



DESIGN AND FABRICATION OF FIXTURES FOR A GEAR SHIFT LEVER

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ABSTRACT:

Productivity improvement is a continuous process for any industry. Mass production will restrict the verity of the component as well as increase the rejection rate. The current paper deals the fixture design to minimize the rejection and rework of the component. Major contribution of this paper is to design the fixture to minimize the rejection rate, force analysis, rejection rate analysis and cost analysis. Force analysis shows that the clamping force is more than the machining force. The rejection rate analysis ensures the quality improvements

KEYWORDS: Gear shift lever, Fixture design, Perpendicularity error, Rejection rate, Force analysis.

1. INTRODUCTION

Sustainable development in manufacturing sector more vital for global economy [1]. Improving the quality, enhancing the productivity, increase the safety and decreasing the cost are continuous process in any manufacturing industry [2]. Jigs and fixture design is one of the way to enhance the productivity and safety. Jigs and fixtures are required to translate the standard machine tools into specialized machine tools. Fixture is used to locate and hold the jobs in appropriate position to perform the machining operations [3]. The fixtures aid to achieve the large-scale production by using the semiskilled operators. Fixtures are indispensable element of manufacturing processes as they are necessary in the majority of the automated manufacturing, inspection, and assembly operations. Inspection fixtures are used for the positioning the holes and faces which are to be checked. Assembly and welding fixtures are used to grip the parts so that the operator will use both hands to perform the operations. Special tools are used when complicated shapes are to be produced. Jigs are a machine shop device that is used for tool guiding. It is applicable for only drilling process. These devices can reduce the time of setting and act as foolproof for job setting. This device does not allow the job for wrong setting. Reduction in job setting time minimizes the time of production in turn increase the productivity. At the same time, the higher degree dimensional control can be achieved and rejection of component will decreased. Hence, unit cost of product is decreased and competitive advantage was increased. These special devices sometimes may be provided for small quantity production either interchange ability is demanded or if the work piece is difficult to hold. Karad et al [4] reported the various advantages of using jigs fixtures like reduction in cycle time, reduction in operator fatigue, reduce the accident, reduce inspection time, easy loading and unloading of the component and to achieve interchangeable parts. If the number of component to be manufactured is less than the break even quantity, the cost of the fixture may be uneconomic i.e. the cost of the product will increase. In some critical cases wherever the interchange ability of the component is vital, the fixture may be used for producing even lesser number of products. However, the increase cost may be compromised for the quality. Pachbhai and Raut [5] established the step by step procedure for designing the fixture. Further, they established the empirical

relationship between the cost per product, setup cost and tooling cost for optimizing the fixture design. Liu [6] developed a conceptual design to convert the dedicated fixture into modular fixtures. The validation of design indicates that the considerable cost saving potential and the usage of the fixture in most economic way. Pachbhai and Raut [7] designed the fixture for machining of hydraulic lift which is an integral part of engine of an agricultural tractor. They modelled the various elements of fixture assembly by using Pro-E and finite element based analysis of by using ANSYS software. Analysis of the result illustrates that the 18 % improvement in productivity and 17 % reduction in manufacturing time. Wang et al [8] described a fixture design based on the concurrent engineering. They successfully modelled a verity of parameters like physical space, loads, stress, deformation, thermal effects and vibration. A provision also made to resolve the load and deflection take place from the locating, clamping and machining, and calculate their influence on component quality. This approach enables to the designer for making the near optimal design of fixtures prior to the manufacturing. As on date, the design of fixture activity completely dependent on the familiarity of the designer, adoption of rule of thumb and trial and error process. This activity costs consumes time, cost and lesser reliability. Therefore, the current paper is aimed to establish the procedure for fixture design and quantify the benefits over existing manufacturing process. The outcome of this research helps to industry personal to design the fixture for their component and compute the benefits prior to the manufacturing of the fixtures.

