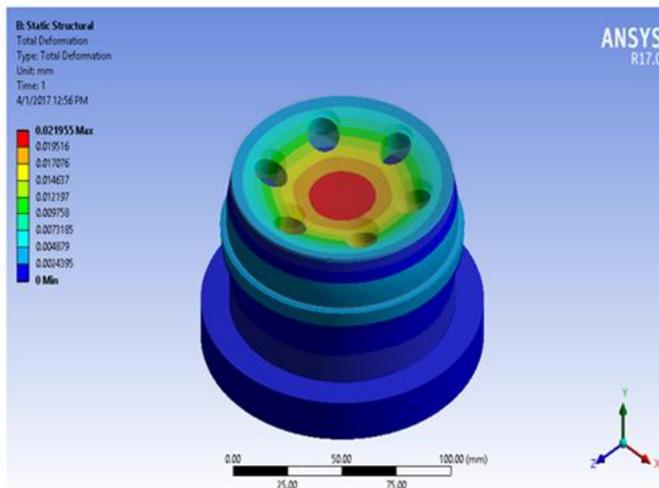


Figure 13: Element Solution

ANALYSIS OF BASE PLATE

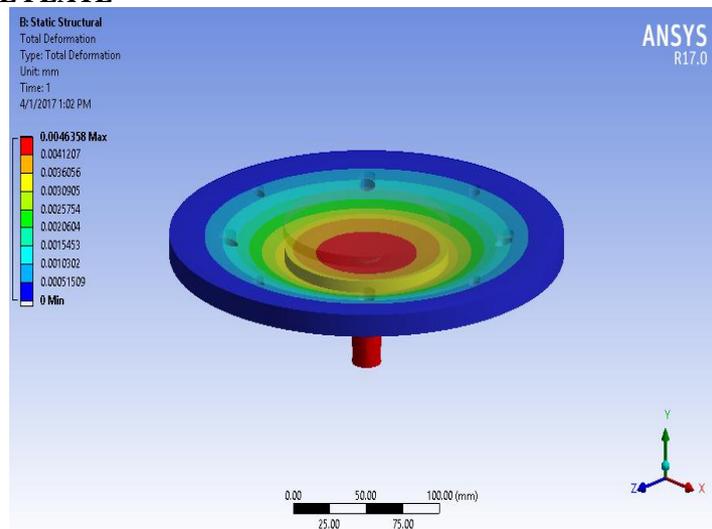


Figure 14: Deformation of base Plate

ANALYSIS OF BUSH:

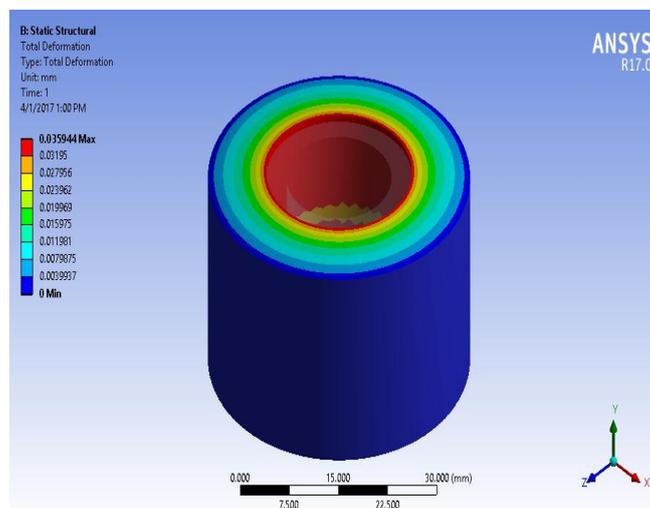
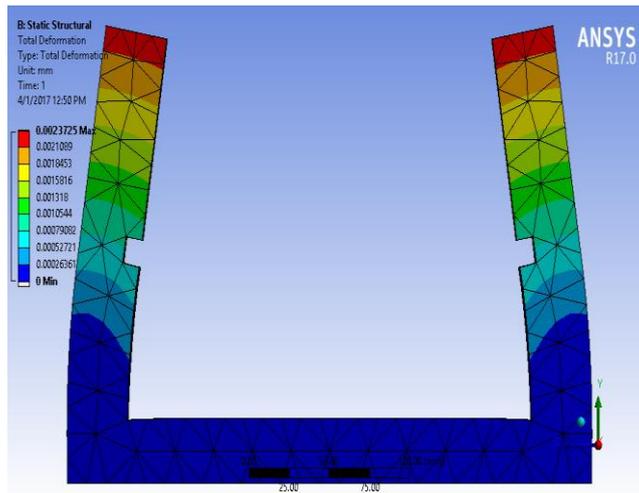


