Design and Fabrication of Multi Operational Fixture

V. Karthikeyan¹, P. Sampth², S. Suresh³, K. Vinod⁴, Prof. P. Ravikumar⁵
¹,²,³UG Students, Mechanical Engineering, Kathir College of Engineering, INDIA
⁴Associate Professor, Mechanical Engineering, Kathir College of Engineering, INDIA

ABSTRACT
Manufacturing is the process of converting raw materials, components, or parts into finished goods that meet a customer’s expectation or specifications. Manufacturing commonly employs a man-machine set up with division of labor in a large scale production.

In order to achieve effective manufacturing there are three main factors time, cost and quality which are very important for a company to run efficiently. So in order to reduce the production time and cost, achieving uniform quality of a product in mass production Fixtures are employed about which this project deals about. Fixtures are mainly used for holding, supporting, and locating the work piece. So as per our project “DESIGN AND FABRICATION OF MULTI OPERATIONAL FIXTURE”, to perform multi-operation in a single fixture to increase the production rate with decrease in time. It empahsizes to produce the component at good quality and to increase productivity.

Keywords--- Multi operational Fixture.

I. INTRODUCTION

Material used in fixtures:
Fixtures are made from a variety of materials, some of which can be hardened to resist wear. It is sometimes necessary to use non-ferrous like phosphor bronze to reduce wear of mating parts or nylons or fiber to prevent damage of work piece. Given below are the materials used in fixtures, press tools, collets etc.

High speed steel:
These are used mainly for cutting tools such as drill, reamer and high milling cutters. These can be oil or air hardened to 66 RC. 18% tungsten to 22% tungsten. HSS also contains 4.3% chromium, 1.6% vanadium and less quantities of carbon, molybdenum.

Die steel:
These are used mostly for dies for hot or cold working. Cold die steels are used for press tools and can be hardened up to 65 RC. These contain about 1% carbon, 0.5% to 1.5% tungsten and less quantities of silicon and manganese and can be oil hardened. Hot die steels are used for extrusion, forging and die-casting dies which are subjected to high temperature due to hot working.

Carbon steel:
These are used for primarily for cutters tools. They contain 0.85% carbon, 0.5 to 0.8% manganese, and less quantity of silicon. These can be water hardened to 62 to 63 RC. This steels can be used for drill bushes, locators and other parts which are subjected to wear and need to be hardened.

Non-shrinking tool steels:
This is also called as high carbon 1 to 2% of carbon or high chromium (4 to 12%) steel. These steels distort little during heat treatment. They are convenient when it is not possible to do finishing operation on a component to remove heat treatment distortion. Oil hardened to 60 to 64 RC. These steels are used widely for fine, intricate press tools.

Nickel chrome steel:
Used mainly for gears these steels contains 3 to 4% nickel, 0.6 to 1.1% chromium and less quantities of carbon, silicon and manganese. These can be case hardened to 61 to 63 RC. Alloy steels En 36 falls under this category.

High tensile steels:
Used for mainly fasteners such as high tensile screws, these contain 0.4 to 0.6% manganese. These can be oil hardened to 45 to 50 RC steels En 9 is a high tensile steel.

Mild steel:
Used for most of the parts in fixtures, mild steels contain less than 0.3% carbon and 0.1 to 0.8% manganese steels and falls En 14 contains less than 0.15% carbon and cannot be hardened. Generally all the parts which require no hardening are made of mild steel because it is the cheapest material available among steel.
Cast iron:

Used for add shapes to some machining and laborious fabrication, CI usage require a pattern for casting. Pattern cost should be compared with the cost of machining and fabrication. Cast iron contains more than 2% carbon. It can withstand vibration well and very suitable base bodies of milling fixtures. Self-lubricating properties of cast iron make it suitable for machine slide and guide way.

Phosphor bronze:

When screw operated clamps are worn out the screw as well as the nuts need to be replaced. Generally screw are longer and costlier then nuts. So nuts are made of phosphor bronze which has high tensile strength. As phosphor bronze is softer than mild steel it will wear out before the mating screw causing much wear. Phosphor bronze nut bushes can be replaced periodically and thus, the life of steel screw can be prolonged. Nuts for lead screws for most of the machine tools are made of phosphor bronze.

II. FUNDAMENTAL PRINCIPLES OF FIXTURES

Locating points:

The most important requirements in fixtures design are good facilities to be provided for locating the work and the article to be machined may easily inserted and quickly taken out from the jig so that no time is wasted in placing the work piece in the position to perform the operation.

The position of work piece should be accurate with respect to tool grinding in the jig or setting elements in the fixture. Tenon strips should be provided for bed accuracy and quick location of the fixture on the machine.