2. PROBLEM DESCRIPTION

Gear shift fork is a component of Dozer and it is used in the final derive assembly in order to shift the gear. This component requires milling, drilling, reaming and chamfering operations. The processing of the component has associated with lot of errors and the greater scope for rejection due to fixture problem. These operations were performed in a common fixture. The major source for rejection due was lack of concentration on work by the operator due to supporting and holding problems. The rejection cost and reworking cost of a gear shift fork was being high.

Therefore, an effort has been made to design and manufacturing

a suitable fixture to reduce the rejection and reworking cost of the gear shift fork. The aim of this work is to provide fixtures, which would provide good dimensional control along with reduced machining time thereby enhance the productivity. The following problems are identified in the existing fixture namely: lack of perpendicularity between hole axis and pad faces, dimensions of pad thickness was not matched due to the deviation in perpendicularity and dimension of drilling centre was not correlated with the pad faces. Route cause for the aforesaid problems was the lack of perpendicularity between hole axis and pad faces.

This is due to locating the component on a screw locators and clamping near the pads. Since there is a deviation in pad thicknesses from pad to pad and component to component, the small variations in pad thicknesses also magnifies its deviations on to the hole axis. Further, the spring back property of the material after releasing clamping force to the component. By considering the above-mentioned challenges a new design was proposed which is discussed in the next section.

3. DESIGN OF FIXTURES

3.1 Design of Machining Fixture for Staggered Milling with the Help of Side and Face Cutters Base plate (30 X 230 X 450)

The base plate dimensions are taken from the design data book. This was selected based on the size of the component.

Vertical Plate (30 X 180 X 210)

It is used to support the work piece from the right side and it is designed based on the dimensions of the component.

L-Blocks

Using L-blocks as the primary locating elements for the component two linear degree of freedom and two angular degrees of freedom being arrested out of total 12 degrees of freedom of the component. For resting component the material of the L-block should have high wear resistance and shock load capacity.

Front Stopper

Using rectangular block as positive stopper in the front of the component one linear degrees of freedom of the component is restricted. The total thrust force will come on to this block during the milling operation.

Top Clamp

Using rectangular block with M16 bolt at the top of the component will arrest a linear degrees of freedom of the component.

Front Clamp

The remaining five degrees of freedom which is necessary for loading and unloading of the component, which is arrested by clamping. The clamp is situated at the very suitable place of the component from where maximum load can be shared by it with very less effect on the component.

L-block

L-block with adjustable screws and lock nuts arrangement will restrict one linear degrees of freedom out of six degrees of

freedom. Now only five degrees of freedom are remaining to arrest and gives rigid support to the component.

Setting Block

Using rectangular block as positive stopper for the cutter, the operator can have reference from the fixture.

Locating Pins

The locating pins are used to align the fixture in line to the machine table.

3.2 Design of Machining Fixture for Drilling Operation

Base Plate (25 X 200 X 450)

The base plate dimensions are taken from the design data book. This was selected based on the size of the component.

V-Block

Using V-block as the primary locating element for the component two linear degree of freedom and four angular degrees of freedom being arrested out of total 12 degrees of freedom of the component.

Strap Clamp

Using strap clamp as a primary clamping element for the component two angular degree of freedom and one liner degree of freedom out of six degree of freedom.

Side Clamps

Using rectangular blocks with M16 bolts from side of the component one linear and one angular degree of freedom of component is restricted.

Butting Pin

Using cylindrical block from side of the component the remaining one linear degree of freedom out of 12 degree of freedom also restricted.

Slip Bushes

Slip bushes are used to guide the drilling bit while drilling operation.

Screw Locaters

Using Screw locator from the base plate the component is supported firmly in perfect position.

