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Modular Fixture for Key Way Slot Milling on Gear Shaft

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Abstract:- The objective of this paper is to develop an efficient fixture for key way milling a gear shaft. The fixture is developed to not only provide or facilitate uniform quality in manufacturing but also to provide a system that eliminates individual marking, positioning and frequent checking. This system makes use of a Modular type of fixture which provides an added advantage interchangeability of parts of the fixture. The clamping position of the fixtures, the kinematic constraint balance and the cutting forces are taken into account for the design of the fixture. Solid Edge is used to design and draft the fixture. In addition, the system provides the manufacturer the feature of doing 2 milling operation without the need to interchange the component after each operation. Isometric Standards are followed in the design of this fixture.

Keywords:- *Gear Shaft, Keyway Slot, Modular Fixture.*

I. INTRODUCTION

A Modular fixture system is a versatile alternative to a single purpose, dedicated fixture. Constructed from a kit of interchangeable components, the modular fixture is easily reconfigured for any work holding application. Single modular fixture system is capable of doing the same work as numerous dedicated fixture system. [a]

Gear shafts provide the rotation that allows one gear to engage with and turn another and contains a set of keyways in the shaft. The keyway slots functions as a locking mechanism which locks the corresponding gears in place constraining the linear and rotational motion of the gears locked. Figure 2.2.3 shows the design of the Industrial component with a slight modification in their dimensions.

II. LITERATURE SURVEY

- *A Review on Design of Fixtures.*

International Journal of Engineering Research and General Science Volume 2, Issue 2, Feb-Mar 2014 ISSN 2091-2730. S. S.Pachbhai, L. P.Raut.

"The requirement of the fixture is minimizing deformation of work piece. With the help of fixture operation time is considerably reduce and machining become easy. Fixture is also beneficial for reducing cycling time and increasing production rate."

III. PRINCIPLES OF LOCATIONS

"The principle of location is being discussed here with the help of a most popular example which is available in any of the book covering jigs and fixtures. It is important that one should understand the problem first. Any rectangular body many have three axes along x-axis, y-axis and z-axis. It can more along any of these axes or any of its movement can be released to these three axes. If the operation to be done on the cylindrical object requires restriction of the above mentioned free movements also than some more locating provisions must also be incorporated in addition to use of the V-block.**"**

Rajkumar.D.Patil , Dothre Dinesh , Hegade Sachin , Urane Vivek and Killedar Vishal , **Design of Milling Fixture in Mass Production of Pivot Block**

"3-2-1 Principle of Fixture Designing: For a fixture design the major portion of design time is spent deciding how to locate the work piece in fixture. We know that any free body has a total of 12 degree of freedom. 6 translational degree of freedom +X, -X, +Y, -Y, +Z, -Z. [1] 1. Clockwise around X axis 2. Anticlockwise around X axis 3. Clockwise around Y axis 4. Anticlockwise around Y axis 5. Clockwise around Z axis 6. Anticlockwise around Z axis. From these 12 degrees of freedom 9 degrees of freedom should be restricted, rest 3 degrees of freedom should be keep free for loading and unloading of job**.**"

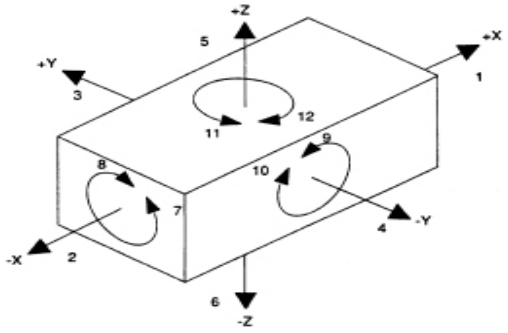

Fig 1:- The twelve degrees of freedom.