Fool proof:

The design of Fixture should be such that it would not permit the tool to be inserted in any position other than the correct one. In this case, dowel pins or other devices can be placed to incorporate in correction position.

Clamping devices:

It should be as simple as possible without sacrificing effectiveness. The strength of the clamp should be that not only to hold the work piece firmly in the place but also to take the strain of the cutting tools without springing or giving when designing the fixtures. The direction in which the strain of the cutting tools or the cutter act upon the work should always be considered, and the clamps so placed that will have the highest degree of strength to resist the pressure of cut. The clamps should be convenient, quick operated and less fatigue to operator. After detached from the work, the clamps should be still connected with the jig or fixture itself.

Reduction of idle time:

The idle time can be reduced by loading and unloading arrangements. Design of jigs and fixture should be still connected with the jig or fixture itself.

Weight of the fixtures:

The jigs and fixture should easily be handled, smaller sized and low cost in regard to the amount of materials used for their making. But at the same time, it should not sacrifice any of the rigidity and stiffness

Material used for fixtures:

Fixtures made of hardened material to avoid frequent damage and resist water. The material used for jigs and fixture are mild steel, cast iron, die steel, carbon steel, high speed steel, nickel- chrome steel, phosphor bronze, plastic material.

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Die steel:

These are used mostly for dies for hot or cold working. Cold die steels are used for press tools and can be hardened up to 65 RC. These contain about 1% carbon, 0.5% to 1.5% tungsten and less quantities of silicon and manganese and can be oil hardened. Hot die steels are used for extrusion, forging and die-casting dies which are subject to high temperature due to hot working. These are generally oil/air hardened to 40 to 50 RC and contain 2 to 5% chromium, 4 to 9% tungsten, 0.4 to 0.5% vanadium and less quantities of manganese and silicon.

Carbon steel:

These can be used for standard cutting tools. They contain 0.85% carbon, 0.5 to 0.8% manganese, and less quantity of silicon. These can be water hardened to 62 to 63 RC. This steels can used for drill bushes, locators and other parts which are subjected to wear and need to be hardened.

Collet steels:

These are spring steels which contain 1% carbon, 0.5% manganese and less quantity of silicon, collet steels can be oil/ water hardened to 47 RC.

Non- shrinking tool steels:

This is also called as high carbon 1 to 2 % of carbon or high chromium (4 to 12 %) steel. These steels distort little during heat treatment. They are convenient when it is not possible to do finishing operation on a component to remove heat treatment distortion. Oil hardened to 60 to 64 RC. These steels are used widely for fine, intricate press tools.

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III. LOCATING PRINCIPLE

Basic principles:
To ensure precision in any machining operation, the work piece must be properly positioned with respect to the cutting tool. The position of the locator is analyzed with respect to degree of freedom, space and surface.

Locating:
Locating refer to the dimensional and positional relationship between the work piece and cutting tool.

Locator:
It is a device to establish and maintain the position of a part in a fixture to ensure the repeatability of the work holder.

IV. THE MECHANICS OF LOCATING

Degree of freedom
An unrestricted object is free to move in any of twelve possible direction. Fig 8-1 shows an object with three axes, or planes, along which movement may occur. An object is free to revolve around one move parallel to any axis in either direction. To illustrate this, the plane have been marked X-X, Y-Y, Z-Z.

Six point principle to restrict movement
In order to accurately locate a part in a fixture, movements must be restricted. This is done with locators and clamps. The fixture for the part is illustrated, the principle of restricting movement. By placing the part on a three pins base, five direction of rotation movement in +X,+Y,-X,-Y and linear movement in -Z axis are restricted. Flat bases may also be used, but these should be installed rather than machined into the base. Installed locators are less expensive to use because they take less time to install and are replaceable. If button or flat locators are used, the most important consideration is keeping the part above the chip and is constant contact with all three locators.

To restrict the movement of the part around the Z-Z axis and in the direction y linear, two more pins- type locators are positioned. To restrict direction -X- linear, a single pin locator is used. The remaining direction rotation in X, -Y,Z are restricted by clamping devices. This 3-2-1 or 6 point, locator method is the most common external locator for clamping device or rectangular parts so, in 3-2-1 locator 9 planes of movement restricted.

Still, 3 more degree of freedom are free. To restrict this three more pins are needed in each direction. If the center hole is a locator of work piece, 9 degrees of movement will be restricted. Similarly if the diamond pin locator is used 11 degree of freedom will be restricted.