4. FORCE ANALYSIS

4.1 Machining Force Analysis for Milling Fixture

Φ200 Milling Operations

Cutter diameter (D)= 200 mm

Speed (N)= 35 rpm

Feed (S)= 0.114 mm/rev

Material factor (k)= 1.98

Thrust force (F_x)= 1.16 x k x D (100 x S)^{0.85}

= 1.16 x 1.98 x 50 (100 x 0.114)^{0.85}

= 908.78 kgf

= 8.915 KN

4.2 Clamping Force Analysis for Milling Fixture

Selecting four M16 bolts at appropriate location in a fixture, Maximum force encountered by the five bolts are

Permissible clamping force encountered by M16 bolt =2.97 KN (from data book)

Therefore total clamping force = No. bolts x Permissible clamping force for each bolt.

$$= 5 \times 2.97$$

$$= \mathbf{14.85KN}$$

Factor of safety obtained with four bolts

$$= 14.85/8.915$$

$$= \mathbf{1.66}$$

4.3 Machining Force Analysis for Drilling Operation

Core drill diameter (D)= 28 mm

Speed (N) = 150 rpm

Feed (S) = 0.06 mm/rev

$$\text{Thrust force (Fx)} = 1.16 \times k \times D (100 \times S) 0.85$$

$$= 1.16 \times 1.98 \times 28 (100 \times 0.06) 0.85$$

$$= 422.046 \text{ kgf}$$

$$= \mathbf{4.1402 KN}$$

4.4 Clamping Force Analysis for drilling operation

Selecting two M16 bolts and one M20 bolt at appropriate location in a fixture, Maximum force encountered by the bolts are Permissible clamping force encountered by M16 bolt =2.97 KN (from data book)

Permissible clamping force encountered by M20 bolt =5.59 KN (from data book)

Therefore total clamping force = No. bolts x Permissible clamping force for each bolt.

$$= 2 \times 2.97 + 1 \times 5.59$$

$$= \mathbf{11.53 KN}$$

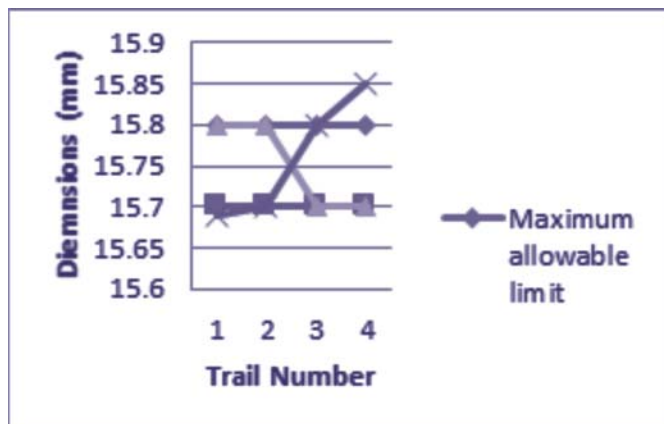


Figure: 1 Perpendicularity analysis

Factor of safety obtained with four bolts

$$= 11.53/4.1402$$

$$= \mathbf{2.283}$$

4.5 Cutting Force Analysis for Pad Milling Operation

Cutter diameter (D)= 150 mm

Speed (N)= 90 rpm

Feed (S)= 0.114 mm/rev

$$\text{Thrust force (Fx)} = 1.16 \times k \times D (100 \times S) 0.85$$

$$= 1.16 \times 1.98 \times 37.5 (100 \times 0.114) 0.85$$

$$= 681.59 \text{ kgf}$$

$$= \mathbf{6.686 KN}$$

4.6 Machining Force Analysis for Milling Operation

Selecting two M16 bolts and one M20 bolt at appropriate location in a fixture, Maximum force encountered by the bolts are

Permissible clamping force encountered by M16 bolt =2.97 KN (from data book)

Permissible clamping force encountered by M20 bolt =5.59 KN (from data book)

Therefore total clamping force = No. bolts x Permissible clamping force for each bolt.

$$= 2 \times 2.97 + 5.59$$

$$= \mathbf{11.53KN}$$

Factor of safety = 1.725

5. REJECTION RATE ANALYSIS

Perpendicularity between whole axis and pad faces was described in the Figure 1. Four trails conducted to ensure the right angle whole axis and pad face. All the trails are within the specified limit except the fourth trail of the rear pad thickness.