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IV. ELEMENTS OF FIXTURES

- Base Plate: It absorbs forces arising due to vibration effect and chatter. It is usually made of mild steel plate. [5]
- Locating and Guiding System: The location has to meet dimensional requirements of the workpiece stated on the component drawing. Location should be done on the most accurate surface of the workpiece. The main function is to prevent linear and rotary motion of the workpiece along and around the three major axes X, Y and Z.
- Clamping: Clamping elements hold the workpiece firmly engaged with location elements during operations. A fixture may have one or more clamping devices to clamp the work piece rigidly against all disturbing forces. [5]
- Locating System: The locating system is used be in conjunction with the clamping system to completely constraining the work piece or eliminate as many of the six degree of freedom as are necessary for the operations to be completed with the required accuracy. [5]

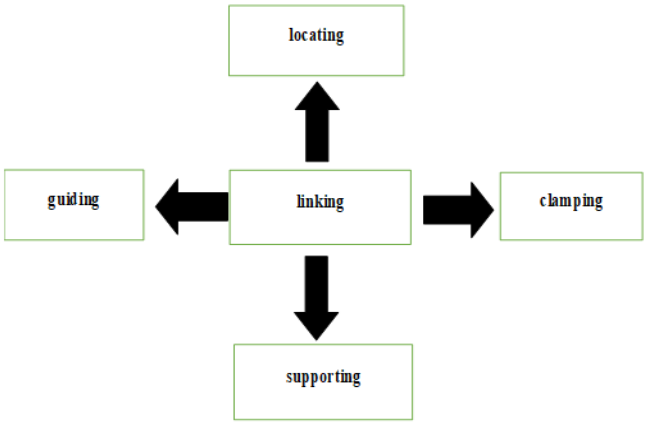

Fig 2:- Elements of Fixtures

A. *Factors to be Considered for Design of Fixtures*

- Component: [3] Drawing of the component to be studied carefully. Ensure work is performed in a proper sequence. Maximum operations should be performed on a machine in single setting.
- Capacity of the machine: [3] Careful consideration to be performed on type and capacity of machine.
- Production requirements: Design to be made on basis of actual production requirements.
- Location: Location should ensure equal distribution of forces throughout all sequence of operation. Location should be hard resistant, wear resistant and high degree of accuracy. Movement of work piece should be restricted. We should be fool proofed to avoid improper locations of the work piece. We should facilitate easy and quick loading of work piece. Redundant locators should be avoided. Sharp corners must be avoided. At least one datum surface should be established.
- Loading and unloading arrangements: There should be adequate clearance for loading and unloading. Hence process becomes quick and easy. Size variation must be accepted. It should be hardened material and non-sticky.
- Clamping arrangements: Quick acting clamps must be used as far as possible. The clamping should not cause any deformation to the work piece. It should always be arranged directly above points supporting the work. Power driven clamps are favored as they are quick acting, controllable, reliable and operated without causing any fatigue to the operators.
- Base and Body construction: Methods used: Machining, Forging and machining, Casting, Fabricating, Welding.
- Tool guiding and cutter setting: By adjusting the machine or using cutter setting block, the cutter is set relative to the work in a fixture. The drill bushes fitted on jig plates guides the tools.
- Rigidity and vibration: fixture must possess enough rigidity and robustness. Should not vibrate as it may lead to unwanted movement of work piece and tools.
- Safety: Operation should be assured full safety.

B. *Design Requirements*

The aim is to mill 2 key way slots [8mm and 6mm respectively] on a gear shaft of given dimension, it is to be machined on a milling machine [Operation: end milling]. The Fixture must mount on standard vertical milling machine. Clamping forces must withstand tool forces by a factor of safety of **2.0.**

The project focuses on the design and fabrication of modular fixture which can be installed on any vertical milling machine. It will incorporate cutting of keyways for gears of different dimensions. This will not only make the manufacturer's job easier, but also cut down on its manufacturing cost and in-turn on the selling cost of the particular gear shaft with a keyway slot.

V. DESIGN AND DEVOLOPMENT

The overview layout of the project along with the components, design calculations with its assumptions are shown below.