V. DESIGN CALCULATION

Data for calculation
The data used here for calculation is for milling operation performed in Vertical Machining Centre

Material to be machined: Mild steel
Weight of the part: 1000gm (9.8 N)
Cutting force for milling in mild steel: 1950 N/mm². (From table 1)
So the clamping force must be greater than the cutting force, so let us consider the clamping force to be 2200 N/mm². (From table 1)
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The fixture base is considered to be a Uniformly Varying Simply Supported beam. The reaction has been calculated and the maximum bending moment is found using the formulae in

\[ W = \text{Total load acting on the beam.} \]
\[ R_1 = \text{Reaction at point 1.} \]
\[ R_2 = \text{Reaction at point 2} \]
\[ Y = \text{Distance from 'A' where shear force is zero.} \]
\[ L = \text{Length of the beam.} \]

**Calculation:**

\[ W = 1950N + 1kg + 2200N = 1950N + 9.8N + 2200 = 4150N \]
\[ \text{Reaction at A} \]
\[ RA = W/3 = 4.15/3 = 1.38KN \]
\[ \text{Reaction at B} \]
\[ RB = 2x \text{w}/3 = 2 x 4.15/3 = 2.77 KN \]

**Maximum Bending Moment:**

\[ Y = 1/\sqrt{3} = 345/1.732 = 199.1 \]
\[ \text{Shear force at } x = 0 \]
\[ Fa = WL/6 = 4.15 x 345 / 6 = 238.5KN/mm^2 \]
\[ \text{Shear force at } X = L; \]

Fb = -wL/3 = - 4.15 x 345 / 3 = -477.25

\[ \text{N/mm}^2 \]

Shear force will have zero at C = wL/6 = wX^2/2L.

Where,

\[ X = 1/\sqrt{3} = 0.577 \]

So maximum bending moment is

\[ M_{\text{max}} = wL^2/9\sqrt{3} = 1.5 x 345^2 / (9 x 1.732) = 31688.07 \text{ KN/mm}^2 \]

Mild steel has a yield stress of about 250 MPa. With allowable stresses in

- Tension = 150 Mpa = 0.150 KN/mm^2
- Bending = 165 Mpa = 0.165 KN/mm^2
- Compressive Strength of Mild steel is 450 MPa =0.450 KN/mm^2

**Moment of inertia:**

\[ I = \frac{m}{12} \left( \frac{a^2 + b^2}{12} \right) = 16/12 \left( \frac{345^2 + 120^2}{12} \right) = 177900 \]
\[ I_y = m/12 \left( b^2 + c^2 \right) = \frac{16}{12(345^2 + 50^2)} = 22533.33 \]
\[ I_z = m/12 \left( a^2 + c^2 \right) = \frac{16}{12(345^2 + 50^2)} = 162033.33 \]

\[ I = I_x + I_y + I_z = 177900 + 22533.33 + 162033.33 = 362466.66 \text{ Kg} \cdot \text{mm}^2 \]

By using bending moment equation equivalent width has been calculated.

\[ M/I = F/Y \]

where,

\[ M = \text{Moment of Inertia} \]
\[ I = \text{Bending moment} \]
\[ F = \text{Bending stress} \]
\[ Y = L/2 \]

Bending stress = My/I = 31688.07 x 199.1 / 362466.66 = 17.4 KN - mm^2

By 101.1mm

**Advantages of fixtures**

**Productivity**

Fixtures increase the productivity by eliminating the individual marking, positioning and frequent checking. The operation time is also reduced due to increase in speed, feed, and depth of cut because of high clamping rigidity.

**Interchangeability and Quality**
Fixtures facilitate the production of article in large quantities with high degree of accuracy, uniform quality and interchangeability at a comparative cost.

**Skill reduction**

There is no need for skilful setting of work on tool. Fixtures makes possible to employ unskilled or skilled machine operator to make savings in labour cost.

**Cost reduction**

Higher production, reduction in scrap, easy assembly and saving in labour cost result in ultimate reduction in unit cost.

- It increases the versatility of machine tool.
- It becomes possible to accommodate components at one setting and thus taking advantages of multiple machining.
- The use of fixtures partially automated the tool.
- The use of fixtures enable complex shaped part to be machined by being held rigidly to the machine.
- Fixtures reduces the expenditures on control machine parts.

VI. CONCLUSION

Thus the multi operational fixture has been successfully designed and developed as per the requirement of the company for the component that consumes more set up time. The overall design method has been designed to a separate analysis function. The plate the screw and the dowel pins are designed for a particular dimension. The fixture help to reduce the production cost by reducing the set up time, increase in tool life and easy design. This design is a perfect solution for the problem sought out. The usage of the fixture certainly help the industry to reduce production cost and set up time apart from increased productivity. The cost involved in manufacturing of Fixture can be obtained in the passage of time without affecting the company profit.

REFERENCES