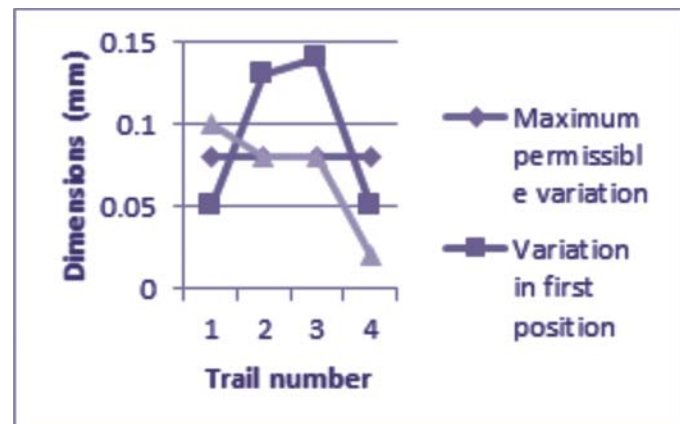


Figure: 2. Pad thickness analysis

Pressure pad thickness analysis also carried out based on the four trails. First position of trail 2 and 3 slightly away from the permissible value. The allowable limit for perpendicularity analysis and pad thickness analysis are 0.3 mm and 17mm respectively. Since the obtained values are very nearer to the allowable limits, So that necessary corrections are made and then the design was finalized. The assembled view of the fixture was illustrated in the Figure 3.

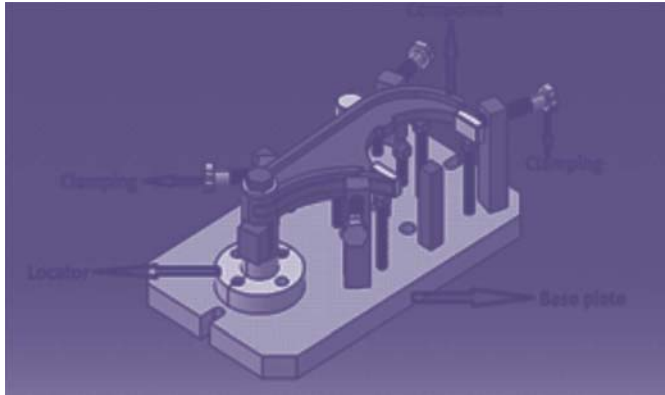


Figure:3 Assemble view of fixture

6. COST ANALYSIS

The savings in machining cost also calculated by using the following relation.

Machining cost = Existing machining cost - Proposed machining cost.

$$= 103342.8 - 41228.6$$

$$= \mathbf{62,114.2 \text{ Rs.}}$$

Percentage saved in machining cost per year =

$$\frac{\text{Net saving in machining cost}}{\text{Machining cost for existing fixture}}$$

Machining cost for existing fixture

$$= \mathbf{60.10\%}$$

Cost of rejected components (Rs) = 37,372

Manufacturing Cost of fixtures (Rs) = 20114

Net savings = saving in machining cost + saving in rejection cost - fixtures cost

$$= 62,114 + 37,372 - 20114$$

$$= \mathbf{79372 \text{ Rs Per year.}}$$

7. CONCLUSION

New fixture for machining the Gear shift fork component was designed. Integrated fixtures for Milling, drilling and pad milling are clearly described. Arresting each and every degrees of freedom concerned with fixture procedure was illustrated.

The perpendicularity problem between the hole axis and pad surfaces is avoided and ensured the dimensional accuracy of the pad surfaces are maintained within the range. Cost analysis shows that the 54% of machining cost reduction was achieved. However, the number of setups was increased from 3 to 5. Increase in setup cost was comparatively less than the reduction in machining cost, rejection cost and reworking cost. The clamping force was greater than the machining force and the factors of safety value for all fixtures are more than one. Hence the design was in safe limit.

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