A. *Milling Parameters*

Width of slot 1 'b1' = 8mm
Width of slot 2 'b2' = 6mm
Depth of slot 'd' = 5mm
Diameter of workpiece @ slot 1 'D1' = 30mm
Diameter of workpiece @ slot 2 'D2' = 40 mm

- *Cutting speed*

$$Vc=\frac{\pi DN}{1000}$$

where D = Diameter of workpiece [mm]
N = Speed of the cutting tool [rpm] [N = 1000 rpm]
Vc1=(π*D1*N)/(1000) = 94.24 m/min

Vc2=((π*D2*N)/(1000) = 125.663 m/min

- *Feed*

f = $\frac{Vc}{N}$

Where Vc = cutting speed [mm]
N = Speed of the cutting tool [rpm]

f1 = 94.24/1000 = 0.0942 m/rev
f2 = 125.663/1000 = 0.1256 m/rev

- *Cutting force*

Fc = $\frac{4.5*K*f*d*b}{Vc}$

Where K= Material constant [Mild Steel] [$8.5 * 10^3$]
f = feed rate
d = slot depth [mm]
b = slot width [mm]

Fc1 = (4.5 * *8.5 * 1000 * 0.0942* 8 * 5)/(94.24) = 1529 N [cutting force of slot 1]
Fc2 = (4.5 * *8.5 * 1000 * 0.1256* 6 * 5)/(125.663) = 1149 N [cutting force of slot 2]
As Fc1>Fc2 the fixture is designed considering Fc1

- *Allowable Shear Stress*

Yield strength of plate material, ∂_{st} = 200 N/mm^2
Factor of Safety = 3
$\tau_{all} = \frac{0.5\,\partial st}{fos} = \frac{0.5*200}{3}$ = 33.33 N/mm^2

B. Design of Parts

- **Component:** The component is first/ primary gear shaft. Two Keyway slots are needed to be end milled on 2 different parts of the component. The draft and 3d model of the component is shown in Fig 3 and 4 respectively.

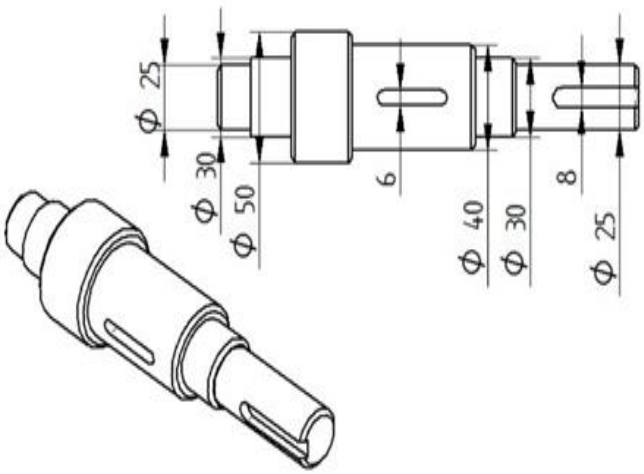

Fig 3:- Draft of the component

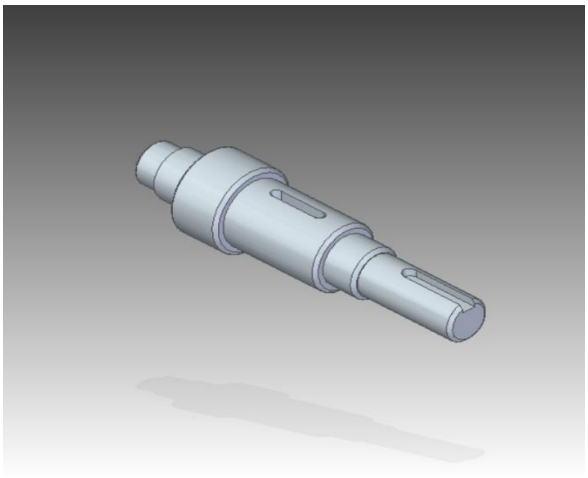

Fig 4:- 3D model of the component

- **Base Plate**: Base plate is the main component of this milling fixture. The whole assembly of the fixture is fitted on the base plate. The weight of base plate is more to possess high damping capacity. The figure 5 shows 2D drawing of milling fixture plate and Figure 6 shows 3D model of milling fixture plate.

The Dimensions of the base plate is 300mm x 150 mm, Base plate is 20 mm thick. Four 6mm holes with m6 tap are drilled for **m6 bolts** and four 8 mm holes with m8 tap are drilled for a distance of 10 mm at the side of the plate i.e perpendicular to the thickness of the plate.