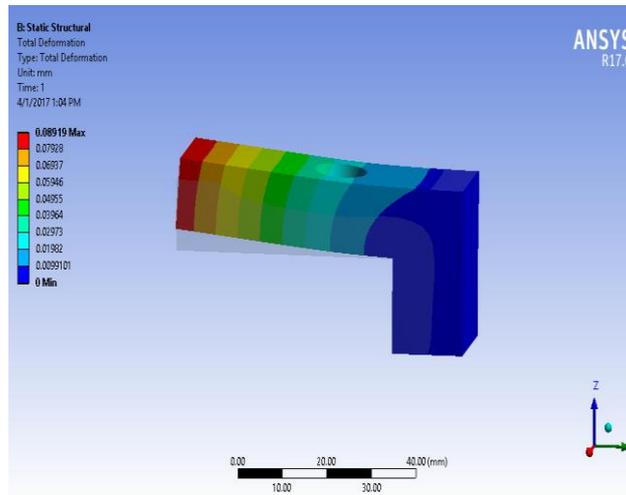
Figure 15: Deformation of Bush

**ANALYSIS OF BOX:**



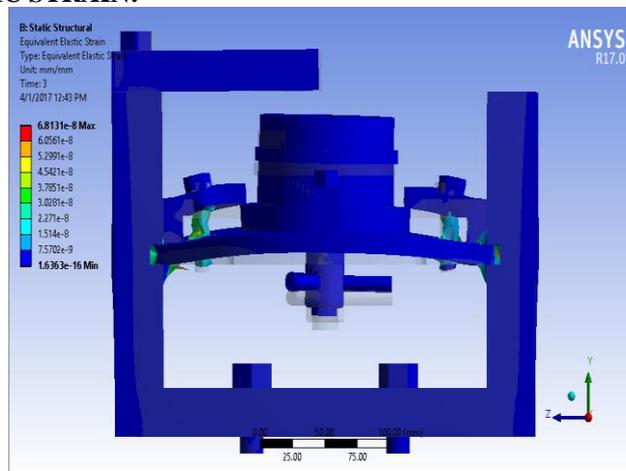
**Figure 16: Deformation of Box**

**ANALYSIS OF CLAMP**



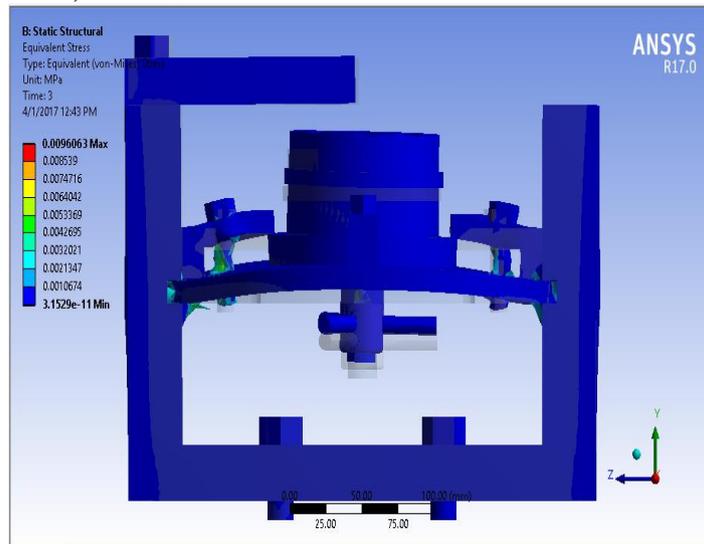
**Figure 17 : Deformation of Clamp**

**EQUIVALENT ELASTIC STRAIN:**



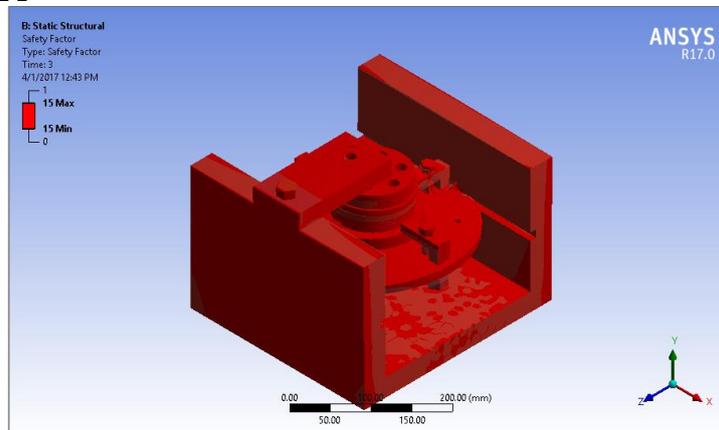
**Figure 18: Equivalent Elastic Stress**

**EQUIVALENT (Von-Mises) STRESS**



**Figure 19:** Equivalent (von-Mises) Stress

**FACTOR OF SAFETY**



**Figure 19:** Factor of Safety

**V. Results**

While designing for selecting the required parts of the Box Type Of Drill Jig the following calculations are done and compared with allowable limits for individual parameters like rpm, thrust and clamping force

PARAMETERS	CALCULATED VALUES
TORQUE (M) kgf cm	479.5kgfcm
THRUST (Px) kgf	323.99kgfcm
POWER DRILLING kW	2.67k w
DRILL THRUST kgf	141.176kgf..
CLAMPING FORCE kgf	195.kgf

From the above table it can be clearly understood that the Clamping Force is more than drilling forces therefore the design is safe for machining

Hence the design made satisfies the interchangeable part concept, and the design is fool proof and the design is validated.

The results obtained after drilling like bore, surface finish etc. are found to be within the limit.

The Stresses in the Nodal Solution indicate that the component as well as the assembly are reliable and safe under working conditions.

## **VI. Conclusions**

1. The design of Box type of drill jig involved about 287mm x 203 mm dimensions
2. The material of the component is Aluminum Alloy (LM 20).
3. The Clamping force is more than the drilling force (calculated)
4. The assembly of the Box Type of Drill Jig is found satisfactory.
5. The results obtained after drilling like bore, surface finish etc. are found to be within the limit.

## **Reverences**

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