The Base plate is designed to withstand the cutting forces of vertical milling machine.

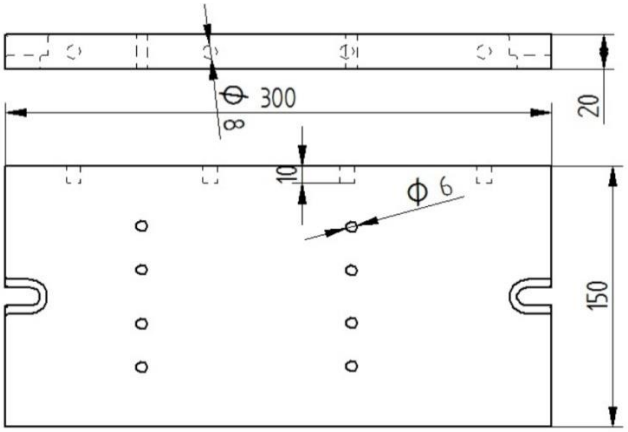

Fig 5:- 2D Draft of base plate

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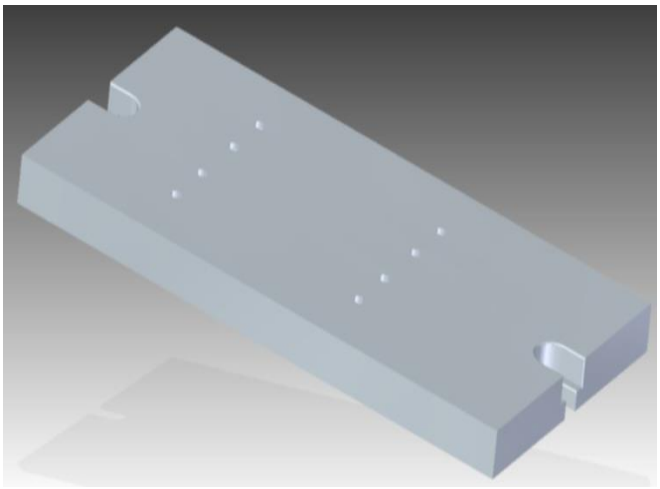

Fig 6:- 3D model of Base plate

- **V-Block:** V block is used to locate the component accurately on the plate and also to clamp the component. V block used is of Standard dimension with modifications made with respect to the thickness. V blocks are fixed to the base plate with the help of m6 allen bolts and component is clamped to the v block by m16 hexagon bolts. Figure 7 shows the drawing and 3d model of the V-Block used.

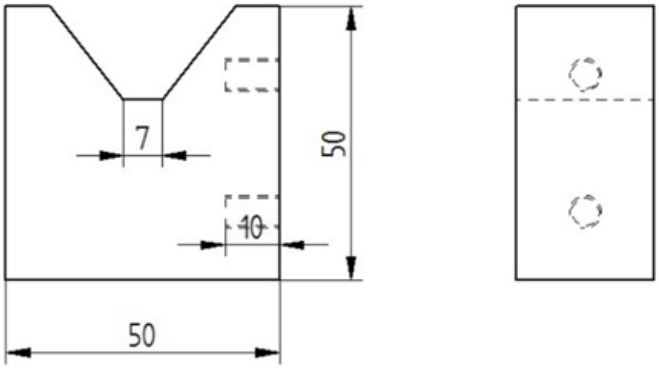

Fig 7:- (i) Draft v-block

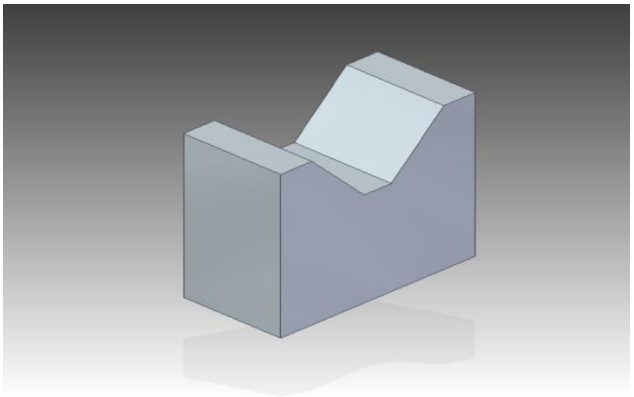

Fig 7:- (ii) 3D model of V-block

- **Clamp Plate:** A Clamp plate of 10 mm thickness is fastened to one side of the base plate. The main function of clamp plate is to provide a rigid clamping. Comparing to other clamping methods the use of clamp plate makes the clamping more rigid and holds the component and the v block together. The figure 8 illustrates the 3d model of the clamp plate.

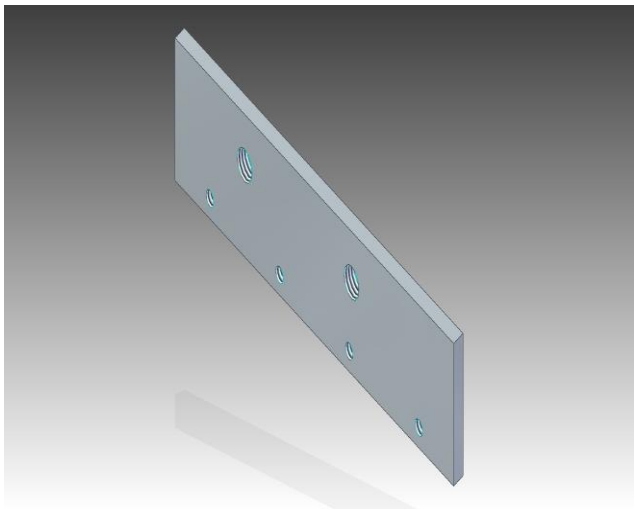

Fig 8:- 3D model of Clamp plate

VI. WORKING PROCEDURE

- **Base plate** is located on the bed of the milling machine such that its orientation with respect to each axis is orthogonal, a key which lock to the base plate ensures the proper locating of the base plate as it sits in the t-slot gap.
- Two V **blocks** are used to hold at each side of the component. The first V block is fixed to the base plate and the component is placed between the V – shaped channel. A moving v block is then placed at the other side of the component and this v block is used to hold and clamp the component
- **Clamp Plate** fixed to the side of the base plate, the clamp plate has a through hold where an M16 clamp bolt runs through. The clamp plate provides a rigid support to clamping while the idea of using a clamp which is held by a grove in v block is inefficient as the grove compromises the strength of v block.
- **M16 bolt:** M16 bolt provides the clamping force. Instead of clamping the component, the bolt clamps the v-block together thus tightening both the v blocks with the component. This method prevents damage to the component by the bolt.

The below figure [9] shows the assembly of the components of the proposed modular fixture.

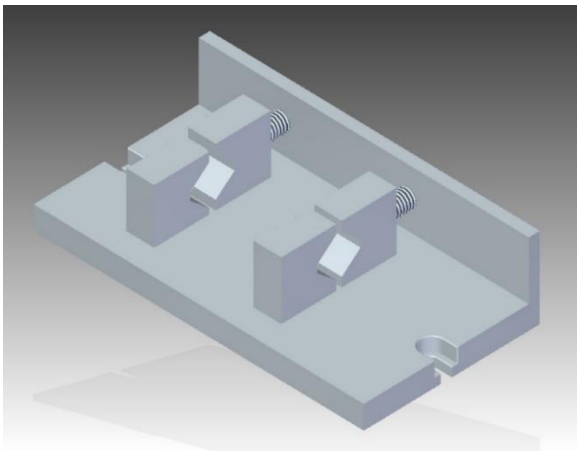

Fig 9:- Assembly of the fixture.

VII. CONCLUSION

This modular fixture is first of its kind. The modular fixture not only holds the component efficiently and stable but also reduces the setup time and provides for mass production of the component. The component selected is an industrial component and thus industrial standards are followed strictly. Therefore, there can be chances of increase in mass production and productivity. In addition, the parts of the system are re-placeable and the fixture can be upgraded with reference to further upgrade of the component.

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